# The complementarity of mechanical and chemical recycling

A plea to technology openness focused on common goals

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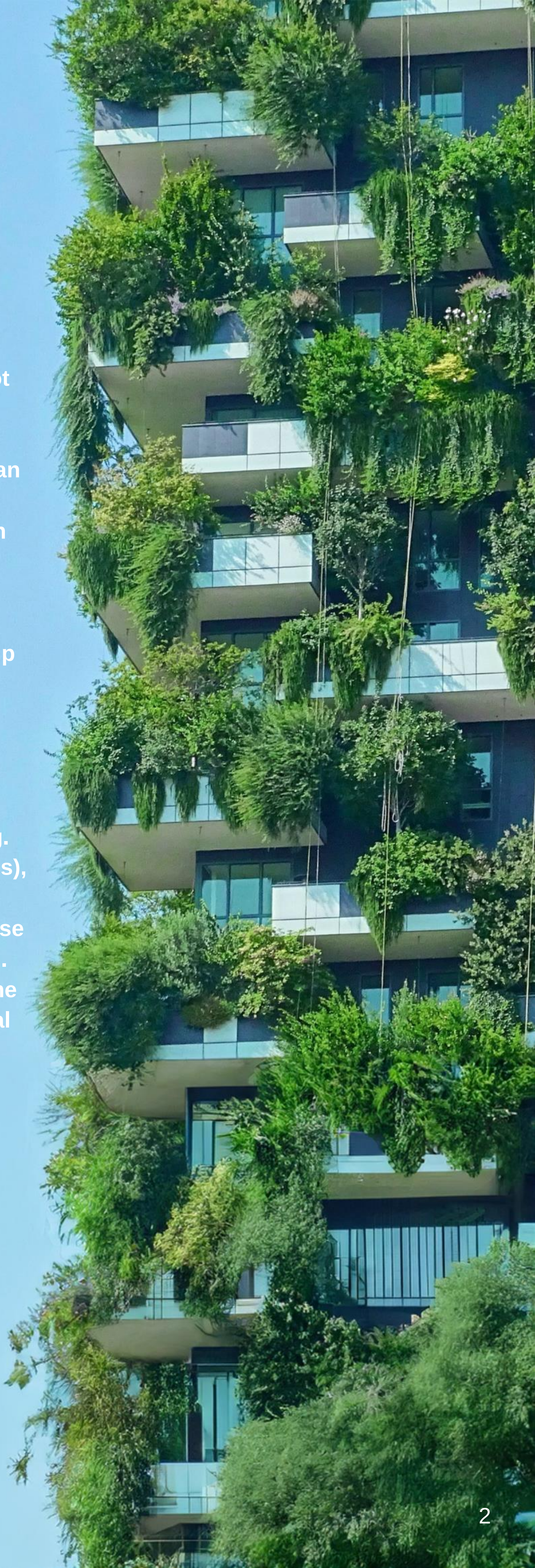
**Managing plastic waste is one of the major challenges to solve for a more sustainable society that still wants to benefit from the versatility and performance of plastics. The business-as-usual case for plastic waste is not sustainable, and as we are seeing demand for plastics growing significantly at global scale, the implementation of circular solutions play an essential role in responding to the challenge. Recycling and circularity has to play its part in the triangle of "reduce, reuse, recycle". Nonetheless, with a current global plastics recycling rate below 10%[1], there is no doubt that a major undertaking is required to ramp up recycling.**

**Besides the more well-developed mechanical recycling, other approaches can do so: chemical recycling, a term that encompassed various technologies such as liquefaction (e.g. through pyrolysis and hydrothermal processes), depolymerization, as well as dissolution. Chemical recycling has the potential to increase the share of materials that are kept in the loop. To maximize impacts and take advantage of the benefits inherent to each technology, chemical recycling has to complement existing, mechanical recycling technologies. Together, both routes can pave the way for the circular economy of plastics.**



[1] OECD: Plastic pollution is growing relentlessly as waste management and recycling fall short, says OECD, 2022.

