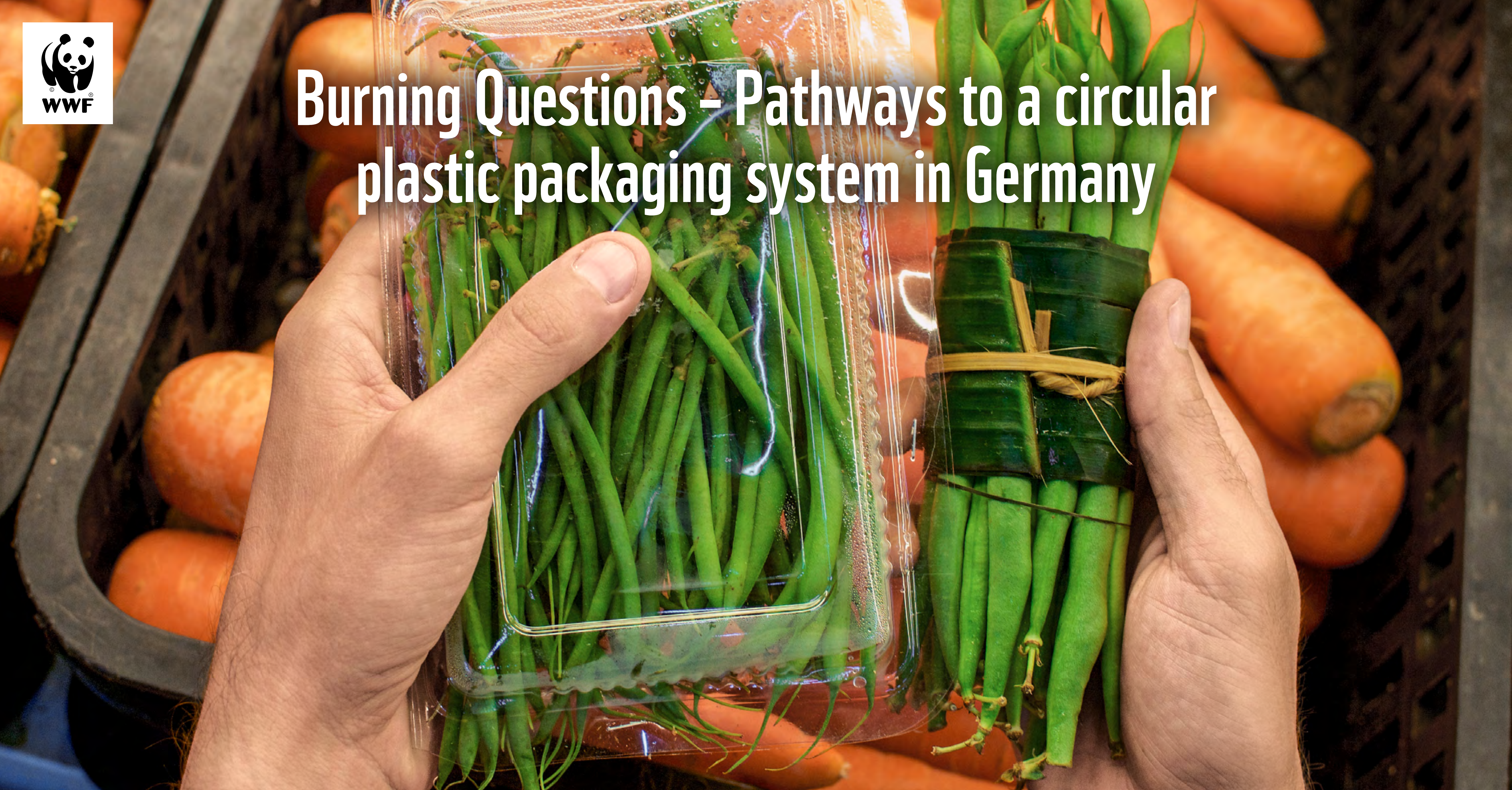
Burning Questions – Pathways to a circular plastic packaging system in Germany



Imprint

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Testimonial

"This report compellingly demonstrates that creating a circular economy for plastics would yield significant economic, environmental and climate benefits for Germany. To realise this opportunity, a fundamental shift is required.

We need to eliminate the plastics we don't need, innovate towards new materials and business models, and circulate all the plastics we do use. The case is there, now let's make it happen."

Rob Opsomer
Executive Lead – Systemic Initiatives
Ellen MacArthur Foundation

SYSTEMIQ is a B Corp created in 2016 to drive achievement of the UN Sustainable Development Goals and the Paris Agreement by transforming markets and business models across three areas: land use, circular materials, and energy. Working with partners across sectors, SYSTEMIQ aims to unlock economic opportunities that benefit business, society and the environment. SYSTEIMQ is a global company in London, Munich, Jakarta, Amsterdam, Sao Paulo and Paris. To learn more, visit www.systemiq.earth.

Preface – Martin Bethke & Martin Stuchtey

Martin Bethke
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Plastic is a versatile and affordable material. It is also the epitome of the current, linear production and consumption model, which is not compatible with the planetary boundaries, the safe operating space of our Earth. While plastic pollution abounds in the Global South, plastic packaging systems in the Global North, including Germany, are also problematic: materials are typically incinerated after only one use. Although Germany is often heralded as a model for circular economy and recycling, the reality is far more complicated.

Plastic packaging consumption is growing, and materials are becoming increasingly complex and difficult to recycle. In Germany, more than half of the waste is still waste-to-energy incinerated, and of the other half most is exported "out of sight", or recycled into low value products. As a result, just over 10% of the inputs for packaging are recyclates; and the rest is made of virgin plastic based on fossil oil. The country's trajectory, as it stands, is neither aligned with the Paris Accord, the European Green Deal nor the Sustainable Development Goals.

In short, Germany currently is a long way from a circular economy for plastics. But the study shows that we have a choice – system change is possible and within reach; however, concerted, courageous action is required from policymakers and industry leaders alike.

This study shows there is a way out, building on momentum that is happening today. It comes at a time when UN member countries are negotiating a global treaty to stop plastic pollution, when policymakers are revising packaging laws and regulations, and industry leaders are rethinking their waste and resource strategies. These critical decisions will set the direction for the years, if not decades, to come.

While the need to transition toward a circular economy has been made abundantly clear by many, this study addresses the question of how such a vision can become a reality: The goal of "Burning Questions – Pathways to a circular plastic packaging system in Germany" is to accelerate a transition towards circularity by showing feasible pathways towards a zero-waste economy. We created an analysis that evaluates different strategies and quantifies their impact, in terms of volume and recyclability of plastics, but also in terms of cost, GhG emissions and jobs. We show that Germany can reduce overall waste volumes by 40%, virgin consumption by over 60% and waste to energy-incineration by over 70% by 2040 with superior economic outcomes.

Building on the methodology of 'Breaking the Plastic Wave' and on the findings of the Circular Economy Initiative Deutschland (CEID), this study is a one-of-a-kind quantitative analysis, providing a new, data-driven and science-based perspective of the flows of plastic packaging in Germany. The study was a five-month effort, supported by five experts and input from numerous interviews with stakeholders along the value chain.

The goal of this study is to help policymakers, industry, investors, and civil society navigate this complex space and make courageous decisions to improve plastic packaging strategies and achieve zero plastic packaging waste, and to strengthen Germany as a technology leader in this important space.

We hope this study will help Germany build on past achievements and become the blueprint for a circular plastic economy in Europe, setting an example and paving the way for others to follow suit.

Executive Summary

Germany is often heralded as a leader in circular economy: With high waste collection rates, a sophisticated deposit-return scheme for bottles and relatively high recycling rates, at least in international comparison, Germany can indeed serve as a role model for many.

The system is still highly linear: 89% of plastic packaging is made of virgin content; over 50% of packaging waste is incinerated after single-use

Our analysis reveals that much potential for a truly circular economy for packaging remains untapped; however, there is a pathway to radically improve performance: Today, 89% of total packaging is made of virgin content and over 50% of the packaging waste is used for waste-to-energy-recovery through incineration. This translates into burning more than 1.6 million tons of plastic packaging waste, with the equivalent value of 3.8 bn Euros every year. Of the remaining half that is not incinerated, 18% are exported, 10% are open-loop recycled and lost to the system after one, short use-cycle. As it stands, the German packaging system, and its trajectory, is neither aligned with the Paris Accord, the European Green Deal, nor the Sustainable Development Goals.

Building on the work and methodology of *Breaking the Plastic Wave*, this study analyses and quantifies the circularity levers available to the packaging system today and shows that a transition towards a circular packaging economy in Germany is possible: Our analysis shows that plastic packaging waste generation can be lowered by up to 40%, while providing the same utility and performance as single-use packaging. Compared to business-as-usual, a system change scenario can reduce incineration rates by 73% and cut virgin demand by 64%. By 2040, more than 68 mt CO_{2eq} emissions and 20 mt of virgin plastic could be saved – more than six years of annual consumption for plastic packaging.

A transition to a circular economy is environmentally and socially desirable, as well as economically viable

A transition towards a circular packaging economy requires a fundamental shift: A shift from “waste management” towards the paradigm of circular resource management, including a focus on waste prevention, on keeping materials in the loop, and retaining their value as long as possible. We show that a circular packaging economy is not an end in and of itself, but that such a transition is socially and environmentally desirable, as well as economically viable. We also show that it can be done with currently available tools and technologies. However, system change depends on courageous political will, ambitious action by brands and close collaboration between industry, policy, and academia.

In this report we lay out our 11 critical findings – what will happen without action, where would current efforts get us, and what are key interventions to enable a circular packaging economy.

1. At present, plastic packaging is a major contributor to plastic consumption (27%), plastic waste generation (59%) and GHG emissions (15.3 mt CO_{2eq} p.a.).

Despite high collection rates and an advanced Extended Producer Responsibility (EPR), the German plastic packaging system is highly linear, with 51% being incinerated, 18% exported, and 10% recycled open-loop, while only 20% is closed-loop recycled. Recycled content use in packaging remains low (11%), with a significant share coming from post-industrial sources. Equally, much of packaging recyclates (63%) is used in other sectors, such as automotive or construction.

2. **In a business-as-usual scenario (BAU), a moderate plastic packaging growth is expected (~0.6% p.a., or 14% by 2040).**
However, consumption trends including to-go and convenience risk perpetuating the current linear trajectory beyond the increases in recycling capacity. Compared to 2019, waste (+13%) and waste-to-energy incineration volumes (+24%) are expected to increase further, despite a growth in recycling volumes and also due to decreasing plastic exports. Under BAU, we estimate that CO_{2eq} emissions from plastic packaging production and waste management will grow, amounting to an estimated 329 mt CO_{2eq} between 2019 and 2040. We estimate that in 2040 emission from the product and end-of-life management of plastic packaging will amount to over 17.2 mt of CO_{2eq} per annum – the equivalent of almost 5% of the German GHG emission budget (375 mt in 2040) to stay under the 1.5 degrees threshold as defined by the Paris Accord.

3. **Current commitments, including committed policy and voluntary industry initiatives, fall short of enabling the transition towards a circular packaging economy.**
If all commitments were completely implemented and achieved, they would increase overall recycling amounts, but reduce overall plastic packaging waste generation by only 5% by 2040, waste-to-energy incineration (WtEI) by 15%, and increase virgin plastic consumption by 4%, respectively (compared to 2019). We show that, unfortunately, current policies and commitments are not sufficient to enable a transition towards a circular packaging economy.

4. **A systems change is within reach:**
Our analysis shows that by pulling all levers that are at our disposal today, we can lower overall plastic packaging waste generation by 40%, reduce virgin consumption by 64%, and waste-to-energy incineration by 73% in 2040. Such a systems change scenario would result in cumulated savings of 68 mt CO_{2eq}, and deliver a system benefit of close to 1bn Euro over BAU until 2040, the horizon of this study.

To enable this systems change scenario, we have identified 7 core interventions:

5. **Intervention 1 - Elimination and minimization of unnecessary packaging can result in a reduction of 8% of plastic waste, without significant negative consequence for people and the environment.**
The integration of elimination and minimization principles in the packaging design is required to achieve this potential. Standards and guidelines, developed in collaboration between policymakers and industry, the creation of transparency concerning packaging usage are key enablers for realization of the lever.

6. Intervention 2 - Reuse models are a significant lever to increase circularity, providing plastic utility, while reducing plastic waste by up to 23% by 2040 (909 kt).

By leveraging its history of reuse and deposit-return systems, Germany is ideally positioned to scale reuse systems and drive circularity. We have identified three core areas to maximize the impact of reuse models:

- Food-grade bottles (395 kt)
- Transport packaging and e-commerce (192 kt)
- Reuse and refill concepts in retail supermarkets (167 kt)

Given a history of unachieved reuse targets in Germany, a number of drivers could be considered including clear timelines, implementation measures or sanctioning mechanisms for failure to achieve targets. Measures could include a right to return for multi-use bottles, retail space foreseen for refill and reuse as planned for other EU countries and internalizing externalities of single-use plastic bottles such as a plastic tax on single use bottles. Similar approaches to increase the market penetration of reuse systems are possible for the e-commerce sector.

7. Intervention 3 - Substituting single-use plastic packaging with paper, coated paper or biobased material can play a role for specific applications:

Substitution is particularly relevant for applications that cannot be eliminated or reduced, and for which contamination compromises recyclability. We estimate that up to 365 kt (9%) of single-use plastic can be substituted with materials that have a better environmental footprint. This requires clear standards and certifications of materials used, as well as labelling and consumer education.

8. Intervention 4 - Design for recycling can significantly increase closed-loop recycling, improving both yield and value of recyclates.

Phasing out multi-polymer materials alone can increase the output of mechanical closed-loop recycling by 185 kt (30%). Design for recycling is not a once-off effort, but a continuous process of improvement, that needs to be adequately incentivized. As such, transparency on recyclability and a roadmap of increasingly ambitious D4R-Standards could:

i) reduce packaging complexity and enable a high-quality and cost-effective recycling

ii) provide a clear time horizon and expectations for brands.

9. Intervention 5 - Improving separation at source and high-quality sorting to improve efficiency and output of the recycling system.

Despite a relatively high collection rate, incorrect separation by consumers continues to be a challenge. Our analysis shows that increasing collection for recycling rates from 75% today to 85%, while reducing sorting losses in the recycling process from 18% to 10%, could increase closed-loop recycling outputs by 100 kt (22%) and open-loop recycling outputs by 42 kt (6%) in 2040. Standardizing collection for recycling systems, e.g., *Gelber Sack*, as well as campaigns to raise consumer awareness and providing clear on-packaging recycling instructions are being discussed to increase both collection for recycling rates and reduce sorting losses.

10. Intervention 6 - New regulation and technologies to enable closed-loop recycling of food grade plastics, while protecting health and safety of the consumer.

Food grade (FG) plastics represent one of the most challenging application groups: they must rightfully adhere to strict health and safety requirements, they require the most complex barriers and coatings to protect the packaged good, and they are often the most contaminated after use. Even after the reduction and substitution interventions, our analysis reveals that 593 kt of FG waste remains, which can either be 'down-cycled' to non-FG applications or incinerated. The circularity of FG packaging can be increased through two principal levers:

Standards and separated collection for FG rigids: A review and update of the FG regulation by the European Foods and Safety Agency (EFSA) could create the opportunity to use FG recyclates as inputs for FG packaging, and thus enable a 'like to like' recycling. As a precondition, this would require separated waste streams of FG packaging, for example through a DRS system. We estimate that 329 kt could be collected through such a system, recycled, and used as inputs for FG packaging.

Scaling up chemical recycling: While the technology is still maturing – cost and GHG emissions require further assessment – chemical recycling could provide a viable option to increase FG packaging circularity in the absence of a changing EFSA regulation. We estimate the potential for chemical recycling of FG packaging between 253 and 498 kt in 2040.

11. Intervention 7 - Developing demand-side standards, incentives and market norms, including recyclate standards and recycled content incentives.

Our interviews revealed that resolving this stalemate could be achieved through

i) recyclate standards, which define quality, reduce both transaction cost and legal risks, as well as

ii) market incentives encouraging the use of recycled content.

In the German context, the envisioned eco-modulation of the EPR fees and the amendment of Paragraph 21 is seen as an opportunity to resolve these challenges and set the economic incentives for the use of recyclates, stimulate demand, enable investments and level the economic playing field.

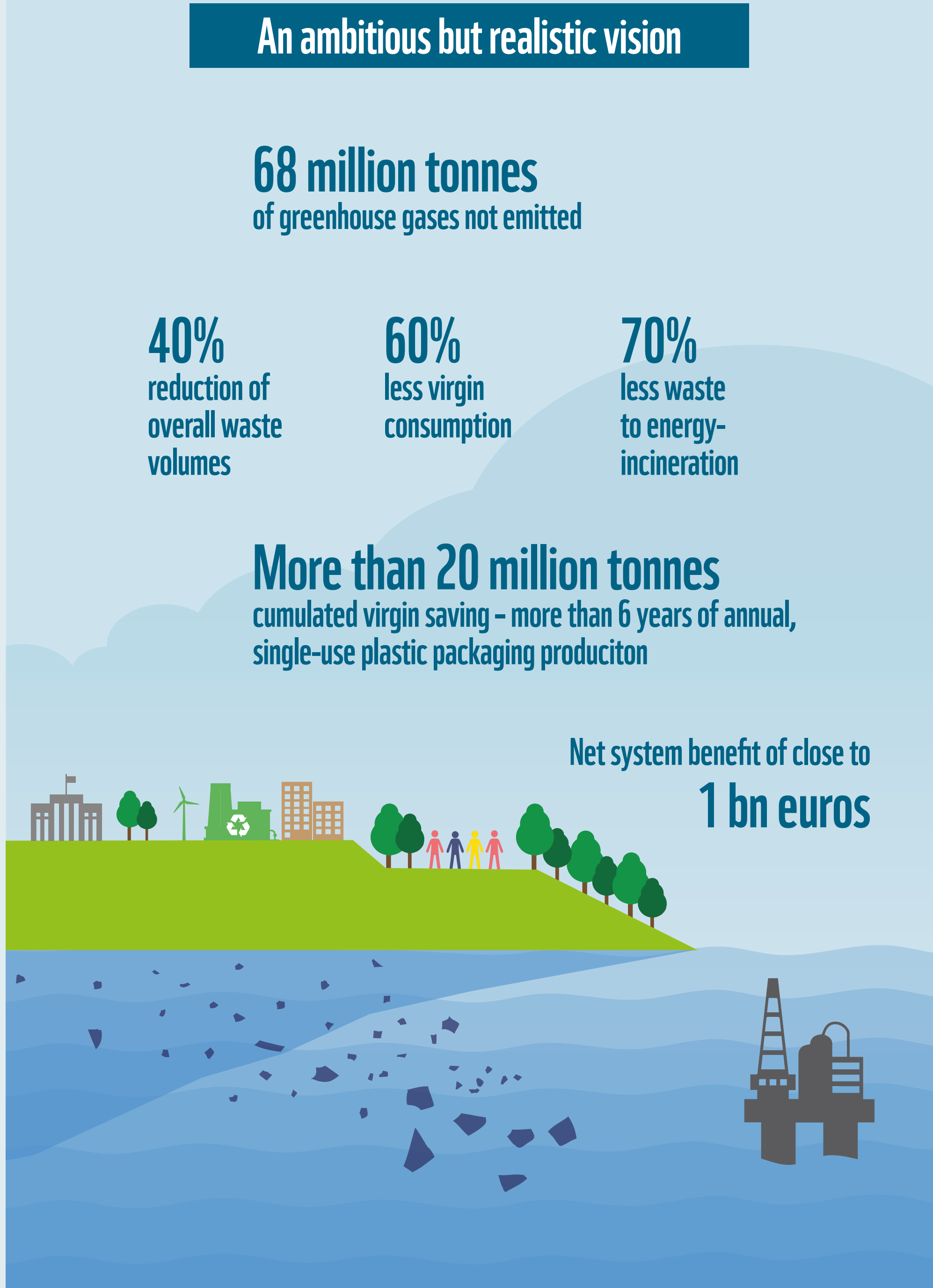
The transition to a circular packaging economy is not an end in itself, but a means for reducing the economic, environmental and social costs of plastic packaging waste. This report offers three contributions to this transition:

While the challenges of a linear plastic economy and the need to transition towards circularity have been rehearsed by many, this report, for the first time, quantifies the levers and shows how such a vision can become reality. It details an ambitious, but realistic scenario, achievable with the enabling strategies, policies, and technologies we currently have at hand.

This report also shows that there are no silver bullets. We will not recycle our way out of this crisis, nor will reduction efforts alone be sufficient to transition towards circularity. Both upstream and downstream solutions need to be employed concurrently and at scale. The report shows that pursuing systems change is a highly worthwhile endeavour – we can reduce virgin plastic consumption, waste generation and GHG emissions, enabling local value and job creation, resulting in an overall net system benefit of ~1bn Euro compared to BAU. The systems change scenario is not yet a scenario that reaches net zero GHG emissions by mid-century, in line with the Paris Climate Accord and therefore requires additional interventions, for example the decarbonization of plastic production – but it is a key building block in Germany's transition.

We close with a call for action: A circular packaging system is possible, but it requires courage, ambition and bold action

Finally, we close with a call for action. We show that a circular packaging system is possible and highly beneficial; however, it requires courage, ambition and bold action, by all actors in the value chain – technology providers, policy makers and investors. By walking the path of systems change, Germany can enable a transition, but also become the blueprint of a circular plastics economy transition in Europe, and for developed countries at large, setting an example that it can be done and paving the way for others to follow suit.



