commentary

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Update on the EASAC Plastics Report: Towards a Plastics Treaty

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Summary

This commentary updates EASAC's 2020 report on 'Packaging Plastics in the Circular Economy' and links its scientific conclusions to the current negotiations by UN Member States for an international agreement on plastics pollution (the Plastics Treaty). The commentary's main points about the Treaty's Zero Draft are as follows.

Primary production. A fundamental point for negotiation is whether to set a target for reducing plastics primary production (Part II/1of the Zero Draft). Increasing production inevitably leads to increased leakage and greenhouse gas emissions, and the inability to recycle more than a small fraction of the end-of-life products will continue. Substitution of plastics by other materials requires careful consideration if the environmental burdens are not to be shifted to another sector. Consumption of materials in general is already well above the sustainability level of the planet, so a fundamental aim should be to reduce the need, demand, and use of packaging.

A **systems approach** is needed to reduce the volume of plastics production and consumption, ensure all plastics are reusable, recyclable or compostable, and to keep plastics in circulation for as long as possible. Models suggest that such an approach could reduce plastic pollution by 80% by 2040. Moves towards this objective can be found in the European Parliament's recent decisions. We discuss the case for a plastics tax to compensate for the exclusion of external costs to society and the environment in the market price of plastic, and include estimates of their scale.

Problematic and avoidable plastic products (Part II/3) include short-lived and single-use plastic products. Measures to reduce the use of products that leak to the environment depend in part on consumer behaviour which is influenced by pricing and the ready availability of simple and convenient cost-free (in terms of both time and money) alternative options, supported by increasing awareness and effective regulations. Changes are thus required in consumer behaviour *and* by retailers and product designers to make the environmentally responsible path the cheapest and easiest option. The European Union (EU) regulation to prohibit intentionally added microplastics sets a standard for the Treaty that should be followed.

Product design, composition, and performance (Part II/5a) is critical because design can interfere with reuse and recycling. Thus the Treaty should commit to the principles of design to increase the safety, durability, and reusability of plastic products, and that they should be recycled and disposed of in a safe and environmentally sound manner.

The **reuse** of plastic products (Part II/5b) could reduce overall demand but requires highly efficient reverse supply chains to achieve net environmental benefits relative to successful deposit refund schemes. To achieve this, regulations will need to incentivise companies to collaborate rather than compete in establishing common formats and reverse supply chains, and for consumers to positively play their part in ensuring high recovery and return rates.

Alternative plastics and plastic products include **bio-plastics or biodegradable plastics** (Part II/5d); a requirement for life cycle assessments for bio-crops and for proper biodegradability standards should be included in the Treaty. Plastic substitutes should have lower environmental impact along their life cycle and should be suitable for reuse, recycling, or sound waste disposal. Substitution has to be properly evaluated through life cycle assessments if it is to reduce environmental burdens at the system level.

Extended Producer Responsibility (Part II/7) can be a very powerful or ineffectual tool depending on its scale, rules, and implementation. Design of Extended Producer Responsibility should aim to cover *all* the costs of managing the waste resulting from the products and their packaging. Eco-modulation can encourage more readily recyclable materials and discourage those that are impossible or difficult to recycle. Where eco-modulation would be too complex, economic instruments can encourage a shift away from problematic, non-recyclable products and packaging.

Export of plastic waste (Part II/10b) from OECD countries to non-OECD countries that are ill-equipped to deal with the quantities delivered continues, despite the additional controls required by the Basel Convention. The Treaty should limit exports to those given Prior Informed Consent and which can be demonstrated to be recycled in a safe and environmentally sound manner.

While monitoring has shown the ubiquity of contamination by plastics in all parts of the environment and damage to marine and other life, uncertainties remain over the risks posed by ingestion by humans. Scientific understanding of effects of **microplastics** should thus be kept under review by the Treaty's Governing Body. The Treaty should also include mechanisms to encourage reductions in the leakage of major sources of microplastics (tyres, textiles, personal care products, production pellets and cigarette butts).

The Treaty will include a section on **definitions**, where the impact of research and development should be considered to ensure that advances can be applied within the terms of the Treaty and not impeded by definitions that prove inflexible. For example, the potential of biodegradability might improve and definitions should be flexible to allow rapid entry of new biodegradable materials into potential markets. Advances in chemical and thermal means of recycling also continue, so the definition of 'recycle' should recognise the recycle hierarchy and allow a role of recycling through simpler chemical precursors for new products.

Finally, many international treaties have been implemented to tackle the social and environmental impacts of humanity's growth in numbers and resource consumption, with varying degrees of success. Negotiations to tackle the worsening problems of plastic contamination in the global environment should seek to craft a new international treaty that can incentivise all countries to make it a success comparable to the Montreal Protocol's delivery of a protected ozone layer.

Current policies

Global plastics use and plastic waste are projected to almost **triple by 2060**

Disposal continues to rely on landfill (50%) and incineration (18%)

12% The use of **recycled plastics** remains a small portion of total use

GHG emissions double to 4.3 Bt of CO_2 equivalent

GHG 4.3 Bt

Accumulated plastics in rivers and oceans triple to **493 Mt**

Scientific estimations of environmental, social and health costs range from

$billions to **$trillions**

Recommendations

Reduce use of packaging and set a target for **reducing plastic primary production**

Internalise environmental, social and health costs into the basic market price for virgin resin

Make the responsible path the cheapest option to **change consumer behaviour** and **minimise single** use

Ban deliberate addition of **microplastics** to products

Increase the safety, durability, reusability, refillability, repairability, and refurbishing capability of plastic products

Include **life cycle analysis** and proper biodegradability standards for resins claiming biodegradability and substitution products

Extend **producer responsibility** to all costs related to waste management

Restrict **export** to non-OECD countries.

Ensure all plastics are **Reusable Recyclable Compostable**

Aims of a Plastics Treaty by 2040

Increase recycling rate to	Reduce plastic pollution by	Reduce demand by
20%	**–80%**	**–30%**

1 Introduction

EASAC (2020) analysed the science related to policy on packaging plastics[1]; since then, the European Union (EU) has implemented its Single-Use Plastics (SUP) Directive, concluded a Regulation on the 'Restriction of microplastics intentionally added to products', and is in the final stages of agreeing a Packaging and Packaging Waste Regulation[2]. Globally, a 'legally binding instrument on plastic pollution, including the marine environment' is under negotiation and its 'Zero Draft' (UNEP 2023a) is being discussed through an Intergovernmental Negotiating Committee (INC) with the aim of preparing a first draft of a 'Plastics Treaty' during 2024.

