Planet Tracker

# THE PLASTIC RECYCLING DECEPTION

## WHY ACTION ON PLASTIC PRODUCTION IS IMPERATIVE

June 2024

# CONTENTS



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# KEY TAKEAWAYS

- The global plastic industry has gone to great lengths over a long period to convince us that global plastic pollution can be solved with recycling.
- By promoting this focus on downstream solutions, policymakers and consumers have been encouraged to avoid examining upstream measures as a pollution control.
- Presently, plastic does not deserve a reputation as a circular material when globally 91% is not recycled.
- The plastic industry has worked hard to promote an aura of recyclability for plastic. For example, what are widely thought of as plastic recycling symbols found on many plastic products are **not** recycling symbols. They are resin identification codes (RIC) revealing the type of plastic used. Note that the RIC does not indicate any additives contained in the plastic.
- The resin identification codes were invented by the plastic industry which subsequently surrounded them with a recycling symbol from the public domain.
- By using these codes, the plastic industry has created the widespread impression that their products can or are being recycled and therefore this is the solution to global plastic waste.
- This illusion has passed the financial burden of waste treatment to others, namely local municipalities or sub-contractors or waste-pickers, one of the poorest parts of the plastic supply chain.
- It has also created the impression that low recycling rates are the fault of consumers. The reality is that for many plastic products to be recycled, they need to navigate an obstacle course.
- Investors need to recognise that recycling alone is unlikely to solve plastic pollution and that upstream measures to limit production, such as extended producer responsibility (EPR) schemes, regulation, or taxation of production are required.[1] We encourage investors to run such scenarios in their forecasts.
- Upstream corporates need to take responsibility for their role in plastic pollution. A clear plan to transition production to safe, environmentally sound and sustainable materials is needed.
- We encourage investors with exposure to the plastics value chain to address plastic pollution at source and support the investor statement calling on petrochemical companies to reduce fossil fuel dependency and eliminate hazardous chemicals from plastics.

# EXECUTIVE SUMMARY

Planet Tracker has argued that greenwashing is not only widespread, but very sophisticated - see 'The Greenwashing Hydra'. In this paper, we argue the plastic industry (see Appendix 1 for the major listed companies) continues to engage in greenwashing by the promotion of recycling as the answer to plastic pollution.

As an example, we examine what many believe are plastic 'recycling symbols' – all seven of them – and demonstrate that they mislead policymakers, regulators and consumers. The oil and chemical industries appear to use these symbols to support the narrative that the solution to global plastic pollution is recycling. This is false as 90% is not recycled.[2]

To underline the absurdity of this claim, Planet Tracker searched for data sets where roughly 10% of a sample demonstrated a particular characteristic, to see whether it was reasonable to apply this to the remaining 90%.

- Around 10% of the world's population is European.
- Around 10% of the world's population is over 65 years old.
- Around 10% of people are left-handed.

No one would suggest that the above statistics mean we can conclude that the entire world population are left-handed, or Europeans, or aged over 65.

By successfully promoting the message that plastic is, or can be circular, the industry has kept policymakers distracted from the benefits of alternative (non-fossil fuel) materials and from implementing production cuts in the existing fossil fuel-based plastics industry.

A report by the Center for Climate Integrity[3] argues that 'the plastics industry has employed a familiar playbook for more than 50 years to escape accountability. Petrochemical companies - independently and through industry trade associations and front groups - have deceived consumers, policymakers, and regulators into believing that they could address the plastic waste crisis through a series of false solutions'.[4] It reveals the messaging from the industry was initially focused on disposability (1950s and 1960s), then moved to incineration and landfilling as "solutions" (late 1960s and 1970s), then followed with the promise of recycling (mid 1980s to mid-1990s). With recycling failing to deliver meaningful results, by 2015, and public pressure to find a solution re-emerging, most lately the plastics industry has started to promote an old technology as a new "solution" to plastic waste - "advanced recycling".[5]

This illusion of a recycling solution has allowed the upstream plastic companies to protect their profit margins and instead leave local government and municipalities, which are often the poorest part of the plastic value chain, to incur the clean-up costs of plastic waste.

This misdirection is presently being played out in the UN-led negotiations on an international legally binding instrument on ending plastic pollution.[6] In late April this year, the Fourth Session of the Intergovernmental Negotiating Committee (INC-4) was held. The negotiations began with a Zero Draft[7] riddled with brackets – i.e. text that has still to be agreed – including the objective of the instrument being negotiated and whether it will "be based on a comprehensive approach that addresses the full life cycle of plastic".[8]

Influential players are keen to limit the definition of the plastic life cycle to the downstream waste management section, rather that incorporating upstream and the production of plastics. Despite progress in some areas at INC- 4, the scope of the revised draft remained highly contentious. Disappointing is the lack of primary polymer production from the intersessional discussions prior to the final INC- 5. For a summary of the key takeaways for financial institutions please see 'What financial institutions should take away from the 4th round of Global Plastics Treaty negotiations'.[9]

The financial markets have bought this narrative, placing the plastic producers on the lowest equity risk premium in the plastic supply chain - see Plastic Risk.

However, a true solution to plastic pollution will have to include an upstream element targeting production, be this via extended producer responsibility, taxes, regulation or some other mechanism. We encourage investors to support the Investor Statement on the role of petrochemical companies in resolving plastic pollution which calls on upstream corporates to take responsibility for their role in plastic pollution.

Plastics is a sector with a significant risk register already and for equity investors, holders of long dated bonds and loans, as well as insurers, these risks should be priced into the cost of capital now. We encourage investors, lenders and insurers to remain mindful of the plastic sector’s full ledger of risks and ensure this is adequately priced into their plastic-related financial instruments. Should sentiment about plastic pollution change and progress be made on an upstream solution, producers, which price in the lowest risk premia, are looking particularly vulnerable.

And if the financial markets believe that the costs of plastic pollution and related health concerns will likely remain an externality – i.e. should not be priced into financial models such as discounted cash flows – they should examine what is happening to Bayer (BAY), where a major company which produces harmful synthetic chemicals has become financially constrained as litigation has mounted and investors have suffered the consequences. Please see ‘Is Bayer a litigation leading indicator?’


# PETCHEM INVESTOR STATEMENT

Petrochemical companies are a major contributor to plastic production, increasing the threats of plastic pollution, climate change, biodiversity loss and human health impacts. However, during the latest round of the UN led Plastics Treaty negotiations, in which countries are aiming to agree on a legally binding treaty addressing the key drivers of plastic pollution, petrochemical companies and their supporters have opposed any cut to production to curb plastic pollution and pushed back against the inclusion of polymer production within the treaty.

We now ask investors to address petrochemical companies as their support for an ambitious agreement is vital:

- Plastic production is due to triple by 2060 and petrochemical companies will become the main driver of growth in oil demand
- Lifecycle emissions from plastics will more than double, making up 4.5% of global emissions
- Plastic polymers contain toxic and hazardous chemicals, out of the 16,000 chemicals present in plastics over 4,000 are identified as toxic
- Toxic chemicals and additives have an impact on human health and are, among other health issues, associated with diabetes, obesity, fertility issues and different types of cancers

This poses significant plastic-related risks to petrochemical companies producing plastic polymers. These risks include regulatory risks (e.g. tighter emission controls, bans, taxation, and extended producer responsibility costs), reputational risks, plastic-related litigation, and increased consumer demand for safe and more sustainable products. These risks could be financially material for corporates and their investors.

We encourage investors with exposure to the plastics value chain to sign this statement and request petrochemical companies that produce plastic polymers to take stronger actions towards plastics circularity. **This statement sets out the following expectations of companies:**

1. **Transparently disclose, define strategies and set clear targets to transition to production of safe, environmentally sound and sustainable plastic**
2. **Address polymers and chemicals of concern in their products**
3. **Build suitable infrastructure for production of sustainable materials**
4. **Establish dedicated governance**
5. **Publicly support an ambitious international legally binding instrument for ending plastic pollution**

Read the full **Investor Petchem Statement** here.

# INTRODUCTION

Plastic is often perceived as a widely recycled material. Consumers are reassured by what they believe are the “recycling codes” on purchased goods, implying that their waste will be converted back into useful products rather than landfilled or burnt. However, this is a deception. Globally, around 90% of plastic is not recycled.[10]

In this paper, we argue the plastic industry (see Appendix 1 for the major listed companies) sets out to misled policymakers and consumers via its focus on recycling as the solution to plastic pollution. It remains determined to promote plastic as circular, the opposite of the present reality in the vast majority of cases. By successfully promoting this message, the industry has kept policymakers distracted from the benefits of alternative (non-fossil fuel) materials and from implementing production cuts in the existing fossil fuel-based plastics industry. In turn, this illusion allows the upstream plastic companies to protect their profit margins and instead leave local government and municipalities, which are often the poorest part of the value chain, to incur the clean-up costs of plastic waste.

# KEY DEFINITIONS

**Plastic value chain** – Planet Tracker includes three main segments in its conception of the plastic value chain; the upstream resin producers (producers), the midstream containers and packaging converters (PC&P), and the downstream fast-moving consumer goods (FMCG) companies, which rely on plastic packaging to sell their goods. We acknowledge that a broader definition could be drawn, particularly of the downstream end-users or by adding in waste management.

**Upstream** – The producers of plastic resins

**Midstream** – The plastic container and packaging companies

**Downstream** – The end-users of plastic, for instance FMCG corporates and also those involved in the management of plastic waste, for instance municipalities.

**Extended producer responsibility (EPR)** - an environmental policy which aims to shift the responsibility of waste management from the consumer to the producers . It aims to ensure that producers take responsibility for the entire life cycle of their products, including postconsumer disposal and recycling. Examples of EPR include: collection fees, collection targets, carbon footprint disclosures, minimum recycled content, product passport, etc.

**Municipal solid waste** - includes waste generated from: households, commerce and trade, small businesses, office buildings and institutions (schools, hospitals, government buildings). It also includes bulky waste (e.g. white goods, old furniture, mattresses) and waste from selected municipal services, e.g. waste from park and garden maintenance, waste from street cleaning services (street sweepings, the content of litter containers, market cleansing waste), if managed as waste. The definition excludes waste from municipal sewage network and treatment, municipal construction and demolition waste.

**Recycling** - The collection, sorting, and reprocessing of used plastics into new plastic products. This might be a closed loop, i.e. plastic bottle to plastic bottle, or downcycle the plastic to a lower grade function.

# A RISING TIDE OF PLASTIC WASTE

First, let us consider the level of production of plastic waste. Data from the US Environmental Protection Agency (EPA) regarding waste generation and management across the US, from materials including paper, glass, metals and plastic,[11] shows that plastic waste by weight (36 Mt) was ranked second to paper & paperboard (67 Mt). **Plastic waste tonnage was greater than that of all metals together at 26 Mt**. Although paper & paperboard has the higher tonnage, 68% was recycled (46 Mt). For plastics, only 9% (3 Mt) was recycled – see Table 1.

***Table 1:*** *Generation and Recycling, of Materials in municipal solid waste in 2018 (in millions of tonnes - Mt) and percent recycled of each material) / Source: Data f Sustainable Materials Management: 2018 Fact Sheet.*

| Material | Weight Generated | Weight Recycled | Recycling as Percent of Generation |
|---|---|---|---|
| Paper and paperboard | 67.4 | 46.0 | 68.2% |
| Glass | 12.3 | 3.1 | 25.0% |
| Metals | | | |
| Steel | 19.2 | 6.4 | 33.1% |
| Aluminium | 3.9 | 0.7 | 17.2% |
| Other nonferrous metals* | 2.5 | 1.7 | 67.3% |
| Total metals | 25.6 | 8.7 | 34.1% |
| Plastics | 35.7 | 3.1 | 8.7% |
| Rubber and leather | 9.2 | 1.7 | 18.2% |
| Textiles | 17.0 | 2.5 | 14.7% |
| Wood | 18.1 | 3.1 | 17.1% |
| Other materials | 4.6 | 1.0 | 21.3% |
| Total materials in products | 189.8 | 69.1 | 36.4% |

This poor recycling rate for plastic waste is repeated at the global level. In 2019, **91% of plastic was not recycled**. 19% was incinerated and almost 50% went to sanitary landfill.[12] The remaining 22% was released into the environment in an uncontrolled way (e.g. unregulated dumpsites or leaked into the environment such as rivers and oceans). This mismanaged waste presents a much higher risk of entering waterways or being burnt which then releases unintentional persistent organic pollutions (UPOPs) and therefore contributes to climate change - see Figure 1. UNEP calculated that of the seven billion tonnes of plastic waste generated globally so far, less than 10 per cent has been recycled.[13]