Introduction

Over the last 60 years, plastics and plastic packaging have become near ubiquitous in our everyday life and essential to the economy.

This growth is owed to its phenomenal properties – plastics are durable, lightweight, cheap to produce and easy to process. Plastic packaging fulfils critical functions without which modern life would be impossible: Plastic packaging protects goods and extends the shelf-life of perishables, it reduces transport cost and emission, and ensures sterile healthcare equipment.

On a global level, plastic pollution is now abundant throughout the world

While the utility of plastic packaging is undisputed, the way we currently produce, consume, and dispose of plastics often has catastrophic implications. On a global level, plastic pollution is now abundant throughout the world, from the beaches of Asia to the depths of the Mariana trench and the remote corners of Antarctica. Worse, unless we fundamentally reconfigure the plastics system, from a linear to a circular system, the impacts are expected to worsen dramatically over the next decades:[6]

By 2040,
global plastic production is forecast to double, plastic leakage to the environment to triple and plastic stocks in the ocean to quadruple.

95%
of the packaging value is lost after one short use cycle, the equivalent of $80-120 bn per annum.[7]

On a global level,
it is estimated that the plastics industry contributes up to 19% of the available carbon budget to remain below the agreed upon 1.5 degrees threshold of the Paris Climate Accord.[8]

While plastic pollution is concentrated in the global south, plastic packaging systems in the global north, including Germany, equally remain fundamentally linear:[9]

In Germany, **27% of plastic consumption is for packaging,** but plastic packaging contributes close to **60% of plastic waste.**

With 38 kg
annual packaging consumption per capita, Germany is well above the European average[10] and, while Germany is praised for its high collection and utilization rates, only 11% of plastic packaging is made from recycled content.[9]

Most packaging waste is waste-to-energy incinerated, exported or open-loop recycled. Given the characteristics of the German plastic packaging system, the focus for a system change scenario is on circularity of plastics, rather than on preventing leakage to the environment. Increasing awareness and attention to the problem of plastic pollution brought packaging into focus, both globally and locally. The challenges associated with single-use plastic packaging are now the topic of lively public debates, the subject of a host of policy initiatives and industry commitments. They all are critical to avoid the potentially catastrophic implications outlined above, and to enable transition from a linear to a circular plastics economy, where material is kept in the loop, reused, recycled, substituted, or, ideally, not needed altogether.

The need for urgent, concerted action has been made abundantly clear. Equally, the characteristics of a better, more sustainable, and circular packaging economy have been defined, for example through the seminal work of the Ellen MacArthur Foundation. This report offers a perspective on the missing piece of the puzzle – how such a transition could be achieved in Germany, what it would take, and what the implications would be. It quantifies the utility plastic packaging provides, estimates the volumes and potential to transition to a circular model, and assesses the economic, environmental, and social impacts of the solutions, including GHG emission, capital and operational expenses, and jobs.

By doing so, this report builds upon the foundational work of the global study, Breaking the Plastic Wave (BPW)[6], the accompanying Science publication[11], as well as the Packaging Working Group of the Circular Economy Initiative Germany (CEID).[12]

BPW pioneered the 'wedges' methodology used in this analysis and developed the most comprehensive fact base and analysis to quantify and offer solutions to the plastics crisis to date. The CEID laid the foundation for the Germany-specific lens, developed a vision, defined the potentials, challenges, and trade-offs of a circular economy for plastic packaging in Germany. As such, this report transposes and adapts the global, archetype-based methodology of BPW to a country-level. Equally, this report quantifies the vision and recommendations developed by the CEID and provides a roadmap for such a transition.

Specifically, this study seeks to provide insights and solutions to a set of six strategic questions:

1. What is the trajectory of business-as-usual?
2. Where would current commitments and policy get us to?
3. Do we have the technological solutions to transition towards a circular plastics economy?
4. Is the solution attractive for citizens, business, governments, and the environment?
5. What does it cost, what are the benefits for the environment and communities?
6. What are the enablers – and challenges – to such a transition?

The study has the goal of providing decision-makers across government, industry, civil society, and academia with a new evidence base to address the packaging waste challenge, assess impacts, and design solutions. The aspiration is that the conclusions and recommendations from this analysis will inform the thinking, discussion, and planning around a systemic response to this systemic challenge, to enable a transition to a circular plastics economy and to provide a first country-level roadmap and thereby offer a blueprint for replication in other countries.

Our Linear Packaging Economy

Germany prides itself with high plastic packaging waste collection rates, an advanced EPR and sophisticated deposit-return-scheme (DRS) for bottles and has a reputation for being a recycling champion. Still, at least for plastic packaging, Germany is far from a circular economy.

Our Linear Packaging Economy

The BAU and Current Commitment (CC) modelling results show that unless concerted and urgent action is taken, the German plastic packaging system will remain linear for the next decades. Even though the current German system exhibits very low rates of mismanaged waste, it is characterized by high degrees of waste-to-energy-incineration. Germany is one of the leading plastic waste exporters, low recycled content use in packaging, and even lower like-to-like recycling rates. Using an output-oriented definition of recycling[i], only 30% of the plastic packaging waste is effectively recycled within Germany, out of which 10% is open-loop recycled and only 20% replace demand for virgin plastic, the majority of which is replacing demand in other sectors. Additionally, 18% is exported for recycling. Assuming that all exported waste is indeed recycled, this would result in a nominal recycling rate of 48%[ii].

In a BAU scenario, plastic utility demand is expected to grow by 14% over the next two decades, and the share of harder-to-recycle materials, such as films or multi-layer materials, to increase from 45 to 48%. Incineration is projected to increase by 5%, effective in-country recycling to 38% and the nominal recycling rate to decrease to 42%. If all current policy and industry commitments were completely implemented and enforced, demand for virgin plastic would increase by 4%, whereas waste generation would decrease by 5% and waste-to-energy incineration by 32%, compared to BAU in 2040. While recycling rates would grow to over 50%, the growth is fuelled by open-loop recycling. Given the near-exhausted recycling potential for PET and the dysfunctional markets for other recyclates, the recycling targets are ambitious, and it is unclear whether they can be achieved given the current system.

Hence, the transition to a circular packaging economy in Germany faces a set of challenges:

- Current policy focuses on recycling targets, rather than a reduction of waste generation and stimulating reuse models.
- The trends towards to-go and convenience products shifts demand towards harder to recycle materials. This shift is enforced by brand-driven packaging differentiation.
- Use of recycled materials in non-food applications is limited due to missing standards, recycling markets for non-PET polymers are dysfunctional.
- The current recycling targets are ambitious, and their achievement would require significant additional measures, such as increased separation at source, design for recycling as well as adoption of advanced sorting technology.
- Overall, current regulation is not enough to set Germany on a trajectory towards a circular packaging economy and requires the alignment of players' incentives along the value chain and rewarding leaders.

i An output-oriented calculation of recycling rates does consider losses during sorting and recycling as non-recycled and is less optimistic than an input-oriented view. The EU introduced an output-oriented calculation method in Directive 2008/98/EC in 2019.

ii Assuming the nominal recycling rate is calculated as domestic recycling plus exports

Status Quo

In 2019, Germany processed 14.2 mt of plastic, of which 12.1 mt were consumed domestically. Of the domestic consumption, 3.2 mt were packaging and other single-use products (SUP). Although packaging and SUP represent only 27% of domestic consumption, they contribute 59% to plastic waste. Moreover, over the last 25 years, Germany's plastic waste has more than doubled, growing from 1.5 mt in 2004 to 3.2 mt in 2019. In comparison to other countries, German plastic packaging waste of 38 kg per person per annum is significantly higher than the European average of 32 kg.[9,16–18]

German recyclers produced 1.9 mt of recyclate in 2019 from post-industrial and post-consumer waste, of which 24% were re-used for packaging products. However, it is noticeable that within the packaging sector, only 11% (474 kt) of the input material currently consists of recycled plastics and the overwhelming majority of input is virgin plastic. The 474 kt recyclate used for packaging consist of 54% recyclate from post-consumer waste (PCR) and 46% is recyclate from post-industrial waste (PIR) which is outside the scope of this study.

Figure 1: An overview of the plastics industry in Germany (2019)

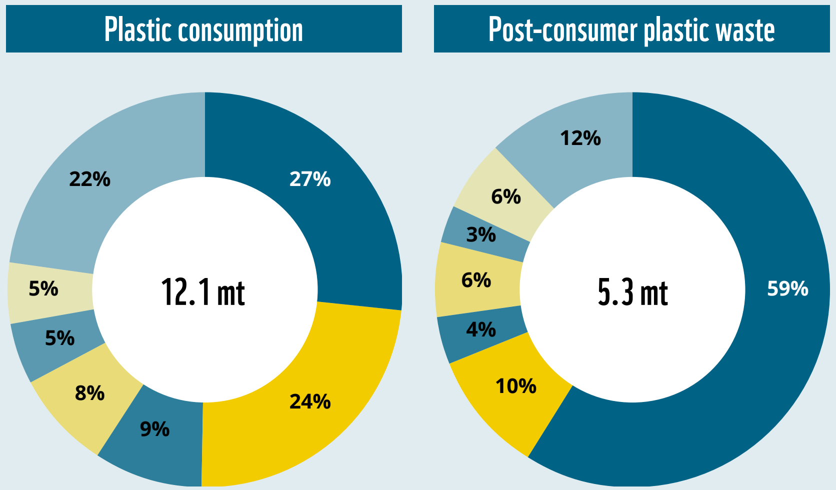
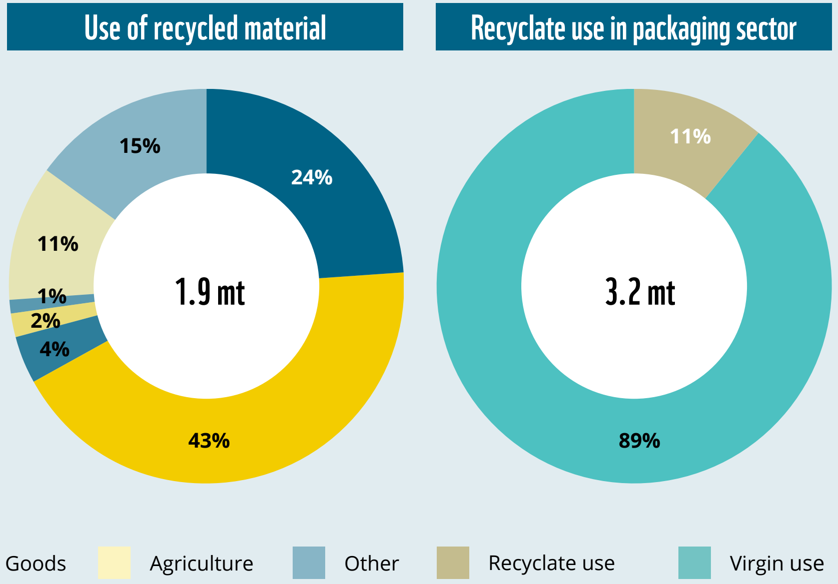


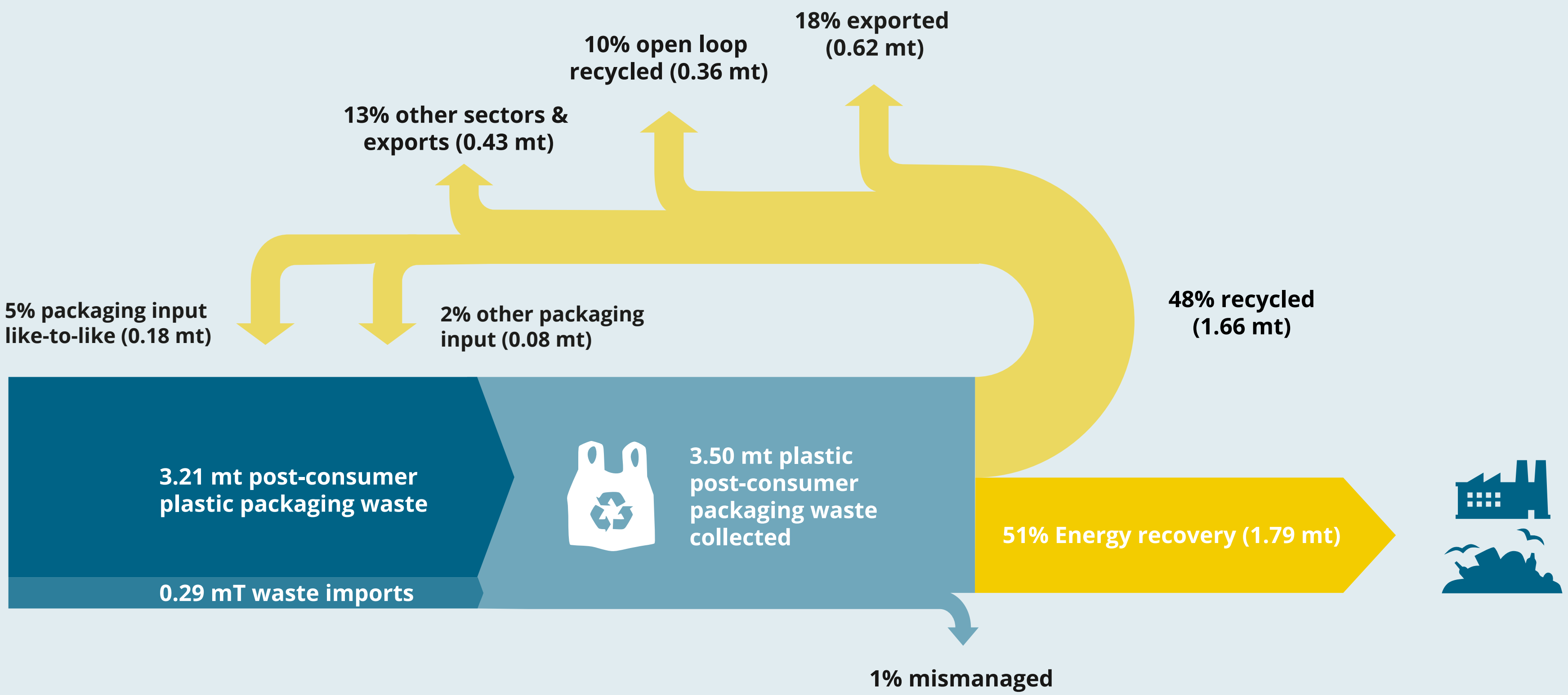
Figure 2: Recyclate processing and effective use per sector in Germany (2019)



Source: SYSTEMIQ illustration, based on Conversio data[9]

To understand the circularity of plastics, its 'fate', i.e., what happens to it once packaging becomes waste, warrants a closer examination. Our analysis reveals that while Germany exhibits near complete collection, the utilization of the materials remains fundamentally linear:

Figure 3: Flows and volumes of German packaging plastics (2019)



Source: SYSTEMIQ analysis, excluding post-industrial waste

Business-as-Usual: Continuing the linear trajectory

Over the next 20 years, under a BAU scenario, Germany's plastic packaging utility demand will moderately increase. By 2040, the time horizon of this study, total utility demand is expected to increase by 14%, from 3.2 to 3.7 mt. This corresponds to a conservative compound average growth rate of 0.6% over the next 20 years.[iii] The majority of this increase is driven by growth in flexible mono-materials (0.7% Compound Average Growth Rate (CAGR)) and multilayer formats (1% CAGR), whereas the contribution of rigid mono-materials (0.4% CAGR) and bottles (0.4% CAGR) is much lower.

The most important plastic packaging demand and growth drivers are:

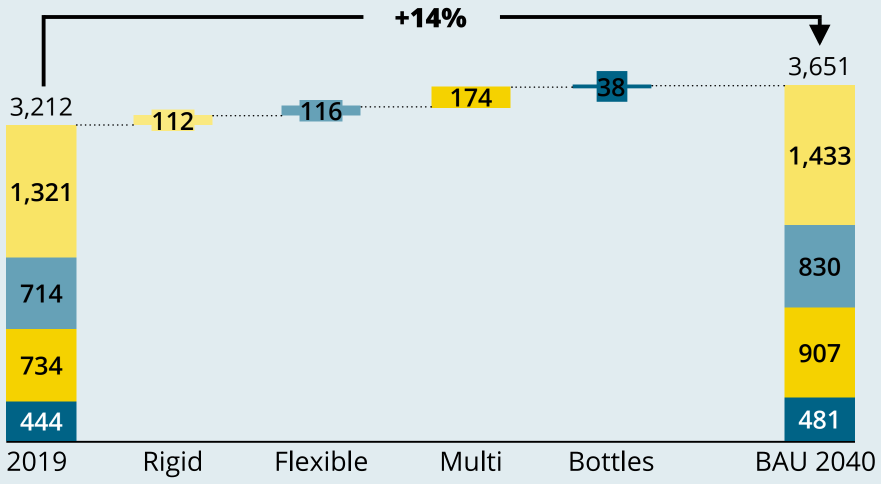
- **Rising per capita plastic packaging consumption**: Driven by GDP growth, large supply of cheap virgin plastic, and a shift to smaller households, smaller packaging units and collective packaging of portioned units.
- **Shift to convenience and to-go and on-demand consumption**: Driven by increasing out-of-home consumption, convenience products (mainly in plastic packaging), more elaborate plastic closures, plastic transport packaging for businesses and a trend towards mail-order bags in the mail-order business (e.g., clothing).
- **Shift to low-value and harder-to-recycle packaging**: An expected "race to the bottom" for packaging, with a shift towards low-cost/low-value, hard-to-recycle/low value will lead to an increased use of plastic materials that are difficult to recycle.

Opposing trends only partially compensate for this development:

- Negative population growth (CAGR -0.1% by 2040);
- Healthy and sustainable conscious consumption;
- Decreasing usage weights for dimensionally stable plastic packaging and films;
- Strongly decreasing consumption of carrier bags (also due to substitution by paper carrier bags);
- Substitution of plastic packaging by paper and paper composites

iii Eurostat database estimates that plastic packaging consumption grew by 1.4% per annum over the last five years, plastic packaging consumption grew by 1.4% per annum. Source[18]

Figure 4: Increase in total volumes of plastic packaging utility demand by 2040 mainly driven by flexible and multi-materials (kt, BAU, 2019-2040)



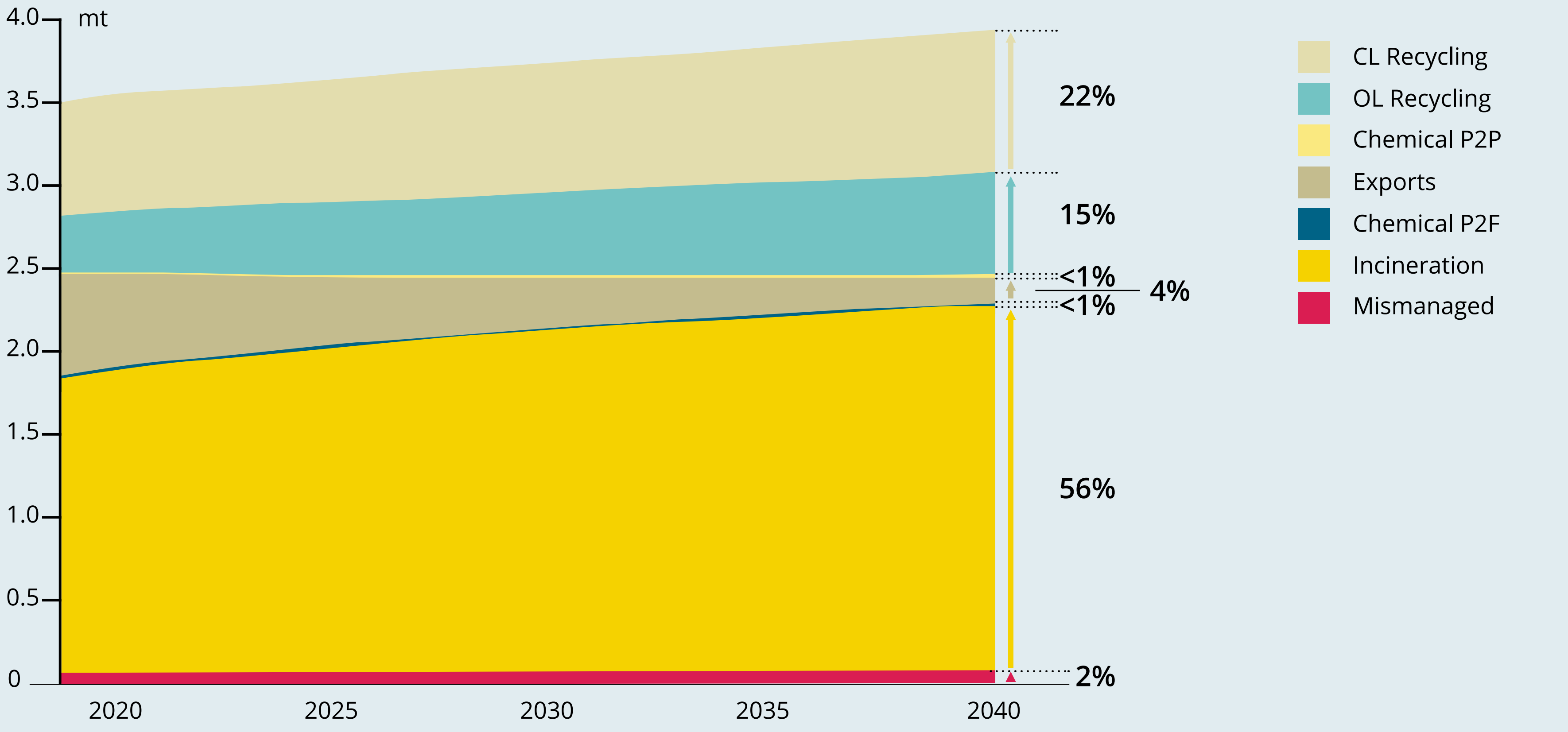
Source: SYSTEMIQ analysis

Figure 5 shows the fate of plastic packaging waste. Contrary to the plastic utility demand depicted in Figure 4, the fate of plastic packaging waste also includes imports and exports.[iv]