The EU is a member of the 'High Ambition Coalition to End Plastics Pollution by 2040' (see Box 1), and can point to its leading role in tackling plastics pollution through the legal measures listed above and to a range of Extended Producer Responsibility (EPR) and deposit return/refund schemes (DRS) in Member States. The Plastics Treaty being negotiated is expected to establish provisions for plastic waste minimisation and environmentally sound collection, sorting, and preparation, and to encourage reuse and recycling of plastic waste, to ensure that recycled plastics can re-enter the economy and avoid leakage to the environment. Several of the issues being addressed are founded on the science examined in the EASAC report 'Packaging Plastics in the Circular Economy' (EASAC 2020). EASAC's Council thus decided to revisit the issues most relevant to the current Treaty discussions and update these to inform the negotiations.

This update re-examines our earlier conclusions and discusses their relevance to the current negotiations within the INC. The focus remains on packaging plastics which, together with textiles, are projected to be the source of nearly two-thirds of all plastic waste (OECD 2022a).

2 Plastic consumption and sustainability: system failures

Many of the studies informing the INC negotiations point to the systemic failures that drive rapid growth in production, consumption, and leakage to the environment of packaging and other (e.g. fishing gear) plastics (see, for example, EMF 2021; IRP 2021; OECD 2022a; UNEP 2023b; and supporting studies such as Pew Charitable Trusts 2023 and WWF/Eunomia 2023). SUPs have been a particular target due to their lack of recyclability, wastefulness of natural resources, and leakage that contaminates soils, rivers, lakes, and oceans (Chen *et al.*, 2021).

The EASAC (2020) report (page 2) pointed to several systemic failures that lead to leakage into the environment:

- monomer producers investing for unchecked growth;
- externalisation of social and environmental costs making virgin resin cheap;
- design and choice of resins/additives ignoring recycle implications;
- retailers focused on operational efficiency and attractiveness to consumers rather than on waste reduction or recyclability;
- consumers like and are used to 'on-the-go' and easy disposal, while small retail outlets lack the will or options to support recycling;
- lack of profitability and technical challenges restrict capacity and diversity of recycling infrastructure.

Box 1 High Ambition Coalition to End Plastics Pollution by 2040

Strategic objectives

1. Restrain plastic consumption and production to sustainable levels.
2. Enable a circular economy for plastics that protects the environment and human health.
3. Achieve environmentally sound management and recycling of plastic waste.

Key deliverables for success

1. Eliminate problematic plastics, including by bans and restrictions.
2. Develop global sustainability criteria and standards for plastics.
3. Set global baselines and targets for sustainability throughout the life cycle of plastics.
4. Ensure transparency in the value chain of plastics, including for material and chemical composition.
5. Establish mechanisms for strengthening commitments, targets, and controls over time.
6. Implement monitoring and reporting at each stage through the life cycle of plastics.
7. Facilitate effective technical and financial assistance, scientific and socio-economic assessments. (https://hactoendplasticpollution.org/)

[1] See also Norton (2020); Sheldon and Norton (2020).

[2] Despite political efforts and increasing public awareness (Matthews *et al.* 2021), there has been an increase in per-person generation of plastic packaging waste in the EU; this was 188.7 kg in 2021 and is expected to increase to 209 kg in 2030 without additional measures (https://www.europarl.europa.eu/news/en/press-room/20231117IPR12213/parliament-adopts-revamped-rules-to-reduce-reuse-and-recycle-packaging).

Box 2 Estimating the external costs of plastics production and use

Landrigan *et al.* (2023) estimate that the current linear patterns of plastics production, use, and disposal that are associated with low levels of recovery, reuse, and recycling lead to health and environmental damage, economic costs, and societal injustices that together range from US$300 billion to 1.5 trillion per year (see also Merki and Charles 2022).

An estimate by Dalberg Advisors (2021) included the costs of plastics production, use, and leakage into the environment and assigned costs of more than US$171 billion from GHG emissions, over US$32 billion for the management of plastic waste, and US$3.1 trillion (±US$1 trillion) as the result of the reduction in marine ecosystem services from marine plastic waste. This led to an estimate of all external costs of more than US$3.7 trillion (±US$1 trillion) for the plastic produced in 2019, more than 10 times the market price paid by producers of primary plastics. Another aspect examined recently is how these external costs are distributed (WWF 2023), where middle- to low-income countries carry a burden 8 to 10 times that of high-income countries.

Solving such systemic failures is critical to achieving the first objective of the High Ambition Coalition – to restrain the quantities of plastic produced for packaging – since growth inevitably leads to increased pollution that damages ecosystems and poses risks to human health. The OECD (2022a) found that under Business As Usual, global plastics use is projected to nearly triple by 2060 with the largest increases expected in emerging economies in sub-Saharan Africa and Asia, where historically large leakages into the environment have occurred (Nyberg *et al.* 2023). The use of recycled plastics may increase but is expected to remain a small proportion of total consumption (12% of total plastics use in 2060). Plastic waste would almost triple while disposal would continue to rely on landfill (50%) and incineration (18%), and mismanagement of waste would lead to a doubling in leakage to the environment (44 million tonnes (Mt) a year), so that accumulated plastics in rivers and oceans would more than triple, from 140 Mt in 2019 to 493 Mt by 2060. Greenhouse gas (GHG) emissions from the plastics life cycle would also more than double, to 4.3 billion tonnes of carbon dioxide equivalent. The same OECD study confirmed that packaging and other short-lived applications would constitute almost two-thirds of the 1014 Mt of plastic waste envisaged in 2060. A study on plastic pollution's impacts on planetary boundaries (Bachmann *et al.* 2023) also concluded that even a circular, climate-optimal plastics industry would breach sustainability thresholds and that fundamental changes are required in the production and use of plastics.

There is strong agreement between EASAC, OECD and other reviewers that the Plastics Treaty should address these system failures and engineer a substantial shift away from the current linear to a more circular model. Such global aspirations are expressed in the EMF (2017) vision of a '*circular, zero-pollution plastics economy that eliminates unnecessary production and consumption, avoids negative impacts on ecosystems and human health, keeps products and materials in the economy and safely collects and disposes waste that cannot be economically processed*'. Plastics Europe (2023) succinctly characterise this aim as to '*end plastic pollution by 2040 through a circular economy where all plastic applications are reused, recycled, and responsibly managed during and after use while enabling a lower greenhouse gas emissions plastic economy*'.