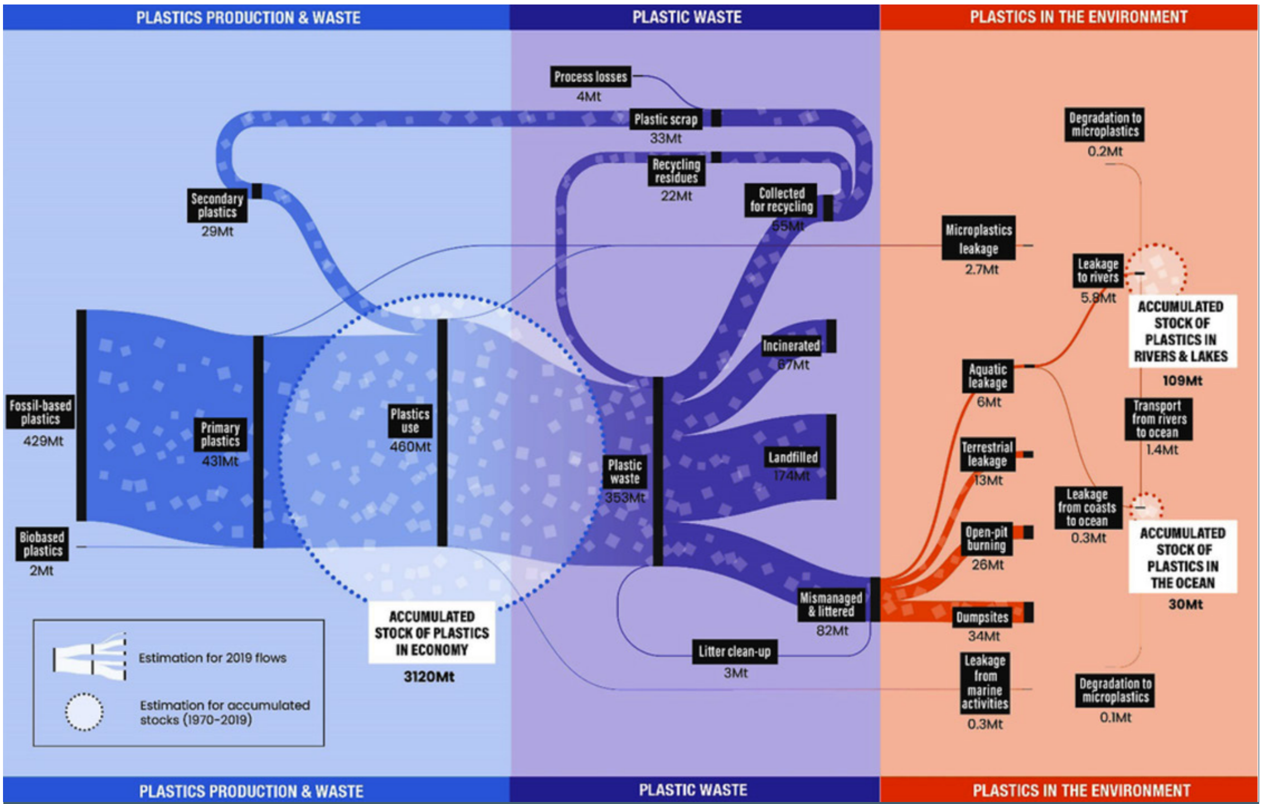



***Figure 1:*** *Only 33 million tonnes (Mt), or 9% of the 353 Mt of plastic waste, was recycled in 2019 Source: OECD (2022), Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options.*

Keeping the spotlight away from the growing rate of plastic production as the driver of plastic pollution has allowed the industry to maintain its expansion plans. History clearly demonstrates the relentless growth of plastic production, increasing steadily at a rate of 8% per year, from 21 Mt during the 1950s, to the current production level of >405 Mt in 2020.[14] By projecting these rates, an alarming forecast appears possible.

Figure 2 shows both the history and projected trend of global plastic production.[15] The dotted line indicates actual production data while the dashed one indicates the second-order polynomial trend.[a] The arrows indicate the short-duration reduction in production during the global oil crisis and financial crisis.

a A polynomial trendline is a curved line that is used when data fluctuates. It is useful for analysing gains and losses over a large data set.

The green shaded area represents the actual data while the pink shaded area indicates the projected data; note that the R2 is 0.998[b].

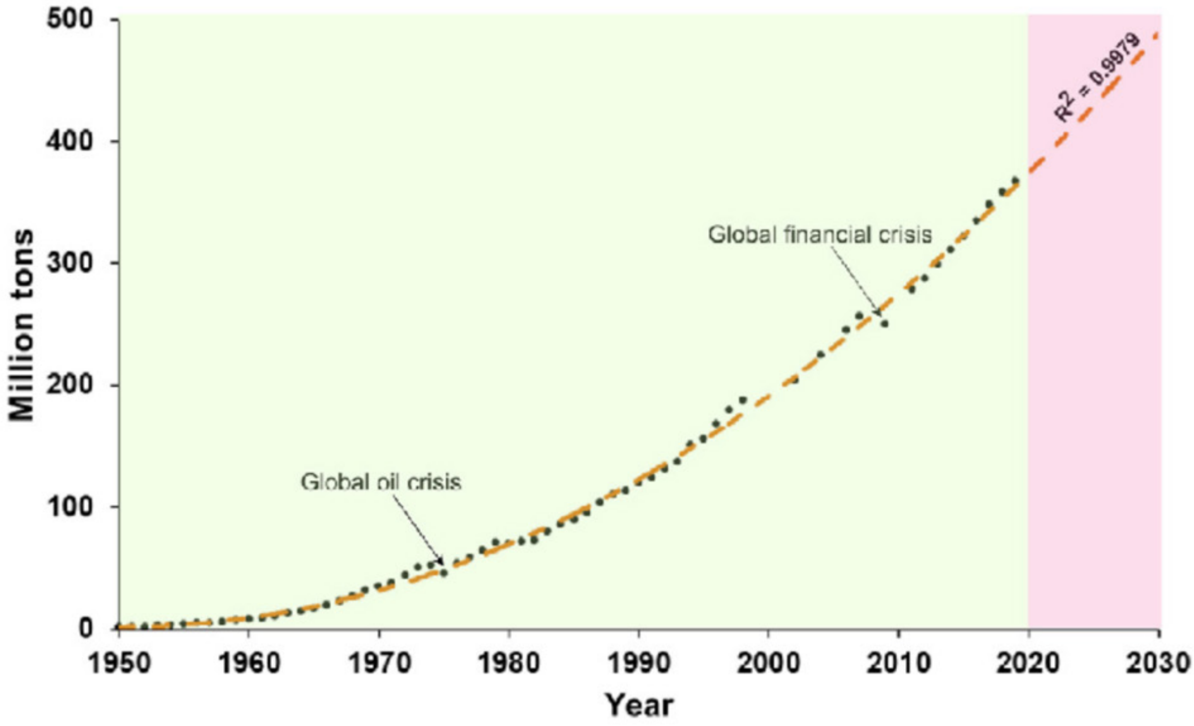



***Figure 2:*** *Historic and forecast global plastic production / Source: Ramkumar et al. (2021).*

If we examine just **single-use plastic (SUP)**, planned capacity growth is also significant, although at a slightly slower rate. Planned plant expansion (2019-25) was 4.8%, which is in line with the historical capacity growth rate. Actual capacity growth from 2019-21 was 3.1%. Note that there can be a divergence between capacity expansion and production. For example, actual production output of polymers grew slightly faster than capacity, at 3.4% CAGR, suggesting marginally higher asset utilisation rates – although this global average masks both increases and declines in utilisation rates across regions and for individual assets – see Figure 3.

b R-squared ($R^2$ or the coefficient of determination) is a goodness-of-fit measure for linear regression models. R-squared measures the strength of the relationship between the model and the dependent variable on a 0 to 1 scale. In other words, the r-squared shows how well the data fit the regression model (the goodness of fit).

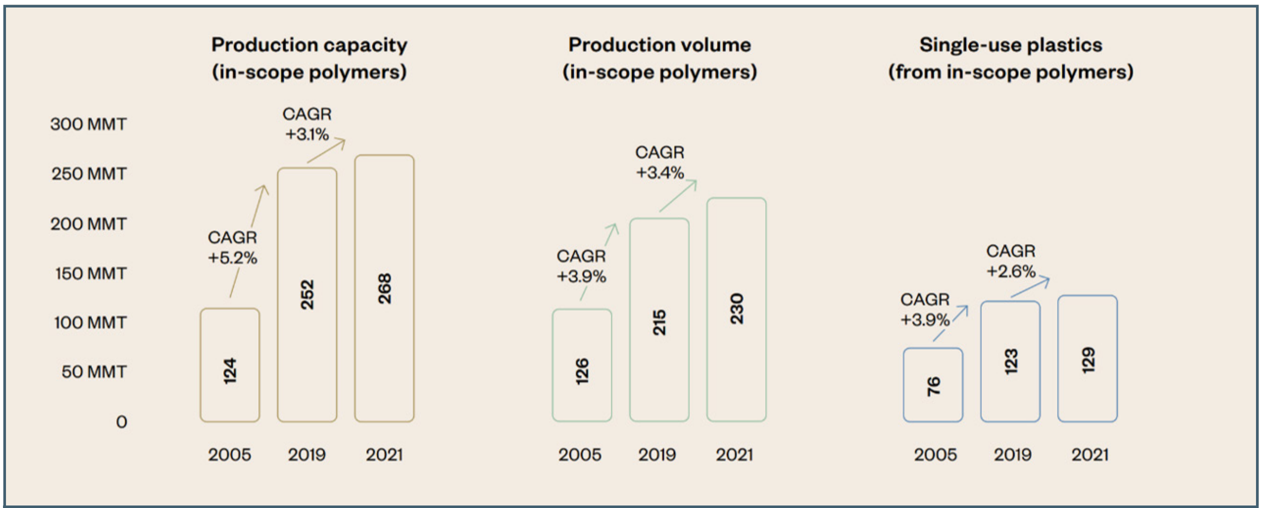



***Figure 3:*** *Historic production capacity and volume*
*Source: The Minderoo Foundation (2023), The Plastic Waste Maker Index.*[17]

The Minderoo Foundation proposes that it is possible this short-term downwards correction could be due to market cycles, or COVID-19 related issues, or to volatility in commodity prices. **Planned expansion 2021-27 now stands at 3.4% CAGR.** This lower long-term growth rate reflects changing macro trends (GDP and population) and demand for single - use plastic. It is to be noted that there is a significant positive correlation between single - use plastic consumption per capita and population and GDP growth. The Minderoo Foundation calculated the R2 to be 0.85 between 2005 and 2019 - see Figure 4.

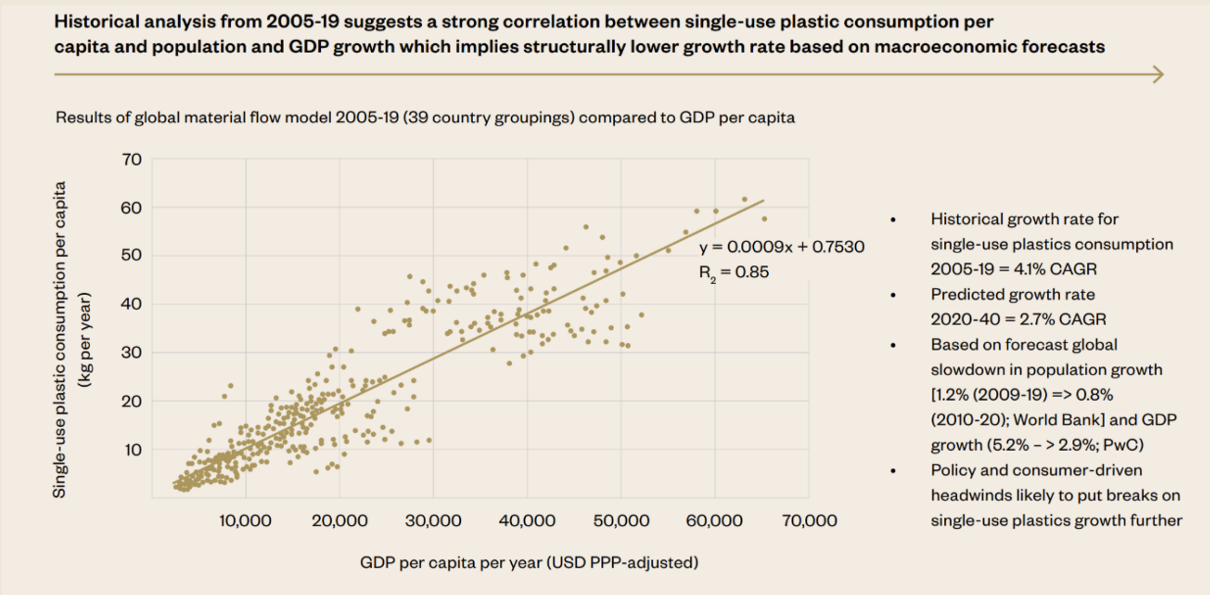



***Figure 5:*** *Historic production capacity and volume 2005-2019*
*Source: The Minderoo Foundation (2023), The Plastic Waste Makers Index.*

It is possible that demand may be dampened further by growing pressure from policy and consumers to combat plastic waste and pollution, and plastic marine litter.

An analysis by SYSTEMIQ of the European plastic sector suggests that the current actions scenario, which assumes that all major commitments already made by the public and private sectors until 2020 are implemented and enforced – including European regulation and voluntary industry commitments – would result in the industry achieving only 14% circularity.[18] Note that 'circularity' in this instance is not limited to recycling but is measured as the share of expected plastic demand that is reduced, reused, and/or recycled.

On evidence to date, capacity and output growth are likely to lead to evermore plastic waste. The OECD states, 'Globally, plastic leakage to the environment is seen doubling to 44 Mt a year, while the build-up of plastics in lakes, rivers and oceans will more than triple, as plastic waste balloons from 353 Mt in 2019 to 1,014 Mt in 2060'.[19]

# FAR FROM CIRCULAR

The term 'circular economy' refers to a closed loop model where materials are used more efficiently, for longer periods and then are recovered to make new products. Theoretically, they should embody all three "Rs" of the waste management hierarchy: reduce, reuse, recycle.

Planet Tracker has measured the perceived risk to the plastics production industry, from a corporate management perspective, by scrutinising management filings and statements - see Figure 5. In this analysis, we demonstrated that the majority of plastic risk disclosures focus on circularity, accounting for 73% of all risk disclosures; interestingly the more upstream the company, the keener it is to push the circularity messaging – see Exposing Plastic Risk.

