MIXED WASTE SORTING

Mixed Waste Sorting to meet the EU's Circular Economy Objectives

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Glossary of Terms

Calculation point – the point where packaging waste materials enter the recycling operation whereby waste is reprocessed into products, materials or substances that are not waste, or the point where waste materials cease to be waste as a result of a preparatory operation before being reprocessed. This definition is consistent with meaning as intended in (EU) 2019/665.[1]

Collection rate – the weight of waste collected of a particular packaging material or type as a proportion of the total weight of that packaging material or type placed on the market. Note this is different from the collected weight of a packaging waste material since a large proportion of this will be non-target materials, non-packaging materials, contaminants, moisture, and so on.

Free riding – an EPR system phenomenon in which producers who are not registered with the scheme, and therefore do not pay EPR fees (including, for example, online sellers and producers below any de-minimus thresholds for EPR obligations), place packaging on the market that goes unrecorded. This also includes situations in which registered packaging producers mis-declare their tonnages placed on the market such that this is underestimated, as well as packaging placed on the market by private importers (i.e. individuals who bring in products from other countries).

Historic Measurement Method (Packaging Recycling Rate) - this refers to the rules for calculating and reporting attainment against the EU packaging recycling targets as they were laid out in Decision 2005/270 (prior to 2019/665). This is calculated the weight of recovered or recycled packaging waste as "the input of packaging waste to an effective recovery or recycling process. If the output of a sorting plant is sent to effective recycling or recovery processes without significant losses, it is acceptable to consider this output to be the weight of recovered or recycled packaging waste."

Mixed waste – municipal waste material that is not separately collected and would otherwise become residual waste unless subject to prior treatment such as the sorting of recyclable materials for recycling from those that will become residual waste.

New Measurement Method (Packaging Recycling Rate) - this refers to the rules for calculating and reporting attainment against the EU packaging recycling targets as they were laid out in Decision 2019/665. These rules must be applied to show attainment against the 2025 and 2030 recycling targets. The amount of recycled packaging waste shall now be calculated as "the amount of waste at the calculation point. The amount of packaging waste entering the recycling operation shall include targeted materials. It may include non-targeted materials only to the extent that their presence is permissible for the specific recycling operation."[2].Further guidance on the implementation of this new method has been provided.[3]

Placed on Market (PoM) - a product is placed on the market when it is made available for the first time on the Union market. According to Union harmonisation legislation, each individual product can only be placed once on the Union market. This term is used consistently with the meaning in the Commission's Blue Guide.[4]

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02005D0270-20190426
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02005D0270-20190426
[3] https://ec.europa.eu/eurostat/documents/342366/351811/PPW+-+Guidance+for+the+compilation+and+reporting+of+data+on+packaging+and+packaging+waste.pdf/297d0cda-e5ff-41e5-855b-5d0abe425673?t=1621978014507
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C:2022:247:FULL&from=EN

Product basis – a recycling rate calculation method in which recycling rate is the *collection rate* (i.e., the weight of packaging collected as a proportion of the total weight of packaging placed on the market) multiplied by the *sent for recycling rate* (i.e., the amount of packaging sorted as a proportion of the amount collected). The measurement points are based on bales of material products, which inevitably contain materials other than the pure material, such as moisture and product residues.

Pure materials basis – a recycling rate calculation method in which recycling rate is the weight of target material input into the final recycling operation as a proportion of the weight of that material placed on the market.

Recyclability – the ability of packaging to be effectively and efficiently separated from the waste stream, collected, sorted and aggregated into defined streams for recycling processes, and recycled at scale through established industrial processes, so that it is turned into secondary raw material of sufficient quality that it can find end markets to substitute for the use of the primary raw material.

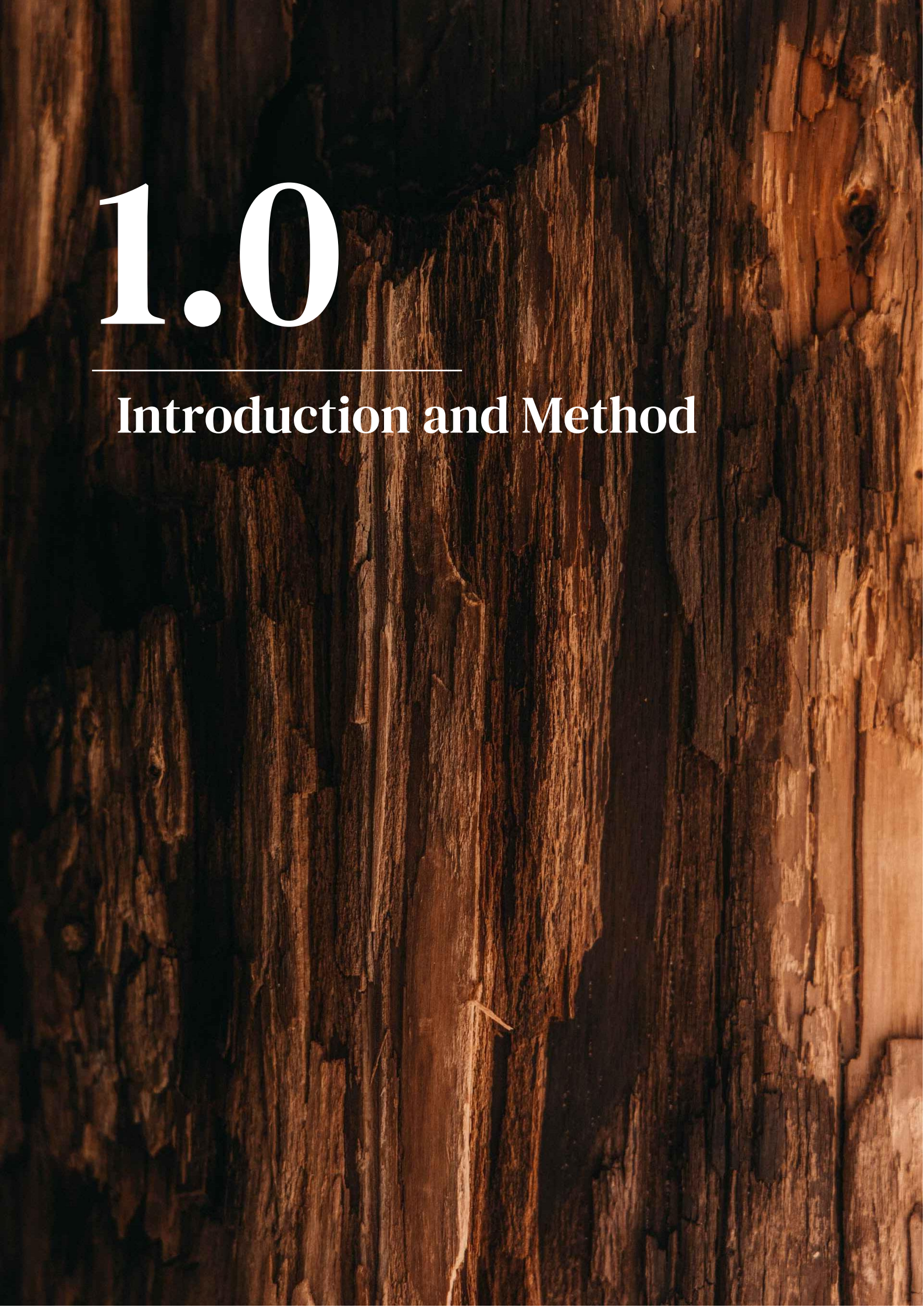
Recycling rate – the amount of waste at the calculation point as a proportion of the tonnage of that material waste generated. This term is used consistently with the meaning in the relevant Commission guidance.[5]

Residual waste – for the purposes of this report the waste stream that is sent to landfill or energy recovery, after any prior treatment including mixed waste sorting.

Sorting efficiency – the weight of a target material that is output from a sorting process as a proportion of the weight of the pure material waste fraction that was input to that process. We conceptualise sorting efficiency on a pure materials basis as per the new measurement method as opposed to on a product basis.

Average / standard loss rate – Average or standard loss rates are calculated as the weight of the average losses from sorted packaging waste up until the calculation point, in relation to the weight of the sorted packaging waste. Under Article 6a of the PPWD, ALRs may be applied as a derogation to the requirement to measure waste entering the recycling operation in cases where reliable data cannot be otherwise be obtained, such that the weight of packaging waste recycled may be measured at the output of any sorting operation provided that such output waste is subsequently recycled; and the weight of materials or substances that are removed by further operations preceding the recycling operation and are not subsequently recycled is not included in the weight of waste reported as recycled.

[5] https://ec.europa.eu/eurostat/documents/342366/351811/PPW+-+Guidance+for+the+compilation+and+reporting+of+data+on+packaging+and+packaging+waste.pdf/297d0cda-e5ff-41e5-855b-5d0abe425673?t=1621978014507



1.0

Introduction and Method

1.1 Introduction

Eunomia was commissioned to examine the potential role of "mixed waste sorting" (MWS) to complement separate collections of municipal waste in the EU, and to consider whether higher levels of recycling and improved climate change performance can be achieved through this further sorting of municipal waste for recycling prior to thermal treatment or landfill, i.e., "mixed waste sorting" (MWS).

The results were considered through the lens of the policy framework in the EU according to which each member state is obligated[6] to achieve the:

- key packaging waste recycling targets by material in 2025 and 2030; in particular the plastic packaging waste recycling target of 55% by 2030 established in the 2018 revision to the Packaging and Packaging Waste Directive (PPWD)[7]; and

- municipal waste recycling target of 60% by 2030 established in the 2018 revision of the Waste Framework Directive (WFD), increasing to 65% by 2035.[8]

These targets are implemented in the context of wider EU goals to address the climate change impacts of consumption and waste management through a transition from linear economic models to a circular economy, as envisioned in the Green Deal and Circular Economy Action Plan 2.0.

To help achieve these targets, a range of planned policies at EU level are aiming to improve the recyclability of packaging (vis-a-vis ongoing revisions to the PPWD) and to improve and harmonise separate collection systems for municipal waste across the EU.

However, as this report will demonstrate, improved separate collection and improved recyclability of plastics alone will not be sufficient to meet these objectives for all materials, and particularly for plastics. More will need to be done if the EU is to meet its targets – with the ongoing revision of the WFD representing a good opportunity for the Commission to intervene. In these cases, MWS makes important contributions to the recycling and carbon emissions reductions targets that are likely to be necessary for their overall attainment. The resulting increase in materials available for recycling also contributes to the attainment of the EU's recycled content targets.

This analysis is also relevant in the context of ongoing revisions to the EU Emissions Trading System (ETS)[9], the Industrial Emissions Directive[10] and the Renewable Energy Directive (RED III)[11], which consider further regulation on the incineration of waste such that, for example, associated emissions could be counted in the ETS and subject to mandatory pre-treatment using MWS in RED III. At the member state level, the recently introduced Own Resource[12] based on unrecycled plastic packaging waste provides an additional economic incentive to capture and recycle the maximum possible proportion of plastic packaging waste placed on the market. Policies that ensure comprehensive and effective MWS of municipal waste streams prior to

[6] Noting that derogations apply as per Article 6 paragraph 1a of the PPWD and Article 11 paragraphs 3,4,5 of the WFD
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01994L0062-20180704
[8] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0098-20180705
[9] https://oeil.secure.europarl.europa.eu/oeil/popups/summary.do?id=1708651&t=e&l=en
[10] https://environment.ec.europa.eu/publications/proposal-revision-industrial-emissions-directive_en
[11] https://resource.co/article/zwe-responds-european-parliament-s-new-position-red-iii
[12] In place since 1 January 2021, this consists of a national contribution based on the weight of non-recycled plastic packaging waste in each member state at a uniform rate of EUR 0.80 per kilogram. This is not the same as a tax, as member states can choose whether or not to recover these funds through in-country taxes, fees or other mechanisms.

incineration or landfill throughout Europe in the WFD would therefore also be coherent with wider developments in EU policy.