The system of plastic packaging waste in the BAU scenario is linear and the increased amount of waste generated can only be partially compensated by more effective and efficient recycling. Today's nominal recycling rate (in-country + exports) is 48% and will decrease to 42% by 2040.

iv Plastic packaging waste= utility demand-reduce and substitute savings+waste imports-waste exports

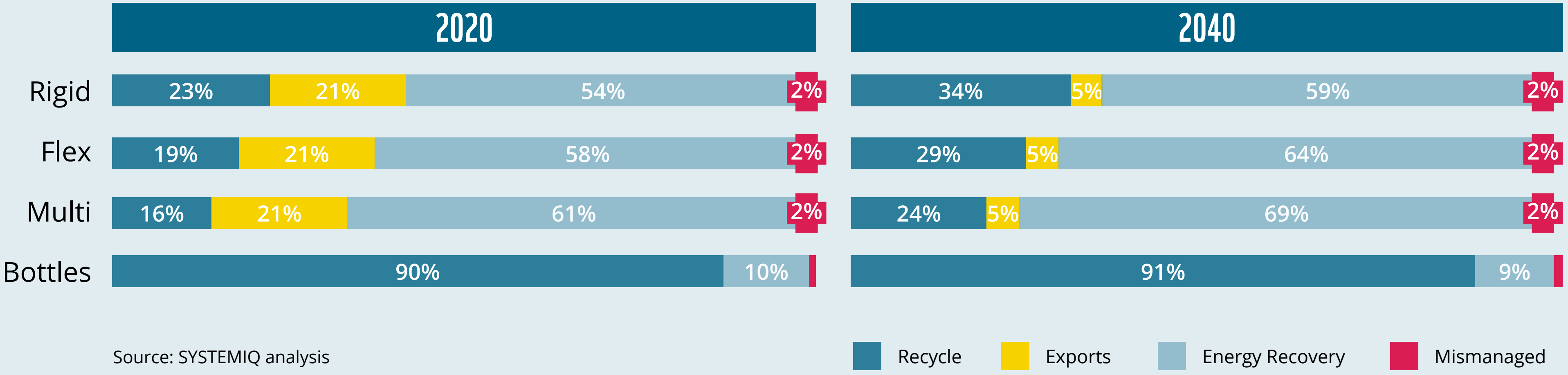
Figure 5: Fate of plastic packaging waste in BAU scenario



Source: SYSTEMIQ analysis

Figure 6 below depicts the fate of plastic packaging waste per material type. There are significant differences between the different material types, particularly for beverage bottles. Due to Germany's deposit schemes and the resulting clean waste stream and return incentives, beverage bottles have the highest recycling rate among all material types. Rigid mono-materials have good recyclability and are the second biggest driver for closed-loop recyclate output after beverage bottles. Flexibles and multi-materials are more problematic, especially multi-materials due its low recyclability.

Figure 6: Fate of plastic packaging waste per material type in 2020 and 2040.



Source: SYSTEMIQ analysis

A BAU scenario will also result in continued, high GHG emissions. We estimate that by 2040 the plastic production and end-of-life plastic waste management will contribute almost 17.2 mt of CO_2 emission, the equivalent of almost 5% of the German GHG emission budget (375 mt in 2040) to stay under the 1.5 degrees threshold as defined by the Paris Accord. These emissions are predominantly driven by virgin production, conversion, and incineration, whereas circular measures, due to their relatively low emissions per ton and low volume, are only a marginal contributor to overall emissions.

Current Commitments: Increase in recycling, but continued growth in waste generation

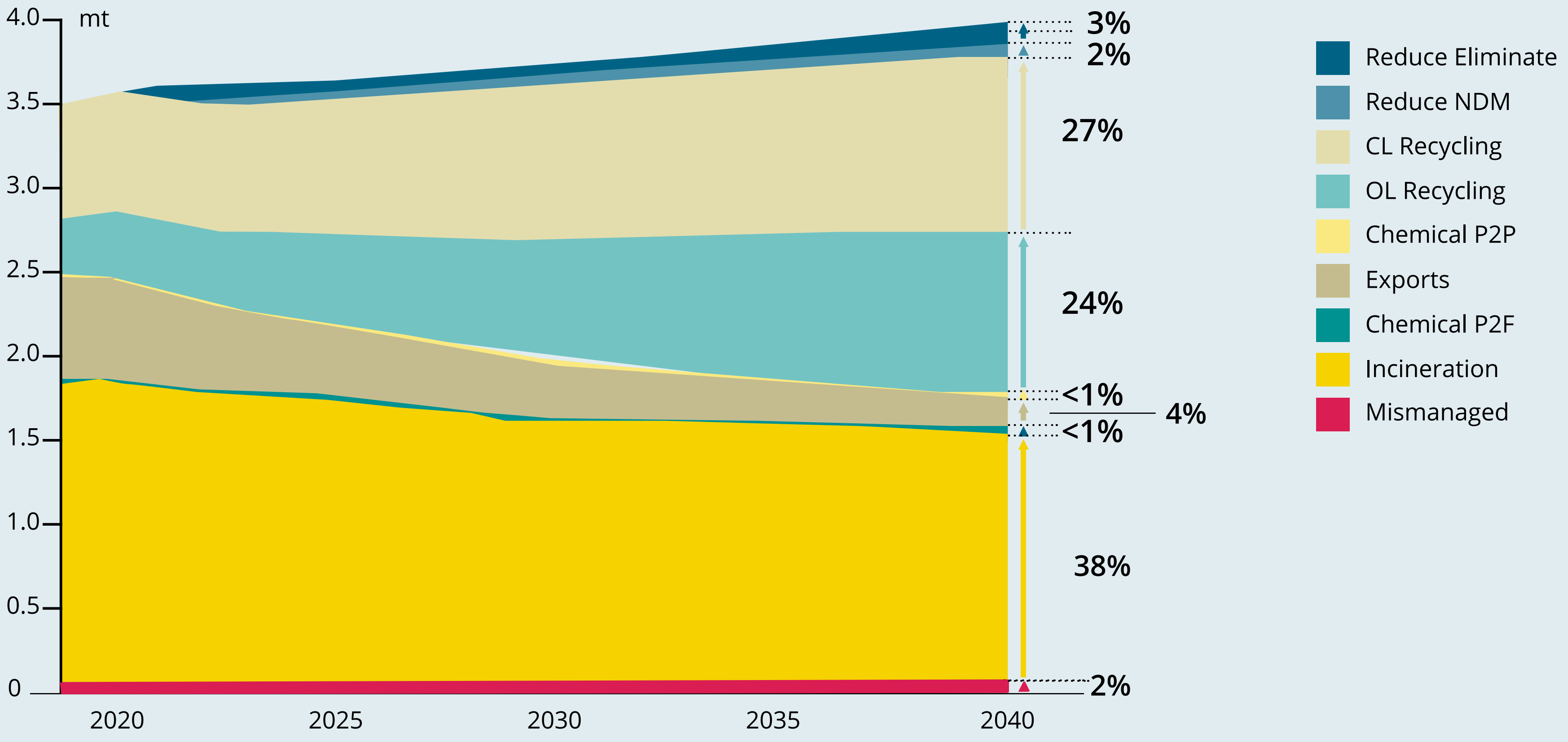
The increasing awareness and mounting public pressure, on regulators and businesses alike, has led to a range of policy and industry commitments to increase plastic packaging circularity. The current initiatives and policies analysed in the current commitments scenario[v] focus on increasing recycling, rather than on reduction of waste, or the substitution of single-use plastics with other materials.

Within the reduction and substitution lever, current policies focus on small volume application groups, such as banning straws, while large-volume applications groups such as bottles or B2B packaging are either not addressed or not enforced. As a result, these policies only have a marginal impact on plastic packaging waste, reducing overall waste generation by 5% relative to 2019.

Recycling is the main lever addressed by current commitments, expected to increase to approximately 55% (Figure 7) and reducing the total volume of plastic packaging waste-to-energy incinerated by 15% in 2040 compared to today (Figure 9).

v See Annex Table 3 on the Current Commitments considered

Figure 7: Impact of CC on waste reduction and incineration (2019-2040)



Source: SYSTEMIQ analysis

As a result, the current commitments fall short of achieving a circular economy for the packaging system in Germany. Even if all current commitments were completely implemented, enforced, and achieved, virgin demand would increase by 4%. Within this scenario, virgin consumption and incineration rates could be lowered, if more recyclate from post-consumer packaging would be re-used for packaging, exported or downcycled via open loop recycling processes. Achieving systems change thus requires interventions that address both upstream and downstream challenges; interventions that reduce overall waste generation, improve the recyclability of packaging, drive collection and sorting and incentivize the use of recyclates in packaging.

Figure 8: Current commitments lead to 4% higher virgin plastic packaging demand in 2040 vs today (kt)

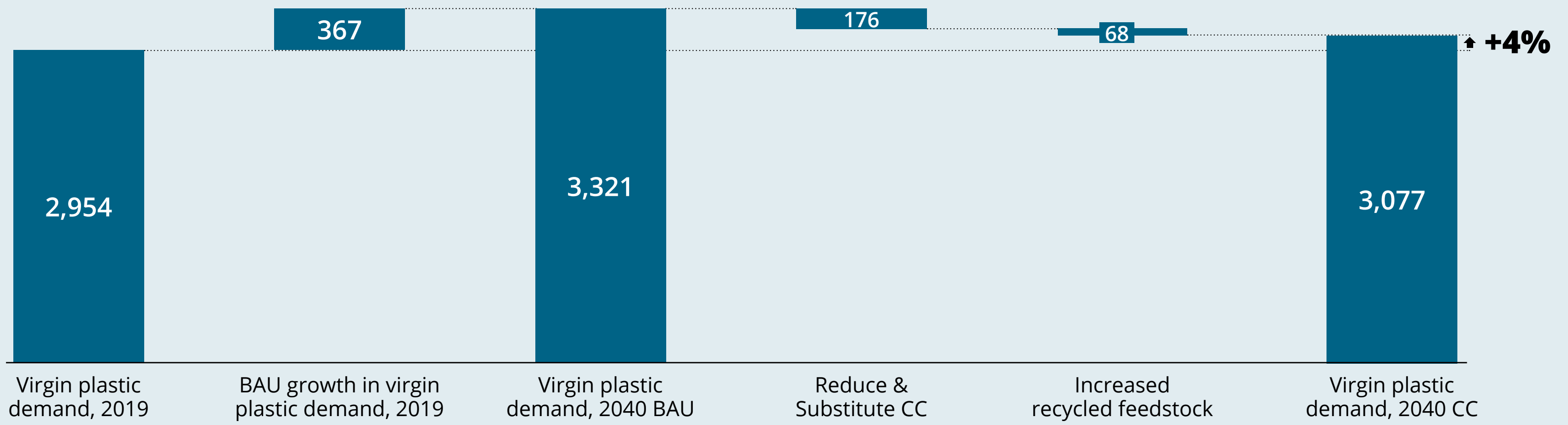
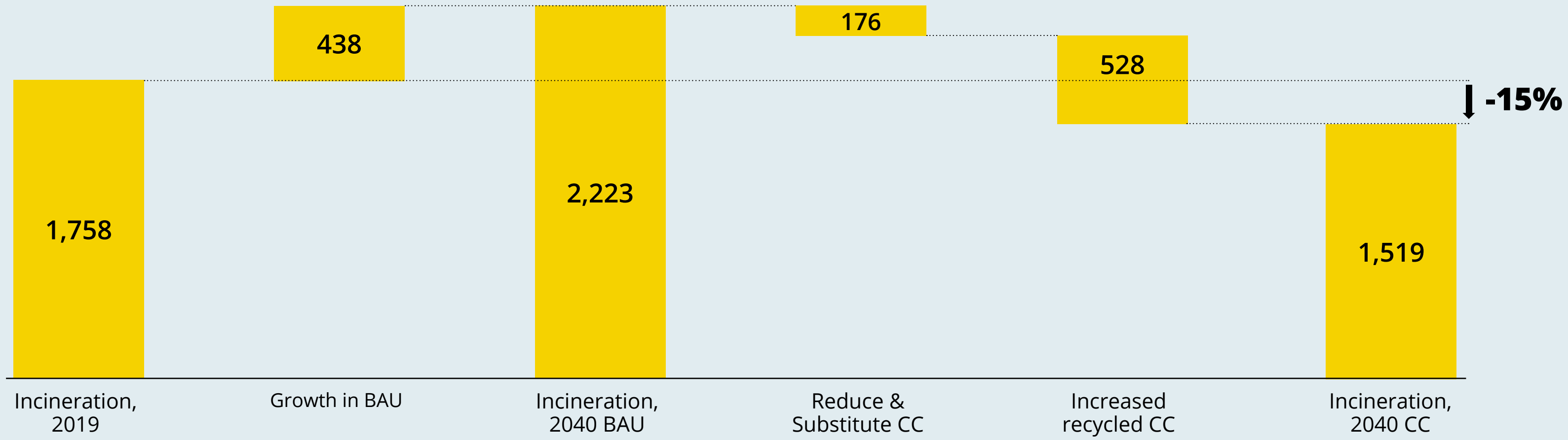


Figure 9: Current commitments lead to 15% less waste incinerated in 2040 vs today (kt)



Source: SYSTEMIQ analysis

System Change Scenario

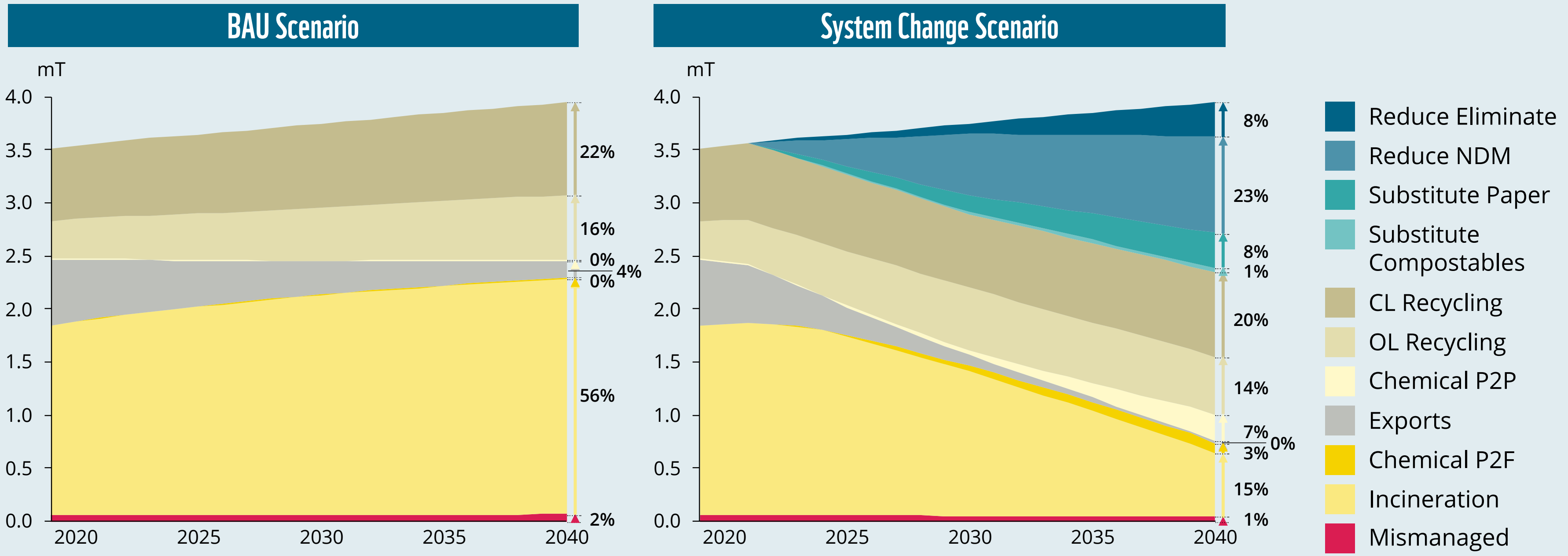
A viable alternative – An integrated circular plastics strategy for Germany

The System Change Scenario modelled in this study offers a compelling pathway to a circular plastic packaging economy, including considerable social, economic, and environmental benefits to the German plastic packaging system.

Comprised of seven system interventions across the entire plastics value chain, the System Change Scenario demonstrates that we have the necessary tools and technologies to transition to a circular packaging economy: simply, it is not the lack of technical solutions that prevents a circular plastic economy in Germany, but rather insufficiently aligned regulatory frameworks, business models, incentives, and funding mechanisms across the value chain.

Overcoming these challenges will require significant leadership and collaboration, but the reward is equally attractive. Figure 10 below provides an overview of the fate of plastic packaging, both in a BAU and in a System Change Scenario and illustrates the potential for impact.

Figure 10: Fate of plastic packaging waste in BAU vs System Change Scenario



Source: SYSTEMIQ analysis

Figure 11: Comparison of system outcomes between Business-as-usual and the System Change Scenario

2040		Business-as-usual	System Change Scenario
A more sustainable and circular plastic industry	Plastic demand after R&S	**3,651k** tons	**2,054k** tons
	Fossil-based plastic production	**3,321k** tons	**1,212k** tons
	Incineration	**2,212k** tons	**601k** tons
	Recycling	**1,492k** tons	**1,595k** tons
	GHG	**17.2Mt** CO_{2eq}	**10.2Mt** CO_{2eq}
	Mismanaged plastic	**65k** tons	**41k** tons
At no trade off for society	Cost	**781mn** EUR	**-130mn** EUR
	Jobs	**44.5k** jobs	**45.1k** jobs

Source: SYSTEMIQ analysis

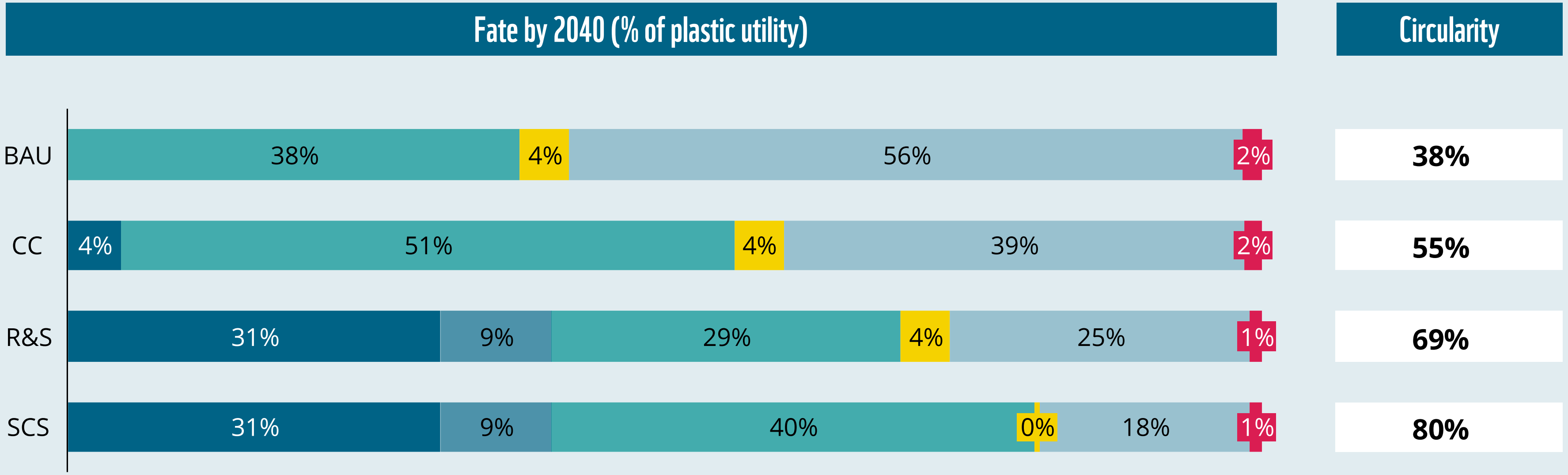
As depicted in Figure 11, the System Change Scenario provides considerable benefits at no trade-off to society. Figure 11 is based on following definitions:

- **Plastic demand:** Total amount of plastic utility projected in 2040 minus effect of reduce & substitute interventions.
- **Fossil-based plastic production:** Total amount of virgin plastic production in 2040.
- **Incineration:** Total amount of waste incinerated in Germany in 2040 (excluding imports).
- **Recycling:** Total amount of waste recycled in Germany or internationally from the waste generated in Germany including mechanical recycling and chemical conversion (but excluding plastic-to-fuel technology).
- **GHG emissions:** Total 2040 life-cycle assessment emissions of all plastics (and substitutes), including production, con-version, collection, sorting, mechanical recycling, chemical conversion and incineration.
- **Mismanaged plastic:** Total amount of plastic waste generated and littered in Germany.
- **Costs:** Value of net costs incurred in 2040 (CAPEX and OPEX) caused by all waste generated in Germany (including revenue streams) and and covering the entire the entire plastic value chain (i.e., plastic production, packaging con-version, collection, sorting, recycling and disposal including export cost, as well as the same cost for substitute materi-als, and estimated cost for the new business models).
- **Job creation:** Number of new direct jobs created in Germany in 2040, including in production, conversion, collection, sorting, mechanical and chemical recycling, incineration, landfill as well as new delivery models.