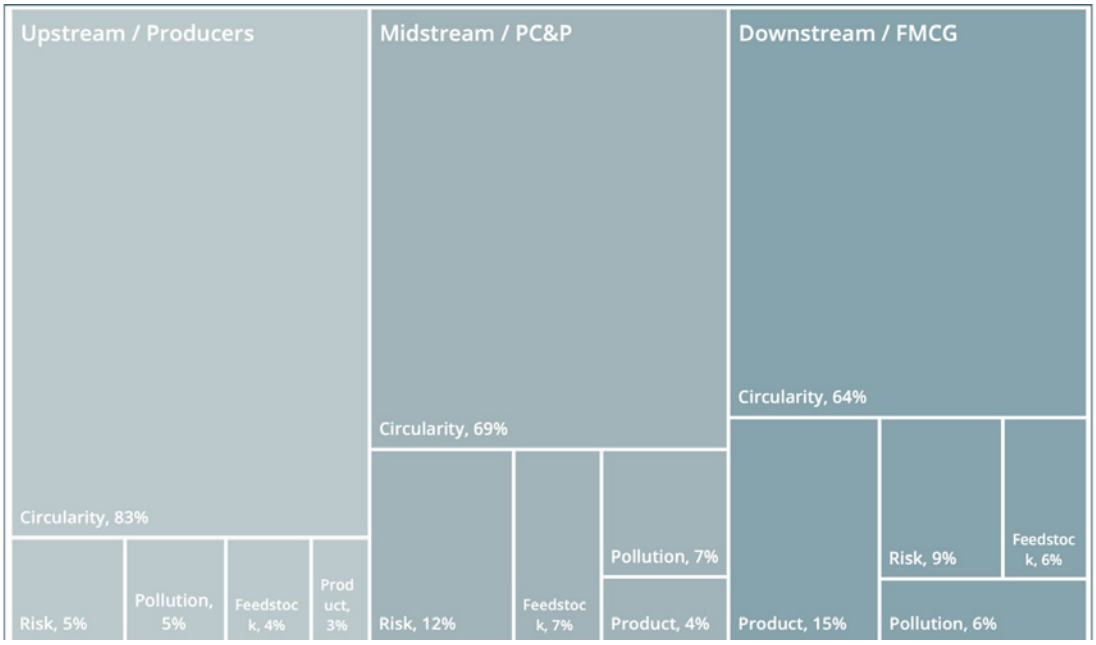



***Figure 5:*** *Plastic risk disclosure by general theme, by value chain segment. Source: Planet Tracker*

However, despite management teams talking up the potential circularity of plastic as a material, a global average of only 9% of plastic being recycled suggests we are very far from that situation. A more accurate picture would emerge if we examined **non-recycling rates**.

To underline the absurdity of the claim that plastic is circular, Planet Tracker searched for data sets where roughly 10% of a sample demonstrated a particular characteristic, to see whether it was reasonable to apply this to the remaining 90%.

- Around 10% of the world's population is European.
- Around 10% of the world's population is over 65 years old.
- Around 10% of the world's landmass is Russia.
- Around 10% of global car sales in 2022 were electric vehicles.
- Around 10% of people are left-handed.

No rational person would use these statistics to extrapolate the identified characteristic to the rest of the relevant group.

Interestingly, the plastic industry lobbyists have been keen to explain to the EU Commission and Parliament that plastic recycling rates should be lower than for other waste products, presumably because of the hurdles with recycling. Under the present status of the EU Packaging & Packaging Waste Directive negotiations, plastic has a target of 55% by 2030 compared to 75% for glass and 85% for paper and cardboard - see Table 2.

***Table 2:*** *EU Packaging & Packaging Waste Directive present targets. Source: EU Council (17 March 2024)*

| Type of packaging | by 2025 | by 2030 |
|---|---|---|
| All packaging | 65% | 70% |
| Paper and cardboard | 75% | 85% |
| Glass | 70% | 75% |
| Plastic | 50% | 55% |
| Wood | 25% | 30% |

Note that these circularity targets, which are still being negotiated at the time of writing, exclude products within these categories. For example, 'milk and other perishable beverages are exempted from the obligation to meet beverage packaging re-use targets'.[20] Furthermore, for products to meet recycled content for contact sensitive packaging (other than PET) there is a 10% threshold and for single use plastic beverage bottles 35%. So a circularity target of 55% might not be as demanding as when first seen.[21]

# RECYCLING OUTLIERS

Whilst the global average is that currently only 9% of plastic is recycled, this hides variation between countries in how plastic waste is treated. For instance, globally, whilst 49% goes to landfill, the US stands out as sending 73% of its plastic waste to landfills. Mismanaged plastic waste is high in all regions with Asia leading with 34% - see Figure 6 & Figure 7.

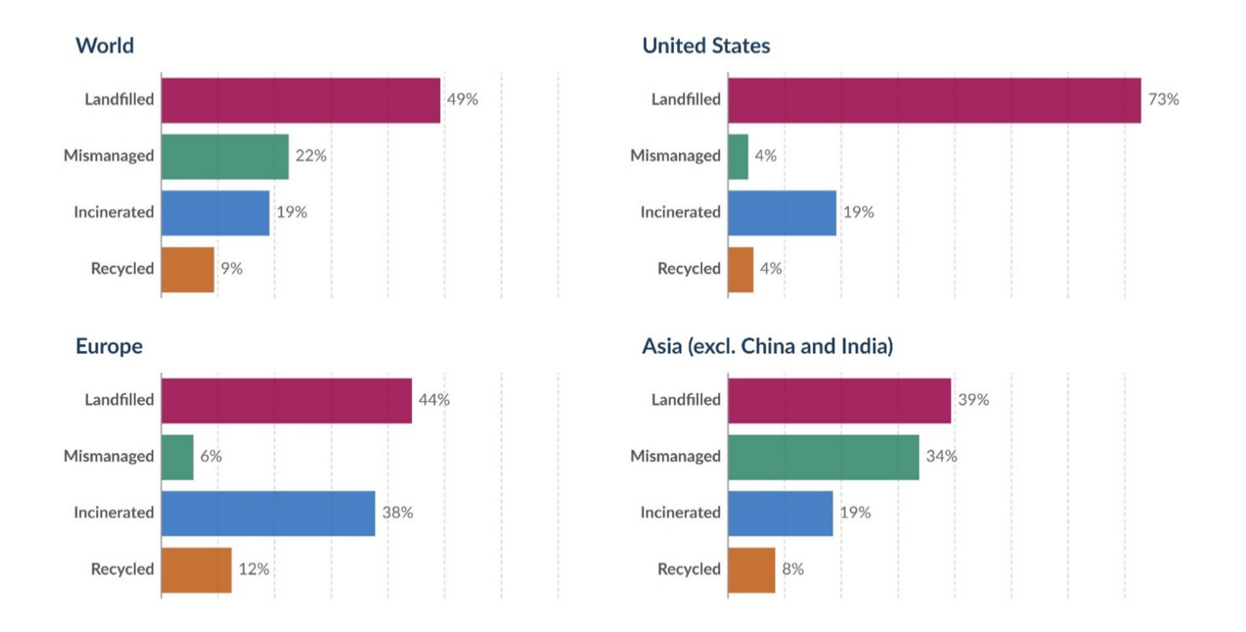



***Figure 6:*** *Share of plastic waste that it is recycled, landfilled, incinerated and mismanaged (2019) Mismanaged plastic waste includes materials burned in open pits, dumped into seas or open waters, or disposed of in unsanitary landfills and dumpsites Source: OECD, Our World in Data.*[22]

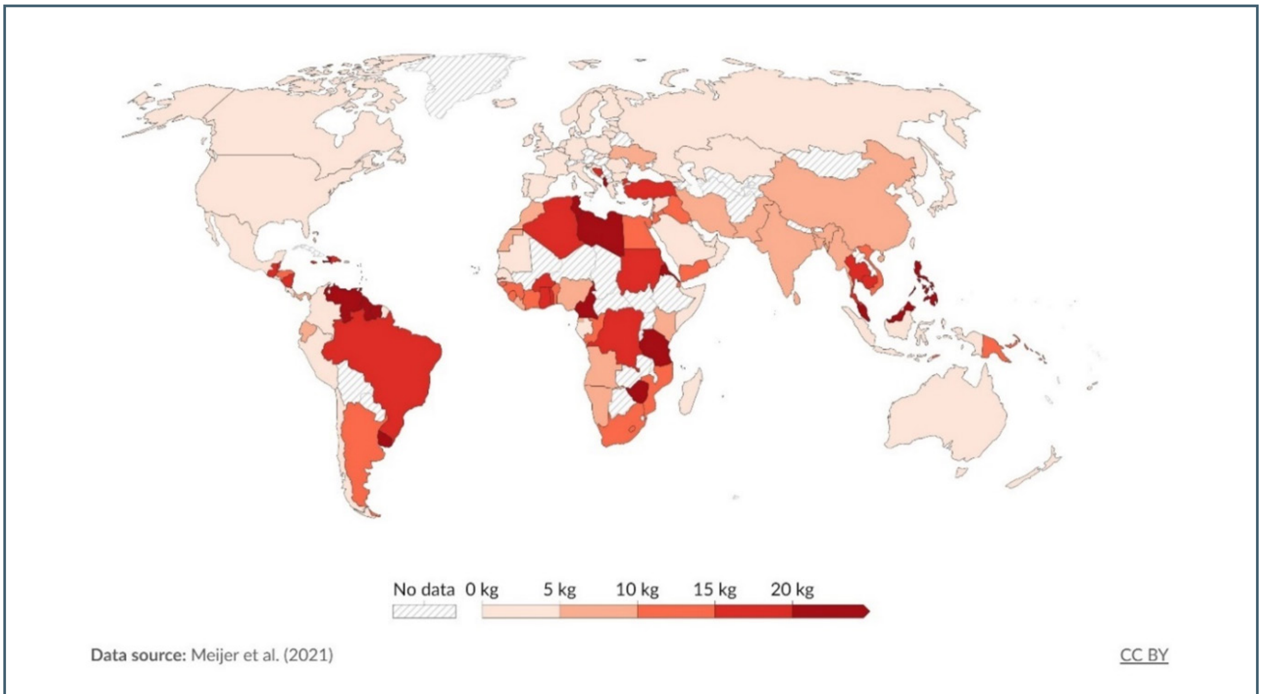



***Figure 7:*** *Mismanaged plastic waste per capita, 2019. Mismanaged plastic waste includes materials burned in open pits, dumped into seas or open waters, or disposed of in unsanitary landfills Source: Meijer et al. (2021) – Our World in Data.*[23]

The industry's response to the point that only a small percentage of plastic is recycled may be that there are countries which have achieved notably better rates, which demonstrates what is possible.

However, there are two main responses to this. Firstly, these superior recyclers (including all materials) represent only a handful of the 193 sovereign states recognised by the UN.[24] Figure 8 shows the top 10 countries based on municipality waste recycled for all materials between 2012-2021; only Korea managed to have recycling rates of more than half of the municipal waste generated (59%). Germany comes second with 48% and Slovenia third with 40%. These should be viewed as outliers rather than the norm. They have managed to suitably combine legal and economic instruments with highly-performing solid waste management systems.

Secondly, even the top 10 best recyclers achieve only recycling rates of 28% of the total municipal waste they have generated.

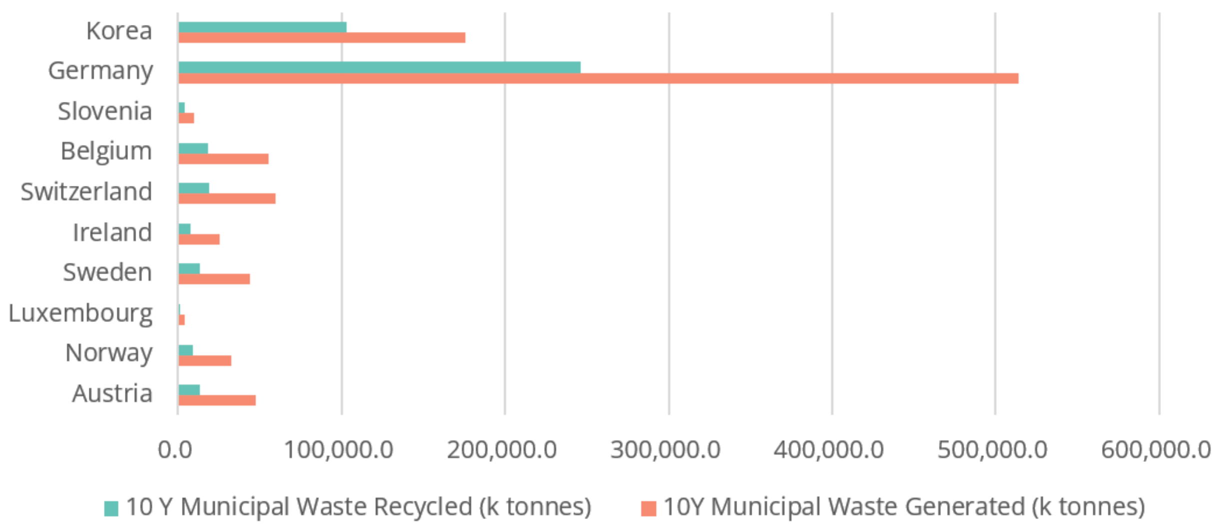



***Figure 8:*** *Top 10 countries based on municipality waste recycling of all materials ('000 of tonnes) Source: OECD/Planet Tracker.*

# THE RECYCLING OBSTACLE COURSE

The Alliance to End Plastic Waste, an association of many corporates across the plastic value chain[c] acknowledged the difficulties of the recycling process in its latest year-end-reflections: "... so much of our product and food packaging uses flexible plastic and film. As waste, these are of low value because they're difficult and expensive to recycle. So, most of it – as much as 95% – ends up in landfills, incinerators and the environment".[25]

The poor plastic recycling rates, even among leading countries, raises the obvious question as to why this is the case. In Figure 9, we show the obstacles that a container or package needs to overcome before making it into a recycled end-product.