To achieve this, the forces driving increased investment in plastics production and use must be connected with the end-of-life environmental, social, and health damage, through market mechanisms and comprehensive policy packages that target all phases of plastics' life cycle. Such calculations are complex and depend on assumptions and valuations of non-market factors such as climate damage costs and ecosystem damage costs. Nevertheless, recent work gives an indication of their likely scale (Box 2).

Box 13 of our 2020 report referred to the case for a plastics tax to compensate for the exclusion of these external costs to society and the environment in the market price of plastics. Because of current low market prices, there are few incentives for consumers to restrict their use or dispose of responsibly, or for retail outlets to provide or encourage return and recycling, or producers to reduce production. The EU has introduced what is sometimes referred to as a plastics tax but is rather a levy based on the amount of non-recycled plastic packaging waste produced by each Member State, and therefore unlikely (Powell 2018) to influence production or consumption decisions.

As pointed out by Powell (2018), the aims of a plastics tax would be to reduce the overall level of plastic use in the economy and incentivise reuse and recycling. Taxes on production could affect overall supply, whereas taxes on consumption could help to change individual behaviour; as a result, a suite of taxes could be optimal. Walker *et al.* (2020) found that a plastics tax could influence the design, production, consumption, and waste sectors if designed properly but should be combined with other instruments to reduce the occurrence of unfavourable side effects. The huge disparity between market prices and the estimates of external costs in Box 2 suggest that, to remedy the current system's inadequacy, a plastics tax would have to be substantial indeed!

Other policies include more durable product designs; while recycling systems need to be substantially upgraded to provide the quantities and quality of feedstock for increased recycle content demand. DRS schemes have a role to play along with recycled content targets, EPR schemes, and measures to tackle plastic pollution. UNEP (2023b) estimate that such systemic changes can deliver a 30% fall in the use of virgin material for short-lived plastics through reuse or recycling, while leakage into the environment could decrease by more than 80%.

3 Limitations to recycling

The EASAC (2020) report pointed to the many technical barriers that exist to recycling; outside highly selective and well-separated container recycle streams (e.g. PET (polyethylene terephthalate) bottles or HDPE (high-density polyethylene) containers), mixed packaging plastics contain a wide range of chemicals used in their manufacture (the average plastic contains 93% polymer resin and 7% additives (OECD 2019)), making recycle difficult. Additives, together with contamination from packaging contents, make it impossible to match the quality of virgin material. With common packaging plastic resins, molecular degradation can also occur in thermal recycling processes, affecting properties. In addition, adding recycled polymers to virgin polymers can require the use of compatibilisers, which further increases the degree of contamination of the final product and the difficulties of recycling.

As a result, recycling from mixed plastics is unlikely to be used again in food-grade packaging (Stina 2021), so that downcycling is the norm, and is one reason waste handlers have depended on low-cost disposal routes through exports. UNEP (2023b) and other studies (for example, Garcia-Gutierrez *et al.* 2023) see such problems as the reason up to 80% of the plastic in short-lived plastic products is not economically recyclable, and why the future scenarios in the OECD (2022a) study predict only modest increases in the proportion of plastics recycled (just 12% by 2060).

The leading resin that is recyclable is PET, where recycling can feature prominently in commercial advertising (Figure 1), creating the image of a future with a closed loop system where PET is entirely sourced from recycled sources. The reality, as examined in ZWE (2022) and Eunomia (2022) and summarised in Box 3, is, however, that the current situation and its future potential remain far from the ideal circular-economy goal of closed loop recycling and are hindered by the limited supply of clean containers for recycling, and competition for recycled PET from other applications.

Figure 1 Examples of advertising 100% recycled beverage bottles.

Box 3 Recycling pet bottles: current and future

Of the 5.549 Mt of virgin PET resin consumed in Europe in 2020, 47% was used to make PET bottles while the rest went to other uses (tyres, textiles, trays, etc.) that led to little if any recycling. Countries with DRS recover around 96% of beverage bottles, while those without DRS recover on average around 48%, giving an average collection rate for Europe of 60%. Of the bottles collected, 22% are coloured or opaque, which may require separate treatment from the majority of clear PET bottles. As a result, just 2.717 Mt of PET is processed, providing 1.793 Mt of PET flakes (recycled PET, rPET) that can be used to replace virgin PET. However, just because the rPET has been derived from bottles does not mean that they are used to make bottles. Demand for other uses can be high and, at the time of the studies, only 31% of the rPET returned to make bottles. New bottles placed on the market thus contained an average of just 17% of recycled PET. Overall 75% of the original PET ultimately leaked from the total PET system.

As illustrated in Figure 1, some brands are committing to higher recyclability in their bottles, with some offering 100% rPET. Plant-based plastics have also been used by some brands, although from the end-of-life perspective these should still be considered as virgin PET because they are handled in the same way as their fossil-fuel-based equivalents. The diversion of some of the currently limited supply of rPET to '100% recycled' products may not change the average recycle rate but could, through increased demand and prices, improve the economic attractiveness of expanding the supply of recycled material.

EU Directive (EU) 2019/904 sets a collection target for beverage bottles of 77% by 2025, rising to 90% by 2029; and for an average recycled content in PET beverage bottles of 25% by 2025 and 30% by 2030. ZWE (2022) concludes that to achieve a target of 75% recycled content would require a collection rate of greater than 90%, a switch of colour or opacity bottles to clear PET to allow them to be included on the main clear PET recycle streams and increased capacities for food content rPET production. An additional source could be if the caps were also made from PET, as is technically viable.

In short, even the PET system is a long way from circularity. Bottles currently include an average of 17% rPET, while much of the recyclate 'cascades' into other products and is then lost to the value chain when these products reach their end-of-life. Even if a target rate of 75% recycle content for bottles were met, the current 24% recycle rate for all PET applications would just increase to an upper limit of 41–42% in the future. Currently, debate continues on whether there should be a priority assigned in regulations for rPET from beverage containers and other food-grade sources, to be used for new food-grade applications rather than downcycled to uses incapable of high recycling rates.

