ZERO WASTE EUROPE

Ensuring safe recycled content in food packaging: ambition vs reality

Policy Briefing

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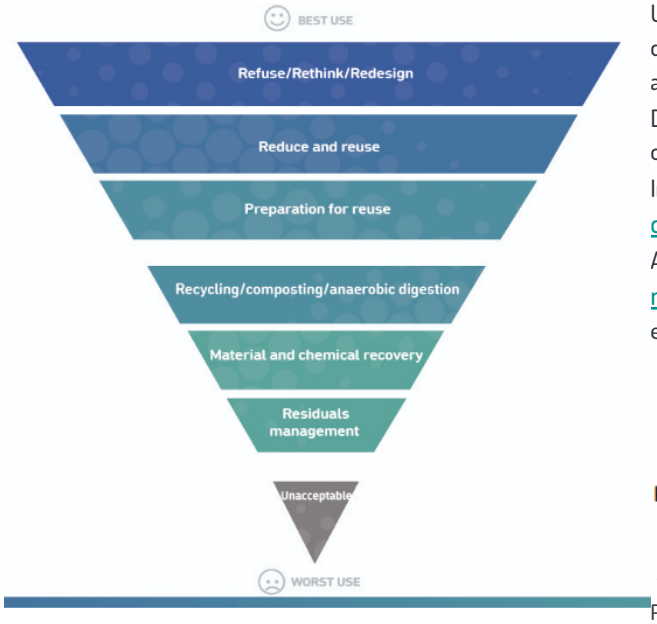
Introduction

To support the ambitions of the European Green Deal, respect planetary boundaries, and create a toxic-free environment, packaging and products should follow the principles of circular economy and the waste hierarchy, thus keeping resources in use for as long as possible. This means prioritising waste prevention strategies to avoid and minimise material consumption in the first place.

Therefore, we must focus on 'products' not waste, expanding the 'prevention' level of the traditional hierarchy out into the 5Rs - 'Refuse/Rethink/Redesign, Reduce and Reuse'. This includes anything that stops waste from being produced, from behavioural changes, prevention of consumption of single-use items, to rethinking business models to make products waste-free by design. This should be the central priority of economic, circular and environmental EU policies and funding.



Zero Waste Hierarchy (2019). Source: Zero Waste Europe

Unfortunately, in the case of **plastic packaging**, a linear economy is still dominating, to the detriment of the environment, resources, ecosystems and public health.

Decades after the launch of the first recycling system, still less than 20% of global plastic packaging is actually collected for recycling.

In Europe, less than half of the EU's plastic packaging waste is currently recycled, with most of it going to landfill or incineration.

According to estimates, 95 % of the value of plastic packaging material, i.e. between EUR 70 and 105 billion annually, is lost to the economy after a very short first-use cycle. **This system is unsustainable.**

Plastic demand (2018) in million metric tonnes. Source: ING

The EU still works more on how to manage waste, as opposed to how to manage resources. Today, the main focus for policymakers and the industry is ensuring all packaging is collected for recycling, and on solutions such as chemical recycling, which is promoted as a technological innovation that could enable the recycling of problematic (non-recyclable through mechanical recycling) plastic waste streams. However, it is an "innovation" that one can trace back the commercial development of chemical recycling at least to the 1970s. On the other hand, the European Commission admits that even though recycling can improve, it also has its limits and recycling and secondary raw materials cannot actually match demand and provide 100% of the supplies needed, as the demand keeps increasing and losses occur during any recycling process.

With the use of plastics set to triple globally by 2060, plastic waste is forecast to rise with the packaging sector being the largest generator. Following the United Nations' decision to adopt a global and legally-binding treaty by 2024 to end plastic pollution, an international group of scientific experts is calling for a cap on the production of virgin plastics leading to the phase-out of new production by 2040. According to them, even when applying all political and technological solutions available today, including substitution, improved recycling, waste management, and circularity, annual plastic emissions into the environment can only be cut by 79 % over 20 years.

A recent report by Zero Waste Europe and Eunomia clearly shows that current levels of resource use, including plastics, even when pushing recycling and decarbonisation to the extreme, are incompatible with the climate agenda and the only way to respect the 1.5°C of the Paris agreement is by reducing plastic use by 75% by 2050. Key policy interventions should consequently focus on measures that **reduce material consumption in the first place**.

A number of new reports and studies conclude on the failure of voluntary commitments made by the world's largest companies to meaningfully address the plastics crisis; they focus on recycling and packaging over reduction and reuse.[1] Rather than tackle virgin plastics, most companies target packaging and general plastics and frequently emphasise recycling-related efforts. In fact, a study by the Ellen MacArthur Foundation and the United Nations Environment Programme revealed that some **companies are using more virgin plastic despite a pledge to reduce its use**.

Recycling plastic is simply not a solution to our overuse of natural resources. There is also literally no way that we can clean all our rubbish or build enough recycling infrastructure to handle the growing material input until we actually **start designing and using things fundamentally differently**.

Recycling does, however, have an important role to play in closing the loop, once prevention and reuse options, such as refillable packaging, have been exhausted.