**Planet Tracker has identified 15 major conditions that need to be met to allow the container or packaging to make its way along the recycling pathway.** These range from a lack of information as to what is recyclable, to contaminated product, lack of collection infrastructure and the financial incentives in place to treat the waste - see Figure 9.

| Consumer supply | Collection / Haulage | Sorting | Reprocessing | End-product |
|---|---|---|---|---|
| Is the product recyclable and most importantly acceptable to the local recycling program? | Is there a collection service? | Is the Material Recovery Facility (MRF) able to sort all household collection or does it need to send material to other MRFs? | How many times has the item been recycled? | What product purity do corporates require? |
| Are there parts of the product that are unrecyclable and therefore contaminate the batch - e.g. label or lid? | Are household items correctly placed in the relevant bin/bag? | Are the materials sorted in best quality possible to receive highest price? | Are the plastic bales of high quality to ensure high quality pellets or flakes? | What is the cost differential between virgin (fossil fuel) and recycled product? |
| Has the product been washed to avoid contamination? | | Are there outlets secured for non quality bales to avoid sending material to landfill? | Has the feedstock been secured at good prices? | |
| Is there a financial incentive to recycle the product? | | Are the correct reprocessors secured to ensure the quality bales are moved at the correct price and time? | | |

***Figure 9:*** *The Recycling Obstacle Course*
*Source: Recycling Connections, Planet Tracker*

c Planet Tracker defines plastic value chain as outlined in Appendix 1 .

One issue is that not all plastic products made from a particular plastic can be recycled in the same way. For example, products made from polyethylene terephthalate (PET) include both single-use plastic water bottles and durable products like polyester clothing. While both types of products have the same basic material, they require different recycling processes. Research for Zero Waste Europe[d] by sustainability consultancy Eunomia Research & Consulting showed that most PET plastic recovered from bottles in Europe does not make its way back into new PET bottles. Most recycled PET recovered from bottles in Europe was being used in other lower-grade PET applications such as trays, film, strapping or fibres – with new bottles placed on the market containing an average of just 17% of recycled PET.

Another issue is that currently not all types of plastic items can be recycled. Although the plastic item may be made from a plastic that can be recycled in some cases, the item may not actually be recyclable in most schemes due to its size, shape or contamination.

Another challenge is that some types of plastic, such as polystyrene, are presently difficult or impossible to recycle.

Furthermore, consumers frequently throw away non-recyclable material in the mixed recycling bin in the belief that it is better than putting it in the general waste bin; this action has been defined as "wishcycling". However, the waste management facilities argue that wishcycling can lead to contamination, which in turn results in more material ending up wasted.[26]

According to Biffa plc, there are two types of wishcycling materials; the non-target materials and the recycled materials that are contaminated. Non-target materials are those that cannot be recycled or that can be recycled, but need specialist processing such as soft plastics, plastics films etc. Materials are considered contaminated if they have residue on them (usually organic waste), which could jeopardize the ability of the other materials to be recycled. Therefore, even if the resin identification code would appear to indicate that a certain piece of packaging can be recycled, if it is dirty and is not cleaned, or if it requires specialist processing, then it cannot be placed in the mixed recycling bin. In some instances, the code may seem to be advising one thing, but the reality is another.

d Zero Waste Europe - PET, the most circular of all plastics, is far from real circularity (February 2022)

Table 3 shows some general guidelines of what material can widely be recycled.

***Table 3:*** *Mixed recycling bin general guidelines / Source: Planet Tracker*

| Material | Recyclable | Household Collection | Instructions |
|---|---|---|---|
| **Plastic bottles, tubs, trays and containers** | ✔ | ✔ | Plastic pots, tubs, trays and bottles can be recycled at home when they are rinsed and dried, so they don't contaminate the mixed bin. |
| **Plastic bags, crisp packets and wrapping** | ✔ | ✕ | Crisp packets are not currently recyclable through household collections but can be recycled along with plastic bags and wrapping at selected local supermarkets. |
| **Tetra Pak and cartons** | ✔ | ✔ / ✕ | Cartons are generally made from a mixture of paperboard, plastic and aluminium and the recycling process is not able to sort these grades. However, often these cartons are accepted via household collections. |
| **Glass jars and bottles** | ✔ | ✔ | Glass is infinitely recyclable and can be collected via household collections. Jars and bottles need to be emptied and rinsed to avoid contamination of other recyclables. |
| **Paper and cardboard** | ✔ | ✔ | Paper needs to be dry and clean; then it can be recycled. |
| **Aerosols and clean foil** | ✔ | ✔ | Clean aluminium trays and foil are recycled. Scrunch kitchen foil into a ball (the bigger the ball, the easier it is to recycle). If the foil is contaminated with grease or burnt-on bits of food then it needs to go to general waste. |
| **Food tins and drink cans** | ✔ | ✔ | Tins and cans are recyclable via household collections. They need to be emptied and rinsed to avoid contamination. The labels can be left on as they are removed through the recycling stream. |

Another parameter that can affect recyclability is the colour of the packaging. Clear plastics are much easier to recycle than coloured plastics. Coloured plastics may contain additives and pigments that could contaminate the recycling streams and complicate sorting and processing courses. Brand owners, like Coca-Cola company, have tried to replace coloured bottles with clear ones to increase recyclability (e.g., Sprite bottle).

It is worth noting that the label can affect the recyclability of the bottle. The most common material currently used is PVC, but unfortunately it is often not recyclable. Most local recycling facilities do not require the removal of labels from household waste. If the label and container are of the same material, the high temperature during recycling will burn away the ink and the excess glue from the containers. However, if the labels are not removed, they could risk contamination of the total production line.

For example, if a PVC sleeve is on a HDPE bottle and not removed before the bottle is processed in the recycling line, then during the sorting process the HDPE grade could fail its specification and the bottle will be re-directed and end up in a wrong line and as a result will cause contamination – see Packaging Labels.

Finally, with the current availability of recycled plastics unable to keep up with demand, means evermore virgin plastic is used. This imbalance exists because currently only 15% of all plastic packaging waste returns to the packaging sector and the majority of this is PET bottles.[27]

The remainder is downcycled into different applications. For the brand owners to meet their recycling targets, they are currently forced to compete with demand from different sectors, whether they be food, textile, or automotive companies. For example, the textile sector is using rPET from bottles in their polyester fibre supply chains.[28] Even if this is still part of the recycling process and can possibly be viewed as a circular economy, downgrading jeopardises the closed loop of the packaging sector, forcing packaging manufacturers to turn to virgin materials.

Recycling can also be challenged by the cheap cost of virgin materials. With all of the potential hurdles to recycle plastic detailed in Figure 9 come potentially higher costs meaning it may often not be economically viable to recycle a plastic.

## HOW TO CO-OPT A TRADEMARK

In this section we examine the creation of the plastic resin identification code (RIC), which is incorrectly often called the 'plastic recycling code'. We will explore how RICs are an excellent example of how the plastic industry has deflected attention away from the producers of plastics and instead made plastic pollution a waste management problem.

The recycling symbol was created in 1970, the same year as the first Earth Day.[29] An open competition was held by the Container Corporation of America, which sponsored the event. The aim was to design a graphic which could be used on recycled paper products.

The winning entry was one based on the Möbius strip or loop, developed in the 19th century by German mathematician August Möbius[e]. It provides the image of a single surface with no boundaries looking like an infinite loop – see Figure 10.

***Figure 10:*** *A Möbius strip / Source: Smithsonian Magazine, September 25, 2018*[30]

e Although the strip/loop is named after Möbius, two mathematicians worked on geometry and coordinates. The other was Johann Listing who also determined the properties of the Möbius strip at a similar time / Source: Scientific American January 16, 2021.

Based on this image, the three arrows that fold back on themselves, was the winning entry and later became the universal recycling symbol - see Figure 11. This symbol is not trademarked and remains in the public domain.

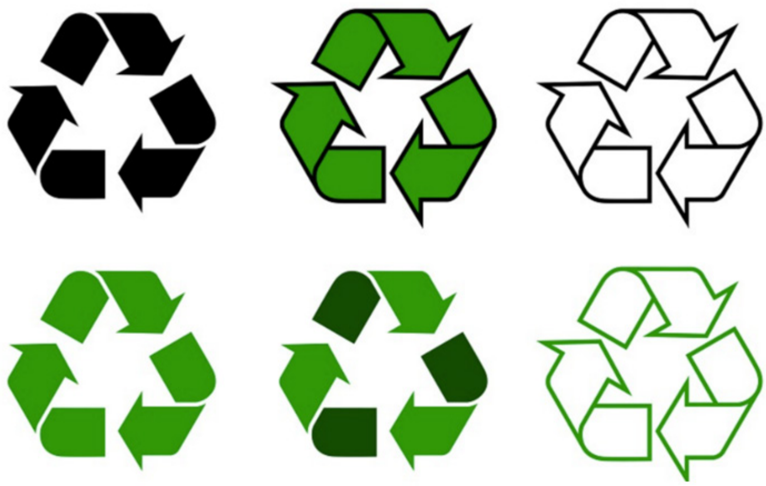


***Figure 11:*** *The universal recycling symbol based on the Möbius loop / Source: Coda Plastics*[31]

This recycling symbol was later adopted by several material companies including the plastics industry. In 1988, the Society of the Plastics Industry (SPI), which was the professional society representing the US plastic industry, developed the resin identification code (RIC). These codes were purportedly designed to help recyclers and consumers identify and sort different types of plastic materials, and to promote the recycling of plastics. The RIC system uses numbers from 1 to 7, each corresponding to a different type of plastic resin, along with a recycling symbol.

When the codes were introduced and inserted into the middle of the recycling symbol, most plastic packaging originated from one of six resins: Polyethylene Terephthalate (PET or PETE), High Density Polyethylene (HDPE), Vinyl (Polyvinyl Chloride or PVC), Low Density Polyethylene (LDPE), Polypropylene (PP), or Polystyrene (PS). For each of these plastic types, a code number from 1 to 6 was assigned, being used nationwide and in international voluntary labelling systems. A seventh code was also introduced for when the product was made of a plastic other than the more common six or is made of more than one plastic used in combination. As the plastic industry has developed and new plastic has emerged, an increasing number of plastics do not meet the specific criteria to be labelled 1 through 6 and must be labelled with the generic code of "7 - Other."

The codes are now widely used on plastic products around the world. In 2008, ASTM International – formerly the American Society for Testing and Materials - an international standards organisation that develops and publishes voluntary consensus technical standards – issued ASTM D7611, the Standard Practice for Coding Plastic Manufactured Articles for Resin Identification.

Regulations over which plastic objects should display RICs vary. In the US, for example, individual states sometimes apply different rules, for bottles and containers. For non-containers, such as plastic films, bags or trays, no symbol is mandatory at present.

# WHAT CAN BE RECYCLED?

There are seven RICs for plastic products. We reiterate that these codes are not recycling codes but resin identification codes, revealing the type of resin used in a plastic product. Please note that the RICs do not provide information on the additives used in the plastic container, only the resin type. Given their relatively widespread recognition, it is informative to examine to what degree plastics from the different resin codes are recycled. Generally, the higher the RIC code, the harder it is to recycle – see Figure 12.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| PETE | HDPE | PVC | LDPE | PP | PS | OTHER |
| Polyethylene Terepthalate | High Density Polyethylene | Polyvinyl Chloride | Low Density Polyethylene | Polypropylene | Polystyrene | Other |
| 81% not recycled* | 90% not recycled* | 100% not recycled* | 94% not recycled* | 99% not recycled* | 99% not recycled* | No records* |

***Figure 12:*** *The seven resin identification codes (RICs) / Source: Bunz, OECD.*[32]

In Appendices 2 (1-7), we examine each RIC in turn.

# RECYCLABILITY CLAIMS

There are often regulations in place to ensure RIC codes are not misused.[33] Examples based on the US Federal Trade Commission (FTC) Green Guides are shown below:

- Using the code solely to identify resin content.
- Making the code inconspicuous at the point of purchase, so it does not influence the consumer's buying decision.
- Not modifying the elements of the code in any way
- Not making recycling claims in close proximity to the code, even if such claims are properly qualified.
- Applying appropriate environmental marketing claims whenever the code is used

The SPI, which created the RIC codes later morphed into the Plastics Industry Association (PLASTICS) which claims to be 'the only organisation that supports the entire plastics supply chain'. It also states, 'We believe in working to make our members and the industry more globally competitive. We believe in advancing sustainability and being a good steward of resources. We believe in promoting plastics manufacturing as a viable career option'.[34]

In a press release on 24 April 2023, PLASTICS provided a response to the US Federal Trade Commission's (FTC) request for public comment on its Guides for the Use of Environmental Marketing Claims (Green Guides or Guides). It stated, 'PLASTICS recognises the FTC Green Guides as important guidance to industry on making environmental marketing claims, as the Guides assist the plastics industry with crafting truthful messages about the environmental benefits of their products and appropriate methods of disposal.[35] Planet Tracker notes the reference to "crafting truthful messages about environmental benefits" and questions whether RICs perform this task.

We note that often the RIC code can be seen in the labelling of a product even if it is not directly next to a recycling claim. The industry could argue that on small labels or containers the proximity of symbols and text is hard to avoid. In turn, this could lead to misunderstandings which influence consumer behaviour – see Figure 13 (a).