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## Common objectives, individual strengths

Chemical and mechanical recycling are driven by clear and common goals: mitigate plastic waste pollution, increase recycling rates, advance circularity for plastics, and reduce dependence on virgin fossil resources. To achieve these goals, all technologies, whether mechanical or chemical, will play their part, complementing each other to ensure their different capabilities are leveraged to maximize circularity. While both share these objectives, each brings unique strengths to the table. The benefit of mechanical recycling is the lower energy consumption, whereas chemical recycling excels in processing a wider spectrum of mixed plastic waste materials that are challenging for mechanical recycling. This underlines the necessity of a multi-faceted approach in our recycling strategies, as there is no silver bullet solution to the complex issue of plastic waste. The complementary roles of mechanical and chemical recycling are defined by a combination of economic and environmental factors, as well as the quality of feedstock material and output.

Chemical recycling generally involves more complex processing steps and can result in higher energy consumption (which varies between the different technologies) than mechanical recycling, leading to increased operational costs. However, its ability to process plastics that cannot be handled by mechanical processes is a distinct advantage. Through chemical recycling, materials that would otherwise end in landfills or incinerators can be effectively transformed into high-quality products comparable to virgin materials. This becomes crucial when there is a demand for high-quality recyclates that mechanical recycling cannot meet (e.g. food-contact, medical or other sensitive applications) or when the feedstock is simply unsuitable for mechanical recycling. As previously mentioned, mechanical recycling is often chosen for its cost-efficiency and suitability for certain quality standards. As a result, the choice between these recycling technologies is influenced by factors such as the input, the desired output quality and cost considerations. This interplay ensures that both methods work together to expand the range of recyclable plastics, enhancing the overall quality and efficiency of recycled materials in the industry. Thus, to maximize this effect, four spheres should be considered:

**The choice and application of recycling technologies:**
When do we choose which technology?

**The availability of and competition for feedstock:**
What’s required to avoid feedstock competition and increase feedstock availability?

**The assessment of environmental impacts:**
How should the environmental impacts of recycling technologies be evaluated?

**The regulation of recycling:**
How can regulation provide a framework fostering complementarity?

By understanding how each sphere interacts and influences the others, we can identify opportunities for collaboration and innovation that will drive the recycling industry towards a more sustainable future.

### Maximizing Circularity with Mechanical and Chemical Recycling

First, a clear understanding is necessary: the incineration and landfilling of plastics are two waste management methods that should be strictly avoided by prioritizing recycling. To transition to a more sustainable circular economy of plastics – and to maintain Europe's competitiveness in recycling technologies – we must enhance all recycling routes and leverage their individual benefits.

Mechanical recycling is cost and energy-efficient but limited in processing complex waste streams. Certain streams are unsuitable, for example those that are highly impure and consist of multiple different materials. Furthermore, mechanical recycling can lead to a quality loss of materials undergoing multiple cycles. There, chemical recycling can serve as a "reset button" to "renew" materials, restoring them to original quality. This synergy between recycling technologies is crucial. Collaborative efforts should ensure that waste is treated by the most suitable method, based on its characteristics and the required output quality.

Standardized guidelines are essential to achieve this, guiding the allocation of waste streams and taking into account local demand and infrastructure, as different recycling systems may have different usages and benefits depending on the location. As plastics continue to play a significant role in various industries, a future where circularity is the norm is necessary and will require close integration of various recycling technologies. This approach not only aligns with reducing plastic usage, but also paves the way for a sustainable and resource-efficient future.

### Feedstock Availability and Competition in Recycling

The concern about competition between mechanical and chemical recycling is often justified by the collected waste availability. Accordingly, the availability of waste will be key for the successful implementation of chemical recycling. In the EU, where recycling rates are yet to reach their full potential, there is a significant amount of waste that can be diverted to both recycling methods instead of incineration or landfilling. It must be ensured that mechanical and chemical recycling scale up side-by-side to maximize recycling rates as soon as possible. For that, the collection and sorting of plastic waste needs to be stepped up as well.

