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Advancing plastic recycling in Europe

ECRN position paper

ECRN | European Chemical Regions Network

Key messages

Plastics are essential to Europe's economy but remain one of the most complex waste challenges. The European Chemical Regions Network (ECRN) recognizes that **advancing plastic recycling** is a key pillar in **achieving the European Green Deal and a circular economy**.

While mechanical recycling remains the most energy-efficient method and therefore preferred method, it is limited in scope and quality. **Chemical recycling provides a complementary solution for hard-to-recycle plastics that cannot be mechanically recycled**, offering high-purity outputs or other valuable products that can be fed back into the circular economy. However, both systems face challenges related to additives, sorting, and infrastructure gaps. Furthermore, the emergence of bio-based and biodegradable plastics calls for clearer policy and infrastructure alignment to avoid disrupting existing recycling systems.

Regional administrations occupy a pivotal position for **turning EU ambitions into tangible local achievements**: they can **forge alliances** across the plastics value chain, **back pilot projects** and R&D in advanced recycling technologies and **adapt policies and infrastructure to the specific waste profiles of their territories**. Complementing this effort, national governments should design programmes that make it easier for SMEs to comply with REACH and circular-economy rules.

Europe’s mostly SME-driven chemical sector needs rules that are clear, stable and proportionate. A streamlined, SME-friendly revision of REACH should free up resources for innovation and for scaling both mechanical and chemical recycling. Coupled with targeted finance and technical-training programmes—and a guaranteed seat at the policymaking table—SMEs can adopt circular practices without sacrificing their competitiveness.

ECRN recommends that EU legislators **advance plastics recycling** as follows:

- **Strengthen market pull through recycled-content obligations**, green public-procurement quotas, targeted tax incentives and transparent price indices for recycled and bio-derived polymers.
- **Channel EU and national funding** into integrated mechanical- and chemical-recycling plants, upgrade sorting with AI and sensor systems, and fast-track permits for new capacity.
- **Enforce EU-wide design-for-recycling standards**, issue safer-by-design additive guidelines, and link Extended-Producer-Responsibility fees to true recyclability and low toxicity.
- **Harmonise separate-collection rules across Member States**, introduce polymer-specific streams where viable, and sustain public-awareness campaigns to cut contamination.
- **Finalise EU definitions**, mass-balance accounting and recycled-content targets for chemical-recycling outputs and adopt one clear label that distinguishes bio-based, biodegradable and compostable plastics.
- **Deliver a streamlined, SME-friendly REACH revision** and pair it with dedicated finance and technical training so smaller firms can invest confidently in circular technologies.
- **Empower regions as circularity hubs** by launching pilot projects and living labs on circular plastics, promoting interregional collaboration and knowledge sharing and easing access to structural and cohesion funds for circular-economy investments.

Integrated recycling pathways: mechanical & chemical recycling

Europe produces approximately **29.5 million tonnes of plastic waste annually**, of which about **34.6% is recycled** (Plastics Europe, 2022). Mechanical recycling remains the most widespread method, yet its effectiveness is restricted to clean, homogeneous plastic streams. As a result, substantial volumes of plastic waste continue to be incinerated or landfilled (Cefic, 2023).

First, **mechanical recycling** consists of **physically processing plastic waste into secondary raw materials** without altering the chemical structure of the polymers. It is efficient for mono-material and uncontaminated plastics, such as PET bottles or HDPE containers.

However, key limitations persist:

- **Degradation of polymer properties** through multiple recycling loops.
- **Contamination,** including food residues or incompatible additives, which hinder recyclability and quality.
- High separation costs that often make mechanical recycling economically unfeasible, leading to landfilling of otherwise recyclable materials

Technological advancements in **automated sorting**, such as near-infrared (NIR) scanners, and the **development of additives** that improve the mechanical performance of recycled plastics are critical to enhancing the process (Schwarz et al., 2021; Ragaert et al., 2023). Mechanical recycling is strongly limited by the presence of contaminants and the multi-material nature of many plastic products, which make efficient separation and treatment of polymers difficult.

To address these challenges, advanced sorting technologies (e.g., optical robotic systems) and pre-treatment methods that improve the quality of input materials are becoming increasingly important—not only for large facilities but also for SMEs, which often lack the scale and resources to manage complex waste streams effectively. For SMEs, these innovations can significantly improve the quality of input materials, yet their adoption hinges on access to funding and technical training. Promoting investments in collection and sorting infrastructure, including through public-private partnerships, is essential to increase the availability of high-quality secondary raw materials.