1.2 Methodology

To demonstrate the potential role that MWS could play in helping the EU achieve its recycling and carbon reduction objectives, a model of the relevant EU waste flows was developed. This focussed on plastic packaging, but also included tonnage flows of other packaging materials and relative contributions to per capita municipal waste.

Given that Eurostat waste data is only available at the level of the main materials (plastic, paper, glass, etc.), a more granular waste composition was developed for specific packaging types and applications (in plastic packaging waste in particular) based on Eunomia's previous work. The modelled waste flows therefore reflected our best estimates of waste generated for each of these waste types, and the associated variations in the collection rate, sorting efficiencies and recycling losses for each. In this way, a detailed model of the likely actual recycling rate for plastic packaging across the EU in 2019 was developed. This varied from Eurostat reported estimates, as adjustments were made to reflect:

1. the current recyclability of packaging (i.e., compatibility with collection, sorting and recycling systems at scale across the EU)
2. the extent of underestimation in packaging waste generated (particularly in member states that use placed on the market figures as a proxy for waste generation without adjusting for the impact of freeriding in EPR schemes); and
3. the new measurement method for recycling rate calculations as per the 2018 revisions to the WFD and PPWD.

These baseline figures were then projected into the future to estimate the EU recycling rates for packaging in 2030. This considered ongoing policy efforts to improve separate collection rates and the recyclability of plastic packaging. The following scenarios were therefore developed –

1. Baseline (2019) – representing estimates of actual current recycling performance in the EU 27 in 2019 as discussed above
2. Improved recyclability (IR) – In this scenario, we consider the impact of improved recyclability of plastic packaging alone (without any additional effect from improved collection rates). This reflects a scenario in which additional tonnages of plastic packaging can be targeted for collection and sorting as they would now become recyclable at scale across the EU by 2030.
3. DRS +IR – In this scenario, we overlay a minimum expected improvement in collection rates over and above the improved recyclability in the previous scenario. In this scenario, the only improvement to existing collections is the roll out of DRS for beverage containers across the EU by 2030.
4. IR + improved collection rate (IC) – This scenario reflects an alternative "best-case" scenario of improvements to separate collection systems such that all MS across the EU are achieving a 75% rate of collection of plastic packaging, over and above the recyclability improvements in the IR scenario. This is an optimistic alternative to the DRS + IR scenario.

Finally, MWS was overlayed to estimate the likely contribution of MWS to the 2030 packaging recycling targets in each of the above scenarios. Using these results, alongside estimates of the amounts of non - packaging recyclables in municipal waste, a high-level estimate of the potential contribution of MWS to municipal waste targets was also calculated. Using GHG emission factors to reflect the likely emissions associated with recycling waste fractions that would otherwise end up in residual waste (and therefore incineration or landfill), the likely GHG impacts of overlaying MWS were also estimated (at EU level).

Given that plastic packaging recycling rates vary widely across individual member states in the EU 27, we also considered three case studies of individual member states that are recognised as being best performers within their respective waste management systems. The plastic packaging recycling rates of Germany, Belgium and Sweden were therefore also analysed within the above framework. The case studies did not include consideration of GHG emissions at member state level, or of the potential contribution that MWS could make to the municipal waste targets in each country, and were focussed mainly on plastic packaging.

This report summarises the findings of the above analysis, in the structure below:

- In Section 2.0, the EU's recycling targets are discussed, particularly for plastic packaging, and how improving recycling and especially MWS will help meet these targets. The resulting estimates of current recycling performance, the impacts of planned improvements to recyclability and collections, and the impact of overlaying MWS are considered in separate subsections, with the associated results for each of the three case studies presented alongside each.
- Section 2.2 presents the results of the analysis in relation to packaging materials other than plastics, assessed at a high level
- Section 2.3 presents the estimated likely contribution of MWS to the municipal waste recycling targets
- Section 3.0 presents the impact MWS can have on GHG emissions at the EU level.
- Conclusions are presented in Section 4.0.

2.0

EU Recycling Targets

2.1 Plastic Packaging Recycling Targets

The PPWD (Article 6) sets recycling targets for each of the key packaging materials. In the 2018 revision of the Directive, the targets set to be achieved by 2025 and 2030 were increased significantly as shown in Table 2-1 below.[13]

Table 2-1: PPWD packaging recycling targets in the EU

	Before 2025 (%)	By 2025 (%)	By 2030 (%)
All packaging	55	65	70
Plastic	22.5	50	55
Wood	15	25	30
Ferrous metals	50 (incl. Aluminium)	70	80
Aluminium	-	50	60
Glass	60	70	75
Paper and cardboard	60	75	85

At the same time, the measurement method used to calculate member states' achievement against these targets was updated and harmonised such that recycling rates are now based on the total waste that enters a final recycling operation as a proportion of the tonnage of waste generated (a proxy for which is the tonnage placed on the market [PoM]). There is general agreement that the increased targets, together with the new measurement method, will make the attainment of the targets more challenging in the future.

This is particularly true for plastic packaging waste, which has one of the lowest recycling rates of packaging at present and for which exports for recycling have come under stricter controls under the Basel Convention. A large proportion of recyclable plastic packaging still ends up in energy recovery and landfill, resulting in a loss of valuable materials from the circular economy and a continued reliance on virgin fossil based plastic production. If the EU is to meet its targets, it is imperative to divert this material to recycling.

2.1.1 Current Situation

In 2019, member states reported an average of 41% plastic packaging recycling across the EU 27, with only a few opting to report using the new measurement method. From 2022, member states were required to report using the new measurement method for the reference year 2020, which was published during the time of writing this report and lowered the plastic packaging recycling rate across the EU 27 to 38%. Given the range of updates to the historic measurement method, member states will need to modify to their own monitoring and verification systems to gather the relevant data. It will therefore almost certainly take further years of data gathering, analysis, reporting, and auditing before the figures reported to Eurostat accurately reflect all elements of the updated methodology by which member states will be judged on the 2030 targets.

Given that data is more widely available for the year 2019, the analysis is based on the 2019 EU waste statistics rather than the more recent 2020 update. The 41% estimated recycling rate for plastic packaging in 2019 is based on a reported plastic packaging waste generated figure of 14.5 Mt. It is notable that these figures reported to Eurostat are likely to be underestimated because of inaccuracies in the way they are reported. For member states reporting waste generated based on PoM data gathered from packaging EPR schemes, this is largely attributed to free riding. While consistent estimates of the extent to which tonnages

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01994L0062-20180704

of plastic packaging PoM are underestimated across the EU are not available, this underreporting will overinflate the reported recycling rates. It is therefore not overcautious to assume that the actual 2019 plastic packaging recycling rate is lower than what is currently being reported.

Other sources of data estimate the tonnage of plastic packaging PoM in the EU27+UK to be 19.9 Mt[14],18.4 Mt[15], and 20 Mt[16]. For this study, we use the tonnages of plastic packaging PoM calculated in previous Eunomia reports for Plastic Recyclers Europe (state of play for PET, HDPE & PP, and flexible films)[17], scaled down to the EU27, to model a tonnage PoM of 17.3 Mt. This increase in the PoM figure against which the recycled tonnage is measured would reduce the reported EU-27 recycling rate in 2019 from 41% to 36%.

Further to addressing the PoM underreporting issue, we attempted to estimate the tonnage of plastic packaging waste entering a final recycling operation in line with the new measurement method. The historic measurement method measured recycled tonnages on a 'product' basis, which included some non-target material such as labels, lids, product residues, and wrongly sorted materials that subsequently do not get recycled. The new measurement method intends to exclude these non-target materials using a 'pure materials' basis, which measures the amount of target material that is recycled as a proportion of target material PoM.

To calculate the plastic packaging recycling as shown in Figure 2-1 in accordance with the new measurement method we have excluded a several categories of waste from the amount considered to be recycled:

- plastic packaging waste not collected for recycling (53% in teal),
- plastic packaging that is collected for recycling but is unrecyclable and therefore is likely to be sorted and sent as residual waste (13% in orange). This was calculated based on our understanding of the recyclability of plastic packaging fractions in the EU.
- recyclable plastic packaging that is lost in the sorting and recycling process prior to the calculation point (9% in purple); and
- further losses of recyclable material in processing steps (2% in yellow), for instance losses of undersized fractions from flaking. materials lost through dust discharge, process disruptions, start up and shut down processes, test batches and so on.

It is noted that this estimation is based on the current performance of plastic packaging waste collection, sorting and recycling systems across the EU 27 as an average and is not therefore representative of any specific member state or waste management process. Better performance can be expected in individual member states utilising the best available technologies.

[14] Plastics Europe 2021, quantities in 2020 (figures are researched by Conversio, among others). Slide 19: Converter requirement in EU27+3 = 49.1 million tons. Of this, 40.5% is packaging (including commercial and industrial packaging) see slide 20, also 19.9 million tons of packaging: https://plasticseurope.org/knowledge-hub/plastics-the-facts-2021/=

[15] Conversio – Global plastics flow 2018. Slide 29 and 30: Plastics processing (packaging) is 22 million tons. And this results in around 18.4 million tons of plastic packaging waste. The numbers are slightly higher than above because there was a small drop from 2018 to 2020 (due to Corona): https://www.bkv-gmbh.de/files/bkv-neu/studien/Global_Plastics_Flow_Feb10_2020.pdf

[16] Since most of the figures come from Conversio (Plastics Europe, etc.), the company Material Economics once did a "counter-study" and they say that far more plastic waste is produced. But, Material Economics also predicts a similar magnitude of plastic packaging entering the market. See page 11 for their forecast of volumes ~ slightly less than 20 million tons: https://materialeconomics.com/publications/europes-missing-plastics

[17] https://www.plasticsrecyclers.eu/plastics-recyclers-publications

Figure 2-1: Estimated plastic packaging collection and recycling in 2019

These two assumptions (i.e., the higher tonnage of plastic packaging PoM and the lower tonnage of plastic packaging entering a final recycling operation) result in a plastic packaging recycling rate of ~23% in 2019 across the EU.

In an alternative approach to estimating the actual recycling rate in 2019, the data published by Eurostat was adjusted based on existing information on the measurement methods used by each member state, and the extent to which these deviate from the new measurement method. The resulting recycling rate for plastic packaging was estimated at ~34% - still considerably below the ~41% reported in 2019, and significantly lower than the 55% target for 2030.