Plastic waste recycling: the gap between ambition and reality

New legislation and targets for the recycling of plastics and the use of recyclates are changing the way the plastics industry operates. In the EU, the European Plastics Strategy envisioned that by 2030, all plastic packaging placed on the EU market should either be reusable or can be recycled in a cost-effective manner.
The recently proposed Packaging & Packaging Waste Regulation (P&PWR) should finally close the gap between which packaging is 'recyclable' and which is in fact 'recycled' at scale, and puts greater emphasis on truly circular goals such as waste prevention and increasing reusable packaging. It also sets recycled content targets as 50 % for contact sensitive plastic packaging and 65 % for single use plastic beverage bottles and other plastic packaging, by 2040.
The proposed P&PWR does not however sufficiently address non-toxic aspects of packaging, i.e. it does not incentivise materials and products that do not contain hazardous chemicals (Art.5.4.: "*Recyclability requirements [...] shall not restrict the presence of substances in packaging or packaging components for reasons relating primarily to chemical safety*"). Therefore, proposed regulation does not eliminate risk to human health arising from the presence of hazardous substances in packaging or packaging components.

While players in the chemicals industry aspire to expand access to recycling, adopt new technologies, and grow sustainability efforts, many existing European recyclers that have pursued these goals for years have made little progress.

Plastic Waste Recycling Figures(2022). Source: ECOS

Though there are around 79 plastic material types commercially available on the market, only a handful of polymer types are actually recycled. Production of plastics recyclates in Europe was 8.2 million tonnes in 2021 and is forecast to grow at a rate of 5.6% per year to 2030. That compares with the 35.6 million tonnes of commodity plastics that entered the waste stream in 2021. This implies that Europe achieved an overall plastic recycling rate of 23 %.

Today, about 40% of plastic packaging is reported as recycled in the EU. However, estimates state that the effective recycling rate, i.e. the substitution rate of recycled plastic or the ability to replace the production of virgin equivalent plastics, is closer to 10%. Recyclability claims are not necessarily based on real-life conditions such as the availability of recycling infrastructure, market

[1] Corporations and plastic pollution: trends in reporting - Oct 2021, Sustainable Futures; Ellen MacArthur Foundation report, Oct 2022, the Global Commitment 2022 Progress Report; Voluntary commitments made by the world's largest companies focus on recycling and packaging over other actions to address the plastics crisis - Nov 2022, ScienceDirect

conditions and the financial viability of recycling operations. In addition, one third of plastic packaging destined for recycling is still shipped outside of EU territory, where safe and effective recycling and traceability cannot be guaranteed.

At present, most recyclers practice open-loop recycling, as closed-loop systems[2] are not yet technically and economically feasible. Regulators can draw from a variety of mechanisms to foster recycling, such as deposit refund systems, extended producer responsibility schemes, recycling mandates, separate collection infrastructure, and levies or subsidies. Currently, the poor design of plastics limits the feasibility of recycling to build a safe circular economy. Proper recycling of plastic packaging is particularly impeded by the huge variety of types of plastics complicating bulk recycling schemes, incompatible and inseparable combinations of synthetic polymers (and other materials such as labels or sleeves) as well as the use of chemical additives (see also a 2021 paper: "Designing for real recycling, not plastic lock-in").
Overall, recycling delays but does not avoid plastic disposal. Plastic quality is compromised with successive recycling, partially due to the introduction of non-intentionally added substances (e.g., byproducts, breakdown products, contaminants). Most plastics are only recycled once; between 1950 and 2015, only 9% of global plastics have been recycled, and only 10% of the 9% have been recycled more than one time.

This article provides context for the current state of Europe's recycling industry. Within a sample of 57 European recyclers, a large majority have been in the business for decades. Of these companies, 47% are considered small (capacity of up to 10 thousand tons per year /kta/), 25% are medium size (10 to 50 kta), and 28% are large (more than 50 kta). Overall, these operations are of a modest scale compared with producers of virgin plastics or the capacity of large packaging companies. Plastic recycling is not yet thriving as an industry and many recyclers struggle to overcome a lack of product standardisation, inefficient sorting processes and volatile customer demand. These challenges have been exacerbated by the COVID-19 pandemic and the current energy crisis.

Therefore, before plastic recycling in Europe can truly scale up, the industry needs to overcome sizable obstacles. This means not only increasing the collection rates and improving recycling technologies but above all, implementing fundamental changes in the design of packaging and the way it is used.

[2] In closed-loop recycling, the inherent properties of the recycled material are not considerably different from those of the virgin material. The recycled material can thus substitute the virgin material and be used in the identical type of products as before. In open-loop recycling, the inherent properties of the recycled material differ from those of the virgin material in a way that it is only usable for other product applications, mostly substituting other material (The recyclability benefit rate of closed-loop and open-loop systems: A case study on plastic recycling in Flanders - ScienceDirect)

The two main possible technologies for recycling are mechanical recycling and 'chemical' recycling.
This review presents a comprehensive description of the current pathways for recycling polymers, *via* both mechanical and chemical recycling. The principles of these recycling pathways are framed against current industrial reality, by discussing predominant industrial technologies, their advantages and challenges, design strategies, and recycling examples of specific waste streams. The toxicity of pyrolysis and gasification products is addressed as well.