An alternative way to tackle this issue could be for the RIC code to appear on the bottle itself, making it more difficult to be seen by consumers during purchasing. Further, often the language used could mislead the consumer as the RIC code implies recyclability instead of packaging specification, e.g., one of the marketing images used in Ocado online shop for the Dove Body Wash Shower Gel says under the RIC code 2 – for HDPE that "This product can be recycled by most councils" which, despite the fact that may be true, implies that the RIC code is connected to recyclability – see Figure 13 (b).


***Figure 13 (a):*** *Unilever's Dove Body Wash bottle and 13 (b): code description in online store*
*Source: Zoom by Ocado (website).*[36]

# RECYCLABILITY LABELS

The resemblance of the recycling symbols with the plastics identification symbols has made it hard for consumers to know what is recyclable. Some countries have taken the initiative to introduce an extra label to show which products are recyclable and which are not.

In 2018, for example, Australia and New Zealand introduced the ARL (Australasian Recycling Label) which is an on-pack labelling scheme that aims to help consumers understand how to recycle the packaging in the right way – see Figure 14.[37] Planet Tracker supports this initiative, however recognises that labels themselves are a recycling issue as not all of them can be recycled - Packaging Labels .


***Figure 14:*** *Australasian Recycling Label*
*Source: BUNZL'S FORTÉ*

# NOT MY PROBLEM...

So who is responsible for plastic pollution? There are three main groups in the firing line: governments, plastic suppliers (i.e., plastic producers, plastic containers and packaging companies or retailers) and consumers.

Plastic suppliers often argue that consumers are at fault and point the finger at the public's poor recycling habits. The industry has been "educating" consumers for many years that recycling can deal with plastic pollution. For instance, as we note in this report by displaying RIC codes on containers and packaging, often widely interpreted as "recycling symbols", and by their focus on circularity as a solution.

However, much of household waste is not actually recyclable either because of the product itself or because of a lack of waste collection or waste management infrastructure. The OECD countries (notably US and Europe) used to transfer non-recyclable waste to Asia for processing while reporting high recycling rates. However, many of the plastic waste importers were just burying or burning much of it. This was largely hidden from consumers' view, but all this became more widely known in 2018, when China introduced the operation "National Sword"[f] and banned all imported waste; then the recycling problem became more widely recognised.

Municipalities are often the ones left to deal with the plastic waste problem, but they are the part of the supply chain that can least afford it! UNEP forecasts that **the estimated global cost of municipal solid waste management is set to increase from USD 38 billion in 2019 to USD 61 billion in 2040** under a business-as-usual scenario.[38]

Even if municipalities could be held responsible for the issue of plastic waste, many countries do not have a publicly funded collection system according to the UNEP, with 2 billion people still lacking access to solid waste collection.[39] This could, of course, be partially resolved through extended producer responsibility (EPR) or deposit return schemes (DRS).[40] However, the plastic industry does not want to support schemes such as these in order to preserve their profit margins – see Table 4.

***Table 4:*** *ACC The Business of Chemistry by Numbers /Source: ACC.*[41]

| ACC Business in numbers | Billions USD |
|---|---|
| Money spent on recycling | 8 |
| Capital investments (2012) | 26.1 |
| Profit | 53.8 |
| Sales (2012) | 614.2 |
| R&D spending (2022) | 13.4 |

To avoid profit margin compression, the plastic industry – which includes many oil & gas and chemical companies – lobbies politicians and regulators to avoid further regulation. As an example, in April 2024, during the latest round of the Intergovernmental Negotiating Committee (INC-4) to negotiate a legally binding Global Plastic Treaty by the end of 2024, an analysis of the participant list showed 196 fossil fuel and chemical industry lobbyists in attendance, a 37% increase from INC-3[42], underlining the strong lobbying efforts by the industry.

f Operation National Sword was a policy initiative launched in 2017 by the Government of China to monitor and more stringently review recyclable waste imports.

Given the ongoing success of the fossil fuel lobby (i.e., oil & gas, chemicals and petrochemicals companies) in stalling meaningful progress on the Global Plastic Pollution Treaty threats of limits on plastic production or financial responsibility for plastic pollution look a distant probability at present, unless imposed nationally.[43]

A further example of strong lobbying activity by the plastics industry can be identified during the European Parliament's latest round of voting on the Packaging and Packaging Waste Regulation (PPWR) in November 2022, where the negotiations were described as the most lobbied piece of EU legislation "ever".[44] Although national governments will be mindful of employment and economic benefits of the plastic industry, their calculations should include the municipality waste costs that local and regional governments incur as well as the possible health bills resulting from plastic waste and the additives they contain.

Furthermore, corporates often undertake intensive lobbying to delay the dissemination of information or improvements to environmental regulation. Many argue this is presently happening with fossil fuels – the 28th COP has finally recognised the term fossil fuel – and the negotiations over the global plastic pollution treaty, and the EU Packaging & Packaging Waste regulation.[45] A number of these companies deliberately shifted the responsibility for environmental management onto the consumer – e.g. providing personal carbon footprint calculators[46] – rather than dealing with the unsustainable product or adjust their business models. And the waste issue if often left to the poorest part of the value chain to address, the municipalities.

# FINANCIAL REALLOCATION

As ever, sustainability and environmental measures require financing. Corporates are unlikely to move unless forced to do so for fear of reducing their profit margins, and in turn disappointing investors, unless it applies to all competitors at the same time.

There is already plenty of capital available in the plastic industry. It is its allocation that is the primary hurdle. This can be seen from two viewpoints.

Firstly, the oil & gas industry, which has some of the largest plastic producers in the world, already receive large fossil fuel subsidies. The OECD calculates that fossil fuel subsidies are expected to reach USD 8.2 trillion by 2030 – a 17% increase from 2022 (USD 7 trillion).[47]

Secondly, as mentioned earlier in this report, municipalities, or sub-contractors working on their behalf, are often left to pick up the expense of waste collection, in turn facilitating the recycling process. In 2022, the gross public debt of local governments in the US is estimated at USD 2.13 trillion, and it is expected to increase to USD 3.68 trillion by 2028.[48]

## Measuring risk

The expected return on any investment can be written as the sum of the risk-free rate and an extra return to compensate for the risk. To calculate this extra return, equity risk premia (ERP) are central to risk and return models in finance.[49]

Planet Tracker calculated the risk premium for components of the global plastic value chain in the Plastic Risk report. This analysis examined the top 148 plastic-related companies, ranked by market cap, for three value chain segments – upstream (48 single use plastic producers), midstream (50 plastic container & packaging converters) and downstream (50 consumer staples companies) – see Appendix 1.

Interestingly, the equity risk premium of the upstream segment over the last five years has been the most volatile, especially during the last two years, when it dropped below both the midstream and downstream segments[g]. This implies that the single-use plastic producers are perceived as having the lowest investment risk when compared to the plastic container & packaging converters, and the consumer staples companies – see Figure 15.

g Based on Market Cap figures at the end of 2023.

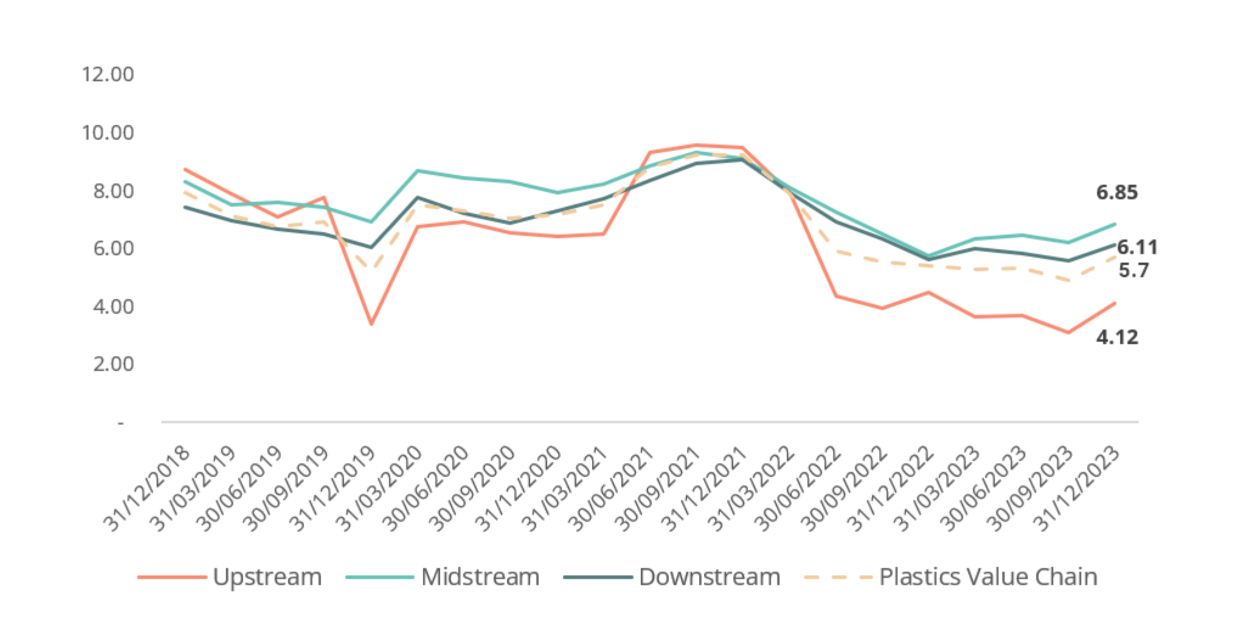



***Figure 15:*** *Equity Risk Premium of the plastic value chain over the last 5 years / Source: Bloomberg, Planet Tracker.*

Perhaps, this is partially explained by most of the environmental focus being on the downstream supply chain players, leaving the perception that the producers are likely to incur little liability. The producers must feel that their recycling focus is working like a treat.

We caution against such complacency as producers of harmful synthetic materials are likely to have to fight a rising tide of litigation. To examine how this can impact a company and damage investor retiurns, we encourage scrutiny of Bayer. Please see 'Is Bayer a litigation leading indicator?'

# CONCLUSION

Why is plastic viewed as recyclable when currently 90% is not recycled? Planet Tracker believes the industry has run, and continues to operate, a highly successful campaign to dump the plastic pollution problem on the downstream players. Even the financial markets have bought this narrative, placing the producers on the lowest equity risk premium in the plastic supply chain - see Plastic Risk.

The plastic industry has not earned the right to call plastic recyclable. Planet Tracker accepts that recycling has a role to play in improving circularity. However, to date, it has proved a flawed solution with global plastic pollution overwhelming the existing recycling infrastructure, while production of virgin plastics continues to rise.

A proper solution to plastic pollution will likely have to include an upstream element targeting production, be this via extended producer responsibility, taxes, regulation or some other mechanism.

Plastics is a sector with a significant risk register already, and for equity investors, holders of long dated bonds and loans, as well as insurers, these risks should be priced into the cost of capital now. We encourage investors, lenders and insurers to remain mindful of the plastic sector's full ledger of risks and ensure this is adequately priced into their plastic-related financial instruments. Should sentiment about plastic pollution change, including the health implications of plastic additives, and progress be made on an upstream solution, producers, which price in the lowest equity risk premia, are looking particularly vulnerable.

We call on investors to support the Investor Statement on the role of petrochemical companies in resolving plastic pollution as an important step in holding the upstream players accountable for their role in plastic pollution.

# APPENDIX

# APPENDIX 1
# PLASTIC VALUE CHAIN UNIVERSE

Planet Tracker has analysed the top 148 corporates, ranked by their market capitalisation, from the three main segments of the plastic value chain: the upstream (single-use plastic, SUP) producers, the midstream containers and packaging converters and the downstream consumers staple companies, which rely on plastic packaging to sell their goods.

| Segment | Corporate Name | Corporate ISIN | GICS Sector | GICS Industry | Country |
|---|---|---|---|---|---|
| Upstream | Abu Dhabi National Oil Co | | Energy | Oil, Gas & Consumable Fuels | United Arab Emirates |
| Upstream | Alpek SAB de CV | MX01AL0C0004 | Materials | Chemicals | Mexico |
| Upstream | Borealis AG | | Materials | Oil, Gas & Consumable Fuels | Austria |
| Upstream | Braskem SA | BRBRKMACNPA4 | Materials | Chemicals | Brazil |
| Upstream | Chevron Corp | US1667641005 | Energy | Oil, Gas & Consumable Fuels | United States of America |
| Upstream | China Coal Energy Co Ltd | CNE100000957 | Energy | Oil, Gas & Consumable Fuels | China |
| Upstream | China Petroleum & Chemical Corp | CNE0000018G1 | Energy | Oil, Gas & Consumable Fuels | China |
| Upstream | China Resources Co Ltd | | Financials | Capital Markets | China |
| Upstream | CHNENERGY Investment Group Co Ltd | | Energy | Oil, Gas & Consumable Fuels | China |
| Upstream | Dow Inc | US2605571031 | Materials | Chemicals | United States of America |
| Upstream | Eni SpA | IT0003132476 | Energy | Oil, Gas & Consumable Fuels | Italy |
| Upstream | Exxon Mobil Corp | US30231G1022 | Energy | Oil, Gas & Consumable Fuels | United States of America |
| Upstream | Far Eastern New Century Corp | TW0001402006 | Industrials | Industrial Conglomerates | Taiwan |
| Upstream | Formosa Plastics Corp | TW0001301000 | Materials | Chemicals | Taiwan |
| Upstream | GAIL (India) Ltd | INE129A01019 | Utilities | Gas Utilities | India |
| Upstream | Hanwha Corp | KR7000880005 | Industrials | Industrial Conglomerates | Korea; Republic (S. Korea) |
| Upstream | Indian Oil Corporation Ltd | INE242A01010 | Energy | Oil, Gas & Consumable Fuels | India |
| Upstream | Indorama Ventures PCL | TH1027010004 | Materials | Chemicals | Thailand |
| Upstream | INEOS Ltd | | Industrials | Industrial Conglomerates | United Kingdom |