This high-level analysis shows clearly that there is a long way to go for the 27 EU member states to achieve the 55% target set out in the PPWD by 2030, and in many cases, even the 50% target in 2025. It is worth noting that the target is applied to each individual member state, so that even if the average across the EU was 55%, it is likely that a significant proportion of member states would still miss the target. These estimates (i.e., 'real' plastic packaging recycling rates of between 23% and 34% in 2019 as shown above) are aligned with other studies that have carried out similar analysis[18,19], concluding that "there is a risk that some Member States will miss the EU's new plastic packaging recycling targets, putting at risk the attainment of the EU's overall target as well."[20]

While the above applies across the EU 27, plastic packaging recycling rates vary widely across individual member states, reflecting variations in waste management and reporting systems. When assessing whether the EU targets are achievable, it is therefore worth considering individual member states, and particularly those that are recognised as being best performers within their respective waste management systems. This enables us to assess whether best practice within existing systems of waste management would be

[18] https://www.minderoo.org/no-plastic-waste/reports/from-waste-to-commodity/
[19] https://plasticseurope.org/knowledge-hub/the-circular-economy-for-plastics-a-european-overview-2/
[20] https://www.eca.europa.eu/Lists/ECADocuments/RW20_04/RW_Plastic_waste_EN.pdf

sufficient to reach the targets, if applied consistently across the EU (which is itself highly optimistic), and if not, the role that MWS could play. The current performance of Germany, Belgium and Sweden is therefore examined in more depth below.

2.1.1.1 Germany

Waste management overview

Germany has historically been a leader in recycling, as evidenced by its top-ranking EU municipal waste recycling rates. In the 1990s[21] Germany was one of the first countries to set up an EPR system for packaging. As a result, the Duales System Deutschland – Gesellschaft für Abfallvermeidung und Sekundärrohstoffgewinnung mbh (DSD) was established as a single, non-profit producer responsibility organisation (PRO). The DSD 'yellow bin/sack' is a household packaging waste collection system for plastic, metal and composite packaging materials. As a result of legislation changes in subsequent years, there are now several competing for-profit PROs that jointly fund the collection, treatment and disposal of packaging. However, the packaging collection system is still commonly referred to as DSD. Germany also has a long standing and high performing deposit return system (DRS) for plastic, glass and metal beverage containers.

Reported data overview

The German Packaging Act (VerpackG) implements the EU packaging recycling targets into national law. The targets set within this Act exceed those in the PPWD.

The Umweltbundesamt (UBA) is the body responsible for reporting the data on annual recycling rates to Eurostat. In 2019, the UBA report included a detailed analysis of the recycling rate based on the historic measurement method compared to the new measurement method[22].

The tonnage of packaging waste generated is estimated using a complex model developed annually by the German market research group GVM, which incorporates data on packaging PoM from the federal statistics office on the production and trade of plastic packaging as well as plastic packaging databases from institutes, associations and manufacturers (including EPR schemes). Due to this method of calculation, underreporting of PoM data by EPR schemes due to freeriding (including online sales) is avoided, though the difference between the final figures that are reported and the figures that are reported by EPR schemes alone are not estimated. No further adjustments are made to the estimates of plastic packaging waste generated.

The new measurement method requires that adjustments are made for composite materials placed on the market where a component makes up for more than 5% of the weight of the packaging. The UBA already splits all tonnages of composite material, even below the 5% threshold. Therefore, this should not have an impact on the reported recycling rates in Germany.

Overall, the reporting of plastic packaging POM would appear likely to produce a reasonable estimate of the actual amounts of waste generated.

[21] https://prevent-waste.net/wp-content/uploads/2021/07/Germany.pdf
[22] https://www.umweltbundesamt.de/publikationen/aufkommen-verwertung-von-verpackungsabfaellen-in-15

The 2019 UBA report also highlights that data on the recycled tonnages are not gathered at the calculation point, but rather at the output of sorting plants to which standard loss rates are applied to account for material losses prior to input to recycling (shown for plastic packaging in Table 2-2).

The loss rates for plastic packaging from the DSD, other household waste, and commercial and industrial all resemble findings from recyclers published in studies by Plastic Recyclers Europe and therefore it seems reasonable to assume these will produce a reasonable estimate of recycled material.

The loss rate applied to the material from the German deposit return system seems particularly low and could potentially be a source of a minor overestimate of the German recycling rate. However, the UBA's report explains that this is the case because foreign material components in the relevant PET bales, such as labels and closures, are not included in the quantities weighed at the measurement point (i.e., they use a pure material basis for this stream) and therefore do not have to be deducted.

Further, there does not appear to be any deduction for non-packaging plastics that are included in the weight of plastics sent to recyclers, apart from a deduction for packaging waste containment sacks. The yellow bin/ bag collection system should in theory only contain packaging items but there will almost certainly be some quantity of non-packaging material passing through this system. This may therefore be a source of overestimation in the reported tonnages of plastic packaging recycled.

In future reports, the UBA plans to further refine the standard loss rates to reflect variations not only by return path, but also by sorting fraction (e.g., by polymer). They aim to publish recycling data on this basis in 2022.

Table 2-2 Standard loss rates in plastic packaging in Germany 2019

Sorted Plastic Packaging Return Path	Standard Loss Rate
DSD	30.3%
Deposit System	0.4%
Other Take-back Systems	24.7%
Commercial and Industrial	24.3%

Overall, the standard loss rate applied to plastic packaging in Germany is 20.2%.

The resulting packaging recycling rates in 2018 (using the historic measurement method) and 2019 (using the new measurement method) are found in Table 2-3. As evidenced by these figures, the new measurement method has reduced the reported recycling performance of the key packaging materials.

Table 2-3 Germany Reported packaging recycling rate 2018/19

Material	Reported to EU 2018	Reported to EU 2019
Paper and cardboard	86.8%	80.6%
Plastic	47.1%	43.3%

Material	Reported to EU 2018	Reported to EU 2019
Ferrous metals / Aluminium (total metals)	91.7%	70.9%
Glass	83%	78%

Further, based on UBA's report, the 2019 recycling rate for Germany (using the historic measurement method) can be compared to the recycling rate in the same year using the new method (as shown in Table 2-4). Overall, it is reasonable to conclude that the German packaging recycling rates as reported are reasonable reflections of the actual recycling rate and this analysis therefore does not include any alternative estimations of the reported rates.

Table 2-4 Reported German recycling rates in 2019 comparing the old and new measurement methods

	Recycling rate 2019 (Old Measurement Method)	Reported to EU 2019 (New Measurement Method)
Paper and cardboard	89.5%	80.6%
Plastic	55.5%	43.3%
Total metals	91.7%	70.9%
Glass	84.1%	78%

2.1.1.2 Belgium

Waste management overview

Like Germany, Belgium has a long-standing separate collection system for packaging recycling. The country has reported nearly 80% packaging recycling rates since 2008 when Eurostat first began reporting recycling statistics and has consistently ranked at the top of this metric. The Belgian recycling system is comprised of two PROs, one for household waste (Fost Plus) and one for commercial and industrial waste (Valipac). The household packaging waste collection system for plastic, metal and composite packaging materials is called the 'blue bag' system, which is standard across the whole country, and between 2019 and 2021 was expanded from rigid plastics only to include plastic films.

In Belgium, the Cooperation Agreement of 2008[23] and subsequent amendments implement the EU packaging recycling targets. Fost Plus and Valipac are the two main packaging PROs accredited and audited by the Interregional Packaging Commission (IVCIE), which is the public institution responsible for Belgian legislation on packaging waste and waste transit. In previous years, recycling rates for Belgium have been calculated based on quantities of packaging waste recycled relative to the tonnages placed on the market by the members of these two PROs, rather than the total amount of packaging waste generated. IVCIE therefore adjusts the packaging data collected by Fost Plus and Valipac to produce the statistics reported to Eurostat. This is described further below.

[23] https://www.ivcie.be/en/category/downloads-en/

Reported data overview

Recycling statistics are published annually by Fost Plus, Valipac and IVCIE, although at a lower level of detail when compared to the German report. We quote where numbers are taken from these published statistics, and additional information was gathered through conversations with Fost Plus, Valipac, and IVCIE.

The statistics reported by Fost Plus and Valipac are somewhat misleading, and recycled tonnages often add up to over 100% of what is placed on the market. This is because the reports calculate recycling as a percentage of the tonnage placed on the market *by their members only*; they make no adjustments for underreporting due to free riders, de-minimis producers, online sales, and parallel imports (or private imports) at this stage. Only when the data is combined by IVCIE are those adjustments made.

Adjustments for what would otherwise be underreporting are determined every 5 years based on a study undertaken by IVCIE in collaboration with Fost Plus and Valipac. The adjustments are calculated using a set of regression analyses and national databases of companies registered in Belgium and Luxembourg to estimate tonnages for free riders and de-minimus producers. Parallel imports are calculated using GfK consumer panel data, and expertise from Vinum et Spiritus (a sector federation). In intermediate years the data are updated using simple extrapolation methods (e.g., based on economic growth).

In the most recent iteration of this audit (done for the 2020 data and thus included in the 2021 activity report), it was found that IVCIE had been underestimating some material imports/parallel imports, predominantly from France and the Netherlands. IVCIE also found imbalances particularly in wine bottles coming in from France and plastic bottles being imported due to the high taxes on these products in Belgium.

This study obtained additional data provided by IVCIE to give further insight into the recycling rate calculation methods used in Belgium.

Adjustments are also made to tonnages placed on the market to account for composite materials. A standard paper/plastic split is applied to beverage cartons with no aluminium content, so the 5% rule is being applied here as allowed under the new measurement method.

The overall adjustment to the plastic packaging POM tonnage that would have otherwise been reported by obligated producers is a confidential figure and cannot be reported but we would comment that this is only around half of the estimated adjustment percentage that we would expect to see based on estimates of underreporting elsewhere in the EU. Establishing whether the Belgian POM figures are reasonable estimates could only really be achieved by examining national residual waste characterisation studies, which are not available. The impact of the reported tonnage underestimating the quantity POM by 10% is shown in the scenarios below to illustrate this uncertainty.

IVCIE provide a comparison of 2020 recycling performance using the historic measurement method and their interpretation of the new measurement method[24] They do not use the term "loss rate" and their terminology as well as methodology explanation leave room for interpretation as to whether it reflects the new measurement method as clarified in the EU guidance. The difference between the estimated recycling rate for plastic packaging using the historic and new measurement methods results in a 10.9% reduction in tonnages of plastic packaging recycled. The associated narrative in IVCIE's activity report implies this would cover most of the concepts of an "average loss rate". If this is the case, then this figure is substantially lower

[24] https://www.ivcie.be/wp-content/uploads/2022/09/Activity-report-2021-IVCIE-EN.pdf

than would be typically expected for the EU (closer to 20% on average, with variations for different waste streams, sorting technologies, etc.).

In conversations with Fost Plus, this was explained by the suggestion that Belgian sorting plants are producing high qualities of bale grade materials. Because these materials are mixed with those from other sources at the recycler, it was felt that the average standard loss rates generally provided by recyclers are too high to be applied to the relatively high-quality sorted packaging fraction. Therefore, Fost Plus commissioned their own study by an independent third party, wherein bales of each product stream were taken from the sorting plant and cleaned, dried and sorted, and the results of this study are used to determine loss rates (and thus recycling rates).

Overall, it is unclear whether this study and associated methodology result in an adjustment that would correspond to the Commission's new measurement method. It is unclear whether the study driving these results covers all the plastic recycling streams which are likely to have differences in actual loss rates. Furthermore, there is no mention of losses of the recyclable materials which would occur between output from the sorting plant and the measurement point, which leaves room for doubt e.g., are they accounting for the losses of PET that would occur through washing and float sink processes?