The fate of plastic packaging in different scenarios

Figure 12 compares the fate of plastic under the different scenarios modelled, as well as the circularity index in each scenario. The circularity index is comprised of the reduce & substitute interventions, closed-loop recycling, as well as Chemical C2P. As the figure shows, the System Change Scenario (SCS) has the highest potential to achieve a zero-waste circular plastic economy among all scenarios.

Figure 12: Plastic waste fate and circularity index under different scenarios



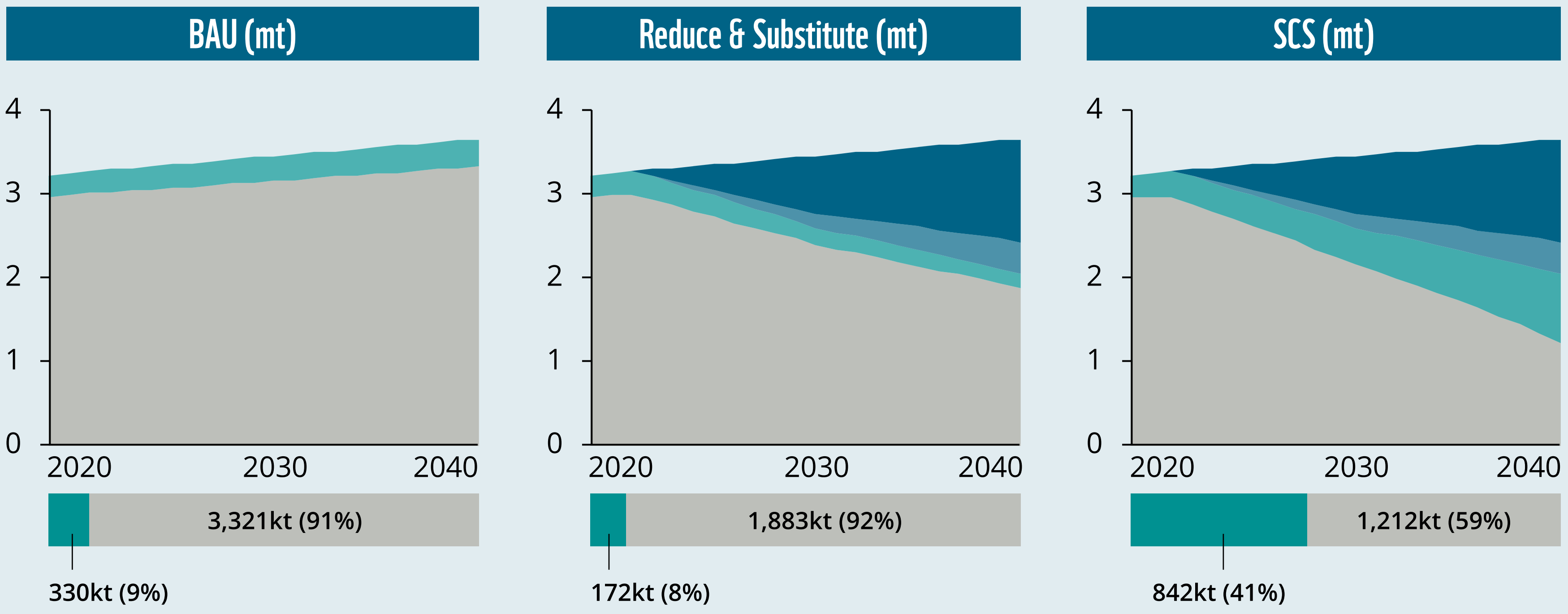
Recycling rates are defined as actually recycled material excluding processing losses. Circularity index is defined as the sum of the reduce, substitute and recycling lever.

Source: SYSTEMIQ analysis

Better for the environment: A reduction in resource use and in GHG emissions

In a BAU scenario, virgin plastic demand is projected to increase from 2,954 kt in 2019 to 3,321 kt by 2040. In contrast, our analysis of a System Change Scenario reveals that it is possible to reduce virgin plastic demand to 1,212 kt in 2040, which would represent a reduction of 59%, compared to 2019, respectively of 64% compared to a BAU scenario in 2040 (see Figure 13) – the cumulated virgin saving resulting from a SCS could amount to an estimated 20.9 mt by 2040 – or more than six years of annual, single-use plastic packaging production.

Figure 13: Virgin demand can be reduced by up to 64% in 2040

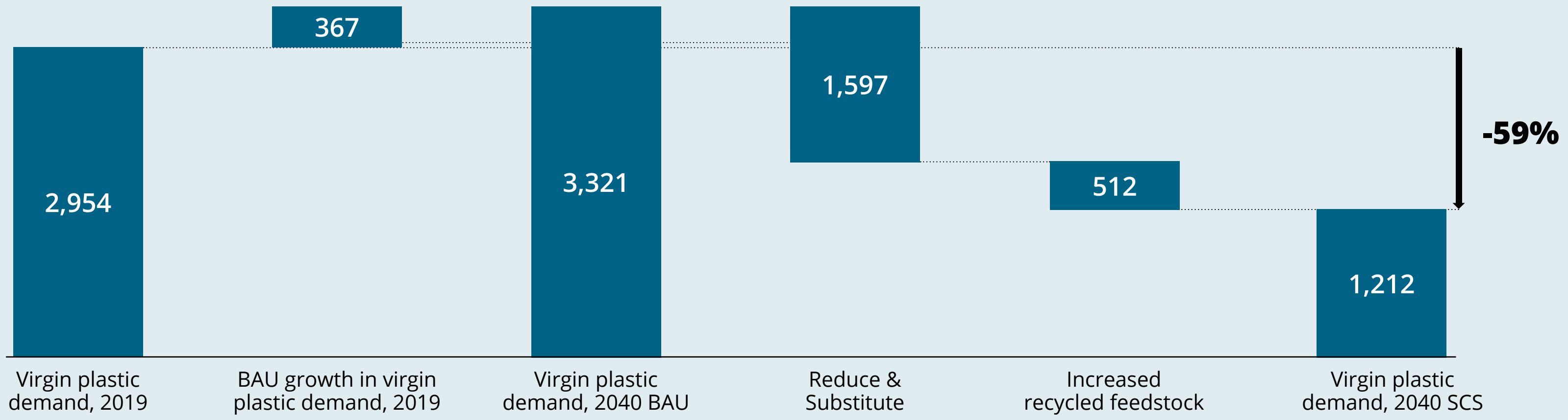


Source: SYSTEMIQ analysis[vi]

vi *Recyclate from post-consumer packaging waste. Remaining demand can be met by post-industrial recyclate or virgin material.

The analysis of both upstream and downstream interventions are of critical importance to realize the reductions in virgin demand. Both the elimination, minimization as well as the reuse interventions lead to direct reductions in virgin demand, but the management of the remaining waste would remain linear, characterized by high open loop and incineration rates. Only the 'downstream' interventions – D4R, improved collection and PCR-use incentives – enable the activation of the full virgin reduction potential: Without these, recycled content use would remain limited, and the linear model prevail for much of the plastic waste. It is only the combination of these interventions that drives a steep decline in virgin demand, as illustrated in Figure 14.

Figure 14: Virgin plastic demand under Business-As-Usual and the System Change Scenario (kt)



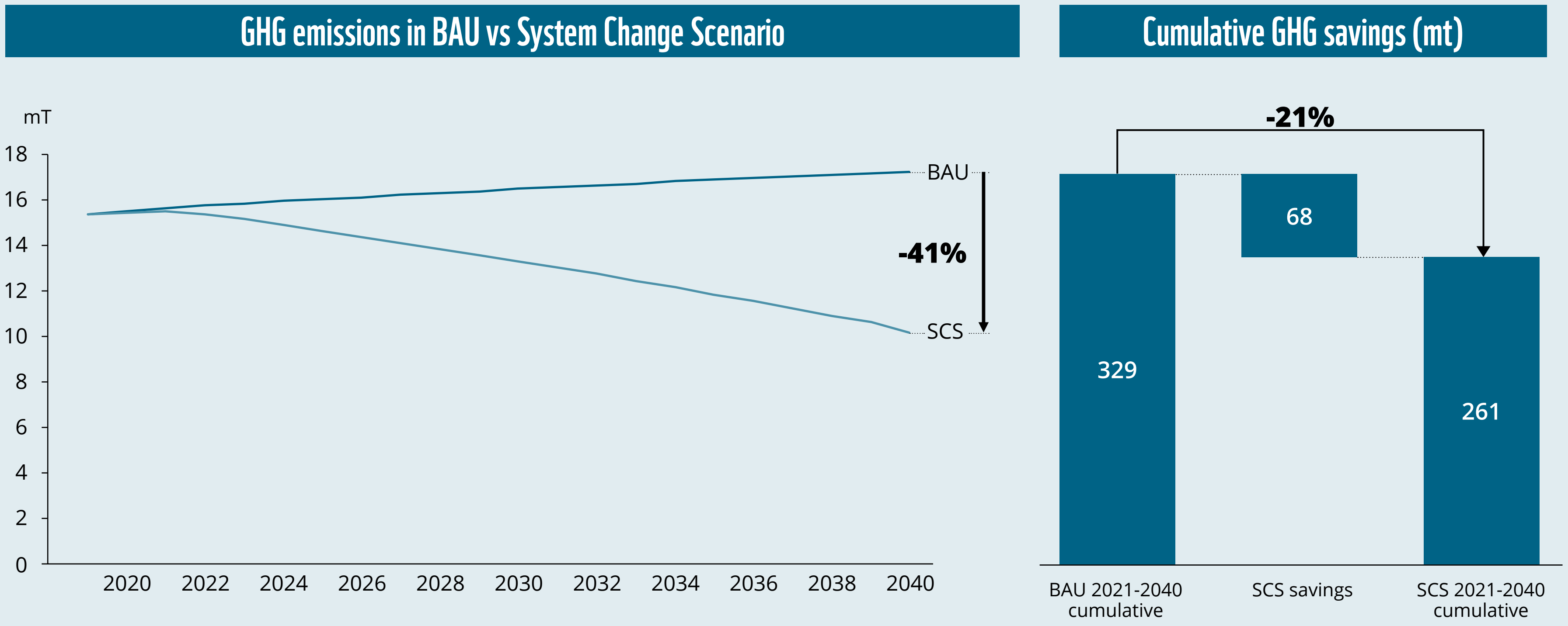
Source: SYSTEMIQ analysis

Our findings also show that the System Change Scenario can reduce GHG emissions by 41% in 2040, compared to Business-as-Usual – from 17.2 to 10.5 million metric tons of CO_{2eq} annually. Cumulatively, the System Change Scenario has the potential to save 68 million metric tons of CO_{2eq} – or 21% compared to a Business-as-Usual scenario.

Reduction of GHG emissions in the packaging system is primarily driven by a reduction in both the production and conversion of virgin plastic, which together account for close to 60% of total system emission, both in terms of per ton utility, as well as in absolute volume.

While the System Change Scenario represents a significant improvement over Business-as-Usual, the GHG reduction is not sufficient to be aligned with Germany's ambition for net carbon neutrality by 2045.[20] However, this scenario assumes a constant energy mix and did not include potential changes in increased renewable energy generation, electrification of vehicles or increasing energy efficiency in the production and operations of plastic production, use, and disposal. Hence, further decarbonization efforts are required that lie outside the system interventions modelled in this study. Potential measures can include further development of technologies that decarbonize the production of plastics, the transport sector, as well as reducing overall consumption.

Figure 15: SCS can lead to 41% less GHG emissions in 2040 than in BAU (mt)



Source: SYSTEMIQ analysis

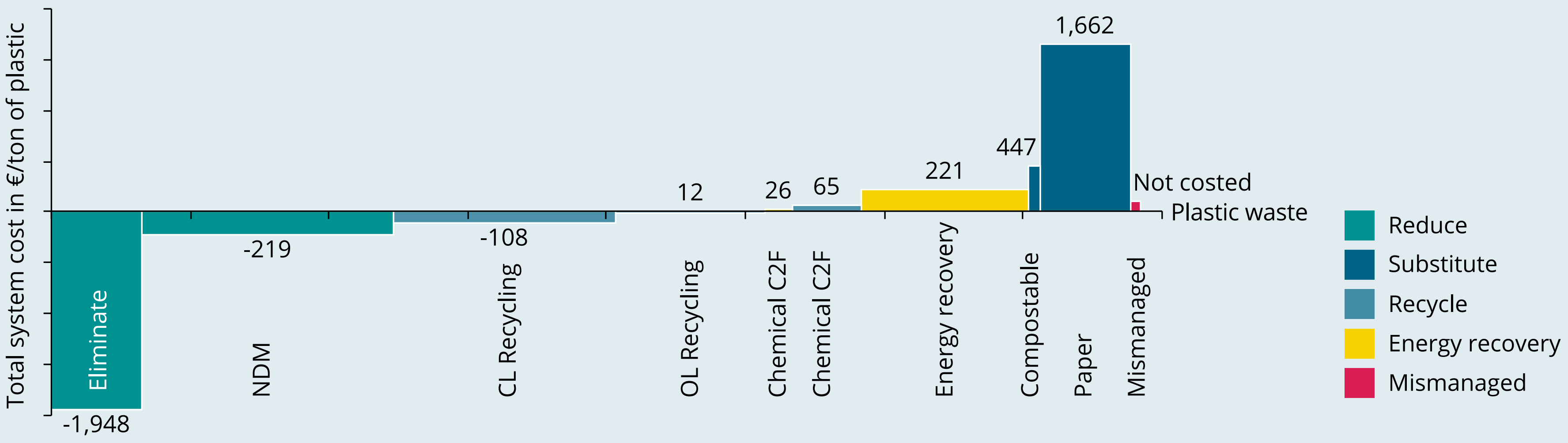
Better for the economy: Reduced system costs and new business opportunities

By 2040, the System Change Scenario can offer a net system benefit of close to 1 bn euros, or a cumulative total system cost reduction of 9%, compared to Business-as-Usual. Instead of incinerating valuable resources, the equivalent of over 3.8 bn euros annually, the System Change Scenario enables a more efficient and productive use of resources.

Primary drivers of this net benefit are the overall elimination and minimization of cost of packaging, the reuse interventions as well as from savings resulting from an increase in closed loop recycling (Figure 14).

- Eliminating plastics through product redesign or innovation would save the full cost of producing and converting one metric ton of plastic in the Business-as-Usual (BAU) plastics value chain, around €2000 per ton.
- Reuse models result in significantly lower material demand and net cost, depending on the number of reuse cycles. Due to the increased logistic costs associated with reuse models, cost savings per ton of utility are less than in the elimination interventions but would still result in net savings of more than €200 per metric ton.
- Of the recycling system interventions, closed-loop recycling is the only one that offers a cost saving. Although the other recycling system interventions, especially Chemical C2P present a net cost today, they could become much more economical in the future with scale, technological improvements, and policy support, and represent a net-saving solution for certain plastic categories.
- Substitution is the most expensive system intervention. The reasons for this for this are that more than a metric ton of paper is required to substitute a ton of plastic. Nevertheless, it can play a role for some applications where other materials result in better overall environmental outcomes and help to reduce food contamination of plastic waste streams, thereby increasing recycling quality and output.

Figure 15: Costs and masses per treatment type in the System Change Scenario (2040)



Source: SYSTEMIQ analysis

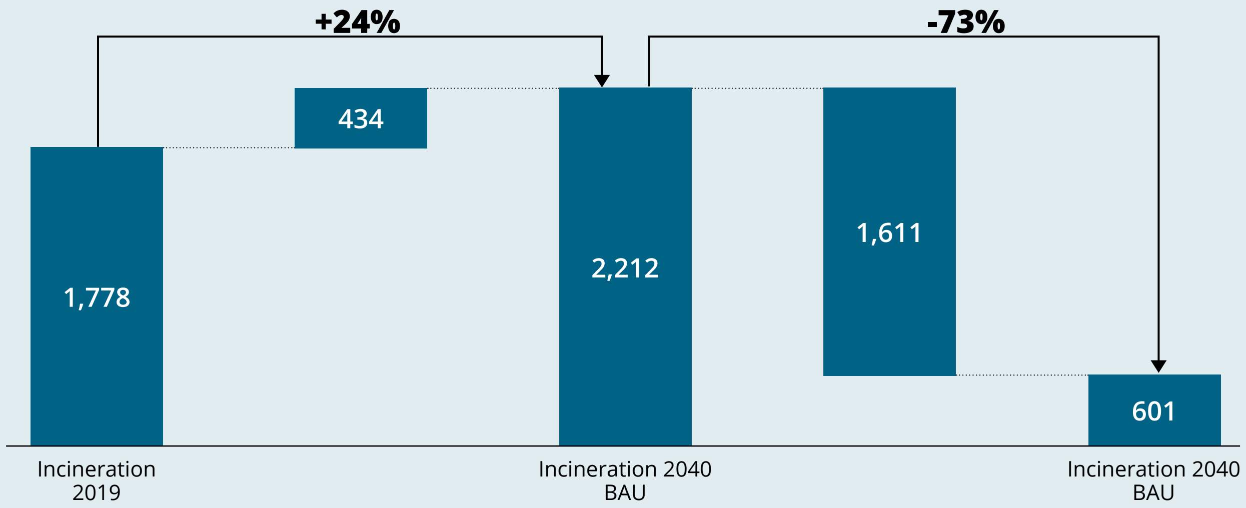
However, benefits and opportunities of a SCS for governments and industry extend beyond direct cost savings. For brands and retailers in Germany, reducing plastic waste presents a unique opportunity to capitalize on increasing consumer outrage and develop circular business models and products. New delivery models based on reuse, such as subscription models, give brand owners the opportunity to build long-term customer relationships, brand loyalty and customer retention, as well as to leverage insights into customer preferences and the performance of the offering.

Better for society: Local value creation at no costs to employment

The economic and environmental benefits of the System Change Scenario come at no cost to employment in Germany. Our results show that in a SCS direct jobs supported by the industry will grow slightly, by 1% compared to Business-as-Usual in 2040, predominantly in sectors linked to the significant growth in reuse and new delivery models. Compared to Business-as-Usual, value will not be primarily based on the extraction, production, and sale of fossil fuels, but rather on the circulation of materials and the retention of value within the local economy.

Reducing overall waste volumes, increasing design for recycling, collection and sorting can reduce incineration by 73% (Figure 17), and therefore retain that material and value for future use. Further, currently more than 620 kt of waste is exported for recycling and an additional estimated 20% of all recyclates, including post-consumer as well as post-industrial, are exported post processing. Reducing exports, both for waste and recyclates, can retain materials for local recycling and as inputs for the packaging industry, decreasing reliance on virgin polymers and ensuring a safe handling of the waste close to the source of generation.

Figure 17: Waste to energy recovery through incineration can be reduced by 73% (kt)



Source: SYSTEMIQ analysis

Seven complementary interventions for System Change

The System Change Scenario shows that a dramatic reduction of virgin demand, waste generation, waste-to-energy incineration and GHG emissions is possible, resulting in substantial economic, environmental, and social benefits. While this is a complex system level challenge, it is a process that is achievable through the implementation of the seven synergistic interventions outlined in Figure 18, concurrently, ambitiously, and starting immediately. Importantly, the seven system interventions are of complementary nature, hence implementing them simultaneously will yield the greatest impact. While innovation and new solutions across every part of the value chain can make the transition better, easier, and faster – it is worth acknowledging that the System Change Scenario achieves the system outcomes outlined in the following section with existing solutions.

Figure 18: Seven critical system interventions to enable a System Change Scenario by 2040

	System intervention	Most relevant plastic categories				Main responsible stakeholder
Upstream	1 Eliminate & minimize	Bottle (Not applicable)	Rigid (Highly applicable)	Flex (Highly applicable)	Multi (Somewhat applicable)	Consumer goods brands; packaging converters
Upstream	2 Reuse	Bottle (Highly applicable)	Rigid (Highly applicable)	Flex (Highly applicable)	Multi (Somewhat applicable)	Consumer goods brands; retailers
Upstream	3 Substitution	Bottle (Not applicable)	Rigid (Highly applicable)	Flex (Somewhat applicable)	Multi (Somewhat applicable)	Consumer goods brands
Downstream	4 Design for recycling	Bottle (Somewhat applicable)	Rigid (Somewhat applicable)	Flex (Highly applicable)	Multi (Highly applicable)	Consumer goods brands; waste management companies
Downstream	5 Increase collection & sorting	Bottle (Not applicable)	Rigid (Highly applicable)	Flex (Highly applicable)	Multi (Highly applicable)	Municipal government; waste management companies
Downstream	6 Food-grade plastics	Bottle (Highly applicable)	Rigid (Highly applicable)	Flex (Somewhat applicable)	Multi (Not applicable)	Waste management companies; packaging converters; retailers
Downstream	7 Recycling markets	Bottle (Not applicable)	Rigid (Highly applicable)	Flex (Highly applicable)	Multi (Highly applicable)	National government

Highly applicable | Somewhat applicable | Not applicable

Source: SYSTEMIQ analysis

Intervention 1.