Currently, mechanical recycling schemes are mainly focused on the recovery of rigid packaging (like bottles), while for flexible packaging, also called films, recycling rates remain very low. A recent study shows that it is possible to increase the mechanical recycling quality of complicated post-consumer flexible plastics waste in an economically viable way.

- **Mechanical recycling** (collecting, cleaning, chipping and remelting of thermoplastics) is the most sustainable option; its technology is proven, it can be managed at a profit, and it emits less greenhouse gas emissions than chemical recycling.
- **Chemical recycling** (for more details see below) includes a wide array of technologies that for the most part are not yet proven at scale. Chemical recycling may be a useful option for products that cannot be mechanically recycled. However, the proponents of chemical recycling seem to overlook the fact that it uses a lot of energy, chemicals, and produces hazardous waste. Chemical recycling can only be used when the overall environmental profile is comparable to or better than other proven waste management options.

The use of recycled plastics in Food Contact Materials/food packaging

Food contact materials (FCM) and articles are a broad category of consumer goods that are intended to be brought into contact with food, such as storage containers, factory equipment, kitchen utensils, beverage bottles and food packaging.
It can be estimated that only 5% of plastic food packaging is currently recycled in a closed loop in the EU. This recycling is mostly done by means of mechanical recycling, where washed and sorted plastic waste is re-molten and processed into a new food packaging.

Plastic recycling for food contact is subject to a complex interplay of regulations. In order to protect human health, the materials used in these products must not transfer their constituents into the food or drink in quantities that could endanger human health. This is in accordance with the FCM Framework Regulation (Regulation (EC) 1935/2004, which sets out the general principles of good manufacturing practice, safety and inertness for FCM).

Polyethylene terephthalate (PET) is a polymer used extensively in single-use food packaging. The demand for high-quality and food-safe recycled PET (rPET) is partly triggered by Directive (EU) 2019/904 (Single-use plastic Directive) which contains specific enforcement dates and PET blend requirements for beverage bottles with a capacity of up to three litters. More specifically, from 2025, beverage bottles which are manufactured from PET as the major component ('PET bottles') have to contain at least 25% recycled plastic, and from 2030 at least 30% recycled plastic (in both cases calculated as an average for all PET bottles placed on the market on the territory of that Member State). The recently proposed Packaging & Packaging Waste Regulation sets recycled content targets as 30 % for contact sensitive packaging made from PET as the major component, by 2030.

However, research shows that currently most PET plastic recovered from bottles in Europe does not make its way back into new PET bottles. Recycled content for all PET product streams – including single-use plastic trays, textile fibres, films and strapping – is sourced from bottles, due to very low levels of recycling for non-bottle PET applications. Of the 1.8 million tonnes of recycled flake output from bottles, only 31% is made into pellets for bottles, with the rest (69%) going into other PET products and being lost after the very first cycle. The optimistic scenario demonstrated in the report predicts an increase in recycled content from 24% to 42% for all PET applications. Significant improvements in PET packaging design, collection and recycling will be needed to improve the circularity of this polymer.

One might speculate that, if the most recyclable and recycled type of plastic struggles to meet the challenges of becoming more circular, other types of plastic may face even greater challenges. The big challenge is transforming today's packaging solutions, often consisting of multiple materials, into recyclable alternatives while maintaining their key performance features. In other words: a transformation from multi-material to monomaterial structures.

Recyclability is becoming more relevant for all FCM manufacturers as food contact plastics will need to be reusable and recyclable if we are to achieve a true circular economy. The same additives that make plastic into useful products can restrict the recyclability of plastic items into food packaging, due to human health safety concerns. Altogether it could be concluded that the complexity of the different legal perspectives, a lack of communication and transparency within the plastic value chain, and technical challenges related to recycling processes have been hindering the effective uptake of recycled plastic FCM.

Importantly, a circular economy only works if the products that are created using recycled materials are safe and regulatory-compliant. **The FCM industry faces several issues in regard to the use of recycled materials in the creation of new products**. Whether food contact plastics contain recycled materials or not, they must always respect the overall migration and specific migration limits under Regulation (EU) 10/2011. This piece of legislation includes an authorised Union List of substances for the manufacture of food contact plastics. Additionally, the European Food Safety Agency (EFSA) has issued guidance to assist stakeholders when manufacturing FCM and articles from recycled plastics. The other key EU legislation FCM stakeholders must consider is the new Regulation (EU) 2022/1616 on recycled plastic materials and articles intended to come into contact with foods (for more detail). These should be considered in combination with Regulation (EC) 10/2011 and Regulation (EC) 1935/2004, respectively defining migration limits and the legislative framework for FCM.