It is understood that there are no explicit adjustments to plastic packaging weights for material in sorting plant outputs that is not packaging. This would appear to be due to the view that non-packaging items are mostly sorted out at the sorting plants and that any remaining would be accounted for in the 10.9% adjustment between the recycling rate estimated in the historic measurement method and the new method. It is unclear whether this is a reasonable approach but would further highlight that the 10.9% appears to be a low rate for an average loss rate adjustment.

Given the fact that both the freeriding estimate and the equivalent loss rate figures used in the official Belgian recycling rate estimate look relatively low, we have also modelled sensitivities to reflect the average loss rate assumptions that are applied to the data from Sweden (below) and Germany (above), and an illustrative 10% higher POM figure. These sensitivities are shown in Figure 2-2, and indicate that Belgium's current 44% plastic recycling rate could be lower if loss rates were equivalent to those in Sweden and Germany, and free riding estimates were higher.

As mentioned above, Belgium has expanded their "blue bag" system for collecting plastic packaging between 2019 and 2021 to include more materials. Modelling this expansion, we projected the 2020 figures on PoM, collection rates and loss rates, with the result that Belgium should theoretically be less than a percentage point short of the 55% plastic packaging recycling rate by 2030 following full roll out of the blue bag system. However, applying the same sensitivities around the PoM figures and loss rates as the baseline, it shows that these planned improvements could fall short of the plastic packaging recycling target in 2030.

Figure 2-2: Estimated plastic packaging recycling rates with sensitivity analysis on PoM and loss rate figures

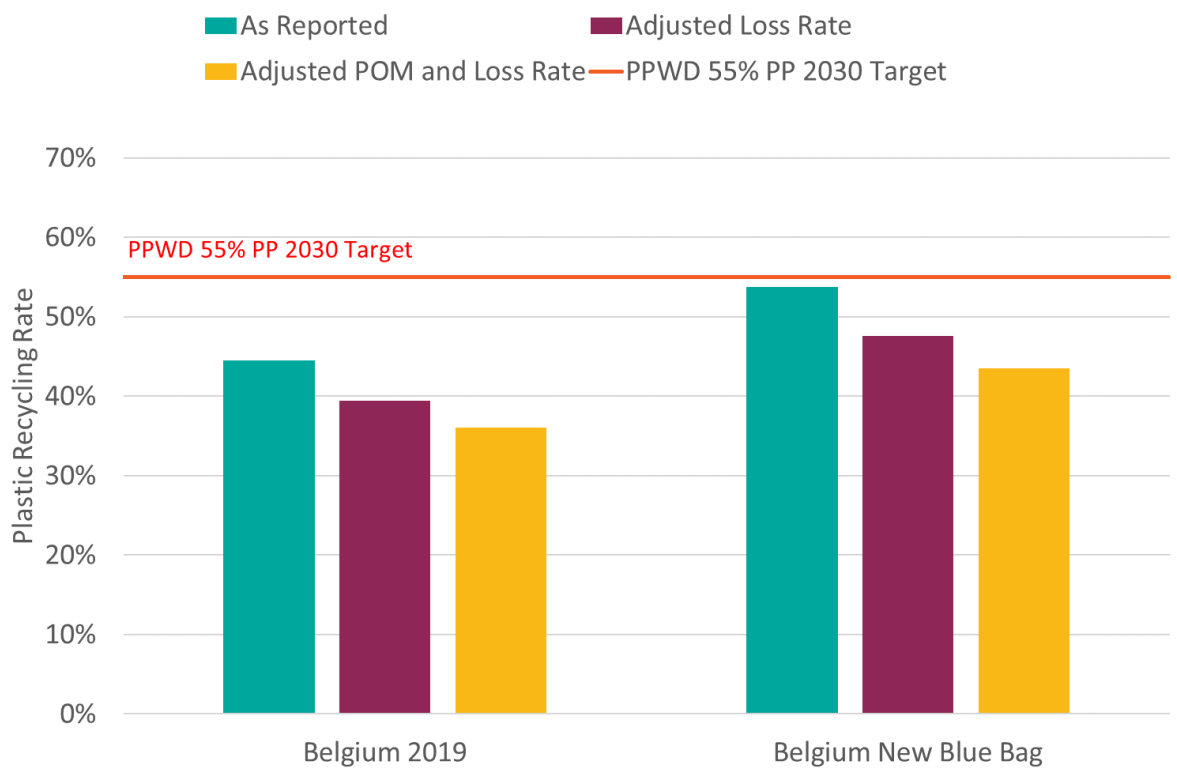


Table 2-5 Estimated impact of additional losses on Belgian recycling rate

	Recycling rate reported to EU 2020	Equivalence to Loss Rate Applied	Recycling rate Revised Losses Applied	Recycling rate with additional losses	Recycling Rate with Increased POM
Paper and cardboard	89.4%	2.9% Fost Plus and Valipac		-	-
Plastic	44.7%	10.9% Fost Plus 0.8% Valipac 6.9% Average	20% primary packaging 10% tertiary/transport packaging 17.5% average	39.6%	36.0%
Aluminium	88.6%	0.6%		-	-
Ferrous metals	98.3%	0.1% Fost Plus 0% Valipac		-	-
Glass	96.9%	2.1%		-	-

2.1.1.3 Sweden

Sweden has previously reported relatively high levels of plastic packaging recycling (~50% in 2019)[25] although this is because under the historic measurement method, waste collected for recycling that subsequently ended up in energy recovery (i.e., recycling residues) were also being counted towards the recycling targets. This has resulted in a large drop in Sweden's reported plastic packaging recycling rate from ~50% in 2019 to ~33% in 2020, though this varies between deposit-bearing PET bottles (for which the recycling rate is ~82%) and other plastic packaging (~30% depending on whether this is from household or business sources, with the recycling rate for household plastic packaging being only ~18%).[26]

When considering these figures, it is important to understand the current system of waste collection, sorting and recycling, as well as the data gathering methods adopted in Sweden. These have been summarised below.

Waste management overview

As per the official Swedish figures, ~248kT of plastic packaging waste was generated in Sweden in 2020, of which ~28kT was deposit-bearing PET bottles.[27] Of the remainder, ~60% of plastic packaging waste is estimated to be generated by households, with the remainder generated by businesses.[28]

Under the Swedish Environmental Code, each municipality is responsible for the collection, disposal and reporting of municipal waste in their territory. Plastic packaging waste is collected in Sweden in a range of ways:

- a deposit return system exists for PET bottles
- households can deposit their plastic waste (including packaging) in a network of public recycling stations operated by Förpackningsinsamlingen (FTI) ("bring system") – approximately 70% of the collected household plastic packaging waste is collected in this way
- a growing number of households also have access to kerbside collections wherein plastic packaging is collected separately from other waste in multi-compartment bins or colour coded bags – accounting for ~30% of the collected household plastic packaging waste[29]
- businesses are responsible for ensuring there are suitable collection schemes for the packaging they place on the market. Collection and sorting of commercial plastic packaging is currently unregulated and managed in the free market.

From 1 January 2023, a permit from the Swedish Environmental Protection Agency is required for a collection scheme to be able to collect packaging waste from households. Producers must then be connected to a collection scheme with a permit. A permit is not required for the collection of packaging waste that arises in connection with professional activities.[30]

At present, large amounts of plastic packaging are not correctly sorted out for recycling, ending up in mixed waste fractions instead. This is expected to be the case for around 50%-65% of plastic packaging which is not collected for recycling, though official estimates are not available due to uncertainties around placed on the market tonnages for plastic packaging (discussed below). These fractions tend to end up in incineration with energy recovery (there is a ban on landfilling for most plastic wastes). There is some sorting of mixed waste prior to incineration, though it is reported that this only accounts for ~7% of the overall plastic packaging waste material that is sorted for recycling with the vast majority (~93%) being collected through

[25] https://www.naturvardsverket.se/contentassets/568ba7678ce94e25b99cfc1b02ad7e2a/forpackningsrapport_2020_211027.pdf
[26] https://www.naturvardsverket.se/om-oss/publikationer/7000/978-91-620-7038-0/
[27] https://www.naturvardsverket.se/contentassets/568ba7678ce94e25b99cfc1b02ad7e2a/forpackningsrapport_2020_211027.pdf
[28] https://www.naturvardsverket.se/om-oss/publikationer/7000/978-91-620-7038-0/
[29] https://www.avfallsverige.se/media/lbdg3vcp/svensk_avfallshantering_2021_en.pdf
[30] https://www.naturvardsverket.se/en/guidance/extended-producer-responsibility-epr/producer-responsibility-for-packaging/

kerbside/ bring systems. Overall, officially, it is estimated that ~50% of plastic packaging is collected for recycling in Sweden. This figure excludes moisture, though it does not exclude all forms of contamination, product residue etc. The collection rate will therefore be lower.

Of the plastic packaging waste that is collected, the majority (~90%) is sorted at Svensk Plaståtervinning's facility in Motala, which is a fully automated plant. However, large quantities of plastic packaging waste input into the sorting plant are not currently sorted for recycling (~50%) at the facility. This is primarily due to recyclability issues, both packages that have not been designed for recycling and a lack of end markets for some materials. To a lesser extent, some of these losses are also process-related (e.g., mis-sorts). The materials currently targeted at the sorting facility are mono-material rigid HDPE and PP, transparent PET trays and bottles and mono-material LDPE.

The sorted material from the Motala plant that is then sent to recycling is reported to be 90-95% pure, and are subject to a total of ~25% losses during recycling (washing, etc.). All of the materials from this plant are recycled outside Sweden but within EU. The estimated 25% of losses during recycling are based on data from recyclers outside Sweden; some of them may be recycling sorted packaging from Sweden together with other fractions/ sources, however this figure is registered also by recyclers who deal exclusively with the Swedish sorted packaging fraction alone. This figure is broadly similar across all sorted streams. In theory, 100% of what leaves the Motala plant is of high enough quality to be used in new packaging. [31]

Data gathering overview

Packaging in Sweden is covered by EPR systems (for both household and non-household streams), with data gathered at the level of the main packaging materials (i.e. paper/ card, glass, plastics, aluminium, steel and wood), but not for individual applications (except those covered by deposit return systems in the case of plastic and aluminium). In the case of plastic packaging, data is therefore differentiated between deposit-bearing PET bottles and other plastic packaging. Producers are responsible for the collection and recycling of packaging materials they place on the market, with most choosing to do so through collective producer responsibility systems (particularly in the case of household plastic packaging waste). For commercial packaging waste, however, this obligation is often fulfilled individually, with businesses responsible for ensuring that their packaging is collected and managed correctly. This means that the data for commercial/ industrial packaging waste is currently somewhat fragmented and lacking in transparency.

Whether individually or through collective schemes, producers are responsible for reporting data on amounts of packaging placed on the market, quantities of waste collected and the treatment of these, to the Swedish Environmental Protection Agency via an electronic survey. EPR schemes gather this data from their producers (for quantities of packaging placed on the market) and from their contracted collection and treatment companies. This data is then compiled by SMED (Svenska Miljö Emissions Data) on behalf of the ministry for the purposes of national and EU level statistical reporting.