System Intervention 1 – Eliminate & Minimize

8% (323 kt) of the 2040 plastic utility demand **can be reduced** through elimination and minimization

The first intervention focuses on eliminating and minimizing low-utility avoidable plastic that does not require a replacement. These are:

- **Eliminate:** This focuses on "eliminating the need for packaging or a packaging component, or making the packaging from an edible or dissolvable material" (i.e. eliminating the need to treat the material after use; edible coating that replaces plastic film on fresh produce).[21]
- **Minimize:** This reduces the plastic packaging per item without sacrificing plastic functionality or user convenience, for example by reducing over-packaging, smart weighting or concentrating products.

The analysis shows that up to 323 kt (8%) of the 2040 plastic utility demand can be reduced through elimination and minimization. Nevertheless, there are three challenges to reducing the amount of unnecessary packaging:

1. **Lack of incentives:** Particularly solutions that amend the product (e.g., shifting to concentrates) require acceptance and adoption from brand owners, packaging designers as well as from consumers. Elimination and minimization could be incentivized by:

   a. **Integrating elimination and minimization principles in eco-modulation of EPR fees:** The introduction of a bonus/penalty system in a potential funding solution in Section 21 of the German Packaging Act could help to incentivise brand owners to avoid low-utility plastic packaging.

   b. **Driving consumer acceptance:** Retailers have the opportunity to drive a mindset shift by incentivizing the purchase of unpackaged/minimized products (e.g. 'Treuepunkte'/'Green Points', instant offsets/plastic credits, gamifications).

2. **Lack of standards:** There are missing guidelines as to what constitutes unnecessary packaging. To activate the reduce potential, considerations include:

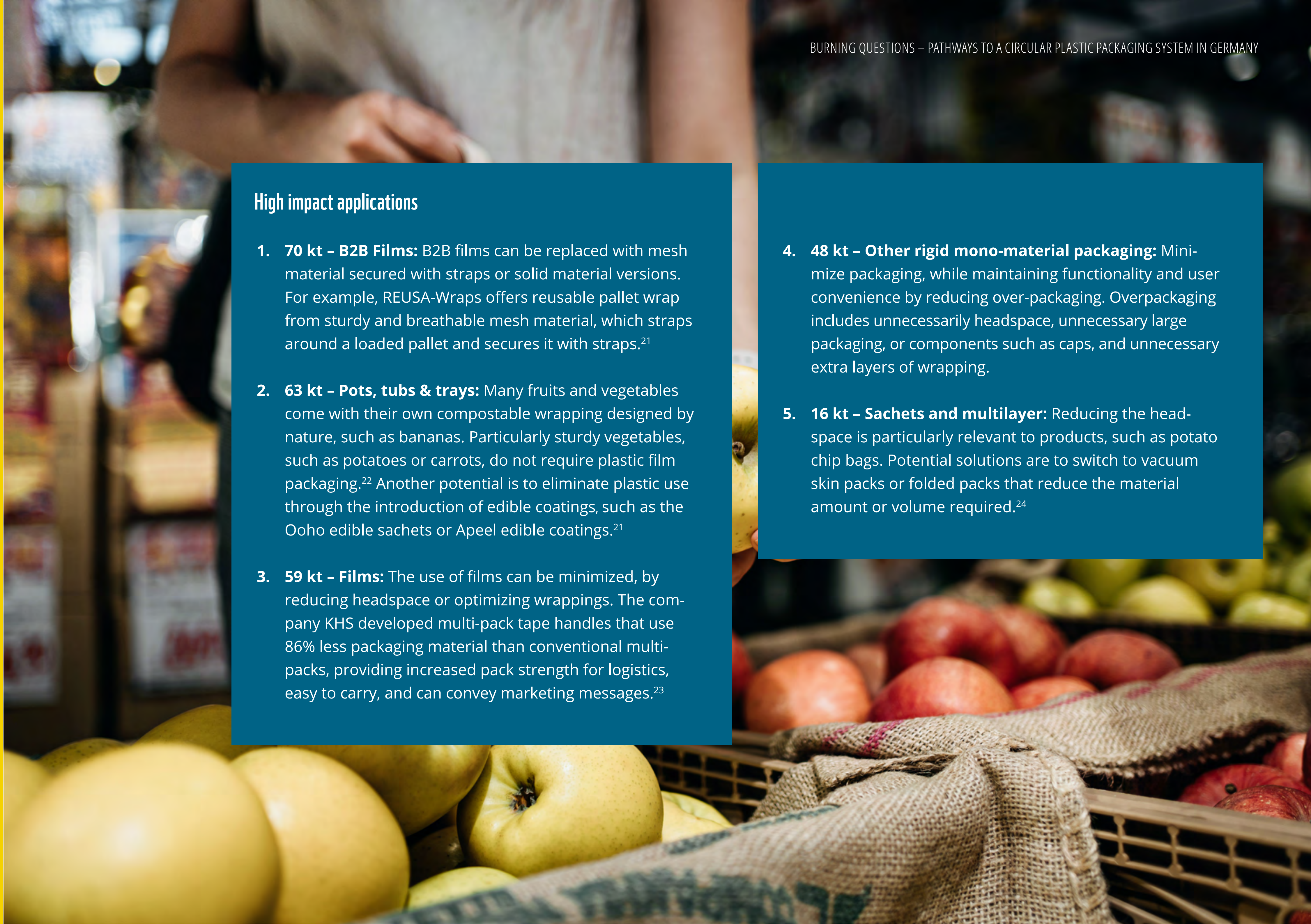
   a. **Standardized guidelines and assessment methodologies:** Brands and retailers should collaborate with suppliers to create a common understanding and alignment as to what constitutes unnecessary packaging and define appropriate standards and assessment guidelines.

   b. **Restrict unnecessary packaging:** Policymakers should enforce the implementation of such standards, by banning unnecessary packaging, such as: 1) excess headspace (e.g. more than 30%) for all flexible packaging; 2) unnecessary overwraps that do not provide a barrier function (e.g. multi-packs). Brands can go beyond regulatory requirements, by making public commitments to redesign their existing product portfolio by 2025 according to elimination and minimization best practices.

3. **Transparency:** A challenge for consumers is to understand what brands and which retailers have ambitious reduction ambitions and are undertaking measures to reduce unnecessary packaging. Increased transparency could help further inform purchasing decisions.

   a. **Publish plastic footprint:** NGOs, brands and retailers can support consumers in their purchasing decisions, e.g., by creating a plastic index, describing the average plastic content per shopping basket, per brand or plastic per product category (virgin/recycled).

   b. **Report on reduction results:** Brands can market their reduction/elimination progress by reporting on the removal of “unnecessary” packaging; for example, by using existing reporting templates (e.g., Global Commitment to a New Plastics Economy).



High impact applications

1. **70 kt – B2B Films:** B2B films can be replaced with mesh material secured with straps or solid material versions. For example, REUSA-Wraps offers reusable pallet wrap from sturdy and breathable mesh material, which straps around a loaded pallet and secures it with straps.[21]

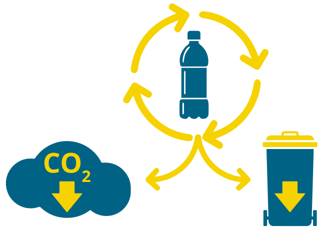
2. **63 kt – Pots, tubs & trays:** Many fruits and vegetables come with their own compostable wrapping designed by nature, such as bananas. Particularly sturdy vegetables, such as potatoes or carrots, do not require plastic film packaging.[22] Another potential is to eliminate plastic use through the introduction of edible coatings, such as the Ooho edible sachets or Apeel edible coatings.[21]

3. **59 kt – Films:** The use of films can be minimized, by reducing headspace or optimizing wrappings. The company KHS developed multi-pack tape handles that use 86% less packaging material than conventional multi-packs, providing increased pack strength for logistics, easy to carry, and can convey marketing messages.[23]

4. **48 kt – Other rigid mono-material packaging:** Minimize packaging, while maintaining functionality and user convenience by reducing over-packaging. Overpackaging includes unnecessarily headspace, unnecessary large packaging, or components such as caps, and unnecessary extra layers of wrapping.

5. **16 kt – Sachets and multilayer:** Reducing the headspace is particularly relevant to products, such as potato chip bags. Potential solutions are to switch to vacuum skin packs or folded packs that reduce the material amount or volume required.[24]

Intervention 2.



23% (909 kt)

of utility could be provided through reuse models, resulting in direct reduction of waste generation, virgin demand and significant CO_{2eq} savings

System Intervention 2 - Reuse

Reducing plastic waste while providing utility through ‘reuse models’ represent the single biggest lever to increase circularity. Reuse models – or so-called new delivery models – reduce material demand by replacing single-use plastics with reusable options, either through products that are owned and managed by the user or through new delivery models.[6] Contrary to user-owned reuse models, new delivery models require elements such as dispensers, reverse logistics, cleaning, delivery, financial incentives for customers, or subscription services.

Overall, we estimate that up to 909 kt or 23% of utility could be provided through reuse models, resulting in direct reduction of waste generation, virgin demand and significant CO_{2eq} savings. Similar to the Circular Economy Initiative Deutschland (CEID), this system intervention highlights the role of mandatory targets for the share of reusable products that extend beyond food-grade bottles to other sectors as well as the need for functioning shared pool systems.[12]

According to the Ellen MacArthur Foundation, there are four types of reuse models, spanning refill models where a customer owns the package or return systems where companies take back a package:[25]

- **Refill at home:** Consumers fill a reusable container at home, with refills either delivered to the door (e.g., a subscription service), or in a shop. Consumers retain ownership of the main packaging and are responsible for cleaning it. Refill at home can work in both traditional and online retail.
- **Refill on the go:** Users refill the reusable packaging at a dispensing point away from home, such as in a store. Users retain ownership of the reusable packaging and are responsible for cleaning it.
- **Return from home:** Users subscribe to a delivery and collection service that allows them to return empty packaging from home. A business or service provider then takes care of cleaning and redistribution of the packaging.
- **Return on the go:** Users purchase a product in a reusable container and return the packaging at a store or drop-off point after use. The packaging is either cleaned where it is returned (e.g. at a retail site) or a business or service-provider takes care of the cleaning and redistribution of the packaging.

This report quantifies the re-use target and the impact of concrete measures along three action areas:

Food-grade bottles

395 kt – Food-grade bottles: Food-grade bottles have the highest reduction impact potential, accounting for 32% of the total reduction potential, or 395 kt. The SCS shows that a respective share of 70% reusable bottles in 2030 and 80% in 2040 are possible. Further, our analysis reveals that reuse systems dramatically reduce virgin consumption and are highly beneficial in terms of GHG. Germany is in an excellent position for driving the reduction of single-use beverage bottles due to the well-established German multi-use bottle pool system for both glass and PET bottles (Mehrwegsystem). In addition, the transition to reuse is enabled by new emerging business models, such as beverage delivery services, such as Flaschenpost or by beverage refill at home (e.g. SodaStream or similar systems).[21] Nevertheless, there are challenges to increasing the share of reuse for beverage bottles.

1. **Policy guidance:** While Germany set a target of 70% of reusable bottles in §1 Packaging Act, currently there are no timelines, milestones, or an enforcement mechanism. To activate the reuse potential, measures to consider include:

   a. Policymakers 'operationalize', implement, and enforce mandatory targets for brands and retailers alike.

   b. As suggested by the CEID, policymakers can promote reuse systems through a reform of Paragraph 21 of the Packaging Act and the eco-modulation of EPR fees. Explicit reuse systems could be promoted bonus incentives from a separate private and public fund.[12]

   c. Both brands and retailers alike should commit to, and hold each other accountable for increasing the share of reusable bottles in their portfolio to 70% by 2030 and 80% by 2040.[vii]

vii This is especially relevant for discounters, which typically only sell single-use bottles. A notable exception is Netto, which has a voluntary commitment to a 50% share of reusable bottles.[37]

2. **Price:** Currently, the traditional German reuse ('Mehrweg') system for bottles is not cost competitive compared to single-use plastics, due to increased logistic costs and high repayment rates for rPET made from single-use bottles. However, this calculation does not take externalities into account such as the use of scarce resources, and the emission of GHG. In comparison, other new delivery models, such as refill-at-home or refill-in-store have considerable cost saving benefits.

   a. Mechanisms to internalize the externalities created through single-use plastics and to provide a strong economic incentive can nudge brand owners and consumers from single- to multi-use bottles. Examples for such economic incentives include a plastic tax on single-use bottles.[26]

   b. Brands and retailers can collaborate to achieve a high number of reuse cycles in practice to ensure environmental and economic viability. This can be done by using durable packaging that will not wear out.

3. **Convenience:** Whereas single-use bottles under the deposit-return scheme can be returned anywhere, this is not the case for multi-use bottles, which reduces customer convenience and increases transport cost.

   a. In combination with a mandatory target of 70% by 2030 a right to return multi-use bottles in all supermarkets, like the existing regulation for single-use bottles, can be considered. Such a measure would simplify return processes for customers and ensure that retailers, in particular discounters, dedicate resources to multi-use bottle handling.

   b. To maximize environmental benefit, brands should prioritize, and the regulator incentivize, the participation in pool systems. Pool systems shorten transport distances and provide material GHG savings. Consider examples of strong brands, such as Fritz-Kola or Bionade, that do not require an individual bottle but can also succeed within a pool system.

B2B and B2C Transport Packaging

192 kt – B2B and B2C Transport Packaging: Transport packaging, and in particular e-commerce, represent the second biggest impact opportunity potential for reuse systems. We estimate that reuse systems for B2B and transport packaging could reduce waste by 192 kt, consisting of B2B packaging (104 kt reduction potential), B2B films (35 kt reduction potential), and films (53 kt reduction potential). Increasing the share of reuse for transport packaging provides a high impact potential due to the large waste streams involved.

Nevertheless, there are three key challenges for scaling reuse systems in B2B and B2C transport packaging:

1. **Policy direction:** At present, there is no explicit focus on the part of policymakers with regard to increasing the reuse share among transport packaging. Potential actions to activate the reuse potential, include:

   a. Policy makers drive the share of reuse systems for transport packaging by introducing a mandatory reuse target of 50% by 2030 and 80% by 2040. This is most effective if supported by clearly defined enforcement mechanisms.

   b. Retailers, online retailers, and brands align their logistics to these targets.

   c. As suggested by the CEID, policymakers can promote reuse systems through a reform of Paragraph 21 of the Packaging Act and the eco-modulation of EPR fees. Explicit reuse systems could be promoted by bonus incentives from a separate private and public fund.[12]

2. **Convenience:** While there are several examples of scaled systems in the B2B sector, such as the Swedish Return System[21] for B2B packaging, reuse systems for the B2C sector remain at an early development stage. In Germany, initial success stories are The Box from LivingPackets[27] or recent pilot initiatives by the German retailers Otto and Tchibo.[28] Approaches to ensure the convenience of reuse solutions in transport packaging include:

   a. Both brands and retailers collaborate to achieve a high scale and convenience for consumers and to reduce costs, by establishing common reverse logistics, collection, storage, and sorting.

   b. Brands and retailers collaborate in the development of more universal standards for reusable and refillable packaging.

3. **Affordability:** According to a 2018 PwC study, 70% of respondents supported the idea of reusable transport packaging boxes and were willing to pay an average packaging deposit of €2.49.[29] Nevertheless, the market uptake of reuse models depends on the affordability for brands, retailers, and consumers. This can vary significantly depending on the set-up and scale. Affordability of reuse systems for B2B and B2C transport packaging can be achieved through:

a. Policymakers support the scale up of reuse systems for B2B and B2C packaging by offering subsidies, reuse incentives in EPR fees or financial support for the development of the necessary logistics infrastructure.

b. Brands and retailers collaborate to achieve a high number of reuse cycles in practice to ensure environmental and economic viability. This can be done by using durable packaging that will not wear out.

c. Brands and retailers collaborate to establish a shared pool system for transport packaging with standardised packaging, shared logistics, transport and reuse infrastructure, thereby minimising costs and GHG impact.

Reuse & refill concepts for retailers

167 kt – Reuse & Refill concepts in retail supermarkets: The introduction of new reuse models in supermarkets can meet plastic utility with 167 kt less single-use plastics. Retail supermarkets have a large potential for leveraging reuse and refill concepts in their stores. Examples are bulk refill stations, such as Algramo, or packaging take-back schemes, such as Loop, which is a reuse platform for groceries, offered online and in store by major retailers, and offering more than 500 products in reusable packaging (including big brands like Tide detergent and Heinz Ketchup).[21]

There are three key challenges for reuse/refill concepts in retail supermarkets:

1. **Policy direction:** At present, there is no explicit focus on the part of policymakers with regard to increasing the reuse share in retailers. Policymakers can drive reuse and refill concepts among retailers. For example, policymakers can consider implementing the following measures:

a. Policymakers provide a clear direction for the establishment of reuse/refill targets. In France, for example, there is current draft legislation requiring retailers exceeding 400m² of floor space to dedicate at least 20% of their store space to reuse/refill solutions beyond 2030.[30]

b. In accordance with the reuse/refill targets, brands and retailers alike commit to these goals and increase the share of reuse/refill systems in their product portfolio.

c. Policymakers extend the right for customers to use their own refill containers from gastronomy to fresh produce sales at retailers (e.g. "Frischetheke"), under the consideration of hygiene and safety standards.

d. As suggested by the CEID, policymakers can promote reuse systems through a reform of §21 of the Packaging Act and the eco-modulation of EPR fees. Explicit reuse systems could be promoted through bonus incentives from a separate private and public fund.[12]

2. **Suitability of different applications reuse/refill:** Not all packaging applications are equally suited for reuse/refill systems in-store. For example, in-store bulk dispensers for detergents or shampoo are considered difficult to implement by retailers, due to space requirements and cleaning costs. We suggest that brands and retailers should collaborate to identify and prioritize which product applications are best suited for a switch to different types of reuse models. For example, if in-store bulk dispensers are not suitable for shampoo, brands and retailers could instead explore return from home options (e.g. Loop), dissolvable dishwashing tablets or a return on the go model (e.g. DRS system for SeaMe).[31,32]

3. **Convenience:** Consumer acceptance is critical for the diffusion of reuse/refill systems at retailers. Potential inhibitors for customer acceptance are if the system is inconvenient or not seamless as well as perceived health and safety concerns.[31] Measures to overcome these challenges could include:

a. Brands and retailers collaborate to develop universal standards for reusable and refillable packaging to enable easy and convenient returns for consumers across different retail chains.

b. Brands and retailers collaborate to develop and test system designs to ensure alignment with user needs. This can include: 1) investments in dispensers that are easy to use and refill, automated, touchless, and safe; 2) design of convenient return processes and incentives for consumers.

c. Policymakers support the scale up of reuse/refill systems in retail, by offering subsidies or financial support for the development of the necessary logistics and dispensing infrastructure.

Intervention 3.

System Intervention 3 - Substitution

9% of the 2040 plastic utility demand can be substituted. Material substitution is a complex topic that requires careful examination and evaluation of case-specific factors

Material substitution is a complex topic that requires careful examination and evaluation of case-specific factors, such as performance, convenience, cost, and potential unintended consequences. The substitution system intervention focuses on substituting single-use plastics with other single-use materials. This system intervention considers two types of substitute materials: 1) paper and coated paper; and 2) biobased materials. These two materials were selected because they are the most prevalent and scalable substitutes for single-use plastics.

There are two main reasons for including substitution as a system intervention:

1. Substitution with paper and coated paper can increase recycling, since paper already has high recycling rates in Germany (77%) and can be recycled about 4-6 times;[6,33]
2. It increases the quality of plastic recyclates since it can potentially divert packaging wastes with high food contamination into the municipal waste and not the packaging waste stream.

For the purpose of this study, only thinly coated paper is considered that is acceptable to paper recyclers (i.e. plastic content is less than 5% of weight).[6] This includes products with dissolvable or other ephemeral barrier coatings, but excludes laminated materials, such as beverage cartons and coffee cups.[6] The use of biobased materials has potential environmental benefits since it can substitute fossil-based with renewable biobased materials. Nevertheless, these substitutes should only replace plastics in applications with very high rates of food contamination (e.g., ready-made sauces or to-go food service disposables) and only if shown to be environmentally advantageous by LCA-studies. To prevent potential misthrows and cross contamination of the organic waste stream, it is suggested that compostable biobased substitutes should be diverted to the general waste and incinerated. Single-use glass, aluminium, and aseptic cartons were not included as possible substitutes, due to negative trade-offs in costs, GHG emissions, and recycling rates compared to rigid monomaterial plastics.[6] The analysis of this system intervention is not a prediction or recommendation, but rather an indication of the future scaling potential of substitute material, under the assumption that there are no unintended consequences.

The analysis shows that up to 9% of the 2040 plastic utility demand can be substituted. Paper and coated paper accounts for 88% of the substitution potential (324 kt), whereas biobased materials account for 12% (42 kt).

There are three challenges for substitution:

1. **Clear communication and labelling:** Clear communication and labelling is important to ensure proper disposal of substitute materials in the paper bin for paper and coated paper, or the general waste bin for biobased materials. The aim is to help consumers clearly distinguish between substitute materials and plastic counterparts.

   a. Policymakers can support the substitution with biobased materials, by amending the Packaging Act to allow for specifically labelled packaging materials to be discarded in the general household waste bin.

   b. Brands can help consumers distinguish between conventional plastics and substitute materials by introducing clear product labels that inform consumers about the proper disposal routes.