Safety remains a vital concern as recycling can create a problem. While Good Manufacturing Practices (GMPs) can ensure **intentionally added substances (IAS)** are kept within safety limits when making virgin plastic, following GMPs will not help if the raw materials are already unknowingly contaminated because of unintended reuse and inefficient recycling technologies.
There are issues surrounding the identification of plastics and **contamination by non-intentionally added substances** (NIAS). Difficulties in identifying and removing NIAS can result in a potential health hazard.

Problematic chemicals – what is the problem?

In the EU, more than 8,000 chemicals can be used in different types of food packaging and other FCMs. Products made from plastic can contain a wide array of chemicals used as additives to achieve desired characteristics including flexibility (softeners and plasticisers), durability against heat or sunlight (stabilisers and antioxidants), antimicrobial agents, brightness agents, colourants, or fillers. The fact that many of those **chemicals are** hazardous for human health **and migrate from packaging into food and beverages**, made the scientific community and multiple organisations raise serious concerns **about their use in food packaging and their potential impact**.

In principle, recyclates should meet the same chemical requirements as new products, which is why, during the recycling process, sorting systems remove contamination and (most) plastic fractions containing hazardous substances, which are then disposed of through incineration. However, some substances of concern may still remain, because most state-of-the-art recycling processes cannot guarantee 100% clean materials. Moreover, the current regulatory regime targets only a small percentage of all hazardous substances.

Consequently, as hazardous chemicals are not always removed during the recycling process, the use of recycled materials potentially creates new pathways through which humans can be exposed to hazardous chemicals in contaminated material flows, as previously highlighted. These can result from impurities, reaction intermediates formed during the manufacturing process, a decomposition product, (legacy) chemicals[3] introduced during the former use of recycled plastic or degradation products created during the manufacturing, lifetime, or recycling process (the last may also result in the formation of novel chemical species), etc.

[3] Legacy chemicals may be NIAS from the original plastics or they may result from legal IAS that have been either restricted or banned during the material's life cycle. Therefore, when the plastics are recycled for use in FCM, effort must be made to ensure the new FCM conform to regulatory limits for these contaminants.

Recycled materials can therefore contain hazardous chemicals, sometimes at levels higher than those found in virgin materials, even in products considered safe - like PET beverage bottles. A systematic review showed that chemicals can migrate from PET drink bottles to their contents and recycling processes may concentrate or introduce new chemicals to the PET value chain. Of the 150 PET chemicals found in drinks, 18 were measured at levels exceeding EU regulatory limits. These include several phthalates and nickel. Only 41 of the 150 detected chemicals are included in the European Union's regulation on plastic food contact materials (FCMs) "positive list" (i.e, a list of substances allowed to be used in the manufacturing of plastic). Although safety and quality implications arising from the recycling of PET bottles remain underexplored, the higher migration of antimony and Bisphenol A has been reported in recycled products, compared to virgin PET. Many of the chemicals that migrate from PET, especially those not included on regulatory lists, may be non-intentionally added substances (NIAS), for which risk assessors lack official guidance. The presence of NIAS in the original PET bottles plus additional contaminants entering the plastic during the recycling process can over time concentrate potentially hazardous chemicals in bottles made from rPET.

Importantly, there are still other unresolved issues related to the safety of recycling, such as the impact of synthetic polymers and microplastics which raise serious concerns for human health and the environment, even if knowledge gaps still exist. Future research and hazard assessments will hopefully provide new insights and identify which polymers will require strong regulation. Until that time, policymakers should adopt the precautionary principle that all synthetic polymers require more toxicity testing before they are placed on the market at certain volumes. One avenue for this would be to include the registration of polymers under REACH.

On the topic of plastic recycling, the *Food Packaging Forum* has prepared a number of excellent resources, including a fact sheet, an in-depth dossier and plenty of reports on publications from regulators, government, academia, and civil society organisations, such as those for example on studies characterising chemicals present within recycled products, assessing migration from recycled HDPE milk bottles, rare earth elements found in FCMs, recycled plastics, and discussing waste management challenges of plastics, chemicals of concern in the circular economy, review on mechanical recycling of plastic packaging, among many others.

New regulation - opportunities & challenges for recycling of plastic into FCM

A prerequisite to any increase in recycled content in food packaging and other food contact materials must be securing a high level of protection of human health.

In September 2022, **the European Commission adopted the new** Regulation (EU) 2022/1616 **on recycled plastic materials and articles intended to come into contact with foods**, repealing Regulation (EC) No 282/2008. The regulation came into force on October 10, 2022, although some transitional provisions apply.[4] Consequently, rules for authorisation and enforcement will be fully harmonised at the EU level.

The Regulation applies to all kinds of recycled plastic materials and various recycling technologies, including different types of polymer, mechanical recycling, the use of recycled plastic behind a functional barrier as well as different forms of chemical recycling (excluding complete chemical recycling into starting substances covered by the Plastics Regulation (EU) 10/2011). At the time of entry into force of the Regulation, the Commission has authorised two recycling technologies: 1) Post-consumer mechanical PET recycling and 2) Recycling from product loops which are in a closed and controlled chain of custody.