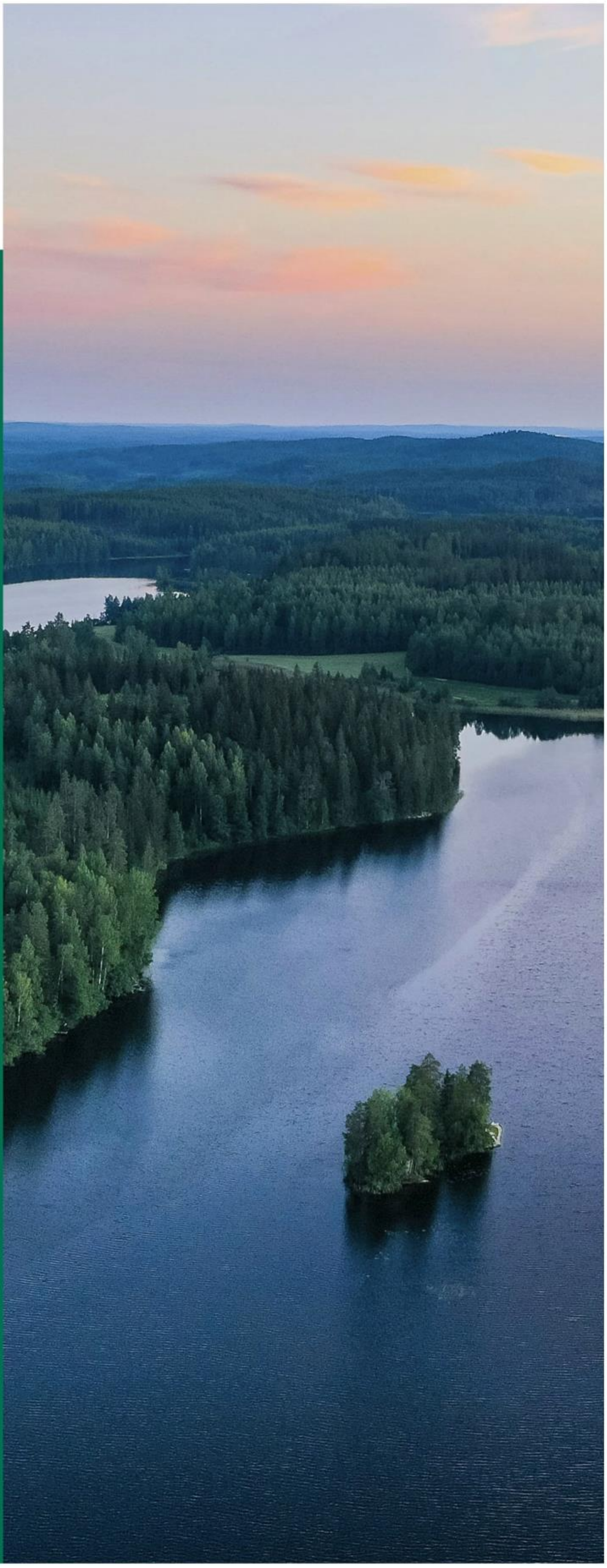
Advanced sorting technologies are already showing promise, offering higher sorting yields and thereby increasing the available feedstock. This is vital, as efficient sorting is the backbone of the recycling infrastructure. Without adequate sorting capacities, the supply of materials for both mechanical and chemical recycling could be constrained. In navigating this landscape, it is crucial to strategically allocate waste streams to avoid competition. Chemical recycling should focus on processing waste that is unsuitable for mechanical recycling, particularly when mechanical methods can produce recyclates of sufficient quality to replace virgin plastics. This approach helps preventing unnecessary market overlap and addresses potential ambiguities.

Aside from the guidelines mentioned above when talking about usage and application of the technologies, a complementary approach to mechanical and chemical recycling should also focus on increasing the availability of collected and sorted waste along the value chain. To do this, a number of factors can be considered:

- **Enhancing collection and sorting:** Collection and sorting will play a crucial role in directing waste streams to the respective recycling routes. Mechanical recyclers have already built a strong technical expertise in this. They also know how to handle a decentralized model with smaller value chain players on a local or regional level. In collaboration with chemical recycling players, mechanical recyclers can therefore play an important role in their value chains

- **Design for recycling:** While design for recycling requires a robust collection and sorting process, it can also help make sorting easier. New requirements for packaging design under the future EU packaging and packaging waste regulation should facilitate easier sorting of packaging aiming towards mechanical recycling. It will be crucial to include downstream parties such as brand owners to ensure the implementation of design for recycling.