As pointed out in EASAC (2020), recycling would be facilitated if industry were to limit the number of polymers that can be used for specific applications while restricting small items (which cannot be readily separated) to just one polymer (e.g. low-density polyethylene). Multilayer films comprising different materials glued together are difficult to recycle, but can be replaced by multilayers based on the same basic resin type. For additives, these could be limited to those that are compatible with repeated recycling stages. Reducing the number of different polymers, favouring design formats that are easier to recycle, are common themes that should be included in the Plastics Treaty.

Even with the major steps described above, it is important to recognise that there is a balance to be struck between the energy costs of some separation and cleaning processes and the benefits of increased recycling. There will inevitably remain a substantial fraction of mixed plastics where the best (or least bad) solution will be to recover simpler chemical products or energy through chemical treatment, pyrolysis, or ultimately incineration with energy recovery. The EASAC (2020) report suggested a waste hierarchy as follows.

1. Recycle to use in the same product as the waste plastic – closed-loop.
2. Recycle for use in another plastic product (down-cycling).
3. Extract valuable chemicals or fuels through chemical treatment or pyrolysis.
4. Finally, to extract energy from the remaining plastic waste.

A similar hierarchy was advocated by Lange (2021a; 2021b) in his analysis of recycling of used polymers to ensure efficient recycling of carbon, while minimising energy consumption and waste production over the whole of the product life cycle. If not able to be reused, the next step should be mechanical recycling, chemical depolymerisation, conversion to a hydrocarbon feedstock, and, as a last resort, energy recovery.

The third stage of recovering chemical precursors from mixed plastics by thermo-chemical processes avoids the loss of carbon to landfill or carbon dioxide emissions (Vela *et al.* 2022), but the technology is still in the development and early commercialisation stages. Eunomia (2020a) examined the potential and economic challenges of chemical and thermal processes, and noted that here is a general lack of transparency or robust evidence that can be used to verify claims or draw conclusions on the viability of many technologies. Some companies have pilot/demonstration plants with an approximate capacity of 68 kilotonnes per annum, and targets of handling approximately 350 kilotonnes of post-consumer PET per annum by 2025 (ZWE 2022).

4 Extended Producer Responsibility

EPR seeks to internalise end-of-life costs of recycling and disposal into the design stage of product development and can be one of the most effective means of reducing waste and improving its proper handling and recycling. EMF (2021) report a clear relationship between the presence and nature of EPR and recycling rates. In the EU, EPR is a central part of waste management and mandatory in the context of the Packaging Waste, WEEE, and Batteries Directives. As we described in EASAC (2020), the charges and rules of EPR schemes vary between Member States. Charges differed by a fact 10, along with the degree to which rules are designed to influence manufacturer and retailer behaviour: for example, in encouraging a reduction in packaging use or in redesign to increase recyclability. Design rules may make the difference between charges being seen as a small tax to be passed on, or as a driver for change across the whole supply chain. The Commission's early warning report (EEA 2023), that 19 Member States will struggle to meet the 50% recycling target in 2025 for packaging waste, suggests that effective EPR schemes remain a widespread challenge.

Much experience on EPR has been gathered internationally (see, for example, EC 2014; OECD 2016; IEEP 2019; Eunomia 2020b; WWF 2020; EMF 2021) and in national EPR schemes where the Extended Producer Responsibility Alliance (EXPRA) includes examples of national EPR schemes from 30 countries. Design for Recycling guidance is also available (for example CEFLEX 2023; EMF 2023a; Recyclass 2023), which covers reducing the diversity of polymer materials, additives, composite materials, caps, labels, and sleeves, etc.

EASAC (2020) concluded that EPR should do the following.

- Create an incentive to reduce the amounts of packaging used and encourage reuse.
- Maximise recyclability of end-of-life packaging.
- Minimise the proportion of packaging that is unable to be recycled.

- Integrate with availability of recycling infrastructure (e.g. by using proceeds to improve local recycle infrastructure).
- Apply to *all* packaging (including imported goods and packaging in products purchased online).
- Aim to eliminate cost burdens on local governments from plastics disposal.
- Ensure the EPR scheme is formulated in such a way as to support recycling within the EU and to disallow export to lower cost and environmentally damaging alternatives.
- Ensure that the EPR exerts its effects across the whole value chain and is not just absorbed by the producers of packaged goods thus negating its influence upstream (e.g. plastic resin producers) and downstream (e.g. retailers and consumers).

The evidence is that mandatory, fee-based EPR schemes should be a central part of the Plastics Treaty and that the Treaty should include guidelines on the following:

- charging sufficient to cover the net cost of collection, sorting, and recycling of packaging;
- ensuring the scope of packaging covered is comprehensive, both in terms of packaging types (such as bottles, cans, flexibles, etc.) and materials (such as paper, glass, aluminium, regular and compostable plastics, etc.);
- design to reduce quantities and improve recyclability of the packaging; and
- the role of stakeholders and mechanisms for reporting, monitoring, and enforcement.

A review by Dimitropoulos *et al.* (2021) concluded that EPR has increased collection rates, promoted recycling, and shifted financial responsibility from municipalities to producers, and that there is potential to steer EPR instruments towards more eco-design and reuse. Equally, however, it is no panacea on its own to the problems of plastic pollution and should be just one of a range of comprehensive policies from the primary production to the waste management stages.

5 Care with substitution

A shift from plastics to paper is already underway as a result of the SUP Directive; plastic trays, cups, straws, and other SUP items are already replaced by paper or paper/plastic-coated materials. A key question raised in the EASAC (2020) report is to what extent substituting plastic for other materials (paper, glass, metal, etc.) is less environmentally damaging and easier to recycle than the plastics they replace. Alternative materials may be heavier or bulkier, and their production may have resource implications, while lacking the flexibility and low cost of plastics. Life cycle assessment (LCA) studies indicate that there may be substantial penalties as well as benefits in terms of increased GHG emissions and other resource demands. LCA studies can also be highly context dependent and outcomes may vary depending on how they deal with end-of-life issues and other factors such as functionality, convenience, and safety (see, for example, IEEP 2018; OECD 2019). In the case of substitution with paper, FERN (2023) also point to environmental and biodiversity impacts of the increased demand leading to industrial monoculture plantations of low biodiversity and being more vulnerable to forest fires in some parts of Europe.