The most imminent **obligation for recyclers is to** register **in the Union Register** of recyclers, technologies, recycling processes, recycling schemes, and decontamination installations.

The new Regulation **aims at ensuring the chemical and microbiological safety of recycled plastic intended to come into contact with food, including food packaging** ('recycled plastic FCMs').

[4] The EC has a dedicated website which includes questions and answers on the regulation.

It focuses on decontamination and requires its demonstration at three levels: recycling technology, recycling process, and recycling installation. Furthermore, it sets out rules applicable to quality control of recycled plastic as well as enforcement thereof by public authorities.

Importantly, to support and encourage the development of innovative recycling technologies, the **regulation allows placing on the market of recycled plastic materials and articles produced using so-called novel technologies, before such technologies prove to be suitable**. As explained in the regulation, "*this should allow developers to gather the data on a large and representative number of samples which is necessary to minimise the uncertainty as to the characterisation of the plastic input and of recycled plastic materials and articles and which is, therefore, necessary to assess the suitability of a novel technology and to lay down the specific requirements, where appropriate*".

New regulation includes a procedure[5] that establishes whether novel recycling technologies are suitable to recycle plastic FCMs. Where, prior to the placing on the market of these recycled materials and articles, data would be insufficient to verify the adequate functioning of the technology, particularly when decontamination is not the main or only principle used to achieve safety, "*complementary tests should be designed based on the specifics of the novel technology*".

To characterise exposure risk, monitoring the presence of hazardous substances should not only focus on average levels but also assess matters such as whether certain contaminants frequently occur in different batches or are linked to a particular source. Moreover, to ensure trust, public knowledge and regulatory scrutiny of technologies that are being developed, **the reports on the safety of the materials and of such monitoring will be made public**.

As early as now, only 2 months after the regulation came into force, it is impossible to see how successful this new law will be in effectively safeguarding FCMs and, consequently, consumer safety. There are however a number of immediate concerns that will need to be well addressed to ensure such safety, among which:

- Rules concerning the analytical monitoring of recycled plastic materials and articles produced with recycling technologies under development and the potential presence of hazardous substances should still be laid down. As those rules are crucial to establish the level of contamination in the input materials, as well as of the residual contaminant levels in the final materials and articles and the potential of their transfer to food, they need to be sufficiently strict and put into force as soon as possible.
- It is unclear how the safety and risk analysis for NIAS should be conducted to be compliant with Commission Regulation (EU) No 10/2011. In that regard, the 2011 regulation only provides that NIAS should be assessed in accordance with internationally recognised scientific principles.[6] It is also not clear how NIAS differ from the "incidental contaminants" in the new regulation.
- One of the new possibilities for using recycled plastic materials in food packaging is their use behind a functional barrier (an inner layer that should protect the migration of substances present behind the barrier towards the food). However, barriers can have a detrimental impact on the quality of recycled material at the end of life of a package.[7] A logical question therefore would be if manufacturers consider that when placing such packaging on the market.
- There is a clear interest from the consumer safety point of view to minimise the risk of any non-suitable technology operating on the market for years. Therefore, the assessment of any novel technology should happen not only with the highest scrutiny, but should also be timely. Currently, it is not clear what criteria will be applied to decide when "*a large and representative number of samples which is necessary to minimise the uncertainty as to the characterisation of the plastic input and of recycled plastic materials and articles*" will be sufficient.
- Time frames for decisions on suspending the status of the decontamination installation, in the case when compliance is not established (like in Article 26 (4)), should be shortened.
- Member States have an essential role, and increased responsibilities, under the new Regulation. Their competent authorities maintain an important role in enforcing compliance with the Regulation, for instance by auditing recyclers for compliance

[5] For example, the notification by the developer shall, among others, provide detailed information concerning the extensive reasoning, and scientific evidence and studies, compiled by the developer, demonstrating that the novel technology can manufacture recycled plastic materials and articles that comply with Article 3 of Regulation (EC) No 1935/2004 ensuring also their microbiological safety, including a characterisation of contaminant levels in the plastic input and in the recycled plastic, a determination of the decontamination efficiency, and of the transfer of these contaminants from the recycled plastic materials and articles to the food, and reasoning on why the applied concepts, principles, and practices are sufficient for meeting those requirements.

[6] The industry published own Guidance on Best Practices on the Risk Assessment of Non Intentionally Added Substances (NIAS) in Food Contact Materials and Articles

[7] PE flexible films recycling: new findings for functional barriers - RecyClass

with requirements on quality control. Considering that controls and enforcement of rules on FCMs are currently very limited or lacking due to the outdated regulatory framework as well as the lack of resources, accredited methods, and specialised knowledge in Member States to enforce the current regulations of FCMs, one might be concerned about the enforcement of these new rules.

Finally, lessons learned and recommendations from a recent Forum pilot led by the European Chemical Agency (ECHA) on the enforcement project on substances recovered from waste which revealed that one in four substances recovered from waste is non-compliant with REACH, should be taken into consideration by waste operators and national authorities/inspectors. The Enforcement Forum should also pursue this subject and consider, where appropriate, including the scope of an EU-wide enforcement project in the future also operators of novel plastic recycling technologies covered by the new regulation.