| | | | | | |
|---|---|---|---|---|---|
| Upstream | JBF Industries Ltd | INE187A01017 | Consumer Discretionary | Textiles, Apparel & Luxury Goods | India |
| Upstream | Jiangsu Hailun Petrochemical Co Ltd | | Materials | Chemicals | China |
| Upstream | Jiangyin Chengxing Industrial Group Co Ltd | | Materials | Chemicals | China |
| Upstream | LG Chem Ltd | KR7051910008 | Materials | Chemicals | Korea; Republic (S. Korea) |
| Upstream | Lotte Chemical Corp | KR7011170008 | Materials | Chemicals | Korea; Republic (S. Korea) |
| Upstream | LyondellBasell Industries NV | NL0009434992 | Materials | Chemicals | United Kingdom |
| Upstream | Mitsubishi Chemical Group Corp | JP3897700005 | Materials | Chemicals | Japan |
| Upstream | Mitsui Chemicals Inc | JP3888300005 | Materials | Chemicals | Japan |
| Upstream | Nan Ya Plastics Corp | TW0001303006 | Materials | Chemicals | Taiwan |
| Upstream | NOVA Chemicals Corp | CA66977W1095 | Materials | Chemicals | Canada |
| Upstream | Octal Petrochemicals FZC | | Materials | Chemicals | Oman |
| Upstream | PetroChina Co Ltd | CNE1000007Q1 | Energy | Oil, Gas & Consumable Fuels | China |
| Upstream | Phillips 66 | US7185461040 | Energy | Oil, Gas & Consumable Fuels | United States of America |
| Upstream | PTT PCL | TH0646010Z00 | Energy | Oil, Gas & Consumable Fuels | Thailand |
| Upstream | Qatar Petroleum International Ltd | | Energy | Oil, Gas & Consumable Fuels | Qatar |
| Upstream | Reliance Industries Ltd | INE002A01018 | Energy | Oil, Gas & Consumable Fuels | India |
| Upstream | Repsol SA | ES0173516115 | Energy | Oil, Gas & Consumable Fuels | Spain |
| Upstream | Rongsheng Petrochemical Co Ltd | CNE100000W60 | Materials | Chemicals | China |
| Upstream | Sasol Ltd | ZAE000006896 | Materials | Chemicals | South Africa |
| Upstream | Saudi Arabian Oil Co | SA14TG012N13 | Energy | Oil, Gas & Consumable Fuels | Saudi Arabia |
| Upstream | Saudi Basic Industries Corporation SJSC | SA0007879121 | Materials | Chemicals | Saudi Arabia |
| Upstream | Shaanxi Yanchang Petroleum Group Co Ltd | | Energy | Oil, Gas & Consumable Fuels | China |
| Upstream | Siam Cement PCL | TH0003010Z04 | Materials | Construction Materials | Thailand |
| Upstream | Sibur Holding PAO | | Materials | Chemicals | Russia |

| | | | | | |
|---|---|---|---|---|---|
| Upstream | SK Innovation Co Ltd | KR7096770003 | Energy | Oil, Gas & Consumable Fuels | Korea; Republic (S. Korea) |
| Upstream | Sumitomo Chemical Co Ltd | JP3401400001 | Materials | Chemicals | Japan |
| Upstream | TotalEnergies SE | FR0000120271 | Energy | Oil, Gas & Consumable Fuels | France |
| Upstream | Westlake Corp | US9604131022 | Materials | Chemicals | United States of America |
| Upstream | Zhejiang Hengyi Group Co Ltd | | Materials | Chemicals | China |
| Midstream | Agnico Eagle Mines Ltd | CA0084741085 | Materials | Metals & Mining | Canada |
| Midstream | Air Products and Chemicals Inc | US0091581068 | Materials | Chemicals | United States of America |
| Midstream | Albemarle Corp | US0126531013 | Materials | Chemicals | United States of America |
| Midstream | Anglo American PLC | GB00B1XZS820 | Materials | Metals & Mining | United Kingdom |
| Midstream | ArcelorMittal SA | LU1598757687 | Materials | Metals & Mining | Luxembourg |
| Midstream | Asian Paints Ltd | INE021A01026 | Materials | Chemicals | India |
| Midstream | Barrick Gold Corp | CA0679011084 | Materials | Metals & Mining | Canada |
| Midstream | BASF SE | DE000BASF111 | Materials | Chemicals | Germany |
| Midstream | BHP Group Ltd | AU000000BHP4 | Materials | Metals & Mining | Australia |
| Midstream | Borouge Plc | AEE01072B225 | Materials | Chemicals | United Arab Emirates |
| Midstream | Corteva Inc | US22052L1044 | Materials | Chemicals | United States of America |
| Midstream | CRH PLC | IE0001827041 | Materials | Construction Materials | Ireland |
| Midstream | Dow Inc | US2605571031 | Materials | Chemicals | United States of America |
| Midstream | Dupont De Nemours Inc | US26614N1028 | Materials | Chemicals | United States of America |
| Midstream | Ecolab Inc | US2788651006 | Materials | Chemicals | United States of America |
| Midstream | Fortescue Metals Group Ltd | AU000000FMG4 | Materials | Metals & Mining | Australia |
| Midstream | Franco-Nevada Corp | CA3518581051 | Materials | Metals & Mining | Canada |
| Midstream | Freeport-McMoRan Inc | US35671D8570 | Materials | Metals & Mining | United States of America |
| Midstream | Givaudan SA | CH0010645932 | Materials | Chemicals | Switzerland |
| Midstream | Glencore PLC | JE00B4T3BW64 | Materials | Metals & Mining | Switzerland |
| Midstream | GMK Noril'skiy Nikel' PAO | RU0007288411 | Materials | Metals & Mining | Russian Federation |
| Midstream | Grupo Mexico SAB de CV | MXP370841019 | Materials | Metals & Mining | Mexico |
| Midstream | Holcim AG | CH0012214059 | Materials | Construction Materials | Switzerland |
| Midstream | International Flavors & Fragrances Inc | US4595061015 | Materials | Chemicals | United States of America |
| Midstream | JSW Steel Ltd | INE019A01038 | Materials | Metals & Mining | India |
| Midstream | L'Air Liquide Société Anonyme pour l'Etude et l'Exploitation des Procedes Georges Claude SA | FR0000120073 | Materials | Chemicals | France |

| | | | | | |
|---|---|---|---|---|---|
| Midstream | LG Chem Ltd | KR7051910008 | Materials | Chemicals | Republic of Korea |
| Midstream | Linde PLC | IE000S9YS762 | Materials | Chemicals | United States of America |
| Midstream | LyondellBasell Industries NV | NL0009434992 | Materials | Chemicals | United States of America |
| Midstream | Martin Marietta Materials Inc | US5732841060 | Materials | Construction Materials | United States of America |
| Midstream | Newmont Corporation | US6516391066 | Materials | Metals & Mining | United States of America |
| Midstream | Nippon Steel Corp | JP3381000003 | Materials | Metals & Mining | Japan |
| Midstream | Nucor Corp | US6703461052 | Materials | Metals & Mining | United States of America |
| Midstream | Nutrien Ltd | CA67077M1086 | Materials | Chemicals | Canada |
| Midstream | Posco Holdings Inc | KR7005490008 | Materials | Metals & Mining | Republic of Korea |
| Midstream | PPG Industries Inc | US6935061076 | Materials | Chemicals | United States of America |
| Midstream | Rio Tinto PLC | GB0007188757 | Materials | Metals & Mining | United Kingdom |
| Midstream | Saudi Arabian Mining Company SJSC | SA123GA0ITH7 | Materials | Metals & Mining | Saudi Arabia |
| Midstream | Saudi Basic Industries Corporation SJSC | SA0007879121 | Materials | Chemicals | Saudi Arabia |
| Midstream | Sherwin-Williams Co | US8243481061 | Materials | Chemicals | United States of America |
| Midstream | Shin-Etsu Chemical Co Ltd | JP3371200001 | Materials | Chemicals | Japan |
| Midstream | Sika AG | CH0418792922 | Materials | Chemicals | Switzerland |
| Midstream | Southern Copper Corp | US84265V1052 | Materials | Metals & Mining | United States of America |
| Midstream | Teck Resources Ltd | CA8787422044 | Materials | Metals & Mining | Canada |
| Midstream | UltraTech Cement Ltd | INE481G01011 | Materials | Construction Materials | India |
| Midstream | Vale SA | BRVALEACNOR0 | Materials | Metals & Mining | Brazil |
| Midstream | Vulcan Materials Co | US9291601097 | Materials | Construction Materials | United States of America |
| Midstream | Wanhua Chemical Group Co Ltd | CNE0000016J9 | Materials | Chemicals | China |
| Midstream | Wheaton Precious Metals Corp | CA9628791027 | Materials | Metals & Mining | Canada |
| Midstream | Zijin Mining Group Co Ltd | CNE100000B24 | Materials | Metals & Mining | China |
| Downstream | Alimentation Couche-Tard Inc | CA01626P1484 | Consumer Staples | Consumer Staples Distribution | Canada |
| Downstream | Altria Group Inc | US02209S1033 | Consumer Staples | Tobacco | United States of America |
| Downstream | Ambev SA | BRABEVACNOR1 | Consumer Staples | Beverages | Brazil |
| Downstream | Anheuser-Busch Inbev SA | BE0974293251 | Consumer Staples | Beverages | Belgium |
| Downstream | Archer-Daniels-Midland Co | US0394831020 | Consumer Staples | Food Products | United States of America |

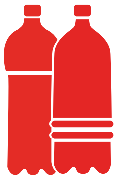
| | | | | | |
|---|---|---|---|---|---|
| Downstream | British American Tobacco PLC | GB0002875804 | Consumer Staples | Tobacco | United Kingdom |
| Downstream | Brown-Forman Corp | US1156372096 | Consumer Staples | Beverages | United States of America |
| Downstream | Budweiser Brewing Company APAC Ltd | KYG1674K1013 | Consumer Staples | Beverages | Hong Kong SAR |
| Downstream | Coca-Cola Co | US1912161007 | Consumer Staples | Beverages | United States of America |
| Downstream | Colgate-Palmolive Co | US1941621039 | Consumer Staples | Household Products | United States of America |
| Downstream | Constellation Brands Inc | US21036P1084 | Consumer Staples | Beverages | United States of America |
| Downstream | Costco Wholesale Corp | US22160K1051 | Consumer Staples | Consumer Staples Distribution | United States of America |
| Downstream | Danone SA | FR0000120644 | Consumer Staples | Food Products | France |
| Downstream | Diageo PLC | GB0002374006 | Consumer Staples | Beverages | United Kingdom |
| Downstream | Estee Lauder Companies Inc | US5184391044 | Consumer Staples | Personal Care Products | United States of America |
| Downstream | Foshan Haitian Flavouring and Food Co Ltd | CNE100001SL2 | Consumer Staples | Food Products | China |
| Downstream | General Mills Inc | US3703341046 | Consumer Staples | Food Products | United States of America |
| Downstream | HALEON PLC | GB00BMX86B70 | Consumer Staples | Personal Care Products | United Kingdom |
| Downstream | Heineken NV | NL0000009165 | Consumer Staples | Beverages | Netherlands |
| Downstream | Hershey Co | US4278661081 | Consumer Staples | Food Products | United States of America |
| Downstream | Hindustan Unilever Ltd | INE030A01027 | Consumer Staples | Personal Care Products | India |
| Downstream | ITC Ltd | INE154A01025 | Consumer Staples | Tobacco | India |
| Downstream | Japan Tobacco Inc | JP3726800000 | Consumer Staples | Tobacco | Japan |
| Downstream | Jiangsu Yanghe Brewery Joint-Stock Co Ltd | CNE100000HB8 | Consumer Staples | Beverages | China |
| Downstream | Keurig Dr Pepper Inc | US49271V1008 | Consumer Staples | Beverages | United States of America |
| Downstream | Kimberly-Clark Corp | US4943681035 | Consumer Staples | Household Products | United States of America |
| Downstream | Koninklijke Ahold Delhaize NV | NL0011794037 | Consumer Staples | Consumer Staples Distribution | Netherlands |
| Downstream | Kraft Heinz Co | US5007541064 | Consumer Staples | Food Products | United States of America |
| Downstream | Kroger Co | US5010441013 | Consumer Staples | Consumer Staples Distribution | United States of America |
| Downstream | Kweichow Moutai Co Ltd | CNE0000018R8 | Consumer Staples | Beverages | China |

| | | | | | |
|---|---|---|---|---|---|
| Downstream | L'Oreal SA | FR0000120321 | Consumer Staples | Personal Care Products | France |
| Downstream | Luzhou Laojiao Co Ltd | CNE000000GF2 | Consumer Staples | Beverages | China |
| Downstream | Mondelez International Inc | US6092071058 | Consumer Staples | Food Products | United States of America |
| Downstream | Monster Beverage Corp | US61174X1090 | Consumer Staples | Beverages | United States of America |
| Downstream | Muyuan Foods Co Ltd | CNE100001RQ3 | Consumer Staples | Food Products | China |
| Downstream | Nestle SA | CH0038863350 | Consumer Staples | Food Products | Switzerland |
| Downstream | Nongfu Spring Co Ltd | CNE100004272 | Consumer Staples | Beverages | China |
| Downstream | PepsiCo Inc | US7134481081 | Consumer Staples | Beverages | United States of America |
| Downstream | Pernod Ricard SA | FR0000120693 | Consumer Staples | Beverages | France |
| Downstream | Philip Morris International Inc | US7181721090 | Consumer Staples | Tobacco | United States of America |
| Downstream | Procter & Gamble Co | US7427181091 | Consumer Staples | Household Products | United States of America |
| Downstream | Reckitt Benckiser Group PLC | GB00B24CGK77 | Consumer Staples | Household Products | United Kingdom |
| Downstream | Seven & i Holdings Co Ltd | JP3422950000 | Consumer Staples | Consumer Staples Distribution | Japan |
| Downstream | Shanxi Xinghuacun Fen Wine Factory Co Ltd | CNE000000DH5 | Consumer Staples | Beverages | China |
| Downstream | Sysco Corp | US8718291078 | Consumer Staples | Consumer Staples Distribution | United States of America |
| Downstream | Unilever PLC | GB00B10RZP78 | Consumer Staples | Personal Care Products | United Kingdom |
| Downstream | Wal Mart de Mexico SAB de CV | MX01WA000038 | Consumer Staples | Consumer Staples Distribution | Mexico |
| Downstream | Walmart Inc | US9311421039 | Consumer Staples | Consumer Staples Distribution | United States of America |
| Downstream | Wuliangye Yibin Co Ltd | CNE000000VQ8 | Consumer Staples | Beverages | China |
| Downstream | Yihai Kerry Arawana Holdings Co Ltd | CNE1000048D3 | Consumer Staples | Food Products | China |