Such limitations underline the need to reduce unnecessary use, and for plastic products to be designed to allow reuse to minimise the amount of waste generated. With regard to the current Packaging and Packaging Waste Regulation under negotiation, this includes the aim of reducing overall packaging waste, limiting overpackaging, and providing consumers with reusable packaging options; such aims should have priority over substitution by paper or other materials. These issues are relevant to the INC negotiations where measures to avoid 'overpackaging', aiming for a plastic-packaging-free supply chain (for example, 'zero waste shops') and reuse of packaging, should be preferred to advocating substitution by pulp and paper or other materials that offer little or no environmental benefit. It is important not simply to assume that replacements for plastic are better environmentally without properly evaluating their full life-cycle effects on climate, biodiversity, water pollution, and air quality.

6 Deposit return/refund schemes

Since the EASAC report in 2020, DRS have expanded and more experience has been gained in their application. The examples cited in Box 8 of the report (Germany, Sweden, Norway, Lithuania) were just 4 of 10 countries that had already implemented deposit return schemes in the EU: EC (2021) provides additional examples in Finland, the Netherlands, and Romania. Of European DRS, Estonia has the lowest (82.7%) return rate covering cans, PET, and glass; whereas the most successful example is Norway, with 97% recycling rate for plastic bottles. Examples outside Europe can be found in OECD (2022b).

DRS can be used not only to create material for recycling but also to provide containers that can be reused, including containers other than plastic PET and high-density polyethylene; generally, these include cans, glass bottles, and sometimes cartons that can be properly recycled and repurposed once collected. A guide to current DRS designs and implementation is available (Reloop 2023a).

Although not addressed in detail in the EASAC (2020) study, a primary means of reducing demand and leakage is to reuse containers by setting up a reverse supply chain. In theory, this would substantially reduce material use, demand for virgin plastics, and littering, and EMF (2023a) see the potential to reduce GHG emissions by up to 35% and material use by 45–75%. To achieve such benefits, substantial shifts are required in infrastructure, business models, and consumer behaviour, where the experience of the German DRS may be relevant: this was set up originally to promote the use of multi-use, refillable plastic or glass bottles. Despite this, the high logistics costs of collecting bottles and providing storage space have not prevented the switch to single-use bottles.

Eunomia (2023) found that reuse delivers greater environmental benefits than recycling or discarding single-use containers, providing return rates are high and containers can be reused from 6 to 60 times depending on the container. However, NISR (2023) found that, when compared against the currently high collection rates of Norway's DRS, a reuse system only offered savings in material consumption and not in GHG emissions because of the long transport distances involved. UNEP (2023b) and EMF (2023b) point to the need to standardise formats for reuse so they can be shared by multiple companies; they envisage industry collaborating on the design and use of containers rather than using them in brand competition. A supportive fiscal regime is also needed to drive the social and behavioural changes required. The behavioural change and shift in societal norms required represent a reversal of trends to a more convenient and hassle-free lifestyle, and the risk of initial consumer resistance, capable of political exploitation, should be considered.

EASAC (2020) summarised the substantial evidence on consumer behaviours and found that achieving changes in behaviour requires combined and consistent messaging, and financial incentives that can show the benefits to the individual as well as to the environment. Subsequent research confirms these basic factors (see, for example, Allison *et al*. 2022; Heidbreder *et al.* 2023; van Oosterhout *et al.* 2023), with some studies examining the effectiveness of various interventions in changing specific behaviours (e.g. using re-usable hot drink cups (Novoradovskaya *et al.* 2021) or plastic bags (Chandra 2020)). Consumer attitudes range from those who are fully aware of the cause and damage of plastic packaging waste and actively adapt their behaviour to minimise it, to those who are wholly indifferent to the problem. As a result, individuals differ markedly in their willingness to accept plastics restrictions and alternative means of delivering goods such as refill systems. Governments can stimulate sustainable consumer behaviour through hard measures, such as taxes and bans, as well as soft measures, such as awareness campaigns. Persuading consumers who are not individually motivated (probably the majority) requires increasing awareness, especially in terms of consequences and effectiveness of individual behaviours and the role and responsibility of consumers in plastic pollution, and ensuring that the sustainable alternatives are easy to use and deliver in terms of functional value (quality and price). Financial incentives, associated where necessary with bans, should make the sustainable choices the most affordable options.

7 Export

EASAC (2020) pointed to the extent to which Europe, North America, Japan, Australasia, and even parts of Central and South America and Africa have relied on exports to other countries for the removal of their plastic waste, leading to widespread environmental and health effects in the receiving countries. Indeed, Wang *et al*. (2020) reported that the 38 member countries of the OECD are responsible for 87% of all plastic waste exports since reporting began in 1988. Following the 2019 amendments to the Basel Convention requiring Prior Informed Consent for exports of plastic waste, the European Commission introduced a delegated regulation prohibiting the export of mixed and unsorted plastic waste to non-OECD countries. Despite this, exports from Member States have continued and the Basel Action Network record that EU plastic waste exports to non-OECD countries have recently increased (from 28,000 tonnes in May 2022 to 50,000 tonnes in May 2023), most likely because of high energy costs leading to the shutdown of some plastic recycling operations in the EU. Similarly, the Basel amendments have led to little reduction in exports from other OECD countries to non-OECD states; a rise in criminal activity to bypass rules is also apparent owing to the lack of transparency in the trade (EIA 2021).

Exporting plastic waste leads to large disparities between the amounts entering a receiving country and its ability to deal with it responsibly. For example, EIA (2021) pointed out that Malaysia's installed recycling capacity of 515,009 tonnes compared with imports of 835,000 tonnes in 2019 on top of the 2.4 million tonnes of plastic waste produced domestically. Similar disparities are found in Vietnam, Thailand, Indonesia, India, and Turkey, which are other targets for OECD country exports. These practices, whereby industrialised countries are relying on non-OECD countries[3] for the disposal of their wastes, have environmental, health, and social justice implications and underline the importance of addressing the issue of trade in plastic waste in the new Treaty. That should ensure

[3] Eighty-nine per cent of Japan's exports of plastic waste were to non-OECD countries in 2021.

traceability and transparency of any plastic waste in trade, that recycling is real and conducted in a safe and environmentally responsible manner, as well as significantly improving inspection and enforcement capacity.

8 Human and environmental impacts of microplastics

EASAC (2020) reviewed the literature up to 2019 and noted that exposure to micro- and nanoplastics in the environment and uptake in humans had already been shown to be ubiquitous, and that ingestion by marine life of macro- and microplastics have both toxic and mechanical effects, leading to mortality through entrapment, reduced food intake, suffocation, etc., and sub-lethal effects such as behavioural changes, and genetic alteration. Laboratory experiments had demonstrated possible adverse effects through both physical and chemical toxicity on human organs and cells; however, because of a paucity of data on exposure levels, it was difficult to assess the degree of risk to human health. The one application under direct control was the deliberate addition of microplastics to consumer products and we endorsed the Commission's proposals to prohibit the deliberate addition of microplastics, subsequently implemented in its 2023 Regulation.