Naturvårdsverket (the Swedish Environmental Protection Agency) acknowledges that figures for plastic packaging PoM reported to SMED are likely to be underestimated and recycling rates therefore overestimated, due to free riding in the system, both by Swedish producers and importers (who, knowingly or unknowingly fail to correctly take part in the system) and by online sellers and private importers (both of whom bring packaging into the Swedish market but are not regulated under the EPR rules). It is further acknowledged that producers who are registered with the EPR scheme may also be mis-declaring the amount of plastic packaging they place on the Swedish market (e.g., if the weight of packaging changes

[31] Personal communication with representative from Svensk Plaståtervinning's

across a large range of products at a fast pace, or if business operations are complex with flows of materials, packaging and finished products across multiple member states and exported outside the EU). As there is no de-minimus threshold for producers to register with the EPR scheme, a large number of free riders are likely to be small businesses who are unaware of the regulations, or who privately import packaged goods from other countries and do not declare this. From 2023, the definition of a producer will be amended to include "anyone that professionally sells a packaged product or packaging to an end user in Sweden from another country".

Estimates of the exact number of free riders and the associated tonnages of plastic packaging are not available, though based on estimates of quantities of plastic packaging in waste generated, total plastic packaging PoM could be as high as ~344 kT including deposit bearing PET bottles (roughly 35% higher than official estimates). This estimate should be treated with caution since it is related to waste arisings (and therefore will contain some proportion of contamination, moisture, etc.)[32,33] We have therefore assumed a lower figure for plastic packaging PoM in Sweden of 320kT (~30% higher than currently reported).

Based on the above, Figure 2-3 shows the estimated recycling rate for plastic packaging in Sweden. The unadjusted figures (i.e., as reported to Eurostat and in the official figures) give a recycling rate of ~33%, with the modelled estimate of ~32% (using official national statistical figures and those shared during interviews) supporting this. However, once PoM figures are adjusted to account for the potential scale of free riding, this drops down to ~25%. For the purposes of this analysis, it was assumed that free riding does not impact the tonnages reported from deposit return systems relative to other plastic packaging from households and businesses, and that overall collection, sorting and recycling tonnages remain the same (i.e., without an increase in the proportion of losses at any stage).

[32] https://www.diva-portal.org/smash/get/diva2:1665130/FULLTEXT01.pdf
[33] https://www.naturvardsverket.se/om-oss/publikationer/7000/978-91-620-7038-0/

Figure 2-3: Estimated plastic packaging recycling rate with different estimated PoM figures in Sweden

For packaging materials other than plastics and glass packaging, we did not make any adjustments based on the calculation point for recycling, assuming that the new measurement method has been fully implemented.

For glass packaging, a footnote to the statistical data release on packaging recycling rates notes that "the calculation point for material recycling is the same for 2020 and 2019, which makes the material recycling rate comparable between the years"[34], which is not the case for other materials for which the calculation points have been moved in line with the new methodology. Therefore, we assumed that in 2020, glass recycling figures in Sweden were still reflective of collection rates rather than input to recycling. If this is the case, an adjustment is needed to account for losses subsequent to collection and prior to input into the recycling operation, as per the revised methodology. We have assumed that these losses or of the magnitude of ~7% (as shown in the table below, based on the German case study), and the final modelled recycling rate for glass in our model is therefore lower than the official reported figures (87% instead of 94%).

It is worth noting, in addition, that the quality report accompanying Sweden's packaging data does highlight a likely measurement error associated with PoM figures for these materials due to the effects of free riding and private imports, as was the case for plastic packaging discussed above.[35] In the absence of estimates of the actual PoM figures for packaging materials other than plastics, we have not adjusted the resulting recycling rates, but note that these will be overestimated (except, potentially, for aluminium cans, for which a DRS is in operation).

[34] https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__MI__MI0307/MI0307T2N/
[35] https://www.scb.se/contentassets/bfe765e440e340069570cc3fc3f39952/mi0307_kd_2020_v2_20221027.pdf

Table 2-6 Estimated impact of additional losses on recycling rate in Sweden for non-plastic packaging materials

	Reported to EU 2020	Additional Losses Applied	Modelled Current
Paper and cardboard	78%	0%	78%
Aluminium	81%	0%	81%
Ferrous metals	83%	0%	83%
Glass	94%	7%	87%

2.1.1.4 Summary of Case Studies

The above case studies indicate that the problem with current reporting of recycling rates can be distilled into the following key themes:

1. The amount of plastic packaging collected for recycling, "the collection rate", is between 40 and 50% on average in the EU. This is far too low and would need to significantly increase for the targets to be met. Even in countries in which the efficiency of separate collection is already high (e.g., Belgium, Germany), the target is not being met, suggesting a need for further improvements.
2. We estimate that between 20 and 30% of plastic packaging placed on the market cannot be recycled because the material is not currently recyclable. This material is not recyclable because the current design of the packaging does not correlate to any "at scale" recycling processes.
3. The data reported is subject to various inaccuracies, with need for further scrutiny, in particular of the placed on the market (PoM) figures if these are generated from EPR schemes that are subject to freeriding. This results in an underestimation of the total amount of plastic packaging placed on the market, and an overestimation of the above collected and sorted proportions and ultimate recycling rates as a result.
4. The scope and application of average loss rates to sorting outputs is inconsistent and may be resulting in overestimation of the recycling rate. The methodology for arriving at these loss rates can be difficult to verify, particularly for plastic packaging which may follow a range of collection and treatment routes.

2.1.2 Improvements to recyclability and collection

Recyclability

The plastic packaging supply chain is working to improve recyclability issues and the EU Commission may well implement polices to further drive this change in the upcoming revision to the PPWD. We believe that the most optimistic approach to account for this ongoing work would be to assume that by 2030, 90% of plastic packaging will be recyclable at scale. This assumes that, by and large, new rules to ensure that plastic packaging is recyclable at the end-of-life are introduced, widely implemented, enforced and successful by 2030. This approach reflects the fact that a proportion of unrecyclable packaging will persist (e.g., in essential applications like pharmaceuticals). This approach also includes assumptions around plastic packaging types that will become recyclable if chemical recycling technologies are successfully deployed, particularly for the pyrolysis of mixed polyolefin flexibles, though yields of recyclate from these technologies are likely to be lower than those associated with mechanical recycling.

Collections

Given the Commission's commitment to improve separate collections of a range of waste streams (biowaste by 2023, household textiles and hazardous waste by 2025), and set harmonised minimum requirements for these systems across the EU, it is also expected that collection rates for plastic packaging are likely to improve in many member states by 2030. However, given the wide disparities in the collection systems currently used by member states, and the performance of these, the key question is by how much collection rates will improve.

The German packaging waste collection system is a good example of a system that drives high separate collection rates. The system is consistent across the country with a clear and well communicated method of separating plastic packaging, high spends on communication and education, and financial incentives to improve recycling (such as taxes on residual waste treatment, deposit refund schemes and EPR fee modulation). With all these features in place, the efficiency of the German collection system at ~75% for plastic packaging (including DRS for beverage bottles) is likely to be one of the highest in Europe. Without DRS the efficiency of the separate collection system is estimated to be around 68.5%.[36] This is corroborated by the statistical report accompanying the official German packaging recycling figures for 2019 in which it is reported that 3249.7kT of plastic packaging waste was generated, of which 2514.3kT was collected for recycling (which gives a separate collection rate of ~77%).[37] The same report also clarifies that the estimated proportion of non-packaging plastics (i.e. non-target material) in plastic packaging collected is not substantial and so no deductions have to be made on this basis (these are made for some other materials like paper and wood). However, it is likely that non-packaging plastics are included within these materials collected (at least considering plastic waste sacks), and the resulting collection rate of 77% is likely to be overestimated. Therefore, for the purposes of this analysis, we assume that a 75% collection rate on a pure material basis (i.e., excluding non-target material) is the highest attainable in separate collection systems.

Modelled scenarios

The study therefore considered the question: "what if 90% of plastic packaging was recyclable and all 27 EU member states averaged a 75% collection rate?" It is worth bearing in mind that both these assumptions are highly optimistic and therefore likely to represent "best case" scenarios of developments in plastic packaging recycling. The results are shown below in Figure 2-4 in the "IR + improved collection rate" scenario. As discussed in Section 2.1.1 above, it is assumed that the baseline recycling rate for plastic packaging across the EU is 23.4%, and in this scenario, this increases to ~50% in 2030. This suggests that even in the best-case scenario of developments in plastic packaging collection and recyclability, the EU average is substantially below the target for recycling plastic packaging waste (55% in 2030).

This further implies that in a more realistic scenario, a high number of MS, if not all, are likely to fail to meet this target. We therefore also considered the likely minimum level of improvements in plastic packaging collection that can be expected by 2030. This has been reflected in a "DRS" scenario, in which it is assumed that the only improvements made to collection systems are the rollout of deposit return schemes for beverage containers across all member states.

Based on the above, the scenarios that have been modelled in Figure 2-4 are as follows:

- Baseline (2019) – representing current recycling performance as discussed in Section 2.1.1 above

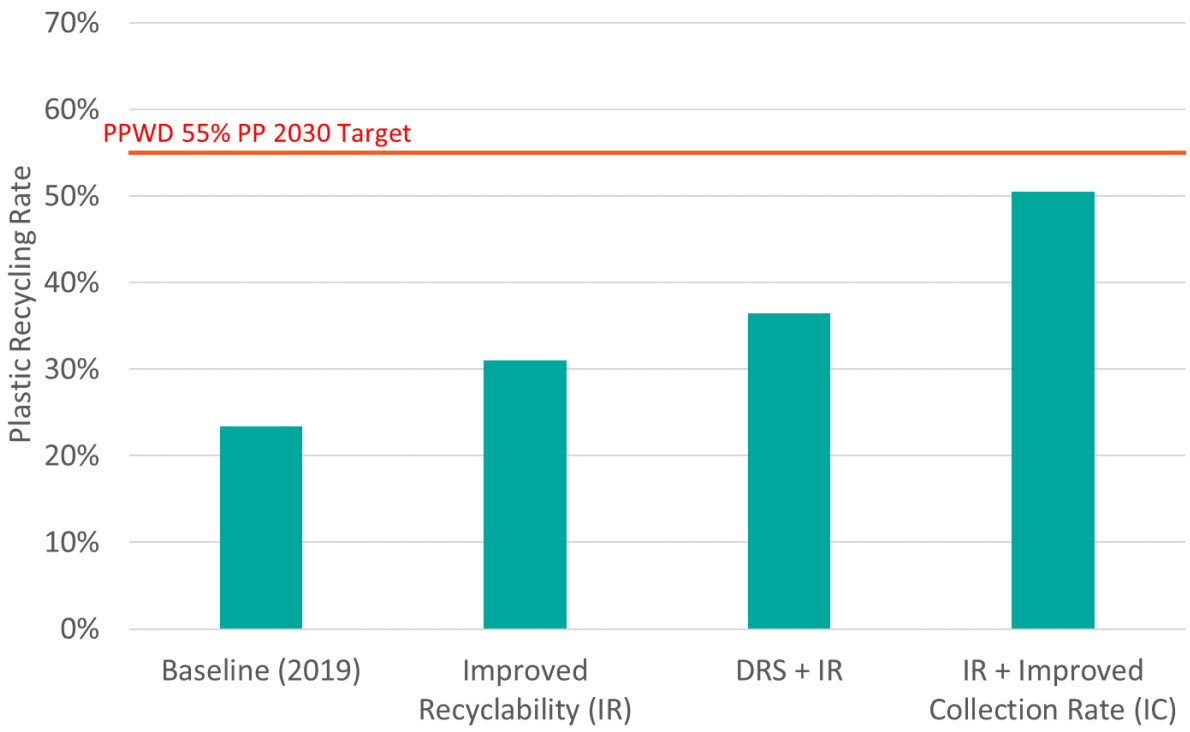
[36] Picuno et al (2021), Flows of post-consumer plastic packaging in Germany: An MFA-aided case study, accessible at https://www.sciencedirect.com/science/article/abs/pii/S0921344921001221
[37] https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2021-11-23_texte_148-2021_aufkommen-verwertung-verpackungsabfaelle-deutschland-2019_bf.pdf (pg. 167 Table 54 and page 99 Table 19)

- Improved recyclability (IR) – In this scenario, we consider the impact of improved recyclability of plastic packaging alone (without any additional effect from improved collection rates). This reflects a scenario in which additional tonnages of plastic packaging can be targeted for collection and sorting as they would now become recyclable at scale across the EU. In this scenario, the anticipated recycling rate in 2030 rises to only ~31%. It is therefore clear that improvements to collections will be necessary.
- DRS +IR – In this scenario, we overlay a minimum expected improvement in collection rates over and above the improved recyclability in the previous scenario. In this scenario, the only improvement to existing collections is the roll out of DRS for beverage containers across the EU by 2030. The recycling rate for plastic packaging relative to the improved recyclability scenario increases from 31% to ~36%, but the target is not met.
- IR + improved collection rate – This scenario reflects an alternative "best-case" scenario improvements to separate collection systems such that all MS across the EU are achieving a 75% rate of collection of plastic packaging, over and above the recyclability improvements in the IR scenario. This is an optimistic alternative to the DRS + IR scenario. The targets are still not achieved in this scenario, though recycling rates increase from 36% in the DRS + IR scenario to ~51% in this one.