2. **Circular and sustainable feedstocks:** A key concern for substitution is that the material needs to be sustainably sourced or based on recycled materials or waste. This is critical for avoiding unintended environmental impacts. To avoid unintended consequences, the following are important considerations:

   a. Brands adopt strict criteria or certifications for the sourcing of sustainable biomass. For paper and coated paper, the focus should be on harnessing biomass from sustainable certified sources, current residual materials as feedstock, such as commercial and household waste, as well as biological side streams such as waste wood.[12] To prevent contamination with with mineral oil-based printing dyes, food grade applications should be sourced from sustainable certified sources (e.g. FSC), whereas non-food applications can also rely on secondary sources.

   b. Retailers prioritize products with certifications for sustainably sourced or recycled substitute materials.

3. **Recyclability:** Design of paper packaging is critical to ensure recyclability of paper and coated paper substitutes. For example, non-paper materials, such as plastic windows or foils, are a significant challenge for recyclability. Ensuring the recyclability can be facilitated by:

   a. Policy direction to clarify and regulate design for recyclability guidelines for fibre-based packaging materials. Among others, this should ensure a limit of plastic linings (i.e., plastic content less than 5%). In addition, design for recyclability can be incentivized through the eco-modulation of EPR fees according to §21 of the Packaging Act.

   b. Brands design paper packaging for recyclability, which can avoid the use of non-paper materials, such as plastic windows or foils, and include water soluble inks, dyes, adhesives, and coatings that do not cause significant recyclability problems.

   c. Brands, retailers, and policymakers invest in the innovation of new materials, packaging designs, and barrier coatings to avoid the use of plastic linings and ensure that coatings and fillers are easily recyclable.[6]

High impact applications

1. **214 kt – Other rigid mono-material packaging:** Paper or coated paper alternatives for expanded polystyrene and other protective packaging.[6]
2. **48 kt – Films:** Paper/coated paper alternatives, particularly where water barrier properties are not necessary.[6] For biobased materials, this can include cellophane or starch.[6]
3. **40 kt – Sachets and multilayer flexibles:** Coated paper alternatives that are already available, such as recyclable paper packaging for snack bars developed by Nestlé.[34]
4. **33 kt – Pots, tubs and trays**: Potential applications are paper substitutes for fruit and vegetable punnets as well as coated paper substitutes for other categories, such as ready meal trays, as long as the material has sufficient moisture resistance.[6]
5. **15 kt – Food service disposables**: Widely available paper/coated paper clamshells or cups as well as bamboo cutlery or banana leaf wraps.[6]

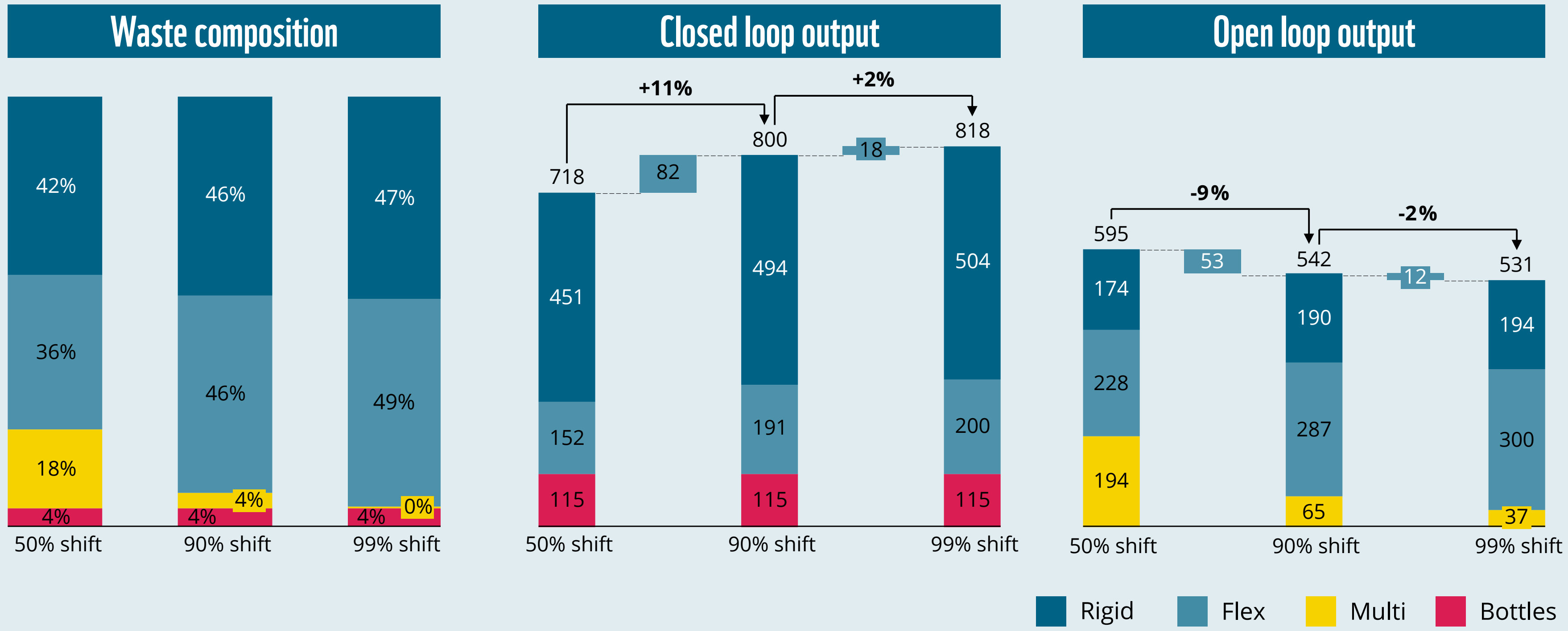
Intervention 4.

System Intervention 4 – Design for recycling

Design for Recycling is indispensable for more closed-loop recycling

Flexible and multi-polymer materials account for 45% of plastic waste but represent much of the waste that is waste-to-energy incinerated or open-loop recycled; hence, the material and its value is lost after one short use cycle. We estimate that currently 33% of packaging in Germany is not recyclable.[35] The findings from the report support the CEID's findings, highlighting Design for Circularity as one of the key challenges for the transition to a circular plastic packaging system in Germany.[12] Designing products or packaging for recyclability can increase the yield and the value of these materials. According to industry experts shifting 90% of multilayer materials to flexible or rigid mono-materials is possible, without losing the advantages of multi-materials, resulting in an increase of closed-loop recycling output by 11%. Harmonizing polymers, colours, additives, and closures can further increase the yield and value of recyclates.

Figure 19: Effect of different Design for recycling (D4R) shift rates on waste and recycling output (kt, 2040)



Source: SYSTEMIQ analysis

We identified 6 key criteria to design packaging for recycling:

1. Phase out all non- food-grade multi-materials by 2030, and all food-grade multi-materials by 2040, switch to mono-materials.
2. Stop the use of PVC, EPS, and carbon black by 2025.
3. Commit to use only transparent, uncoloured containers.
4. Ensure all labels are easily removable, minimal direct printing on the container.
5. Ensure the choice of additives, barriers, coatings, adhesives, and ink are not problematic for recycling.
6. Ensure closure material choices are not problematic, e.g., phase our silicone seal and valves, PS, PVC, aluminium, and steel caps.

While many brands are progressing in their D4R efforts, the process can, and should, be accelerated. We identified three key areas for action to sustain, and accelerate, D4R momentum:

Lack of transparency: The current recycling system is impeded by a lack of transparency with regards to the polymers, additives and other inputs used. This lack of transparency persists on a macro level, e.g., how much of certain inputs are in circulation, or what brands use which inputs, as well as on the micro-level, e.g., what is the composition of a specific piece of packaging that enters a recycling facility, and along the value chain, from the original packaging producers, to filler, retailers, and recycler. This lack of transparency hinders the development of a clear D4R roadmap, incentivizing D4R efforts, as well as the efficiency of sorting and recycling processes.

a. **Increase system level transparency:** Policymakers can increase transparency through the reporting of the recyclability of packaging brought into circulation by brands to the Zentrale Stelle, as a means to i) monitor progress and ii) way to set incentives.

b. **Producer level transparency:** Brands can increase transparency by publishing recyclability targets and report on progress, for example via the Ellen MacArthur Foundation's Global Commitment.

c. **Product level transparency:** The sorting and recycling processes can be enhanced by open-source standards for the whole product lifecycle, on-packaging tracers and markers detailing the packaging composition and origin for traceability. This includes promoting consumer appreciation of recycled materials, and other potential quality limitations common to recycled materials.

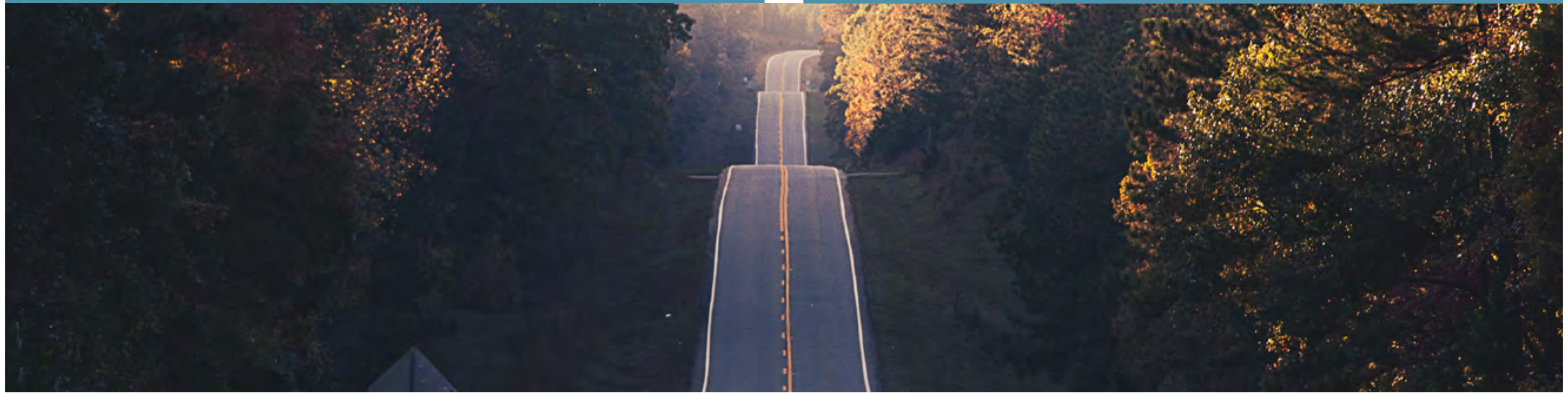
Degree of recyclability: Current efforts focus predominantly on eliminating multilayer materials and problematic polymers. However, Design for Recycling goes well beyond the elimination of multilayer materials and recyclability is not a binary-evaluation and one-time effort, but rather a process of continuous improvement.

a. **Develop a D4R Roadmap:** A roadmap of increasingly strict D4R (minimum) requirements could i) reduce complexity of packaging and enable cost effective recycling and ii) provide a clear time horizon and expectations to brands and producers.

b. **Commit to D4R Principles:** Further, we urge brands to define targets by which all packaging will adhere to minimum requirements, to commit to incorporate D4R principles for all new packaging developments, respectively for all packaging renovations.

Lack of incentives: Currently, beyond the minimum requirements, producers have few incentives to design for high degrees of recyclability. Design for recycling can and should be incentivized, and those who ensure a high degree of recyclability should be rewarded.

a. **Setting incentives:** A potential avenue for providing financial incentives for recyclability could be through an eco-modulation of EPR fees, respectively the update of Paragraph 21. For example, using clear/transparent packaging will result in a higher recyclate value and thus should be incentivized. This system can be designed dynamically and compare a products recyclability to a weighted average recyclability of similar products. As suggested by the CEID, one promising solution is the establishment of a fund financed by private and public players, from which such bonus incentives could be financed.[12]



Intervention

5.

System intervention 5 - Increasing collection and sorting

Improved collection and sorting could increase closed-loop recycling outputs by 22%

Germany has long established separate collection systems for recycling, with currently 9 system operators. Recyclables such as plastic packaging, aluminium, and paper are collected separately from municipal solid waste, creating (relatively) clean waste streams. As a result of this system, Germany boasts a separated collection for recycling rate for plastic packaging of approximately 75%, which is among the highest rates of large, industrialized nations.

Despite this high rate of collection for recycling, incorrect separation continues to be a challenge for the recycling system. Especially organic materials in the collection for recycling system are problematic as they contaminate recyclables. Equally, plastic packaging thrown in the municipal solid waste is typically lost for the recycling system and sent for incineration.

Our analysis shows that increasing separated collection for recycling rates and improving sorting processes represent an impactful lever for circularity: Improving separated collection for recycling rates from 75% to 85%, while reducing sorting losses from 18% to 10%, could increase closed-loop recycling outputs by 100kt (22%) and open-loop recycling outputs by 42kt (6%) while reducing incineration volumes in 2040.

We identified three approaches to improve collection for recycling and sorting:

1. **Standardizing collection systems:** Currently, multiple systems for collection of recyclates exist. Whereas in some areas recyclates must be deposited at a central location ('Wertstoffinsel'), in others they are collected through separated bins and bags at a household level ('Gelber Sack'). Standardizing these systems (collection containers and collection rhythms) could result in a simplification for the consumer and increase separated collection.

2. **Raise consumer awareness:** Investing in continuous consumer awareness and education through public campaigns represent an opportunity to increase quantity and quality of collected recyclates.[12] Further, models such as 'pay per waste volume' as in the Dutch system, could further increase awareness and incentives for separated collection.

3. **Provide clear on-packaging recycling instructions:** As packaging is getting ever more differentiated and specialized, the correct recycling requirements and what consumers should do to ensure a high recyclability are not always obvious. To address this challenge, brands can aid and educate consumers by providing clear and simple on-packaging recycling instructions. At the same time, however, the dismantling of packaging should not be too complicated for the consumer.

Intervention 6.

System intervention 6 – Food-Grade Plastics

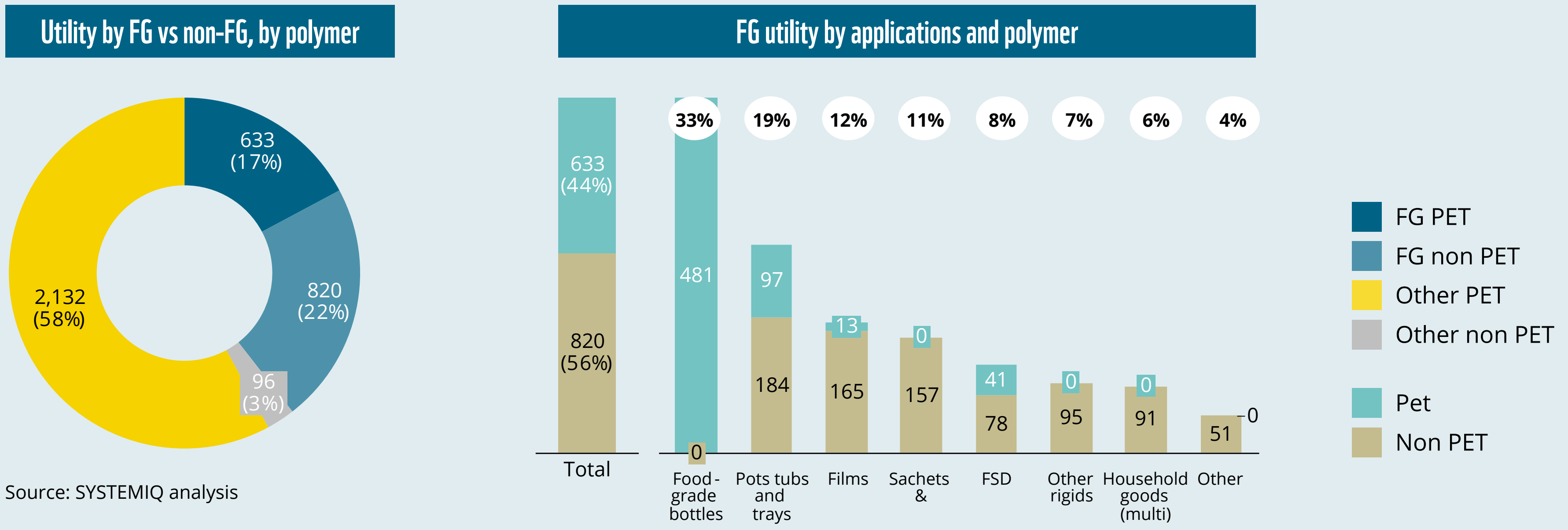
Food-grade plastic packaging is the 'work-horse' of industry, but also a challenging application group

Food-grade (FG) plastics represent an estimated 1325 kt (40%) of all plastic packaging utility and therefore a major contributor to packaging waste.

FG plastic packaging is the 'workhorse' of the plastic packaging industry, but also a challenging application group. FG plastics often require barriers and coatings to protect the packaged good, and are likely to be contaminated with organic residues which complicate the recycling process. Further, they must, rightfully, adhere to strict health and safety requirements and as result, the use of recyclates in FG plastics is limited by the *European Food and Safety Agency* (EFSA).

Currently, FG-to-FG recycling is limited to PET that is collected via a separated waste stream, in practice only PET bottles collected via DRS (481 kt). PET bottles represent 33% of the food grade plastic demand and although they have a 98% return rate, only 38% are recycled into new bottles.[14] FG waste that is collected outside the DRS (897 kt) is either recycled to other non-FG applications, exported, or incinerated.

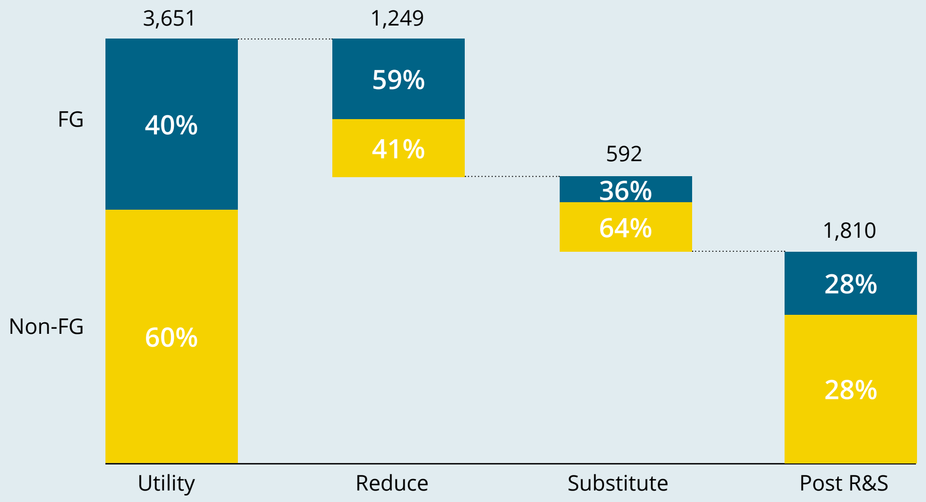
Figure 20: Overview of food-grade and non-food-grade plastics in 2040 (kt)



Source: SYSTEMIQ analysis

The reduction and reuse interventions and, with the outlined limitations, the substitution intervention have the potential to lower FG packaging waste by 871 kt (41%), compared to 727 kt non-FG (33%). Further, they have an outsized impact on FG, reducing the share of total packaging waste from 40% to 28% – underscoring the importance of these levers to address FG plastics as a challenging application group. However, even after these interventions have been applied, 594 kt of FG packaging demand remain. When FG plastics are recycled into other packaging applications, material cascades towards lower-value applications and is lost for FG purposes. While cascading reduces (virgin) demand elsewhere, FG plastics continue to rely on a constant input of virgin material.

Figure 21: Impact of R&S on FG vs non-FG waste (kt, 2040)



Source: SYSTEMIQ analysis

To increase the circularity of FG packaging, we identified two principal levers, the mechanical and chemical recycling routes:

1. **Mechanical recycling:** Following the waste hierarchy, mechanical recycling represents the next best option following prevention. However, current EFSA regulations restrict the use of non-PET mechanically recycled content for FG packaging, even if collected via a separated waste stream. A favourable change of regulation by the EFSA could create the opportunity to use FG recyclates as inputs for FG packaging, and thus enable a 'like to like' recycling. Increasing circularity of FG packaging, can be supported by:

   a. A compilation of a comprehensive science-based data and knowledge base, evaluating the risks associated with the use of (non-PET) PCR in FG packaging.

   b. A critical evaluation of the current regulation and standards pertaining to the use of PCR in FG packaging.[12]

   c. An exploration to establish separate collection for FG recycling waste streams, for example through a DRS system for FG rigid containers. We estimate that 329 kt could be collected through such as system, recycled and used as inputs for FG packaging.

2. **Scaling up chemical recycling:** Apart from the disposal of waste, chemical recycling of plastics to plastics is a 'lever of last resort', addressing the volumes that cannot be reduced, substituted, or mechanically recycled. As such, chemical recycling should not compete with mechanical recycling, but address the remaining waste streams. While the technology is still maturing, cost and GHG emissions require further assessment, chemical recycling could provide a viable option to increase FG packaging circularity in the absence of a changing EFSA regulation. We estimate the potential for chemical recycling of FG packaging between 253 and 498 kt in 2040. The exploration of the potential of chemical recycling can be supported by:

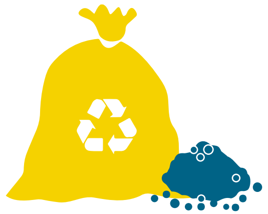
   a. A continuous, industry-academia-policy LCA evaluation of the cost, GHG and yields of chemical recycling;

   b. Investments in pilots and 'early-commercial' chemical to plastic plants to evaluate real life performance;

   c. Once proven senseful, incentives to scale up technology, as well as measures to avoid and reduce chemical-to-fuel conversion of plastic packaging waste.

Intervention

7.