APPENDICES 2

# RIC CODES

## 1. Resin Identification Code #1 - PET (Polyethylene Terephthalate)

| 1 | 1 | 01 |
|---|---|---|
| | **PETE** | **PET** |
| **Polyethelyene** |  | 81% not recycled<br>*USA, 2014 |

### Overview

PET is commonly found in the packaging notably beverage bottles and food packaging. It is easily blown into a bottle or formed into a sheet, thereby becoming the resin of choice for many applications. It is versatile and sturdy and often intended for single-use products. It is usually clear, lightweight, inexpensive, and viewed as safe for food storage.[50]

### Common uses

PET is frequently used in the following applications:[51]

- Single-use plastic bottles - e.g. water, juice, soda, mouthwash
- Food containers and microwaveable food trays
- Detergent and cleaning containers
- Polyester fibres or polar fleece
- Thermoformed sheet
- Strapping
- Furniture
- Carpet
- Panelling

### Recyclability

PET bottles can be recycled into new containers, pallet straps, paneling, carpet and clothing fibers, and fiberfill for soft furnishings and sleeping bags.[28]
Probably the most common recycled plastic resin, however the recycling rates are still very low in comparison to the total amount of PET use (24.9 Mt was recorded in 2019[52]) - e.g. in US, 81% of PET is not recycled (in 2014).[53]

## Health concerns

PET grade is considered “safe”.

The PET grade is intended for single us only. When it is used repeatedly, is heated or contains acidic food, there is a possibility for toxic chemicals to leach[h] into the product of the container resulting in harmful impacts on human health.[54] See examples of such chemicals below:

- **Antimony:** Antimony trioxide is a heavy metal that is used as a polycondensation catalyst in 90% of the PET manufactured worldwide.[55] Antimony is used in small amounts in the production of PET packaging, and it is approved worldwide.[56] According to the Environmental Protection Agency (EPA) the allowed levels of antimony in drinking water should not exceed 6 micrograms/litre. At room temperature, the levels of antimony that leach from PET containers to drinking water are very low; however, the levels of allowed antimony are exceeded when the container is exposed in high temperatures (65°C to 85°C) for long periods (38 to 1.3 days respectively).[54]

Antimony and related chemicals can cause:[54]

- Increased cholesterol
- Estrogen-like effects
- Decreased blood sugar
- Possible cancer

- **Phthalates:** PET itself, even though it is called “polyethylene terephthalate”, it is not a phthalate, but Phthalate esters (PAEs) are added to PET plastic to add flexibility, transparency, durability, or longevity to the container. PAEs leach into the drinking water even when PET bottles are kept under room temperature conditions and for short storage times. In high heat, UV exposure, and long storage time the leaching of the PAEs is increased.[58] Also, phthalates can enter the water during bottling process too.[44]

  The exposure to PAEs can cause: [44]
  - Infertility
  - Type 2 diabetes
  - Allergies
  - Obesity
  - Asthma
  - Defects in newborns and children[59]

- **Estrogen-like chemicals:** Research has shown that a broader range of foodstuff may be contaminated with endocrine disruptors when packed in plastics, especially mineral water can be polluted with xenoestrogens that come from compounds leached from the plastic bottle.[60] These chemicals act like estrogen in the body and cause problems with the normal workings of the hormone system, and therefore they can affect the following functions:[61]
  - Appetite
  - Stress
  - Libido Male or female characteristics
  - Sleep
  - Fertility
  - Fetal growth

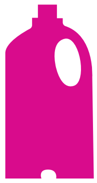
- **Benzaldehyde:** It has been proved that after 3 months storage, the migration of benzaldehyde form PET bottles into acetic acid is increased by about the three times when the storage temperature increased from 20 to 40 °C.[62] Benzaldehyde can affect human health as per below:[63]
  - nose and throat irritation which can cause coughing and shortness of breath,
  - irritation of the skin and eyes; repeated exposure can lead to skin rash,
  - dizziness and when exposure is at higher levels it can lead to seizures and passing out.

***Figure 16:*** *RIC Code #1: PET / Source: 2EA Consulting Ltd*



h Leaching is the transfer of chemicals from packaging into food or drinks.

## 2. Resin Identification Code #2 - HDPE (High Density Polyethylene)

| 2 | 2 | 2 |
|---|---|---|
| | **HDPE** | **PE-HD** |
| **High Density Polyethylene** |  | 90% not recycled*<br>*USA, 2014 |

### Overview

HDPE has a stiffness and good chemical resistance properties making it suitable for the packaging of household products.

### Common uses

HDPE is frequently used in the following applications:

- Water and milk jugs
- Cereal box liners
- Pipes
- Detergents, household cleaners, shampoo, cosmetic, motor oil containers
- Some grocery bags
- Toys
- Cutting boards

### Recyclability

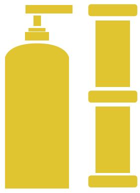
This resin can be recycled a number of times with the recycled material being used to make new containers for non-food items, pipes, buckets and outdoor decking. The exception is often grocery bags which are often not recycled. 55.5 Mt was recorded in 2019 worldwide and expected to rise to 140 Mt by 2060.[52] Approximately, in US 90% of HDPE is not recycled (in 2014).[53]

### Health concerns

Many plastic containers are HDPE safe as is they have chemical-resistant properties. HPDE food-safe containers are not harmful for the user.[64] However, they still release low levels of chemicals that raise oestrogen levels.[65]

***Figure 17:*** *RIC Code #2: HDPE / Source: 2EA Consulting Ltd.*

## 3. Resin Identification Code #3 - PVC (Polyvinyl Chloride)

| 3 | 3 | 03 |
|---|---|---|
| | V | PVC |
| **Polyvinyl Chloride** |  | 90% not recycled*<br>*USA, 2014 |

### Overview

Polyvinyl chloride (PVC) was one of the first plastics discovered and is also one of the most extensively used. It is derived from salt (57%) and oil or gas (43%). It is the world's third-most widely produced synthetic plastic polymer, after polyethylene and polypropylene. PVC comes in two basic forms: rigid (sometimes abbreviated as RPVC) and flexible.[66]

### Common uses

PVC is frequently used in the following applications:

- Pipe
- Siding
- Flooring
- Lawn chairs
- Children's toys
- Window profile
- Fencing
- Shower curtains
- Non-food bottles

### Recyclability

In 2019 51.3 Mt of PVC was used worldwide and it is estimated that this number will rise to 131 Mt by 2060.[52] However, vinyl is rarely recycled – no material was recycled in US in 2014;[53] a tiny percentage of PVC is recycled into mats, speed bumps, cables, flooring, roadway gutters, mud flaps, panelling and decks.[32]

PVC can be recycled through chemical recycling using different technologies, e.g., one new technology is based on chemical oxidation that is used to attack the polymer and break it down to oils, waxes, and other valuable chemicals. This process is done in a closed conversion unit which requires minimal heating and a small physical space – compatible to big treatment facilities and medium/small, decentralized waste producing operations.[67]

### Health concerns

PVC contains a phthalate called diethylhexyl phthalate (DEHP), which is endocrine disruptor and ovarian toxicant and is linked to fertility issues.[68,69] In some products, DEHP has been replaced with another chemical called Diisononyl phthalate (DiNP), which has been shown to have hormone disruption properties.[70]

***Figure 18:*** *RIC Code #3: PVC / Source: 2EA Consulting Ltd.*

## 4. Resin Identification Code #4 – LDPE (Low-density Polyethylene)

| 4 | 4 | 04 |
|---|---|---|
| | **LDPE** | **PE-LD** |
| **Low-density Polyethylene** |  | 94% not recycled*<br>*USA, 2014 |

### Overview

LDPE is defined by a density range of 0.910–0.940 g/cm³. It can withstand temperatures of 80 °C continuously and 95 °C for a short time. Made in translucent or opaque variations, it is quite flexible and tough.[71]
Under code 4, it is also the LLDPE (linear low-density polyethylene) which is a substantially linear polyethylene, with significant numbers of short branches, commonly made by copolymerization of ethylene with longer-chain olefins. LLDPE has higher tensile strength and higher impact and puncture resistance than LDPE. It is very flexible and elongates under stress. It can be used to make thinner films and has good resistance to chemicals. It has good electrical properties. However, it is not as easy to process as LDPE.

### Common uses

LDPE is frequently used in the following applications:

- Plastic bags - Six pack rings
- Various containers - Dispensing bottles
- Wash bottles - Tubing
- Agricultural film - Various moulded laboratory equipment
- Milk carton coatings, electrical cable coatings, heavy duty industrial bags

LLDPE is frequently used in the following applications:[65]

- stretch film - industrial packaging film
- thin-walled containers - heavy-duty, medium, and small bags

### Recyclability

LDPE is rarely recycled, but when it is it is recycled back into similar types of products; in 2014 in US 94% of LDPE was not recycled.[41] Over 54 Mt of LDPE and LLDPE were used in 2019 worldwide and it is estimated to triple by 2060 (165 Mt).[52]

### Health concerns

LDPE is not linked to any harmful health effects for human as it is categorised as a non-hazardous material.[72] Furthermore, thinner resins and rigid applications use a tough material that is chemical resistant, which prevents toxins from entering into food, making LDPE food safe and suitable for food applications.[52] Finally, LDPE is BPA free, however similarly to most plastics, there is a possibility to leach estrogenic chemicals.[72]

***Figure 19:** RIC Code #4: PP / Source: 2EA Consulting Ltd*

## 5. Resin Identification Code #5 – PP (Polypropylene)

| 5 | 5 | 05 |
|---|---|---|
| | **PP** | **PP** |
| **Polypropylene** | | 94% not recycled*<br>*USA, 2014 |

### Overview

The density of PP is between 0.895 and 0.92 g/cm$^3$. Therefore, PP is the commodity plastic with the lowest density. Compared to polyethylene, it has superior mechanical properties and thermal resistance, but less chemical resistance. PP is normally tough and flexible, especially when copolymerized with ethylene.[65]

### Common uses

PP is frequently used in the following applications:

- Auto parts
- Carpet fibres
- Kitchen appliances
- Medical packaging and appliances
- Food packaging (yoghurt, margarine pots, sweet and snack wrappers, microwave proof containers)
- Industrial fibres
- Garden furniture
- Pipes

### Recyclability

This density's recycling rates are not good either as PP often is not recycled. When it is it can be made into trays, pallets, bins, rakes, bicycle racks, landscape borders, auto battery cases, brushes, brooms, battery cables, and signal lights. In US 99% of PP was not recycled in 2014.[53] In 2019, 72.8 Mt used worldwide, and the volume expected to exceed 195 Mt by 2060.[52]

### Health concerns

Polypropylene is generally considered to be one of the safer plastics. The FDA has approved its use as a food container material, and there are no known cancer-causing effects associated with polypropylene.

***Figure 20:*** *RIC Code #5: PP / Source: 2EA Consulting Ltd*

## 6. Resin Identification Code #6 – PS (Polystyrene)

| 6 | 6 | 06 |
|---|---|---|
| | PS | PS |
| **Polystyrene** | | 99% not recycled*<br>*USA, 2014 |

### Overview

Polystyrene is a synthetic polymer made from styrene monomer, which is a liquid petrochemical. It is a thermoplastic polymer that softens when heated and can be converted via semi-finished products, such as films and sheets, into a wide range of items. Polystyrene can be rigid or foamed. General purpose polystyrene is clear, hard and brittle. Polystyrene is naturally transparent but can be coloured with colourants.[73]

### Common uses

PS is frequently used in the following applications:

- Desk accessories
- Disposable cups and plates
- Egg cartons
- Plastic utensils
- Consumer electronics products
- Building and construction, (e.g., insulation foam, panels, bath and shower units, lighting and plumbing fixtures)
- Medical items (e.g., tissue culture trays, test tubes, Petri dishes, diagnostic components, and housing for test kits)
- Cafeteria trays
- Meat trays
- Clamshell containers
- Toys

### Recyclability

Difficult to recycle as it's lightweight and so there's not much material to reclaim. It can, however, be recycled into packaging and containers, as well as foam packing, light switch plates and insulation.[28] In US 99% of PS was not recycled in 2014.[53]
In 2019, 21 Mt of PS was used worldwide, and it is expected to raise to 55 Mt by 2060.[52]

### Health concerns

Styrene is a chemical believed to cause cancer; it can leach out of polystyrene containers, though the amount of styrene in packaged foods is very low.[74]

Exposure to styrene can cause:[74]

- o Irritation of the nose and throat, increased nasal secretion, wheezing, coughing, pulmonary oedema, cardiac arrhythmias and coma.
- o Rash, itching and dermatitis.
- o CNS depression, or else "styrene sickness", which involves headache, nausea, vomiting, weakness, fatigue, dizziness and ataxia.