Thus, the above scenarios allow us to infer the following key messages:

1) **Improved recyclability of plastic packaging alone will not enable us to meet the EU targets. Some improvement in collection systems is also necessary.**
2) **Depending on the extent to which separate collections are improved, a range of outcomes are possible (though in none of these scenarios is the target met without further intervention).**

Figure 2-4 Estimated plastic packaging recycling rate in 2030 with key policies



The question can be examined more closely through the lens of three individual member state case studies (Germany, Belgium, Sweden) as discussed previously.

2.1.2.1 Germany

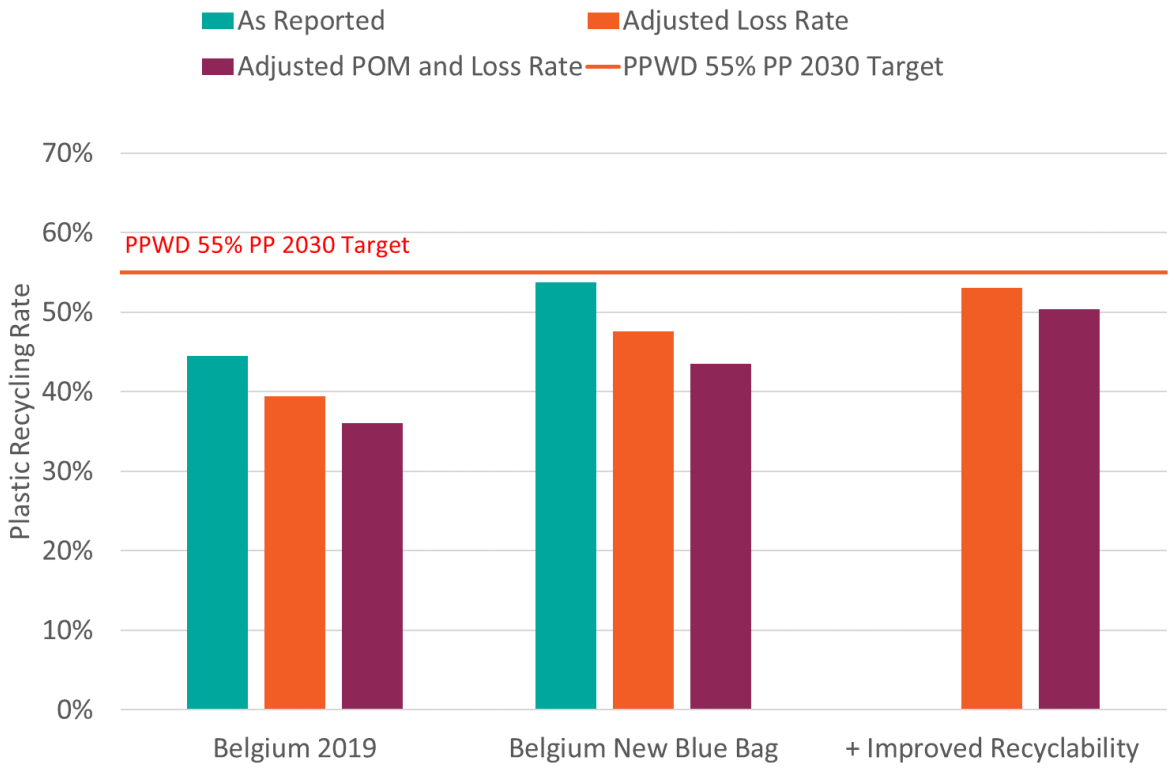
The German separate collection rate is already estimated to be among the highest in the EU and therefore further improvements in plastic packaging collection rates would seem difficult to achieve. Accordingly, we have not modified the collection rate in this future scenario. However, as discussed in Section 2.1.2 above, an improvement in the recyclability of plastic packaging does appear possible. These improvements will result in an increase from 43% to 50% in the plastic packaging recycling rate (Figure 2-5). Despite Germany being a best practice recycling example, the current planned improvements to the plastics recycling system are insufficient to meet the PPWD target of 55% by 2030.

Figure 2-5 Estimated impact of improved recyclability in Germany

2.1.2.2 Belgium

In 2021, Fost Plus rolled out the New Blue Bag system across Belgium. The previous collection system only targeted plastic bottles and flasks. The new system expanded the scope of collected materials to include all plastic packaging, including rigid plastics (pots, tubs and trays) and films. Although data on how the new system has improved collection rate has not yet been published, the expectation is for this to result in 8 kg of extra packaging collected per capita annually (Figure 2-6). This projection was confirmed by Fost Plus during this study. This scenario is shown in Figure 2-6 and indicates that under the New Blue Bag system Belgium is projected to get very close to the 55% plastic packaging target if no adjustments are made to the freeriding and loss rate estimates being reported. However, when sensitivities on these variables are applied, the modelled results show a significant risk of missing the 55% target. Further to the impact of the Belgium New Blue Bag scenario by 2030, the model also assumes an increase in recyclability as discussed in Section 2.1.2 above (+ Improved Recyclability in the figure below). Even when recyclability is increased, the loss rate adjustment and freeriding uncertainty still indicates a clear risk of missing the 55% target.

Figure 2-6: Estimated impact of improved collection and recyclability in Belgium



2.1.2.3 Sweden

Given the impact on Swedish recycling rates that the new measurement method has had, several interventions are already being planned on a national level to enable the country to meet the 55% target in 2030. It should be noted, however, that these interventions are planned based on the current reported rate of recycling (of ~33%,) without any further adjustments for underreporting PoM (which we have previously estimated could result in the recycling rate being lower at ~25%, as shown in the "Sweden Increased PoM" scenario in Figure 2-3). The following interventions are currently planned for *household* plastic packaging waste in Sweden, among others:

- Improved collection rates and quality of material particularly for household plastic packaging through roll out of municipality operated kerbside separate collection systems (in place of the prevalent bring systems) by 2027, funded through EPR. This is anticipated to increase collection rates for household plastic packaging from the current level of ~50% to ~80% by 2030 (bearing in mind that these estimates do not exclude all forms of contamination, product residues etc. and "pure" collection rates relative to what is placed on the market are therefore likely to be a little lower).
- The completion of a state-of-the-art sorting facility at Site Zero in Motala, effectively doubling sorting capacity for plastic packaging and allowing materials that are not currently targeted to be sorted for recycling in the future (with initial end markets for these materials secured). The existing facility at Motala is reported to sort four key fractions of plastic packaging material, with the new facility able to sort twelve (with some offtake of remaining mixed plastic fractions by chemical recycling facilities) such that the proportion of sorting rejects going to incineration should reduce from ~50% to ~20%. Around 80% of sorted fractions will be mono material and the rest will be part of two mixes, one with a minimum of 75% PO content (likely suitable for chemical recycling), and one with a minimum of 50% PO content (likely suitable for downcycling). [38]
- Increasing capacity to sort mixed waste material (i.e., prior to incineration) such that the contribution of MWS to overall material collected for sorting increases from ~7% at present to ~25% in 2025. In this case, contributions from MWS refer to the recyclable plastic packaging materials that are separated

[38] Personal communication with representative from Svensk Plaståtervinning's

from residual waste in a MRF prior to incineration, and then sent to the baling station alongside separately collected material to subsequently be sorted in the Motala plant.

- Increasing the coverage of the existing deposit return system for plastic beverage bottles, which currently applies only to PET bottles and aluminium cans with "ready to drink" beverages. From 2023 this will apply also to plastic bottles for other beverages like juice, squash, cordial, soups, etc. (though beverage containers for dairy products will remain exempt till 2026).[39] Glass bottles are excluded.

It is noted that the above interventions (excluding the increase in mixed waste sorting capacity) are anticipated to improve the recycling of **household** plastic packaging in Sweden to ~50% by 2025 (compared to an overall baseline recycling rate ~33%, of which the household plastic packaging recycling rate is currently only~18%). This is estimated to potentially be sufficient to reach a ~50% rate of recycling across all plastic packaging (given that the recycling rate of commercial plastic packaging is estimated to be much higher to start with at ~40%). No additional interventions are planned to increase this further by 2030, though it is expected that improvements to recyclability of packaging should boost the recycling rate further.

However, as mentioned earlier, this will not be the case once the impact of free riding on the PoM figures is taken into account as shown in the "Sweden Increased PoM" scenario in the figure below. The increased PoM figure was proportionately applied to both household and commercial plastic packaging waste tonnages, though not to DRS materials (for which the estimates of tonnages PoM are expected to be more accurate). With these adjustments, the anticipated collection rate of 80% for household plastic packaging in Sweden by 2030 would drop to nearer 60%, and the resulting overall recycling rate (for both household and commercial plastic packaging) would only be ~44% in 2030 as shown in the "Sweden Increased POM, IC + IR 2030" scenario in the figure below.