System intervention 7 - Recycling Markets

There are currently two principal challenges. First, there is a lack of high-quality supply, traceable through its lifecycle and recycling process. Second, there is a lack of demand, induced by structural price differences.

Currently, markets for recycled content are stifled, resulting in low use of recyclates in the packaging sector: Although 48% of plastic packaging waste enters the recycling system in Germany, recyclates contribute only 11% to the packaging conversion demand. Of those 11% only slightly more than half is made from PCR (255 kt, 54%), with the remaining recyclate input sourced from post-industrial waste (219 kt, 46%). The larger share (63%) of PCR from packaging is currently being exported or used as input in other sectors, such as construction or automotive.

There are currently two principal challenges to recycling markets. First, there is a lack of high-quality supply, with defined and certified quality, traceable through its lifecycle and recycling process. Second, there is a lack of demand, induced by structural price differences between virgin materials and recyclates. Both dimensions need to be addressed to enable functioning recycling markets, and an increased uptake of PCR in packaging:

1. **Missing standards:** Although a variety of standards for recyclates exists, such as DIN EN 15345 for PP or DIN EN 15348 for PET, they are often out-dated and do not cover the technical requirements for 'modern' recyclates'. As result, using recyclates entails high transaction costs for brands and producers, including the sourcing of adequate suppliers or the chemical analysis and quality control of each individual batch.

Especially for smaller brands and recyclers, without large sourcing departments and sophisticated chemical laboratories, these transaction cost represent significant barriers. Further, the lack of standards also creates legal and business risks, for example related to the migration of toxics from the packaging into the packaged good.

a. Industry initiatives such as Cospatox or DIN SPEC 91446 are promising initiatives to address these gaps, to define quality levels, and reduce transaction cost. However, a recognition by the regulators, and ideally a harmonization on EU-level, is critical to enable the large-scale use of PCR in packaging. This includes a critical review of current standards such as the EFSA opinion or ISO 16103.

b. Further, to enable the use of recyclates across a variety of application groups a differentiated system of standards is required: These standards ideally differentiate between different quality levels acccording to the respective chemical-physical properties of the recylate and define for which use cases what quality levels are necessary.

c. Finally, standards should enable the tracing and certification of materials, especially concerning the source and conversion history.

2. **Financial incentives:** Compared to virgin plastic, recyclates face structural cost disadvantages – virgin plastics are produced in large, often integrated plants, with significant economies of scale and low fixed costs. Recyclates in contrast are processed in small to medium, decentralized plants, with significant operational costs and low scalability. Further, virgin prices are highly correlated with the price of crude oil, whereas recycling costs are relatively fixed. As a result, recyclates face structural economic disadvantages, resulting in a lack of demand and investments to scale and thus do not provide the volumes and quality required for a transition to a circular packaging economy.

   Economic incentives could level the playing field between virgin and recyclates and set incentives to maintain polymer quality over as many lifecycles as possible, and thereby enable a circular packaging. Possible measures are:

a. The price of virgin material could include the cost of the environmental impact costs associated with their manufacture, namely pollution and CO_2 emissions, e.g., through a tax mechanism, either on CO_2 or for virgin plastic packaging raw materials.[12]

b. Earmarking the revenue of the European plastics charge (800€ per ton of non-virgin material) for research and development, and recycling infrastructure could further improve recycling economics.[36]

c. Developing clean input streams to ensure high-quality recyclate, for example through deposit return schemes for other types of packaging, in particular rigids.

d. Incentivize the use of recyclates, for example in the context of an eco-modulating EPR fee according to § 21of the Packaging Act. Ideally, such incentives would reward leaders, those who use above-average shares of recyclates, relative to their peer producers, encouraging a "race to the top" for circular plastic packaging.

Conclusion

The transition to a circular packaging economy is not an end in itself, but is critical to enable sustainable and prosperous futures. In line with this, we show that a Systems Change for a circular plastic packaging economy is possible, including reducing the economic, environmental and social costs of plastic packaging waste.

Furthermore, while the challenges of a linear plastic economy and the need to transition towards circularity have been rehearsed by many, this report shows how such a vision can become reality, what needs to be done by whom, and what impact these interventions would have. We detail an ambitious, but realistic scenario, achievable with strategies, policies, and technologies currently at hand.

To enable such a System Change Scenario there is no time to lose, we ought to employ both upstream and downstream solutions concurrently and at scale. This, no doubt, will require significant efforts, ambition and courage from industry and policymakers.

However, we show that this will be a highly worthwhile endeavour – we can reduce virgin consumption, waste generation and GHG emissions, enabling local value and job creation, and resulting in an overall net system benefit of close to 1 bn Euro compared to business as usual. The systems change scenario is not yet a net zero carbon or waste vision, but it is a key building block to this end.

Finally, by walking the path of systems change, Germany can build on achievements in waste collection and become the blueprint of a circular plastics economy transition in Europe and for developed countries at large, setting an example of how it can be done and paving the way for others to follow suit.

Appendix

Plastic utility as a core concept

The concept of plastic utility is integral to the modelling undertaken in this study. As an overarching concept, utility refers to the satisfaction of 'needs received by consuming a goods or a service'. For the purpose of this study, plastic utility is defined as the services provided by plastic under a Business-as-Usual Scenario, such as protection or food preservation. In alternative scenarios, plastic utility can be provided through other goods and services with less (virgin) plastic use. The demand for plastic utility is derived from the amount of post-consumer plastic packaging waste generated.

Waste hierarchy

The assessment of alternatives and evaluation of solutions is based on the waste hierarchy as proposed in the EU Waste Framework Directive (Directive 2008/98/CE)[12] and is operationalized as follows:

1. **Prevention:** Prevention covers measures that are taken before a material or a product becomes waste. The eliminate and minimize system intervention prevents single-use plastic waste by avoiding plastic altogether or increasing the resource efficiency of product designs. The reuse system intervention focuses on the transition to consumer behaviour and new delivery models that ensure the reuse of products. In addition, substitution falls under this category since it substitutes products that are less suitable for recycling by: 1) substituting plastics with recyclable paper or coated paper or 2) substituting plastics with high degrees of food contamination with biobased materials to increase the quality of collected plastic packaging wastes.
2. **Preparing for re-use:** This means checking, cleaning, or repairing products recovery operations that return products or components that have become waste so that they can be re-used.
3. **Recycling:** Recycling covers any recovery operation in which waste materials are reprocessed into products, materials, or substances regardless of whether it is for the same or other purposes. The other four system interventions: design for recycling, increasing collection and sorting, food-grade plastics, and enabling recycling markets, all fit into this level of the waste hierarchy, since they focus on increasing the quantity and quality of plastics recycling.
4. **Other recovery, e.g. energy recovery:** Energy recovery covers any reprocessing into materials that are used as fuels or other means to generate energy.
5. **Disposal:** Any operation in which waste does not serve a useful purpose by replacing other materials which would have otherwise been used to fulfil a particular function.

Balanced Evaluation

To provide a holistic view of the current plastic packaging system, the potential to transition towards a circular packaging economy, we model the GHG, cost and job implications of alternatives and interventions to account for potential for unintended consequences. Further, the evaluation and modelling of alternative scenarios includes health, safety, environmental and operational considerations, so that proposed solutions meet strict standards. Future research could include additional dimensions, such as land or water use, chemical inputs and potential for pollution, or the impacts on human health.

Model typology

The quantitative model to analyse plastic consumption and waste flows assumes a comparable level of plastic packaging consumption and quality of waste service delivery throughout Germany. As such, in contrast to the original BTPW model, it is a country-level model, without differentiation between coastal and non-coastal regions (that influence leakage to the ocean), rural-urban distinctions or income differences. Given the focus on packaging and single-use plastic with an average lifespan of less than three months,[14] this model is a flow-model, and does not consider the build-up of stocks or inventories; for example, locked up in buildings, cars, or other long-living applications. The model is deterministic, as opposed to stochastic, and as such does not consider statistical uncertainties, nor weight future scenarios by their probabilities.

Systems map

To model the flows of material through the German waste system we developed a systems map (see figures 23-26). The plastic value chain was categorized into five major components: production and consumption; collection and sorting; recycling; disposal; and mismanaged are depicted with dashed outlines. The boxes labelled with letters represent mass aggregation points in the model, and the arrows represent mass flows. Boxes outlined in solid lines represent places where plastic mass leaves the system. The boxes to the left of Box A reflect plastic demand. Contrary to the global plastic system map introduced in BTPW, everything related to informal collection and post-collection mismanaged waste was excluded as this is deemed irrelevant in a German context.

Data

Wherever possible, the analysis was based on actual, recent, institutional, and Germany-specific data to estimate the flows of plastic packaging through the waste system. Typical sources include market research reports, statistics from institutions such as the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety or from trade associations. In cases when no direct data was available, the model drew on proxy data to estimate flows; for example, the size of restaurants to estimate the use of disposable food service plastics. Only in cases where no Germany-specific data was available, the analysis made use of the variables for high-income countries as defined in the global study.[viii] The quantitative data used in the model was verified, complemented, and triangulated in expert interviews.

viii An overview of the data mapping can be found in the appendix 1.

Model constraints

The model seeks to explore the potential to transition to a circular plastics economy by analysing constraints and potential for scaling of different interventions, based on historical trends and developments. As such, the model seeks to understand what is possible and what are the measures required to activate the potential, rather than solving for a desired end-state or goal, such as net zero carbon by 2040. All 'user-based' alternatives, i.e., solutions that require the consumer or user of the material to make choices, were evaluated by a four-criteria framework that determines their potential as single-use alternatives (see Appendix). Only if an existing solution is available, satisfies performance requirements, is affordable and convenient for the user, was it considered as an alternative with significant potential. In cases where alternatives do not satisfy these four criteria, their potential was discounted and limited by the worst-scoring criterion.

Non-user dimensions, for example material substitution or recycling, including sorting or recycling technologies, were evaluated and by their technological development, GHG and cost implications. If an alternative or intervention results in significantly higher GHG emissions or costs, its potential as a viable alternative was discounted. For example, chemical recycling may be a complement for mechanical recycling, resulting in virgin-like quality. However, due to its early-commercial stage and high unit costs, its potential to provide a large-scale alternative is limited over mediate timeframes.

ix A detailed overview of the applications and their respective volumes is presented in Appendix 1.

Material scope

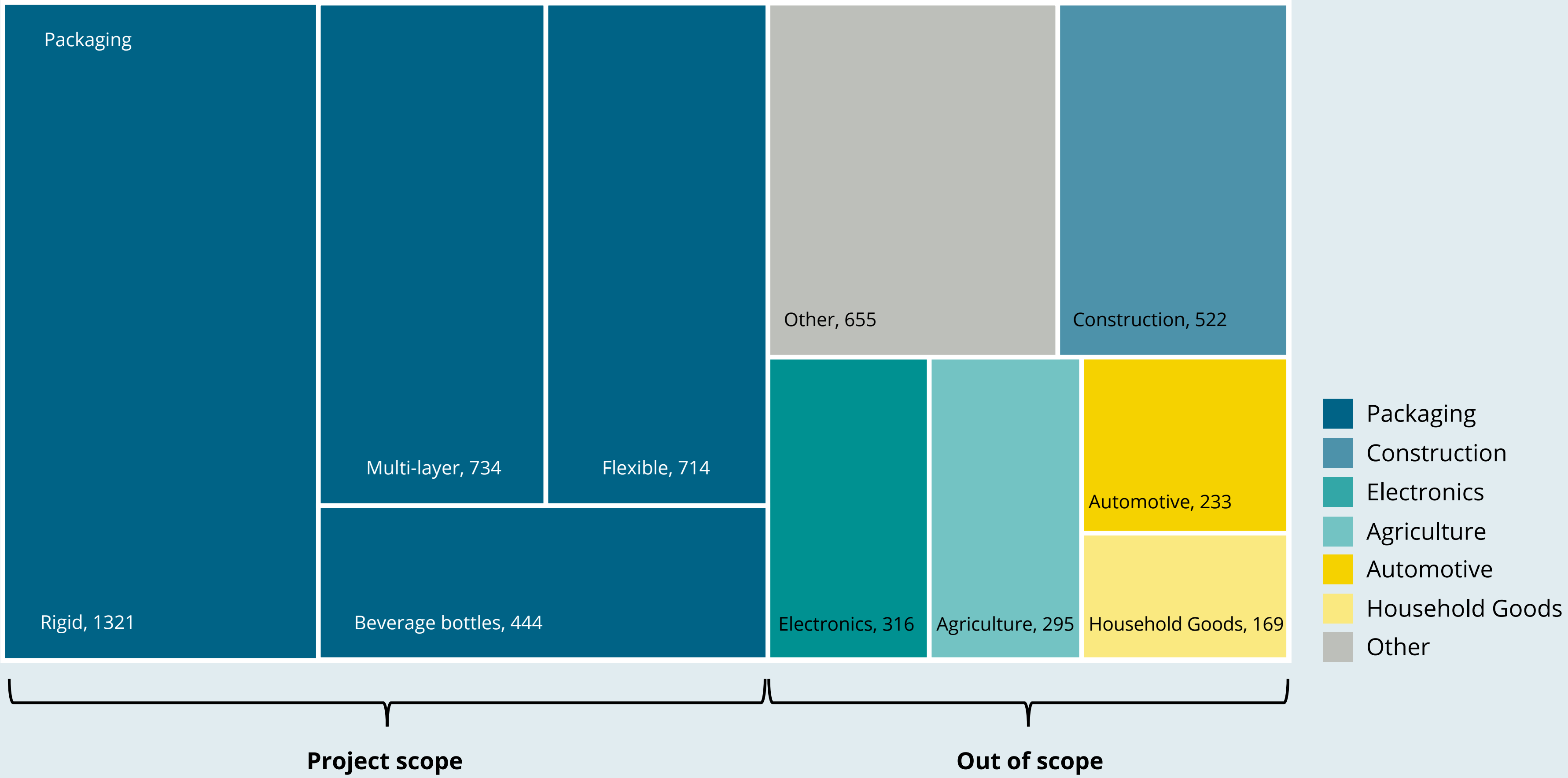
The analysis quantifies the flows of packaging and other 'fast-moving plastics' with an average lifespan of less than three months.[14] The analysis focuses on plastic packaging, both B2C and B2B, as well as single-use household products. These formats and applications represent a major share of the total plastic consumption, the lowest recycling rates, and the largest contributor to plastic waste.[8,9] Excluded from this analysis are medical and hazardous wastes, electronics, textiles, furnishings, agricultural waste, transportation, construction, as well as microplastics.

Due to their differing economics, applications and recyclability, the model differentiates between four material types and 14 application groups:[ix]

- Rigid mono-materials, such as bottles, tubs, pots, and trays.
- Flexible mono-materials, also as bags or films.
- Flexible multi-materials, which combine different polymer layers and/or non-plastic materials, such as beverage cartons, sachets, and hygiene products.
- Food-grade beverage bottles, including mineral water, soda waters, fruit juices and dairy products.

Together these applications account for 27% of total plastic consumption and represent almost 60% of total post-consumer plastic waste:[8]

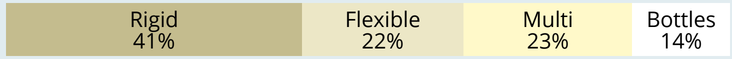
Figure 22: Overview of the material scope, contribution to plastic waste in Germany (kt, 2019)



Source: SYSTEMIQ analysis, Conversio[8]

Plastic packaging is comprised of the four material types. The largest share of the four material types are rigid mono-materials, followed by 22% flexible mono-materials, 23% multi-materials and 14% beverage bottles.

Shares of different material types (2019)



Source: SYSTEMIQ analysis

Table 1: Detailed waste and application split and volumes.

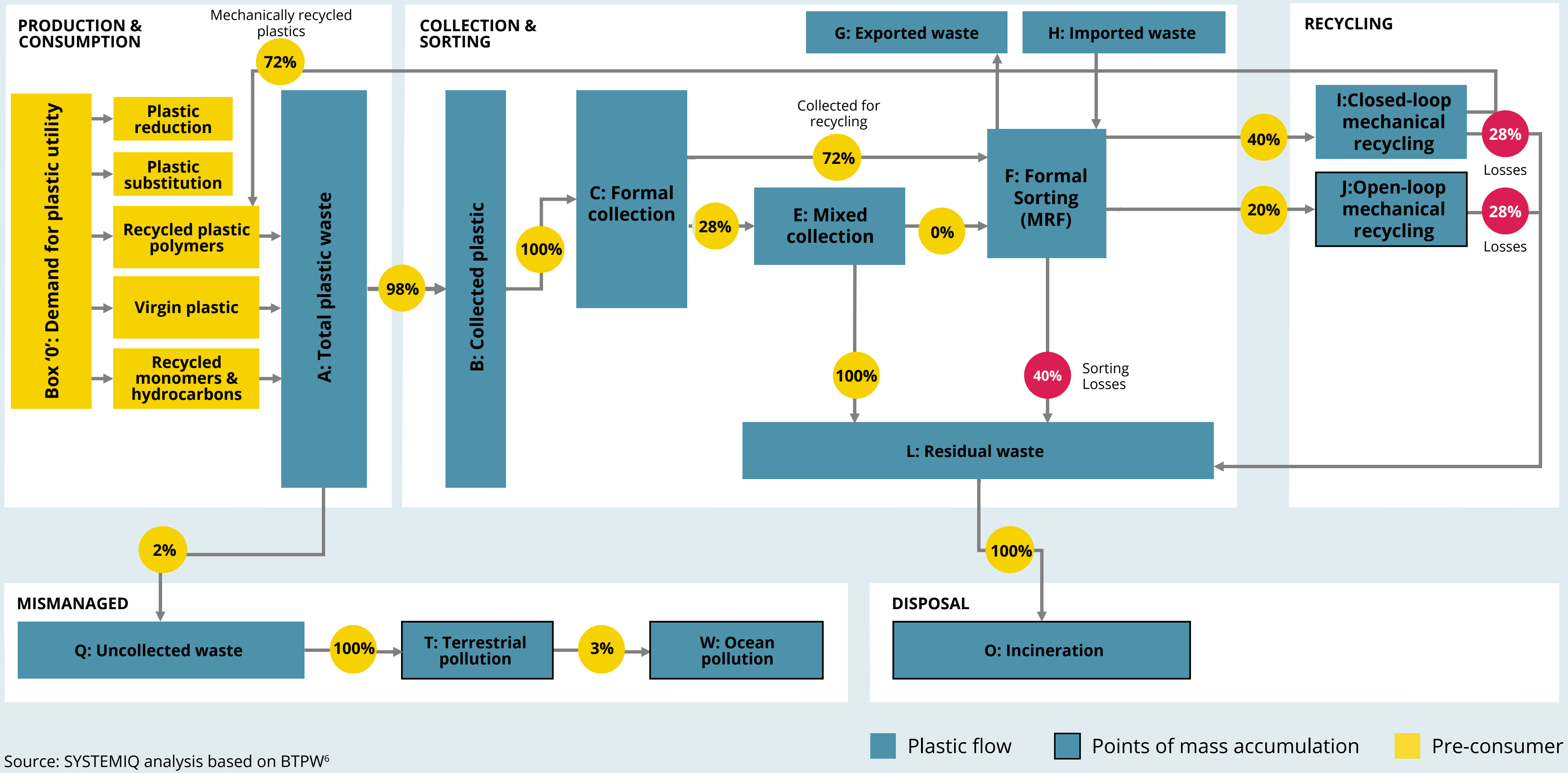
Type	Application	Examples	Germany		
			kt	%	% (group)
Rigid	Non-food-grade bottles	Non-food bottles eg household, cosmetics. Includes spraytops, bottle tops, handles	174	5.4	41
Rigid	Food service disposables	Rigid EPS, PS, PP, HDPE, MDPE and PET takeaway boxes, clamshells, cups, straws, cutlery	110	3.4	
Rigid	Pots tubs and trays	Rigid EPS, PS, PP, HDPE, MDPE and PET pots tubs and trays	261	8.1	
Rigid	B2B packaging	Pallets, crates, Intermediate Bulk Containers (IBCs), drums & barrels, EPS	1	3.7	
Rigid	Household goods	Cosmetics, toys, cotton buds, buckets	222	6.9	
Rigid	Other	goods' EPS packaging, egg boxes, clothes hangers, caps and lids not included in bottles	442	13.7	
Flex	Carrier bags	Grocery bags, shopping bags	85	2.6	22
Flex	Films	Pouches, baggies, mailing bags, film, cling film	514	15.9	
Flex	B2B films	B2B wraps, dunnage	121	3.7	
Multi	Sachets and multilayer flexibles	Sachets, crisps and biscuit packets, wrap labels	127	3.9	23
Multi	Laminated paper and aluminium	Carton, paper and aseptics which have enough plastic coating material to make them incompatible with existing paper recycling streams	49	1.5	
Multi	Household goods	Cosmetics, toys, toothpaste tubes, brooms	494	15.3	
Multi	Diapers and hygiene	Plastic component of pads, tampons and diapers	69	2.1	
Beverage bottles	Food-grade bottles	Water, soft drinks, juice bottles	448	13.8	14
All	Total		3,244	100	100