Novel technologies and chemical recycling of plastic – knowns and unknowns of toxicity aspects

Currently, 'chemical recycling' technologies (often also called advanced recycling, molecular recycling, and referred to in the new regulation for FCM as 'novel technologies') are promoted as the main solution to address the requirements of recycled plastic for food contact materials. The revised *Packaging and Packaging Waste Regulation* (*PPWR)* will likely support this vision as the impact assessment led by Eunomia, a consultancy working on behalf of the EC, stated that recyclate for contact-sensitive packaging can only come from 'chemical recycling', with a focus on pyrolysis.

'Chemical recycling' covers a wide range of technologies (i.e. solvent-based regeneration, chemical depolymerisation, thermo-chemical depolymerization) producing very different types of outputs. Such differences require investigations on a case-by-case basis for each type of technology. Current knowledge about the abilities of different chemical recycling processes to eliminate substances of concern (as claimed frequently by the industry) is very limited because most of the data concerning decontamination procedures has not been made public. Indeed, existing LCA studies show a large knowledge and transparency gap when it comes to the use of chemicals during the process itself and chemical by-products from these technologies. It can however be assumed that contaminants and toxic additives after being "separated" from the plastic waste during processing, will eventually also comprise an additional hazardous waste stream.
At experimental scale, chemical recycling is tested for PA, PS/EPS and PUR, but it has already been demonstrated that products or materials should not be designed for chemical recycling since the understanding of this process is only just emerging, it is energy and emissions-intensive, while economic viability is not clear.

- **Thermo-chemical depolymerization technologies** (i.e. pyrolysis) are now seen as the most promising solution to having chemically recycled content as this is the most advanced 'chemical recycling' technology now in Europe. In the context of plastic-to-plastic recycling, when pyrolysis oil is used to produce recycled content, it is assumed to meet FCM requirements as it undergoes high temperature and chemical reactions removing additives and impurities go back to the molecular level. However, *there is still little to no information available on the output regarding the substances of concern, residues, and toxic emissions*. In the case of pyrolysis for municipal solid waste, it has been demonstrated that toxic substances such as polyaromatic hydrocarbons (PAHs) and dioxins were present in char and emissions. As the use of waste for the manufacture of substances included in the Union list of authorised substances (such as monomers) will be subject to the Regulation (EU) 10/2011, pyrolysis will be exempted from the new recycling regulation.

- **Chemical depolymerisation** produces monomers or oligomers based on mono-material feedstocks. As with most chemical recycling technologies, the toxicity, fate, and characteristics of the residues created by decontaminating the monomers have not been made public. The only large commercial-scale solvent recycling plant was the Vinyloop plant in Italy, which was shut down in 2018 because it could not economically separate the substantial amounts of phthalate plasticizers used in soft PVC to meet EU regulatory requirements.[8]

[8] European Commission - Science for Environment Policy, Incinerating nano-enabled thermoplastics linked to increased PAH emissions and toxicity, 2018

- **Solvent-based regeneration technologies** recover polymers to be directly converted back into plastic products (without going through the repolymerisation process). However, the recovered material may require further additives to replicate the initial products, and there is no knowledge regarding the fate of residual solvent in the final polymer product.

Finally, to echo Erwin Annys, Head of Support and Enforcement Unit of European Chemicals Agency (ECHA), after publishing a report on *Chemical Recycling of Polymeric Materials from Waste in the Circular Economy*: "It is important to understand how the different chemical recycling techniques can reduce the presence of substances of concern in recycled materials to achieve toxic-free cycles under the circular economy. We also need to understand to what extent this will result in new REACH registrations". This is not the case yet.

All in all, the inevitable question arises: with all the concerns about harmful chemicals and NIAS in food contact articles and the uncertainties associated with recycling technologies, how can we create a truly circular economy that delivers safe products from recycled plastic materials?

Start improving where it all begins: producing clean new plastic food packaging

When a manufacturer, supplier, distributor or retailer places a plastic material or an article intended to be in contact with food on the market, they must comply with the requirements of Regulation (EC) 1935/2004 on materials and articles intended to come into contact with food, and Regulation (EU) No. 10/2011 on plastic materials and articles intended to come into contact with food.

The recently completed evaluation of the current EU FCM legislation identified a number of shortcomings with the current regulation, including those hampering the ability to ensure compliance and undertake official controls, such as poor quality, availability and transparency of information in the supply chain.

As things stand (as explained above), in the EU, more than 8,000 chemicals can be used in different types of food packaging and other FCMs, and toxic chemicals are potentially a serious constraint on the recycling of plastics. To reduce the dilution, dispersion and accumulation of hazardous substances in a circular economy, the preferred strategy is to avoid introducing such substances to the economy in the first place, expressed as "toxic free material cycles" and "non-toxic from the start". However, limiting the introduction of hazardous substances upstream is currently neglected, as these substances typically fulfil an important technical function.