- **Improved upstream waste management:** Considering the different level playing fields on collection, sorting and recycling in contrasting geographies, the strategy to expand feedstock availability and technology use can vary significantly. Individual collection, sorting and recycling systems and infrastructure of these geographies need to be considered and, in many cases, further developed.



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## The assessment of environmental impacts

Although the analysis issued by the Joint Research Center of the EU Commision (JRC)[2] shows climate-related benefits of chemical recycling over incineration, chemical recycling technologies regularly face scrutiny when it comes to environmental impact. There are various life cycle assessments (LCA) on chemical recycling technologies publicly available, however, the applied methodologies and scopes differ. Thus, clear and harmonized guidelines are needed to ensure that the impacts of both mechanical and chemical recycling are measured in a standardized manner. When assessing said technologies, a fair playing ground is required to ensure that the assessment is based on facts and objective criteria, also including third-party verifications. Any technology assessment should propose complementary scenarios considering that plastics value chains are undergoing changes. As an example, the future share of alternative material e.g. bio-based vs. fossil origin, that will still need recycling, should be considered. Furthermore, projections in collection and sorting improvement should be added.

While the environmental footprint of recycling technologies is an important factor when it comes to determining the best possible value chains, it should be acknowledged that recycling also contributes to solving other issues by adding value to waste, contributing to mitigating plastic pollution while reducing the use of resources. The EU waste hierarchy[3] features other management principles with similar aims: prevent, reduce and reuse. As recycling comes after these in hierarchy, it does not compete, but rather provides further alternatives to address and add value to unavoidable waste streams.

[2] https://publications.jrc.ec.europa.eu/repository/handle/JRC132067
[3] https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

## Enhancing Recycling Regulation for Circular Economy

Regulation that promotes innovation in all recycling technologies is required to accelerate circularity, increase recycling of plastic waste, and enable the defossilization of industrial value chains as fast as possible. This includes the definition of a clear regulatory framework for chemical recycling to operate, while safeguarding the growing and developing of mechanical recycling. The following aspects are considered the most critical when it comes to the regulatory framework:

- To improve the availability of feedstocks in the EU, regulation must incentivize the collection, sorting and recycling of waste in all member states, while restraining the shipment of waste outside of EU.
- A methodology on choosing the right recycling technology is required and must follow the guidelines mentioned earlier in this chapter. Whenever both routes are technically viable and can maintain the quality for intended uses, the most environmentally beneficial technology from an LCA perspective should be chosen.
- Design for recycling criteria is critical in increasing the recyclable feedstock base. The design for recycling should consider the needs of mechanical recycling in particular, which will indirectly support chemical recycling as a complementary technology.
- When it comes to the quality of the recycling output, it should also be considered that ideally, recycling should target the same quality as the feedstock.
- To ramp up the use of recycled materials, regulatory incentives are needed, while incentives for incineration or landfilling should be reduced. Aside from costs and quantities, Extended Producer Responsibility (EPR) schemes should also consider quality more heavily.
- Promoting and incentivizing recycled content in plastic applications is required to support the ramp-up of recycling technologies.

## Complementarity requires collaboration

The authors of this document are convinced that ensuring complementarity and accelerating circularity requires collaboration. All stakeholders of the value chain must be united by the goal of reducing the amount of plastic waste that ends up incinerated, landfilled or disposed of in the environment, as well as enabling higher recycled content in products. A joint effort from mechanical and chemical recyclers will ensure that both technological routes provide the most favorable impact, combating climate change as well as plastics pollution. The complementarity of mechanical and chemical recycling is underlined by the fact that several companies are either investing in both routes or building commercial partnerships between mechanical and chemical recyclers to jointly increase recycling rates.



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