Surveys have since continued to detect microplastic contamination from the deep ocean to the Polar seas, from drinking water to seafood: essentially wherever traces of micro- or nanoplastic particles are sought. Recently, they were even found in natural clouds and mists at the top of Mount Fuji in Japan (Wang *et al.* 2023) where nine microplastics were detected: polyethylene, polypropylene, polyethylene terephthalate, polymethyl methacrylate, polyamide 6, polycarbonate, ethylene–propylene copolymer or polyethylene–polypropylene alloy, polyurethane, and epoxy resin. Microplastics have been found in human bodies and even in breast milk and the placenta (Braun *et al.* 2021; Ragusa *et al.* 2021; Horvatits *et al.* 2022; Jenner *et al.* 2022). There remain, however, wide disparities in methods of sampling and measurement that call into question the accuracy of many studies, and the inter-comparability between them. As a consequence, much work may be required before any quantitative conclusions can be drawn from such studies and on any trends (see, for example, Schymanski *et al.* 2021; and ISO activities ISO 16094-2:2023 and ISO 16094-3:2023).

Widespread contamination by microplastics contributes to the exceedance of one of the primary Planetary Boundaries (Steffen *et al.* 2015), six of the nine boundaries of which are now being exceeded beyond the safe operating space for humanity (Richardson *et al.* 2023); this raises issues that are not readily addressed by standard evidence-based risk analysis. Furthermore, although several reviews have been published summarising the extensive literature on health effects in food, drinking water, or through inhalation (see, for example, Prata *et al.* 2020; Kumar *et al.* 2021; Udovicki *et al.* 2022; Danopoulos *et al.* 2020; Cho *et al.* 2021; Guanglong *et al.* 2023), quantitative assessments of risk cannot yet be conducted.

Available studies on ingesting microplastics also encounter multiple methodological challenges. Danopoulos *et al.* (2020) reviewed papers containing a huge range of estimates for annual intake of particles from tap and bottled waters and pointed to methodological problems that make comparisons between studies difficult. General conclusions were that microplastic contamination of drinking water was omnipresent, with the studies having indicated higher rates of contamination in bottled water.[4] However, a much clearer understanding of the levels present with improved standardised methods was required before risks could be assessed. Recent work on inhalation (see, for example, Yang *et al.* 2021; Yao *et al.* 2022; Guanglong *et al.* 2023) found that urban areas could contain high concentrations outside from sources such as textiles and vehicle tyres, brakes, etc., but the concentration of microplastic particles indoors tended to be higher from textiles, furniture, building materials, and human activities. A significant potential pathway for micro- and nanoplastics is to enter the lungs along the trachea, pass into the blood vessels through migration, and then spread through the circulatory system so that a wide range of cells, tissues, organs, and systems could be exposed. However, while textile industry workers have reported respiratory lesions from high exposure, health effects in typical indoor and outdoor environments have not been attributed to microplastics.

Assessing health impacts remains dependent on extrapolation from laboratory experiments that can show exposure may cause particle toxicity, with oxidative stress, inflammatory lesions due to the inability of the immune system to remove plastic particles, and transfer of the smallest particles into the blood stream and other organs. The difficulty in drawing any conclusions about risks to human health was emphasised by the World Health Organization (Gouin *et al.* 2022) because of the wide variety of methods applied in scientific studies. Standard methods would be needed to reduce uncertainties and provide robust data on which to assess the risks of exposure, with particular interest on smaller particles of 10 µm and below. In the meantime, measures should be taken to mitigate exposure to nano- and microplastics through reducing

[4] Indeed, a recent study using stimulated Raman scattering found about $(2.4 \pm 1.3) \times 10^5$ particles per litre of bottled water (Qian *et al.* 2024).

the use of plastics and better management throughout product life cycles.

It thus remains important to reduce the uncertainties through international standardisation and research. The precautionary principle is also an issue to be addressed in the context of regulating micro- and nanoplastics to protect human health and the marine, freshwater, and terrestrial environments. The Plastics Treaty offers an opportunity to promote and coordinate such activities and to establish international mechanisms for a response.

9 Plastics biodegradability

As we pointed out in EASAC (2020), the ideal target of a plastic that breaks down naturally in the environment remains elusive since most applications require durability, and should not degrade during use. Only a limited number of products can meet biodegradation tests in the natural environment and even these maintain their integrity for months. A recent review by Wei *et al.* (2020) reminds us that the main resin types are by their very chemical nature not degradable through biological processes, and the only resin to be open to attack is PET where specialised enzymes found in some bacteria can break the ester linkages and return to the monomer building blocks of ethylene glycol and terephthalic acid. Some progress has been made on refining and modifying the original enzymes reported by Yoshida *et al.* (2016), and an enzyme that achieves a conversion rate of 98% from PET to its monomers in 24 hours has been developed (Arnal *et al.* 2023) together with a depolymerising process applicable at an industry-relevant scale (Tournier *et al.* 2020).

Currently, so-called degradable plastics may only be compostable at industrial compost temperatures and not in natural environments. Biodegradable plastics such as polylactic acid and polyhydroxyalkanoates can be used in applications involving deliberate or inevitable leakage (e.g. agricultural mulching films) and should comply with a soil degradation standard or regulation (for example, ISO 17556:2019). Research continues and the French company Carbios has developed a biocatalyst that can be embedded in polylactic acid to promote biodegradability in ambient temperatures (De Francesco 2020).

Polyhydroxyalkanoate offers a wide array of applications in sectors such as food packaging and biomedical industries (Dalton *et al.* 2022) but its biodegradability advantages are slow to be applied owing to high cost and limited availability; widespread confusion among consumers about biodegradability is also a problem. Compostable/degradable labelling confuses consumers (Purkiss *et al.* 2022) who may not know the different meanings of 'compostable' and 'biodegradable'; moreover, labels often fail to specify the conditions needed for composting—some packaging can only be composted by high temperature industrial composting, while even those labelled as for home composting do not fully disintegrate in useful timescales. As a result, such labelling may indicate little or no environmental benefit and can amount to greenwashing.