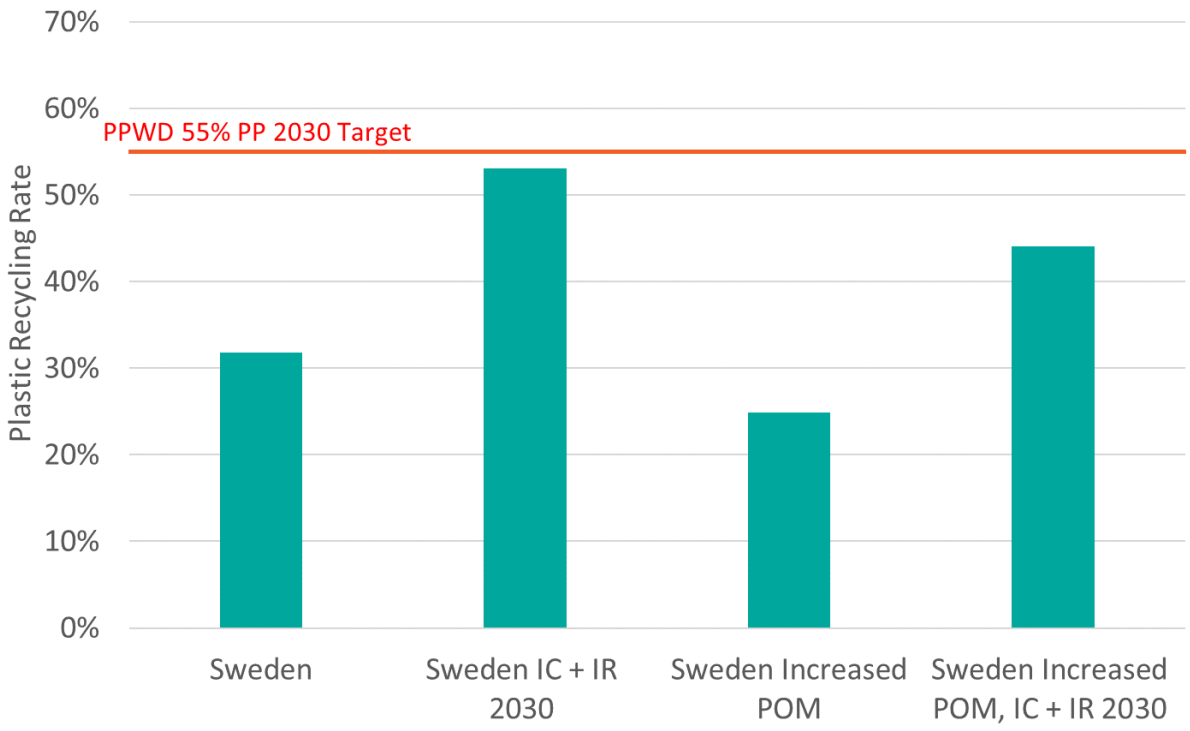
To summarise, the scenarios that have been modelled in Figure 2-7 are as follows:

- Improved collection (IC) + Improved recyclability (IR) 2030: starting from the modelled recycling rates of ~32% (which is slightly lower than the officially reported rate of ~33%), this scenario includes the increase in collection rates from planned changes to household collection systems and improvements in the recyclability of plastic packaging. These changes increase the amounts of plastic packaging targeted for collection, and work together with the improvements in sorting efficiencies to the new Motala plant. This scenario does not include improvements in collection of PET bottles through DRS or in MWS;
- Increased POM: as reported but with the higher estimate for POM;
- Increased POM, IC + IR 2030: as IC + IR but with higher estimate for POM and changes to DRS. This scenario reflects the calculated collection rate for plastic packaging with the adjusted POM figure as discussed above (ca. 60%).

It is worth noting that there are currently no planned interventions at the national level in Sweden to improve the recyclability of plastic packaging, however, EU level interventions in this area will impact the Swedish market as well and these have therefore been included in the 'IR' scenarios below.

[39] https://jordbruksverket.se/languages/english/return-deposit-system-for-plastic-bottles-and-metal-cans#h-Whatproductsareincludedintheregulation

Figure 2-7: Estimated impact of improved collection and recyclability in Sweden



2.1.3 The Contribution MWS Can Bring

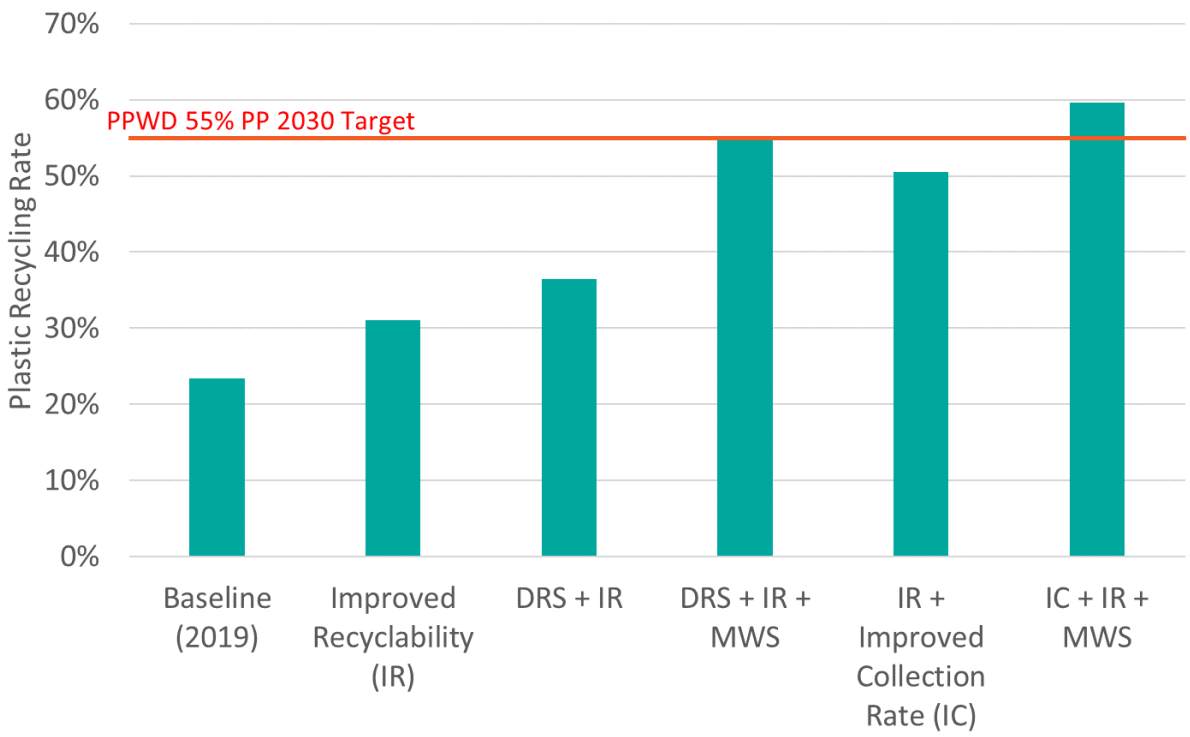
The above analysis at EU level and in the case study member states demonstrates that the only likely way that the EU will meet the 55% plastic packaging recycling target is if higher amounts of plastic packaging are captured and sent for recycling relative to what is possible with separate collection techniques and improvements in plastic packaging recyclability. This can be achieved by using existing techniques to separate plastics (and other materials) from the mixed waste that is destined for incineration or landfill. To reflect this, we assume that the introduction of mixed waste sorting (MWS) on all municipal "residual" waste streams over and above improvements in separate collections and recyclability would have the equivalent effect of an overall plastic packaging collection rate in the high 90's%. The results of overlaying this requirement for mixed waste sorting of all municipal waste streams on the existing assumptions for plastic packaging discussed above, is shown in the figure below.

The analysis suggests that if the efficiency of separate collections is only minimally improved, even the addition of mixed waste sorting will not enable us to meet our targets (as shown in the DRS + IR + MWS scenario), although the difference here is only equivalent to a few percentage points, and this finding is therefore not significant. The figure does clearly show, however, that **the 55% plastic packaging recycling target could be met through the introduction of mandatory mixed waste sorting of municipal waste streams alongside high performing separate collection systems and improved recyclability of plastic packaging** (represented by the IR +MWS scenario in the figure)**.** There would be further benefits from this approach to the attainment of the municipal waste targets and decarbonisation of waste management (discussed in Section 3.0 below).

In none of the other scenarios is the target attainable. These are described in Section 2.1.2 above.

In all scenarios there will be losses of plastic materials in sorting and recycling processes, and these have been properly accounted for in the scenario estimates discussed here.

Figure 2-8 Estimated plastic packaging recycling rate in 2030 with MWS requirement

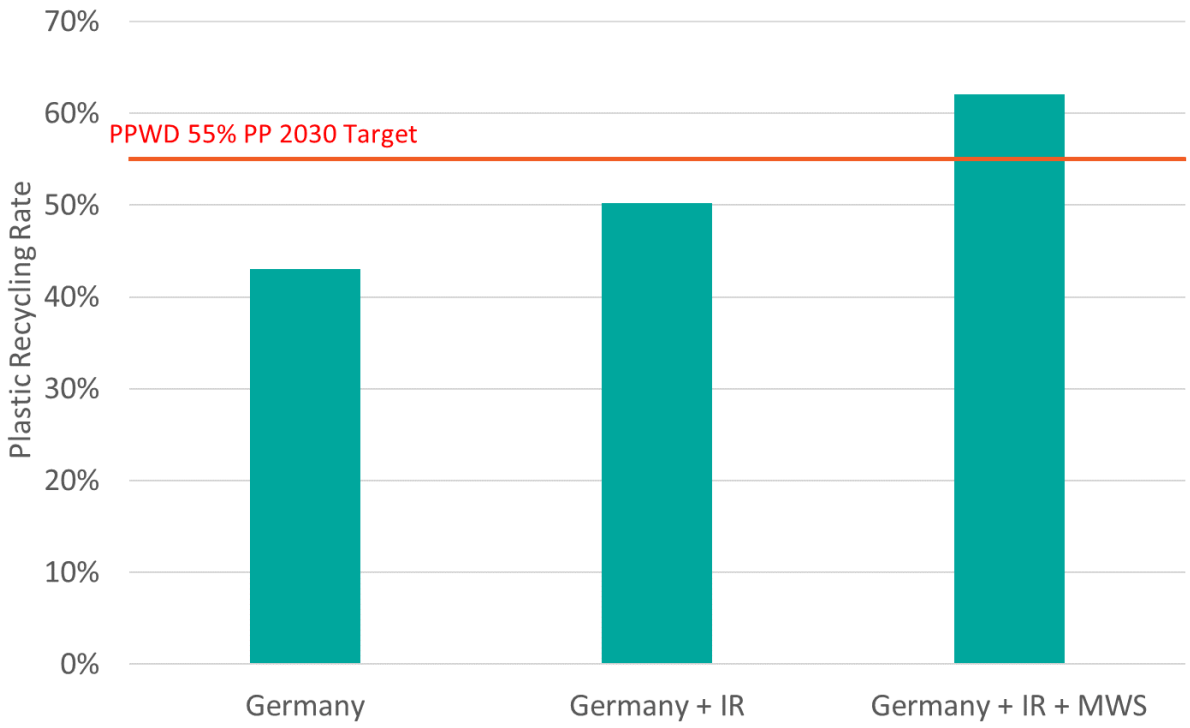


At the level of the individual member state case studies, we have been examining, MWS could have the following effect on recycling rates.

2.1.3.1 Germany

The addition of MWS to the recycling system in Germany is projected to give an additional 12 percentage points improvement, raising recycling rates from 50% to 62%. This will allow Germany to meet and exceed the EU target of 55% for plastic packaging recycling by 2030. It is therefore recommended that the introduction of MWS to the German recycling system begins as soon as possible as both improved recyclability and MWS are necessary to hit the PPWD targets.