Second**, chemical recycling** refers to **technologies that break down polymers into monomers, oligomers, or other feedstocks**, enabling the production of new, high-quality plastics or other valuable products such as liquid fuels or solid for different applications. This method can process waste streams unsuitable for mechanical recycling, including multilayer packaging, coloured plastics, or contaminated fractions (Cefic, 2023; EuRIC, 2022).

Against this background, chemical recycling has emerged as a **complementary solution capable of treating complex, contaminated, or multi-layer plastics** that mechanical processes cannot handle. According to Interreg Europe PLASTIX (2024**), integrating both recycling technologies is essential to reduce Europe's dependency on virgin plastics and to support EU climate targets**.

Notably, chemical recycling can:

- **Output flexibility** (biofuel, syngas, monomers, depending on operating conditions).
- **Remove undesired additives** and impurities.
- Generate **outputs suitable for food contact or medical-grade applications**.
- Complement mechanical recycling by **expanding the range of treatable materials** (CCPE Fraunhofer, 2021).

Despite its potential, chemical recycling must overcome **economic, energy-efficiency, and scalability challenges**. Standardizing definitions and metrics at the EU level is also crucial (Ragaert et al., 2023). Chemical recycling requires significant plant investments and a clear and stable regulatory framework to attract capital and ensure the scale-up solutions. Accelerating permitting procedures for new plants is crucial, as is fostering collaboration between SMEs, large companies, and research centres to share expertise and lower technology access costs. Transparent criteria for calculating recycling rates and mandatory recycled content targets can boost demand for recycled products and foster innovation.

Role of additives

Additives enhance the properties of plastics by improving flexibility, resistance, colour, or durability. However, certain additives, such as flame retardants, plasticizers, or colorants, can **negatively affect recyclability** by reducing the quality of recycled output or introducing SVHC into the process (EuRIC, 2022; IDAEA-CSIC, 2023).

In **mechanical recycling**, additives often remain embedded in the plastic, leading to **accumulated contamination** after multiple cycles. In contrast, **chemical recycling can remove or neutralize** many of these additives, thus allowing for higher-purity outputs suitable for sensitive applications, including food contact materials (CCPE Fraunhofer, 2021). However, in chemical recycling, additives like flame retardants can interfere with catalysts used in catalytic pyrolysis or create undesired side reactions, reducing the purity of obtained fuels or monomers.

To support circularity, Europe needs:

- **Standardized guidelines** for additive use (e.g., safer-by-design formulations).
- Investment in technologies to **detect, sort, and remove** additive-containing plastics.
- Integration of **design-for-recycling principles** from the outset (Rethink Plastic Alliance, 2024).
- Support for SMEs in adopting eco-design practices that minimize problematic additives, improve and promote material compatibility and facilitated access to advanced separation technologies to handle additive-rich materials.
- To develop **digital tracking systems** to trace additives and improve waste sorting.

Integrated collection, sorting & end-of-life management

Efficient collection and sorting form the entry point to a genuinely circular plastics economy, while end-of-life choices determine whether materials stay in the loop or slip into energy recovery and landfill. At present, Europe still fails to sort around **15 million tonnes** of plastic waste each year— material that is then subsequently incinerated or landfilled instead of being recycled. (Plastics Europe 2022; Interreg PLASTIX 2024). Closing this gap demands a single, coordinated strategy that links front-end logistics with back-end recycling routes.

Regarding **collection & sorting**: a clear EU policy framework must:

- **Harmonise collection schemes** across Member States to minimise consumer confusion and contamination.
- Run **public-education campaigns** that emphasise correct separation and the consequences of "wish-cycling."
- Deploy **advanced, AI-assisted sorting systems**—NIR, hyperspectral imaging, robotics—to boost purity and yield, and introduce **polymer-specific collection streams** where economically viable (Schwarz et al., 2021).
- Address regional disparities through **tailored infrastructure investment** and **SME-driven collection consortia** that share logistics costs and stabilise feedstock quality.

For what concerns the end-of-life, following the waste hierarchy, **reuse and mechanical recycling** remain the first choice for clean, mono-material streams; **chemical recycling** is indispensable for multilayer, highly contaminated or composite plastics (Cefic 2023; CEPS 2023). An integrated framework should:

- **Couple complementary recycling routes** to maximise overall recovery.
- Slash GHG emissions by diverting material from incineration or landfill.
- Retain material value in closed-loop (same-product) and open-loop (cross-sector) applications.
- Expand **pre-treatment and separation capacity**, giving SMEs a role in operating these facilities and in compounding recycled polymers for new markets.

Bio-based plastics, derived from renewable sources such as sugarcane or corn, offer the potential to reduce fossil resource dependency, provided that competition for land use with food production is avoided. However, they often present **compatibility challenges with existing recycling streams** (Ragaert et al., 2023).