A major shift to such plastics would also require an end-of-life infrastructure to recycle effectively and labelling to enable valuable biodegradable plastics to be separated from the mixed-plastic waste streams. Standards would also need to be applied to verify biodegradability so that consumers can make informed decisions.

10 Bio-plastics

As noted in EASAC (2020), applying the label of 'bio' offers a marketing option which has been taken up by some companies in labelling their PET bottles. However, alternative feedstocks can have major sustainability impacts (on land and water use, biodiversity, indirect GHG emissions, and creating competition with food production). Moreover, with current technologies, bio-based plastics cannot be scaled up to meet more than a fraction of potential demand. Thus, even though there are applications where biopolymers are excellent, their overall merits should be evaluated on the basis of full LCAs, rather than on simplistic assumptions or claims that 'bio' signifies a lower environmental impact.

Recently, the use of polyethylene furanoate as a replacement for PET has been explored by some beverage makers, because it offers superior barrier properties and is more readily sourced from sugars derived from biomass (Omnexus 2023). It is also more rapidly degraded in industrial composting conditions and can be recycled through similar processes to PET. Although more expensive, its economic competitiveness could improve if full environmental and social costs were applied to its fossil-fuel-derived competitors, as well as the expected cost reductions from process innovation if production were to be scaled up. Nevertheless, the need remains to conduct comprehensive LCA when selecting the feedstock. Any treatment of bio-plastics in the Treaty should reflect these concerns, and LCA methodology should continue to be refined and international guidelines adopted to ensure uniform standards.

11 Implications for the Plastics Treaty

In the light of the current negotiations for a Plastics Treaty, we consider here the relevance of the analyses discussed above to specific areas of the Zero Draft (UNEP 2023a).

A fundamental point for negotiation is the proposal to set a target for **reducing plastic primary production**

(Part II/1). Our analyses (Section 2) would support this because of the inevitability of increasing production leading to increasing leakage, increasing greenhouse gas emissions, and the inability to effectively collect and recycle more than a small fraction of end-of-life products. However, simple substitution of plastics by other materials requires careful consideration if the environmental burdens are not to be shifted to another sector. For instance, we mentioned the concerns over the increasing demand on the forest sector for pulp and paper. Consumption of materials in general is already well above the sustainability level of the planet, and thus the aim of plastics reduction should be to reduce material consumption and not to transfer it from plastics to another. A fundamental aim should thus be to reduce the need and demand for packaging.

EASAC's call for a **systems approach** is consistent with the recommendations by EMF (2023c) for 'elimination' by reducing the total volume of plastics production and consumption, combined with 'innovation' to ensure all plastics are reusable, recyclable, or compostable so as to allow 'circularity' to keep plastics in circulation for as long as possible and out of the environment. Pew Charitable Trusts (2023) generated quantitative models demonstrating that a reduction in plastics production – through elimination, the expansion of consumer reuse options, or new delivery models – is the most attractive solution from environmental, economic, and social perspectives. Models suggest that achieving at least an 80% reduction of plastic pollution by 2040 requires a 47% reduction and substitution of plastics.[5] ISC (2023) also conclude that a systems approach should cover the entire life cycle of plastic and its social, environmental, and economic impacts.

A recent decision by the European Parliament[6] adopts a range of targets covering systemic issues for packaging plastics.

- **Bans on certain single-use packaging** (additional uses including single-use hotel miniature packaging of less than 100 ml, shrink-wrap for suitcases, unnecessary boxes for toothpaste and creams).
- **Reduction targets for plastic packaging** (10% by 2030, 15% by 2035, 20% by 2040) compared with 2018.
- **Reuse targets of at least 20%** by 2030 and 35% for non-alcoholic beverages.
- **100% recyclable packaging by 2030** and recyclable at scale by 2035.
- **Mandatory recycling DRS for plastic beverage bottles and cans** from 2029 unless a separate collection rate of 85% is achieved in 2026 and 2027.

An effective means of allowing the market to set the optimal rate of production and use could be to **internalise all external social and environmental costs** into the basic market price for virgin resin. As we note in Section 2 and Box 2, this could lead to very substantial increases in the price of virgin plastic. An option for the INC would be to establish a mechanism for further consideration of such economic instruments as taxes and their quantification.

Part II/3 of the Zero Draft refers to **problematic and avoidable plastic products**, including short-lived and single-use plastic products and intentionally added microplastics. We referred earlier to the action already taken in the EU in banning some SUP and the deliberate addition of microplastics to consumer products. The science supports measures to reduce the use of products that pose a high risk of direct leakage to the environment, but many more products remain to be so classified. As we discuss, consumer behaviour is central to the littering of many on-the-go items (fast foods, drinks, snacks, etc.) and is mostly influenced by pricing and the ready availability of simple and convenient cost-free (in terms of both time and money) alternative options, supported by increasing awareness and effective regulations. This places a demand for changes in not just consumer behaviour but also the responsibility of retailers and product designers to make the environmentally responsible path the cheapest and easiest option.

Part II/5a focuses on **product design, composition, and performance.** Here, the development of application-specific Design for Recycling criteria for evaluating plastic applications is a core objective of the future agreement. Design for Recycling has already been well-studied (see, for example, EMF 2020) but has had limited impact as shown by the persistence of products such as opaque PET bottles which have been known to interfere with the recycle process. We discussed in Section 3 the ways in which design can interfere with recycling and potential solutions to these challenges. The Treaty offers the opportunity to commit to the principles of design to improve a range of characteristics beyond the narrow considerations of commercial competitiveness—increasing the safety, durability, reusability, repairability, and refurbishing capability of plastic products, and their capacity to be recycled

[5] Assumed to be achieved by a 30% reduction relative to the Business As Usual demand, 17% substituted by other more environmentally-friendly materials, an increase in recycle rate to 20%, 23% disposed of by environmentally sound methods, leaving 10% mismanaged.
[6] https://www.europarl.europa.eu/doceo/document/TA-9-2023-0425_EN.html. This decision will be the Parliament's position in negotiations with the Commission and Council before a final Packaging and Packaging Waste Regulation is agreed.

and disposed of in a safe and environmentally sound manner.

Part II/5b covers **reduce, reuse, refill, and repair of plastics** and plastic products. Reuse could, if effective, contribute to a reduction in overall demand but has major challenges as described in Section 6. Meeting the challenges involves incentivising companies to collaborate rather than compete in establishing common formats and reverse supply chains, and consumers to positively play their part in ensuring high recovery and return rates.