Table 2: Mapping of applications to key distribution channels

		Retail	Gastro	Online	B2B
Rigid	Non-food-grade bottles	High relevance	No/low relevance	Medium relevance	No/low relevance
Rigid	Food service disposables	High relevance	High relevance	No/low relevance	No/low relevance
Rigid	Pots tubs and trays	High relevance	Medium relevance	No/low relevance	No/low relevance
Rigid	B2B packaging	No/low relevance	No/low relevance	No/low relevance	High relevance
Rigid	Household goods	High relevance	No/low relevance	High relevance	No/low relevance
Rigid	Other	High relevance	No/low relevance	High relevance	No/low relevance
Flex	Carrier bags	High relevance	Medium relevance	No/low relevance	No/low relevance
Flex	Films	High relevance	High relevance	High relevance	No/low relevance
Flex	B2B films	No/low relevance	No/low relevance	No/low relevance	High relevance
Multi	Sachets and multilayer flexibles	High relevance	Medium relevance	No/low relevance	No/low relevance
Multi	Laminated paper and aluminium	High relevance	No/low relevance	No/low relevance	No/low relevance
Multi	Household goods	High relevance	No/low relevance	Medium relevance	No/low relevance
Multi	Diapers and hygiene	High relevance	No/low relevance	Medium relevance	No/low relevance
Beverage bottles	Food-grade bottles	High relevance	High relevance	No/low relevance	No/low relevance

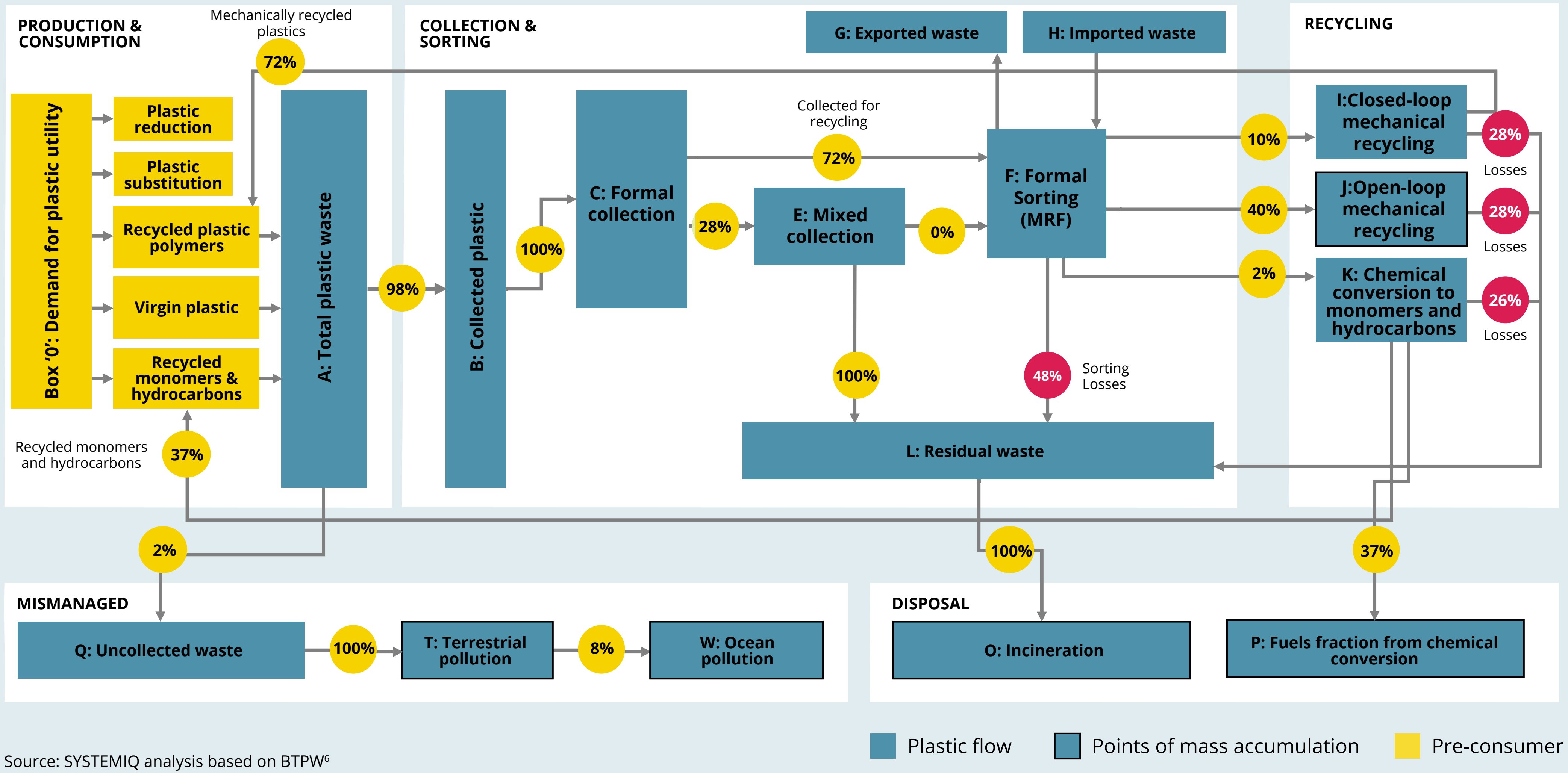
High relevance
Medium relevance
No/low relevance

Overview of the German Plastic System per waste type (2019)
Figure 23: German plastic system map – Rigid



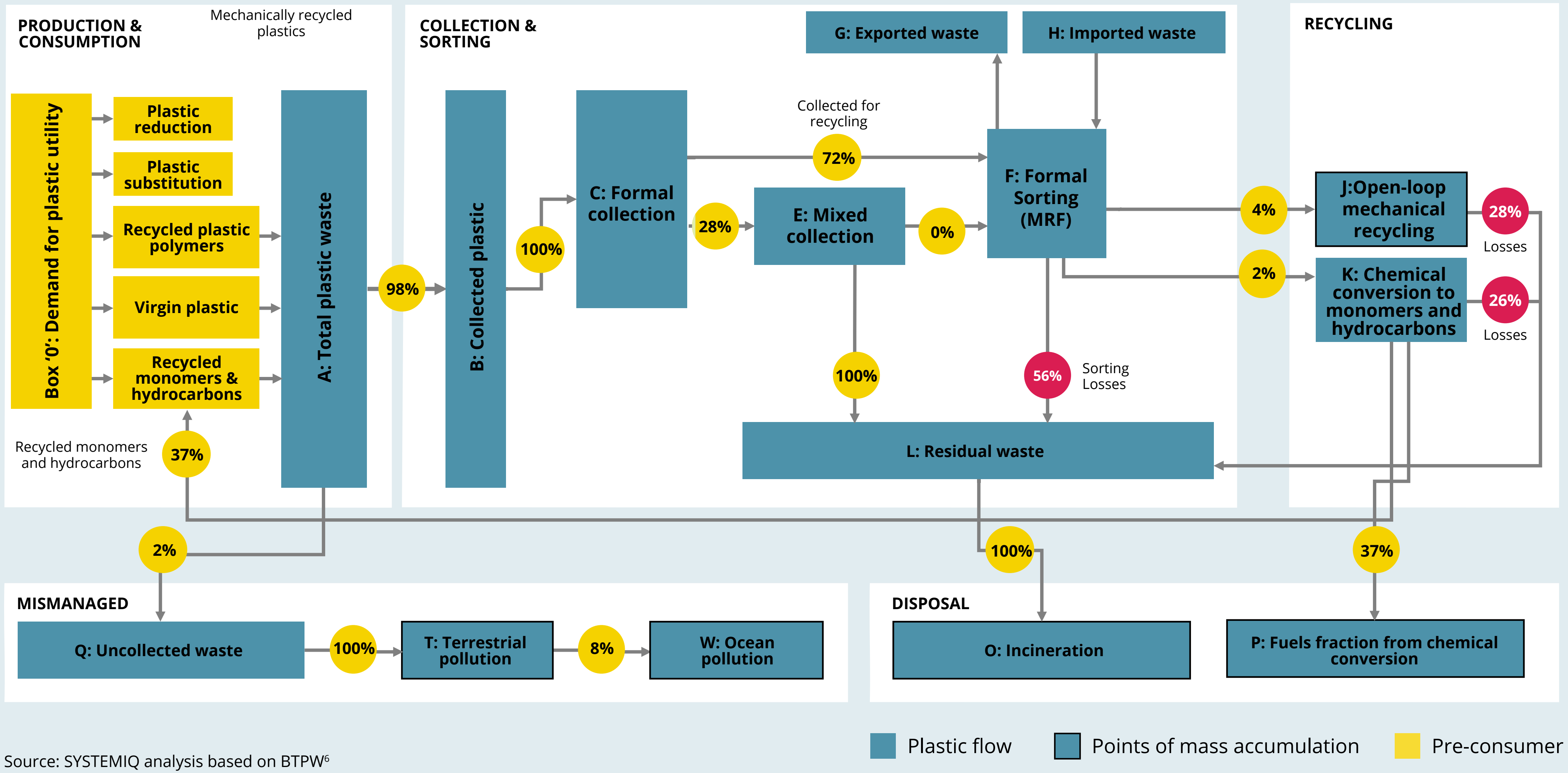
Source: SYSTEMIQ analysis based on BTPW[6]

Overview of the German Plastic System per waste type (2019)
Figure 24: German plastic system map – Flex



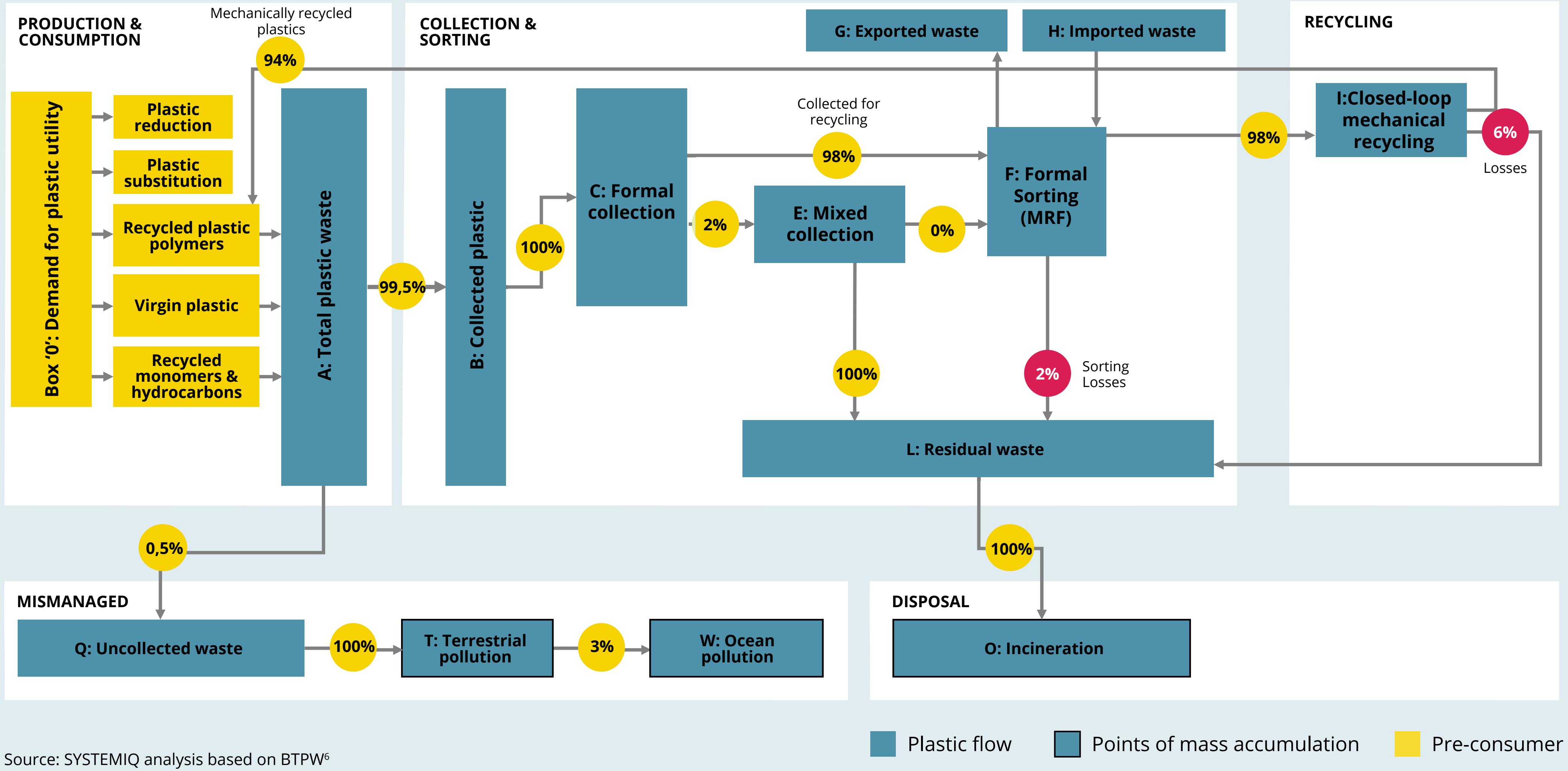
Source: SYSTEMIQ analysis based on BTPW[6]

Overview of the German Plastic System per waste type (2019)
Figure 25: German plastic system map – Multi



Source: SYSTEMIQ analysis based on BTPW[6]

Overview of the German Plastic System per waste type (2019)
Figure 26: German plastic system map – Bottle



Source: SYSTEMIQ analysis based on BTPW[6]

Scenario Scope

The analysis defines three scenarios and 7 different interventions, and estimates the principle economic, environmental, and social implications of these interventions at different ambition levels.[x]

- **Business-as-Usual:** The Business-as-Usual (BAU) scenario builds upon existing trends, extrapolates them into the future, and evaluates the implications of inaction – what would happen if production, consumption, and waste management trends remain unchanged? As such, it assumes that no interventions are made pertaining to packaging related to policy, materials, infrastructure, or consumer trends.

- **Current Commitments:** The Current Commitments (CC) scenario analyses the impact of current policy and industry initiatives on plastic packaging consumption and waste management. The CC scenario is optimistic and assumes that all policies and commitments made to date will be completely implemented and enforced. It evaluates what applications or formats are addressed through which measures, as well as whether current efforts suffice to transition towards a circular packaging economy.

- **System Change Scenario:** The System Change Scenario (SCS) evaluates the potential and implications for transition towards a circular packaging economy. It represents the combined effect if all levers for change were activated at the same time, to the fullest potential. Under each lever, the SCS evaluates a set of interventions, providing the most ambitious, comprehensive, and systemic response to the challenge. Further, this scenario benefits from synergies between the upstream and downstream interventions.

Levers and interventions to enable a SCS: The system interventions in the SCS are grouped into four levers, describing where in principle waste can end up. Each system intervention describes a set of activities to mobilize the potential of the lever and increase the circularity of plastic packaging. For each lever and intervention, the analysis evaluates the most relevant applications, the potential for circularity activated by said intervention, the key stakeholders, and enablers/critical conditions to enable the intervention.

x In contrast to BTPW, we did not model a Collect & Dispose Scenario, as collection in Germany is close to 100%, and incineration the sole disposal pathway. Thus, this scenario would be near congruent with the BAU scenario.

Taken together, these interventions form the SCS:

- **Reduce**: Reduction of single use plastic production and consumption, without switching to alternative, short-lived materials. Interventions under the reduce lever include:
  - Elimination of packaging where possible & minimization of packaging
  - Consumer reuse & new delivery models
- **Substitute:** Substitution of single-use plastic packaging with recyclable paper and coated paper (<5% plastic) or with biobased materials. The inclusion of biobased material can help the quality of plastic recyclates, since it can potentially divert packaging wastes with high food contamination into the municipal waste and not the packaging waste stream.
- **Recycle:** The recycling of plastic products or packaging waste into new materials and objects. This includes mechanical recycling and chemical conversion to plastics, but excludes energy recovery from waste materials as well as the chemical conversion of plastic waste into fuels.
  - Increasing collection for recycling
  - Design for recycling
  - Food grade circularity
  - Creating recyclate demand
- **Energy Recovery, Dispose & Mismanaged:** The disposal of waste in a way that prevents leakage to the environment. Safe disposal includes managed landfilling, waste-to-energy incineration, and plastics to fuel conversion. In Germany collection is near 100% and landfilling of unsorted, unclean waste is prohibited. As such, the dispose lever is reduced to incineration with energy recovery and plastic to fuel.
  - Incineration
  - Plastics to fuel

Given this project's focus on circularity, as opposed to mismanaged waste, the dispose lever is treated as a to-be-minimized residual; what remains in a linear management system once all the other interventions and levers have been applied.

Policy Overview

The conceptual development of this scenario is set against the backdrop of rising EU ambition, summarized by the European Green Deal, the new Circular Economy Action Plan as well as the Plastics Strategy.[18] Most recently, the EU underscored its ambition in this field with the Single Use Plastics Directive (SUPD) (Directive 2019/904), which focuses on phasing out single-use plastics to prevent and tackle marine litter.

In Germany, EU Directives, such as the SUPD, are transposed into the two main laws governing plastic packaging: The Circular Economy Act (Kreislaufwirtschaftsgesetz – KrWG), and the Packaging Act (Verpackungsgesetz – VerpackG). The Circular Economy Act is the central federal waste law, whereas the Packaging Act is the relevant national law for packaging materials. The so-called Single-Use Plastic Ban Ordinance (Einwegkunststoffverbotsverordnung) of 20 January 2021 was also considered, which transposes product bans outlined in the EU SUPD into national law. Finally, the analysis covered two draft amendments that were passed by the Federal Cabinet in early 2021 and will enter into force 3 July 2021.

1) The amendment to the Packaging Act (Verpackungsgesetz Novelle 2021);

2) the Single-Use Plastic Labelling Ordinance (Einwegkunststoffkennzeichnungsverordnung – EWKKennzV).

Apart from policy commitments, the development of the current commitments also included industry initiatives. In the past years, the industry made voluntary commitments through several vehicles: On a global level, most notably the New Plastic Economy Global Commitments (NPEC) and the Alliance to End Plastic Waste (AEPW). On a European level, two relevant industry initiatives are the European Plastics Pact[19] as well as the Circular Plastic Alliance[xi] (CPA), which bring together organisations and governments to accelerate the transition towards a European circular plastics economy.

xi https://ec.europa.eu/growth/content/circular-plastics-alliance-step-closer-10-million-tonnes-recycled-plastics_en

We applied a five-criteria framework to evaluate whether a policy or industry initiative is likely to impact the plastics system and thus should be included in the current commitments scenario modelling:

- **Specific:** The policy needs to target a specific focal area, such as a material type or product application;
- **Measurable:** Progress towards the goal needs to be quantifiable;
- **Actionable/Sanctionable:** The policy or commitment should clearly identify who is responsible and clarify potential enforcement mechanisms or penalties;
- **Realistic:** The objective needs to be realistic considering the available resources.
- **Time-bound:** There needs to be a clarification of when the policy starts or by when the target needs to be achieved.

The policies and commitments included in the modelling of the current commitments are described in Table 1:

Table 3: Overview of current commitments considered

Name	Description
Regulatory Policies	
Packaging Act (Verpackungsgesetz)	• Mandatory recycling targets: By 2025 50% of plastic packaging waste must be recycled and 55% by 2030 (by weight). • Plastic bag ban: From 1 January 2022, there will be a ban on plastic bags (thickness of 15-50 micrometres) from 1 January 2022.
Disposable Plastic Ban Ordinance (Einwegkunst-stoffverbotsverordnung)	• Product bans: From July 2021, single-use plastic cotton buds (except medical devices); cutlery (forms, knives, spoons, and chopsticks); plates; drinking straws (except medical devices); stirring sticks; balloon sticks and EPS cups, food and beverage containers will be banned.
2021 Amendment to Packaging Act (2021 Verpackungsgesetz Novelle)	• Reuse for food service disposables: From 2023, final distributors (e.g., restaurants, bistros, and cafés) that sell 'on-the-go' are obliged to also offer their products in reusable packaging. Businesses with less than six employees and a shop area of no more than 80 square metres are exempted, but they too must provide the option to fill customers' own reusable containers. • Mandatory rPET target: Mandatory 25% rPET (recycled PET) content in PET beverage bottles by 2025. By 2030, all single use plastic beverage bottles need to contain at least 30% recycled content. • Extension of deposit return scheme: From 2022, a deposit will be mandatory on all non-refillable plastic beverage bottles and cans. Previous exceptions for fruit juices or mixed alcoholic beverages in cans or single-use plastic bottles will be eliminated. However, there is a transitional period for dairy products until 2024.
Industry Commitments	
Circular Plastic Alliance	• CPA is an industry-led initiative with the goal to achieve 10 million tons of recyclate in the EU by 2025.[xii]

xii https://ec.europa.eu/growth/content/circular-plastics-alliance-step-closer-10-million-tonnes-recycled-plastics_en

The current commitments scenario analysed current policy and voluntary industry initiatives to determine their impact on plastic waste generation and recycling rates.

Our analysis shows that:

- The impact of the policies and initiatives considered in the current commitments scenario are near congruent, not complementary.
- They focus on end of life recycling and overall recyclate use, rather than reducing plastic waste generation or incentivizing the use of PCR use in different sectors or applications (i.e., plastic packaging).

However, current commitment goals fall short for driving a CE strategy for packaging in Germany. They focus on increasing recycling volumes, with less emphasis on driving waste prevention through circular business models and innovation, or increasing transparency and accountability throughout the system. For example, we estimated that current commitments reduce overall waste volumes by 5%, whereas our analysis reveals that 23% of all plastic utility could be provided through reuse models, leading to a direct reduction in virgin demand, waste generation and incineration. Further, current policies often focus on small volume application groups, such as banning straws, and neglect designing and enforcing policies to address large-volume application groups such as bottles or B2B packaging.

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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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