With the expectation that plastic food packaging waste will be made fully safe for recycling into new products through decontamination during waste treatment, the responsibility for handling the toxic impact of recycling shifts away from the plastic producers onto the recyclers who struggle to process many unrecyclable or difficult-to-manage plastics.

Indeed, as recycling technologies are not able to remove all toxic (intentional and non-intentional) chemicals already present in virgin plastic, they will likely lock us into a toxic circular economy. The list of potential contaminants (such as chemicals) in the market contained in the packaging itself (being intentionally a part of the package for functionality reasons), poses risks to recyclers, converters, packers of consumer goods and consumers, and narrows a suitable supply (of appropriate quality) for processing into food grade PCR. **It is now therefore urgent to phase-out toxic chemicals in primary (virgin) FCMs / food packaging** – i.e. in a feedstock for recycling, to make recycling easier and avoid contaminating recycled materials with toxic chemicals. This process can begin with prioritising the recently identified 388 intentionally used food contact chemicals that are harmful according to the EU's Chemicals Strategy for Sustainability.
Taking into consideration all of the above, **as a matter of priority**, **the Food Contact Material Framework Regulation (EU 1935/2004) needs a comprehensive revision to ensure the elimination of hazardous chemicals**, which the EU Commission is presently undertaking. Also, FCMs should not contain untested chemicals. We, therefore, call on the European Commission to maintain the path it has taken and to timely put forward an ambitious proposal for a revised FCM Framework Regulation.

Final conclusions & recommendations

Changing the way we manage our use of plastics in a more sustainable way and the rate at which we use recycled plastics will depend on the decisions taken today. Food contact articles, including packaging, should follow the principles of circular economy and waste hierarchy, thus minimising material consumption in the first place and then keeping (non-toxic material) resources in use for as long as possible.

Recycling of plastic simply cannot be a solution to our current detrimental overuse of natural resources and massive production of waste. It has also become obvious that cutting on plastic consumption is crucial to reach the EU climate goals. Strategic financing and subsidies should therefore be directed towards prevention, circular design, and reuse systems and solutions. Recycling does, however, have an important role to play in closing the loop, once prevention and reuse options, such as refillable packaging, have been exhausted. Investments here should focus on recycling technologies that are commercially available at scale – or could be available in the short term (e.g. within 2-5 years) – and set ambitious performance thresholds, including an overall environmental profile of those technologies (which should be as minimal as possible).

If we are to justify the continued use of plastics, they need to be handled according to the principles that any product is sustainably designed and toxic-free. The current regulatory framework defines food contact materials as "safe" if they comply with established "safe levels" for a small set of well-studied chemicals, but legislation, so far, fails to ensure the real safety of products, namely the absence of hazardous and untested chemicals in consumer products. Policymakers need to urgently take steps to eliminate the presence of harmful chemicals that pose a threat to human health and the environment when recycled plastic is used as secondary material. The EU Chemicals Strategy for Sustainability clearly defines substances of concern as those problematic in a circular economy.

While recycling is considered an important part of a circular economy, the Ellen MacArthur Foundation estimates that 80% of a product's environmental impacts are determined when it's being designed. The researchers however noted a focus on "lightweighting": making the same products out of smaller and lighter amounts of plastic. This lightweighting of plastic is considered an insufficient response because companies may reinvest the savings into markets that involve new plastic products and/or increase the total mass of plastic produced.

Applying ecodesign principles to plastic formulates a number of circular design principles that should be followed by policymakers and companies. For instance, we strongly recommend including as much separable monomaterial content in a product as possible and avoiding combinations of non-plastic material types. It is crucial that plastic packaging is made of homogeneous polymer streams, without substances of concern, of a colour easy to be recycled, with minimised and separable labels and sleeves, as well as minimised printing, with the use of non-toxic, non-metallic and washable ink. Specific recommendations per material/polymer type are detailed further here.

Thorough circular design principles should ensure that ideally, recycling should maintain or improve material quality (in terms of chemical, physical and mechanical quality), enabling high-value applications rather than downcycling (lower quality and lower value). To leverage further the information necessary to increase the uptake of recycled plastics will be crucial, and in parallel to enhance public safety, a proper assessment of the loss in technical functionality of recycled plastics is essential in order to determine the best possible circular route for the recyclates.

Manufacturers should in fact be obliged to design food packaging for end-of-life recycling. This is why further EU legal rules and regulatory direction are needed to rule out certain **product design features that prevent or impede toxic plastic recycling**, including the development of appropriate standards. Extending appropriate incentives to phase-out harmful chemicals and increase the number of recyclable resin types and their use in packaging could significantly increase the supply of high-quality plastic waste for mechanical recycling. Due to existing and upcoming EU rules and targets for recycled content, harmonised methodology and standards on the calculation, verification and reporting of recycled content must be urgently laid down.