Alternative materials: bio-based and biodegradable plastics

Meanwhile, **biodegradable plastics** may fragment or degrade only under specific conditions (e.g., industrial composting), which are not widely available in Europe. If mismanaged, these materials can contaminate recycling systems or generate false expectations among consumers (Rethink Plastic Alliance, 2024).

Europe should:

- **Develop** clear labelling and collection systems.
- **Provide** obligations to indicate the exact amount of bio-based materials avoiding greenwashing and misleading consumers.
- **Assess** environmental impacts via life cycle analyses.
- **Avoid** creating parallel waste streams that undermine circularity goals.
- **Harmonize** waste management system across Europe
- **Implement** specific recycling systems
- **Provide** SMEs with training on the specific characteristics and proper end-of-life handling of bio-based and biodegradable plastics.
- **Prevent** mismanagement of alternative materials that could compromise traditional recycling systems.

Designing plastics for circularity and safety

The design phase determines up to 80% of a product's environmental impact. Applying Design for Recycling (DfR) principles is key to enabling circularity. This includes:

- Selecting easily recyclable polymers.
- Minimizing harmful or non-recyclable additives.
- Ensuring compatibility with existing recycling infrastructure (EuRIC, 2022).

Policy tools like **Extended Producer Responsibility (EPR**) and the **Ecodesign for Sustainable Products Regulation (ESPR)** should incentivize recyclability, reduce toxicity, and encourage durability and reparability (Rethink Plastic Alliance, 2024).

Embedding safety and sustainability into plastic product design is a long-term investment in a circular European plastics economy. To ensure these principles are widely implemented, it is crucial to support all actors in the value chain, including SMEs, which may lack the internal capacity to redesign products independently. Helping SMEs adopt eco-design strategies—such as reducing material variety, selecting recyclable polymers, and incorporating marking systems for automated sorting—can significantly contribute to safer, more circular plastic products. Promoting technical training and encouraging collaboration with designers and raw material suppliers will be essential to develop innovative, scalable solutions.

Sustainability requirements and competition with imports

The **requirement for auditing processes** in third countries helps level the playing field for European recyclers by ensuring that imported materials meet comparable standards. Enforcing sustainability criteria—such as carbon footprint, water use, and life cycle assessment (LCA)—in chemical recycling, along with external verification of imports, enhances the competitiveness of the European industry and supports the objectives of the Green Deal.

In this context, recent EU regulations play a pivotal role in creating clear, enforceable frameworks that support circularity, innovation, and trust across the plastics value chain:

- **Regulation on recycled plastics in food contact (EU 2025/351):** This regulation clarifies purity requirements, which are critical for high-value applications. Packaging is by far the sector that consumes the most plastic in the industry, and within this category, food-contact packaging is a major driver of demand.
- **Regulation (EU) 2025/40 on packaging and packaging waste:** This introduces essential requirements for Mass Balance Accounting (MBA), which is vital for transparent tracking of recycled content, particularly in chemical recycling. Ensuring transparency in this area is crucial to building market trust and avoiding the redirection of mechanically recyclable materials into less energy-efficient processes.

Key points to highlight:

  - The need to harmonize MBA rules for both mechanical and chemical recycling, in order to prevent market distortions.
  - The importance of independent certification (e.g., ISO 17065) to verify processes and guard against greenwashing.

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The European Chemical Regions Network in a nutshell

Over the last 20 years, the European Chemical Regions Network (ECRN) has and continues to serve as the **collective voice of its member regions**, in which the chemical industry plays a crucial role in economic development, growth, and employment.

ECRN originally started as an INTERREG IIIc project in 2004, to help regions better tackle common challenges by exchanging information, exploring innovative solutions, and by speaking with a single voice in Europe. Today the network has grown from a temporary project to a **recognized European chemical stakeholder and a network full of expertise**. ECRN is a registered non-profit association under Belgian law and the network currently covers various European chemical regions, whose cooperation is supported by a Brussels-based secretariat.

We work together with European and regional chemical stakeholders and contribute to a range of policy areas from industrial policy, competitiveness, chemical regulation and REACH to skills, innovation, environment, and circular economy.

At ECRN, we advocate for a **stronger regional dimension in European strategies and policies related to the chemical industry**. We believe that the chemical industry can effectively respond to Europe's societal challenges with sustainable and innovative solutions if its economic growth is linked to territorial development. By bringing concrete local experiences and solutions into EU policymaking, the network aims to bridge the gap between policy elaboration and local impact.

We currently represent 12 regions in 7 different countries (Italy, Poland, Netherlands, Germany, Spain, Belgium and Czech Republic). Also, we have contributed to the Union policymaking with 44 policy papers and participated in 11 EU-funded projects.

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