The Treaty also considers (Part II/5d) **alternative plastics and plastic products** including bio-plastics or biodegradable plastics (Sections 9 and 10). At the current state of technology, the potential of these to contribute to the primary aims of the Treaty are limited. Switching to alternative feedstocks for the same plastics carries with it the risks of exacerbating other environmental burdens or creating conflicts with land use, while biodegradability is still inadequate to overcome the environmental impacts on leakage. The need for LCA on bio-crops and for proper biodegradability standards for resins claiming biodegradability could be included in the Treaty, and at the current state of technology it would be inappropriate to exclude such plastics from the main obligations in the Treaty.

Part II/6 refers to **substitutions** where these (UNCTAD 2022) are '*all natural materials from mineral, plant, animal, marine or forestry origin that have similar properties of plastics*'. Plastic substitutes should have lower environmental impact along their life cycle and should be suitable for reuse, recycling, or sound waste disposal. Our analysis (Section 5) shows that substitution has to be treated cautiously and properly evaluated through LCA if it is to reduce environmental burdens at the system level. In particular, the main substitute for SUP by paper brings with it a different range of environmental risks, while simplistic assumptions that paper is more readily recycled overlook the difficulty of recycling much single-use paper food packaging owing to contamination by food and mixed materials (EC 2022) and problems in collection from diverse retail and consumer locations. As pointed out in Reloop (2023b), ignoring the impact of producing substitute materials risks inefficient or even counterproductive patterns of substitution. Standards and guidance should aim to encourage only beneficial substitution.

Part II/7 refers to **Extended Producer Responsibility** which we pointed out in Section 4 can be a very powerful or ineffectual tool, depending on its scale, rules, and implementation. Design of EPR is critical but should be based on the simple principle of covering *all* the costs of managing the waste resulting from the products and their packaging. This should include the entire waste management process, covering collection, sorting, recycling, and management of products and packaging that are not recycled, and the costs of treatment and disposal, as well as cleaning streets and other public areas of littered items.

Eco-modulation can be used to differentiate charges to encourage more readily recyclable materials and discourage those that are impossible or difficult to recycle. Other tools such as setting a minimum percentage for the amount of recycled plastic in a given product can be used, such as the EU targets for recycle content of PET plastic drink bottles (25% recycle content by 2025).

Eco-modulation may require procedures that are too complex to apply in some circumstances (Reloop 2023c), in which case the primary objectives of EPR may require economic instruments such as taxes to encourage a shift away from problematic, non-recyclable products and packaging. In all EPR systems, the revenue generated from the fees should be used exclusively for managing end-of-life products and packaging, education, communication campaigns, and for reporting and related administrative measures. As a principle, the guidance in the Plastics Treaty should aim towards EPR systems that lead to true costs of fossil-fuel-based plastics (full costs of plastics production, use, and disposal as described in Section 2).

Part II/9 covering **waste management** and Part II/10b address the issue of **transboundary movement** of plastic waste, which we have shown in Section 7 to be continuing at a high rate between OECD and non-OECD countries, despite the additional controls required by the Basel Convention. Current negotiations address this and propose limiting exports to those given Prior Informed Consent and that can be recycled in a safe and environmentally sound manner. The EU is planning, through its Waste Shipments Regulation, to only allow exports of such wastes to non-OECD countries that consent and fulfil the criteria to treat such waste in an environmentally sound manner. Moreover, plastic waste to non-OECD countries would be banned altogether within 2½ years after the entry into force of the regulation, and stricter conditions that include closer compliance monitoring applied to plastic waste exports to OECD countries. This offers a model for inclusion in the Treaty.

In Part IV, there is a mechanism for reviewing chemicals and polymers of concern, microplastics, and problematic and avoidable products. In this context, concerns over how to assess and manage the **risks to human health of microplastics** discussed in Section 8 is a key issue. The emerging scientific understanding on effects of microplastics should be kept under review by the Treaty's Governing Body to assess the risks of plastic pollution to human health, biodiversity, and ecosystems; indeed ISC (2023) advocates a platform be set up to enable members of the INC to access independent scientific information on policy questions and challenges. Meanwhile strategies to reduce major sources of microplastics (e.g. tyres, textiles, personal care products, production pellets, and cigarette butts) that currently add 1.8 Mt annually to the ocean are proposed to be the subject of specific reduction targets (Pew Charitable Trusts 2023; WWF 2023).

Finally, the Treaty will include a section on **definitions**, where the impact of research and development should be considered to ensure that advances can be applied within the terms of the Treaty and not impeded by definitions that prove inflexible. Two areas have been identified as particularly fluid in terms of technological advancement. Firstly, in the potential of biodegradability, where progress continues and definitions should be flexible to allow rapid entry of improved products into potential markets. Secondly, in recycling technology, where advances in chemical and thermal means of recycling continue; the definition of recycle should thus recognise the recycle hierarchy and the role of recycling through simpler chemical precursors for new products.

12 A final word

It is almost 60 years since Kenneth Boulding pointed to the unsustainability of a global economy focused on perpetual growth in a finite planet (Boulding 1966); yet growth has continued to be a target of policy-makers, and the mechanism of international treaties has had to be applied many times to counter the negative effects. Some, such as the Long-Range Transboundary Air Pollution Convention, the London Convention, and the Montreal Protocol, can justifiably claim to have made substantial progress in combating the original challenge. Others, such as the Convention on Biological Diversity and the Framework Convention on Climate Change, have seen the scale of the problem steadily worsen between the meetings of their contracting parties. Drafting a new international treaty to tackle the worsening problems of plastic contamination of the global environment could well benefit from this history, and seek to craft a treaty that properly addresses the challenges and incentivises all countries to make it a success comparable to the Montreal Protocol's delivery of a protected ozone layer. We hope that our brief analyses of the key issues can be of some assistance in this task.

Abbreviations

DRS	Deposit Refund System
EASAC	European Academies' Science Advisory Council
EC	European Commission
EMF	Ellen McArthur Foundation
EP	European Parliament
EPR	Extended Producer Responsibility
EU	European Union
GHG	Greenhouse gas
INC	International Negotiating Committee
LCA	Life cycle assessment
OECD	Organization for Economic Cooperation and Development
PET	Polyethylene terephthalate
rPET	Recycled polyethylene terephthalate
SUP	Single-use plastics
UNEP	United Nations Environment Programme

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