Recommendations

Realising a circular and toxic-free economy is a complex but achievable process, and closing the loop for plastic waste and plastic recycling is an important element in the equation. **Our paper provides the following recommendations for policy-makers, authorities and packaging manufacturers:**

1. EU legislation should urgently phase out the most hazardous chemicals and ensure packaging and other food contact articles are truly safe for use, reuse and recycling. We, therefore, call on the European Commission to timely put forward an ambitious proposal for a revised Food Contact Material (FCM) Framework Regulation. In particular, the current FCM safety definition (Art. 3, 1935/2004) should replace "*quantities*" by "*no hazardous chemicals and no untested chemicals in materials and articles*", to eliminate risk to human health arising from the presence of hazardous substances in food packaging/ food contact articles.
2. The revised Packaging and Packaging Waste Regulation (P&PWR) should adequately address non-toxic aspects of used materials and define 'high quality recycling', where elimination of risk to human health arising from the presence of hazardous substances in packaging or packaging components is incentivised.
3. Significant regulatory changes are on the horizon for various chemicals used in packaging already. FCM / food packaging industry leaders are therefore advised to develop a proactive approach towards their own hazardous chemicals phase-out plans.
4. Packaging and product designers should consider the full product lifecycle, and address the challenges of toxic-free materials and products for clean material cycles through ecodesign principles. As a principle, products that cannot be safely used, reused and recycled at the end of their life should not be produced or placed on the market in the first place.
5. Safety of plastics, both virgin and recycled ones, depends on the availability of information. While existing FCM laws address to a certain extent harmful chemicals used during plastics production, safety information about polymers is missing due to a lack of requirements on their registration. The Commission should ensure that all polymers used in plastic FCM will fall under obligatory registration under REACH and that their chemical constituents are properly assessed for impacts on human health.
6. To ensure proper implementation and enforcement of the new regulation on plastics recycling, an integrated value chain approach, transparency and traceability of chemical aspects throughout the entire value chain, as well as rigorous standards are necessary.
7. Member States should secure necessary resources to enforce compliance with the existing laws, in particular through auditing recyclers and controls of the products placed on the market.
8. The Commission should facilitate the establishment of rules concerning analytical monitoring, as well as accredited methods, and support Member States to enforce the current regulations of FCMs through specialised guidelines and training.
9. The Commission should enforce more strict timelines for the assessment and authorisation of any novel recycling technology, to minimise the risk of non-suitable technology being operating on the market for years.
10. The policies on real circularity, which require different business models (notably focused on waste prevention and reuse options), should be reinforced by legislation and remain at the top of the EU agenda. External parties, such as the finance sector, governments, consumers, or third-party certification systems, may aid in engaging large companies to promote upstream solutions.
11. Significantly more efforts beyond plastic recycling are required to effectively address plastic pollution challenges. The EU must set general and sectoral targets for reduction in resource use in line with the Paris Agreement's commitments, and create real incentives for dematerialisation and better resource use.

ANNEX I

GLOSSARY & DEFINITIONS

Glossary
FCCoC: Food contact chemical of concern
FCAs: Food contact articles
FCMs: Food Contact Materials - materials and products that come into contact with our food, such as storage containers, factory equipment, kitchen utensils, and food packaging
IAS: intentionally added substances
NIAS: non-intentionally added substances
PCR: post-consumer recycled
rPET: recycled polyethylene terephthalate
vPET: virgin polyethylene terephthalate

Definitions (according to Union Guidelines on Regulation (EU) No 10/2011 on plastic materials and articles intended to come into contact with food)

- "**Adhesives**" means non-metallic substance capable of joining materials by surface bonding
- "**Blend**" is any mixture of plastics in the same physical state, each of which is capable of functioning as a main structural component of finished materials and articles.
- "**Coating**" means a non-self-supporting layer composed of substances applied on an already existing substrate in order to impart special properties or improve technical performances of the finished article.
- "**Layer**" means a homogenous continuous or semi-continuous material of defined composition that is extended in two dimensions separated by an interface from another homogenous continuous or semi-continuous material of a defined but different composition.
- "**Migration modelling**" means a calculation of the specific migration level of a substance based on the residual content of the substance in the material or article applying generally recognised diffusion models. These are based on scientific evidence overestimating real migration and taking into account the Guidance document on migration modelling.
- "**Migration test**" means the determination of the release of substances from the material or article either into food or into a food simulant.
- "**Single use article**" means an article intended to be used once and coming into contact with not more than a single portion of foodstuffs during its lifetime. (Food packaging should be regarded as a single use article, even if the consumer may re-use it. This includes, for example, lids for jars).
- "**Repeated use article**" means an article intended to be used several times that comes into contact with different portions of foods during its lifetime. For example, kitchenware, reusable containers or components of packaging machinery.

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Zero Waste Europe is the European network of communities, local leaders, experts, and change agents working towards the elimination of waste in our society. We advocate for sustainable systems and the redesign of our relationship with resources, to accelerate a just transition towards zero waste for the benefit of people and the planet.

The Toxic-Free Food Packaging campaign is a collaboration between Zero Waste Europe and other NGOs with the goal of creating a toxic-free environment where nobody should have to worry about the presence of health-harming chemicals in the products that come into contact with our food.

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