***Figure 21:*** *RIC Code #6: PS / Source: 2EA Consulting Ltd*

## 7. Resin Identification Code #7 – Other

| 7 | 7 | 07 |
|---|---|---|
| | OTHER | O |
| **Other** | | 99% not recycled*<br>*USA, 2014 |

### Overview

This resin code is used for the packaging that is made of a type of plastic other than the previous six or a combination of plastics.

### Common uses

Under Other code is usually the plastic used in the following applications:

- Acrylic
- Food containers
- DVDs
- Bioplastics Polycarbonate (which contains BPA)
- Composite plastics (e.g., crisp wrappers)
- Computers and electronic devices
- Plastic coated wrapping paper
- Nylon
- Signs and displays
- Sunglasses

### Recyclability

These plastics are almost never recycled, but they could be transformed into plastic timber and certain custom-made products.[32]
In 2019, 81 Mt of plastic under the other category was used worldwide and it is expected to exceed 223 Mt by 2060.[52]

### Health concerns

Plastic under Other category may contain Bisphenol A (BPA), which is a chemical produced for use mainly in the production of polycarbonate plastics. BPA has been detected in numerous products including eyewear, water bottles, and epoxy resins that coat some metal food cans, bottle tops, and water supply pipes.
Temperature is the main factor that affects the level of BPA leakage. BPA can also be found in breast milk.[76] BPA can lead to following issues:

- problems with brain development
- immune function
- learning abilities
- reproductive disorders
- other health issues[76]

The growing concern around BPA has led to the production of several types of BPA-free plastics.

***Figure 22:*** *RIC Code #7: OTHER / Source: 2EA Consulting Ltd*

## APPENDIX 3
# MECHANICAL RECYCLING

Mechanical recycling is explained by ACS Sustainable Chemistry & Engineering  in a research note sponsored by Shell International BV. Foreign materials can be removed by using gravity in air flow (air classifier) or water stream (sink-float) as illustrated in Figure 23 sections a and b. Metals can also be removed by magnetic attraction of ferrous metal or by induced magnetic repulsion of non-ferrous metals – see Figure 23 section c.

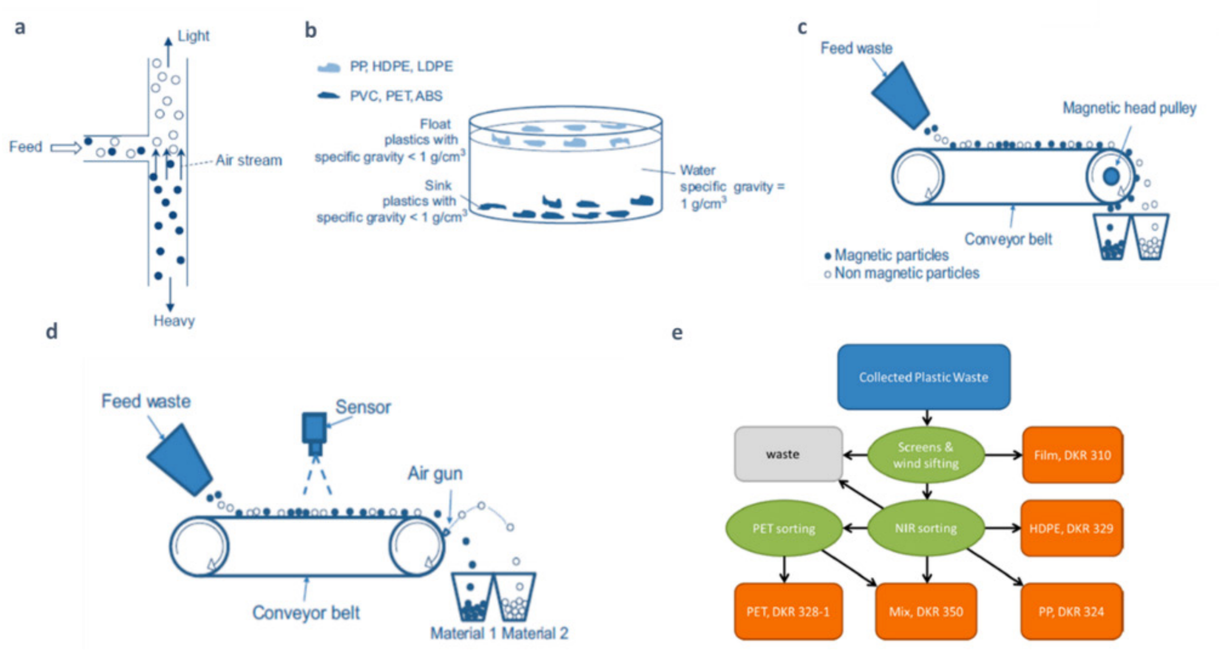



***Figure 23:*** *Archetype sorting technologies:* ***a****, air classifier;* ***b****, sink-float sorting;* ***c****, magnetic sorting of ferrous metals;* ***d****, sensor-based sorting;* ***e****, DKRplastic fractions. / Source: ACS Sustainable Chemistry & Engineering (2021) Managing Plastic WasteSorting, Recycling, Disposal, and ProductRedesign sponsored by Shell International BV.*[77]

Gravity can also be used to sort some plastics, e.g., to separate the polyolefins from PET or PVC. The gravity sorting can further be improved with the assistance of electrostatic or magnetic fields, but this increases the possibility of eventual contamination of the waste.

Commonly, plastics are sorted using an infrared detector (e.g., spreading them on a conveyor belt and they are sorted by a near or short wave infrared NIR or SWIR detector and an actuator or air jet) – see Figure 23 sections d and e.

These efficient sorting technologies appear to recover more plastic than manual household sorting and lead to more efficient and cheaper logistics by transporting the whole waste stream instead of individual sorted fractions.

All of these elements promise to make central post sorting of plastic wastes more efficient and cheaper than pre-sorting at the household level. Hence, post sorting of postconsumer waste is popular globally.

# APPENDIX 4
# RECYCLING AND GREENWASHING

It is not the first time that recycling processes have been related to deceptive claims and greenwashing activities. Planet Tracker is concerned about this possibility in the terminology used to describe different types of recycling (e.g., advanced recycling) or even in the commonly referred to circularity model.

**Mechanical recycling, its limitations and the role of chemical recycling**

Plastic waste is usually sorted through a series of different steps through mechanical recycling; sorting based on size removal of foreign materials (like glass or metals), sorting based on plastic grades and, at the end, sizing and granulation into plastic recyclates – see Appendix 9.

Presently, mechanical recycling is incapable of processing many of the types and volumes of plastics presently produced. This results in a linear flow of "make, use, dispose", meaning that a lot of material doesn't get a chance to be recycled. Instead, it is buried, burned, or litters the environment. See more regarding recycling challenges including PET processes and its footprint on Packaging Labels. We should also recall that many areas have no collection system.

As a solution to the limitations of the mechanical recycling, chemical recycling is being discussed and tested. This type of recycling, which is supported and promoted by the American Chemistry Council and the wider petrochemical industry, is increasing, with more than 40 projects valued at over USD 7 billion in investments built or being constructed, arguing that it will potentially divert nearly 9 million metric tonnes of waste from landfill per year.[78] The Center for Climate Integrity states that 'these processes have interested chemical researchers since the 1970s, but have never proven to be a viable solution for plastic waste'.[79] The petrochemical industry has pushed chemical recycling using various terms such as chemical or molecular conversion, and feedstock recycling. Currently, the preferred choice appears to be **advanced recycling**. It is possible that this 'rebranding' was introduced as the word chemical can be associated with toxicity. Furthermore, by using the term "advanced" it implies that all types of plastics can be completely recycled.

Zero Waste Europe states that originally the petrochemical companies claimed that 100% of the plastics can be recycled via chemical recycling, comparing it to a cake being reverted back to its original components of flour, sugar, butter and eggs.[80] However, this is most improbable as at a minimum there is a yield loss through the process.

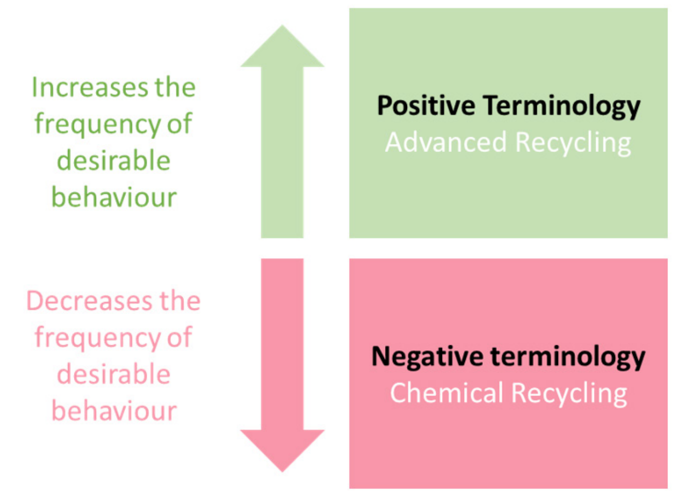



***Figure 24:*** *The use of the right terminology can lead to desirable effects*
*Source: Planet Tracker.*

# APPENDIX 5
# COMMON ADDITIVES USED IN PLASTICS

| Type of additive | Comments | Substances |
|---|---|---|
| ***Functional additives***<br>Plasticisers | Around 80% used in PVC and the remaining 20 % in cellulose plastic | Short and medium chain chlorinated paraffins (SCCPMCCP); Diisoheptylphthalat (DIHP); DHNUP; Benzyl butyl phthalate (BBP); Bis (2-ethylhexyl) phthalate (DEHP): Bis (2-methoxyethyl) phthalate (DMEP): Dibutyl phthalate (DBP); Diisobutyl phthalate (DiBP); Tris (2-chloroethyl)phosphate (TCEP); |
| Flame retardants | Three groups: organic non- reactive, reactive; inorganics. | Short and medium chain chlorinated paraffins (SCCPMCCP): Boric acid; Brominated flame retardants; Tris(2-chloroethyl) phosphate (TCEP) |
| Antioxidants and UV stabilizers | Amount depends on chemical structure of additive and of plastic polymer. Phenolic antioxidants are used in low amounts and phosphites in high. Lowest amounts in polyolefins (LLDPE, HDPE), higher in HIPS and ABS | Bisphenol A (BPA); Cadmium compounds; Lead compounds; Nonylphenol compounds; Octylphenol; 1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC)/1,3,5-tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione (β-TGIC) |
| Heat stabilisers | Used in PVC. Based on lead, tin, barium, cadmium and zinc compounds. Lead is most efficient and used in the lower amounts. | Cadmium compounds; Lead compounds; Nonylphenol (barium and calcium salts); |
| Curing agents | Peroxides and other crosslinkers, catalysts, accelerators | 4,4'- Diaminodiphenylmethane (MDA); 2,2'-dichloro-4,4'-methylenedianiline (MOCA); Formaldehyde - reaction products with aniline; Hydrazine; 1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione (TGIC)/1,3,5-tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione (β-TGIC) |
| Biocides | Soft PVC and foamed polyurethanes are the major consumers of biocides. They are of different chemical strutures and include chlorinated nitrogensuphur heterocycles and compounds based on tin, mercury, arsenic, copper and antimony, e.g. tributyltin and 10,10´- oxybisphenoarsine | Arsenic compounds; Organic tin compounds; Triclosan; |
| ***Colorants***<br>Organic pigments | Insoluble low migration tendency | Cobalt(II) diacetate |
| Inorganic pigments | E.g. zinc sulphide, zinc oxide, iron oxide, cadmium-mangane based, chromium based, ultramarine and titanium dioxide | Camium compounds; Chromium compounds; Lead compounds |
| Special effect | Aluminium and copper powder, lead carbonate or bismuthoxichloride and substances with fluorescence Substances with fluorescence might migrate, the former not | |
| Fillers | Calcium carbonate, talk,clay, zinc oxide, glimmer, metal powder, wood powder, asbest, barium sulphate, glass microspheres, silicious earth | |
| Reinforcements | Glass fibers, carbon fibers, aramide fibers. 15-30% is for glass only due to the high density of glass. | |

*Source:* https://www.byggemiljo.no/wp-content/uploads/2014/10/72_ta3017.pdf

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## ABOUT PLANET TRACKER

Planet Tracker is an award-winning non-profit think tank focused on sustainable finance with the purpose of ensuring that capital markets' investment and lending decisions are aligned with planetary boundaries and support a just transition. Its mission is to create transformation of global financial activities by 2030 to bring about real world change in our means of production so that they align with a resilient, just, net-zero and nature-positive economy. Planet Tracker serves both as a watchdog on corporate behaviour, including issues such as greenwashing, and serves as an ally to support finance and business to know how to undertake transition. Having identified the companies causing the worst environmental and social damage within targeted supply chains, Planet Tracker then identifies the investors and lenders in these companies whose financing is enabling these practices to continue unchallenged.

## PLASTIC TRACKER

The goal of Plastic Tracker is to stem the flow of environmentally damaging plastics and related-products that are creating global waste and health issues by transparently mapping capital flows and influence in the sector starting from resins production through to product-use. By illuminating risks related to natural capital degradation and depletion, investors, lenders and corporate interests across the economy will be enabled to create more sustainable plastics products.

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**For further information please contact:**
Nicole Kozlowski, Head of Engagement, Planet Tracker
nicole@planet-tracker.org

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