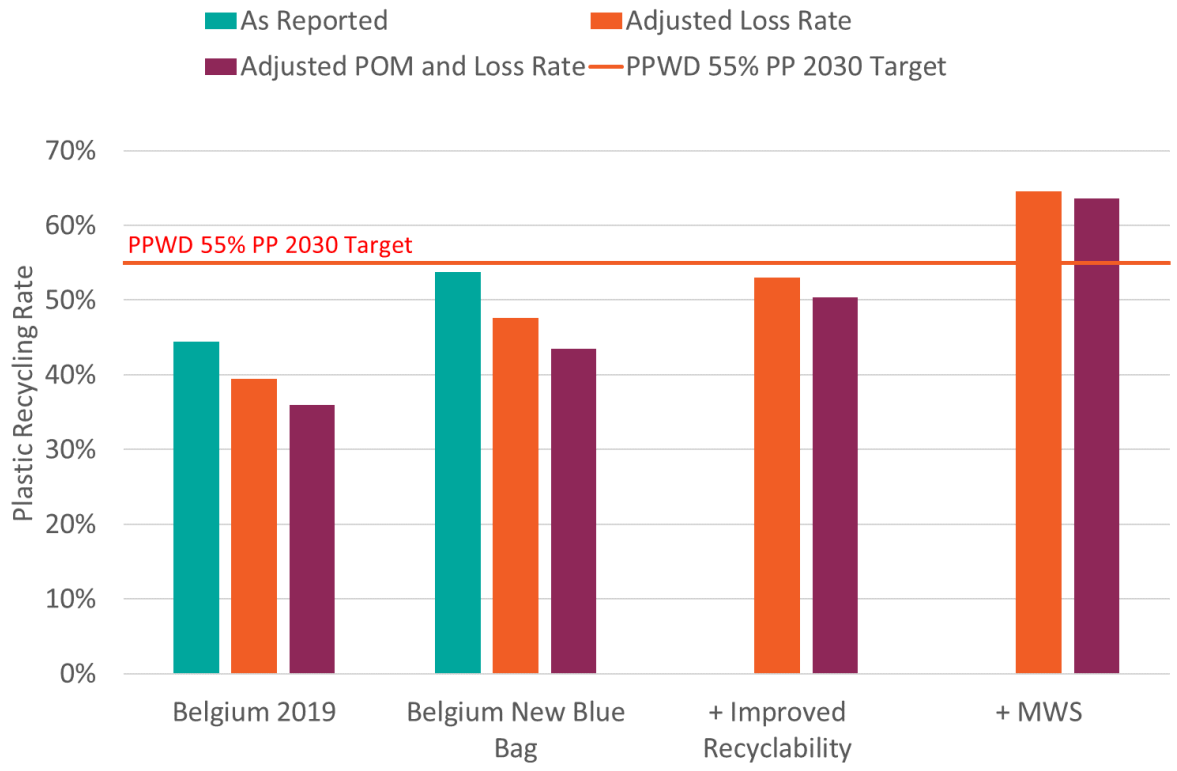
Figure 2-9 Estimated 2030 plastic packaging recycling rate in Germany with MWS



2.1.3.2 Belgium

The addition of MWS to the recycling system in Belgium is projected to give an additional 12 percentage points improvement, raising recycling rates (adjusted for losses) from 53% to 65%. This will allow Belgium to meet the EU target of 55% for plastic packaging recycling by 2030, even if the current POM figure is an underestimate. It is therefore recommended that the introduction of MWS to the Belgian recycling system begins as soon as possible as improved collection through the New Blue Bag system, improved recyclability and MWS are all necessary to hit the PPWD targets.

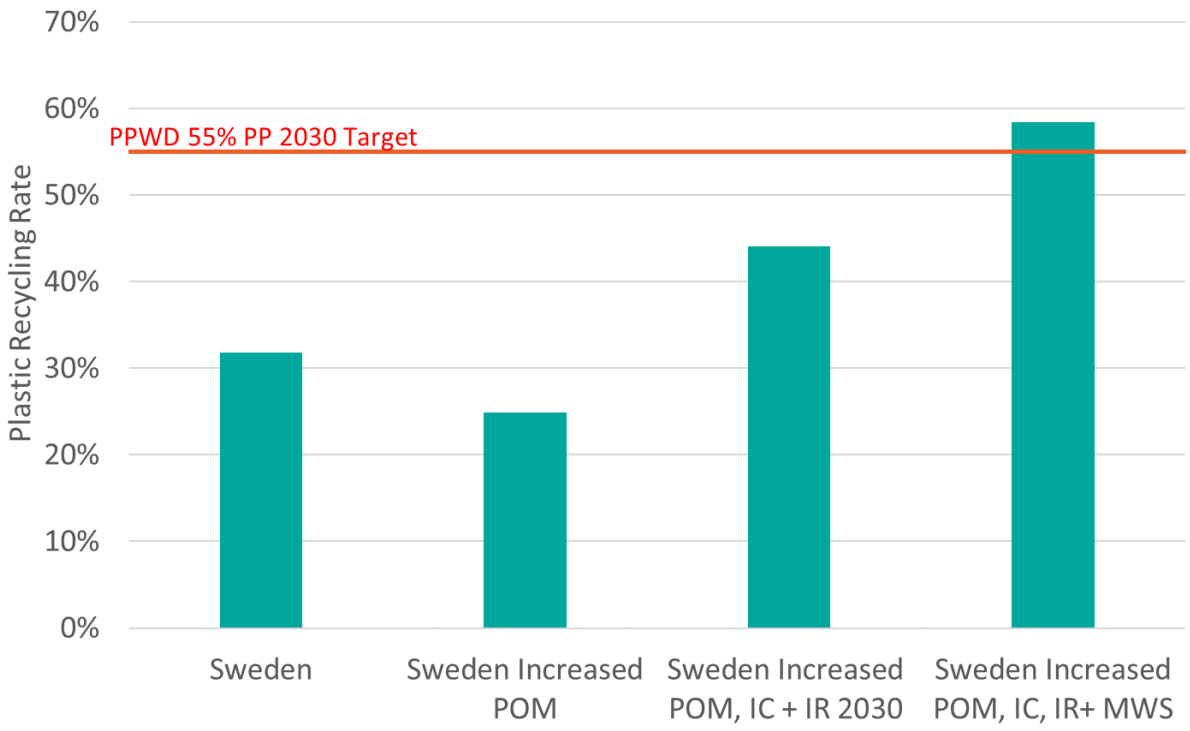
Figure 2-10 Estimated 2030 plastic packaging recycling rate in Belgium with MWS



2.1.3.3 Sweden

The addition of MWS to the existing planned improvements to the plastic packaging recycling system in Sweden is projected to raise recycling rates from ~44% to ~58% (an 14-percentage point improvement). This can be accounted for by the underestimation of PoM figures in the current recycling rate estimates. This underestimation results in overinflated estimates of collection and recycling rates, which, when compared to actual PoM figures, are likely to be much lower than official estimates. This in turn suggests that there is a much larger proportion of recyclable plastics in the residual stream than the statistics suggest, which, will not all be addressed through the planned improvements in separate collection. Once MWS is overlayed, however, capture of these materials for recycling can be maximised.

Figure 2-11 Estimated 2030 plastic packaging recycling rate in Sweden with MWS

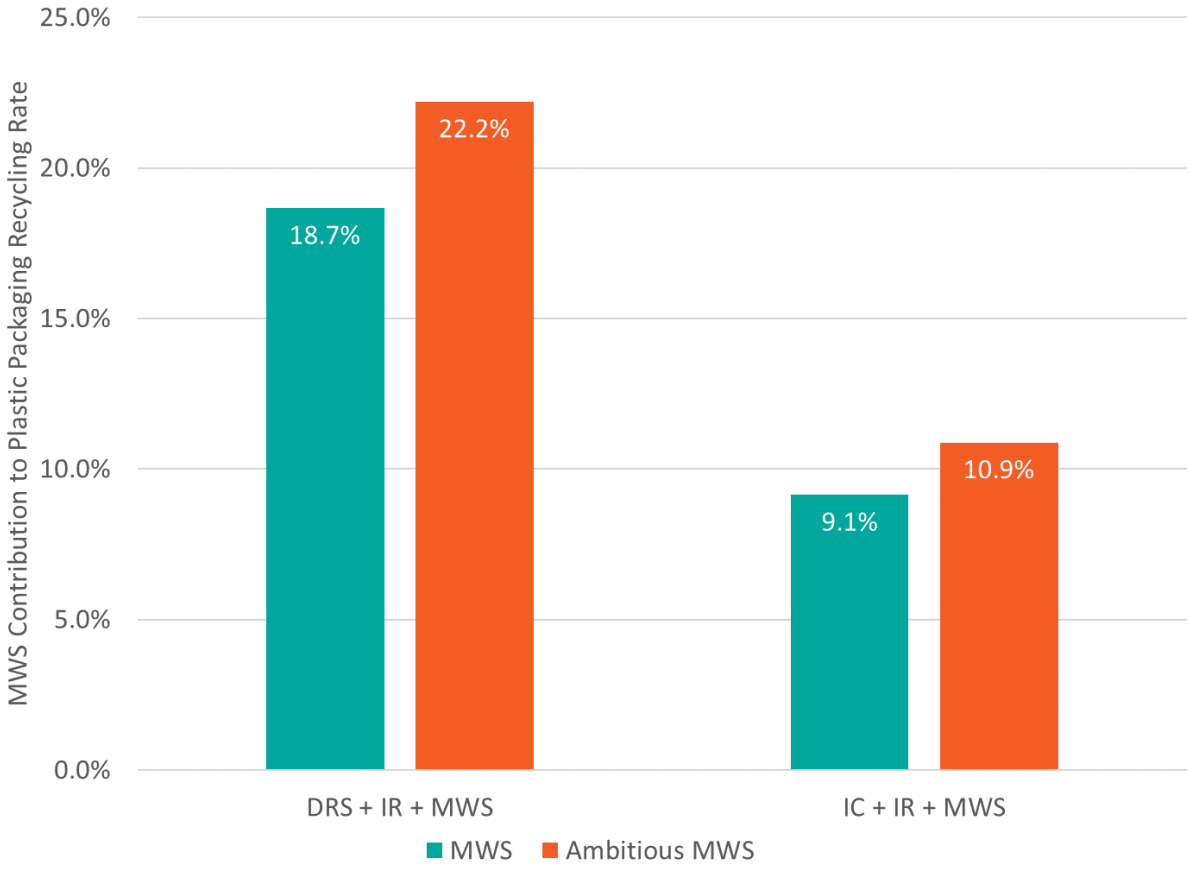


2.1.3.4 Potential for more ambitious MWS

Figure 2-8 suggests that the recycling rate is effectively "capped" at ca. 60%. However, we hypothesise that further improvements beyond 2030 can be driven by improvements in sorting efficiency at MWS plants such that MWS can help not just to meet existing targets but also to meet increasingly ambitious targets in the future. We have therefore included an ambitious MWS scenario to the analysis: the improved sorting efficiencies have been calculated starting from the MWS efficiencies, and assuming that an "additional" sorting with the same efficiencies would be applied to the materials not sorted, e.g. if the MWS sorting efficiency for a specific waste stream was 80%, then we applied that 80% again to the 20% not sorted, giving an overall sorting efficiency of 96%. In other words, this means that an additional 16% of that waste stream by weight would be sorted for recycling. Recyclability, collection and loss rates are instead kept the same as in the MWS scenario. This is technically achievable with the technology available today but would need to be part of a plants design and would come at a higher monetary cost.

Figure 2-12 shows the contributions that MWS and ambitious MWS could bring to the plastic packaging recycling rate. In the case of improved recyclability but only minor improvements to collection rates (DRS+IR), MWS could bring an improvement to plastic packaging recycling rates of 18.7%, and ambitious MWS of 22.2%. Considering the ambitious scenario of improved collections to the best examples in the EU (IC+IR), then the corresponding MWS would bring an improvement of 9.1%, and ambitious MWS of 10.9%. The figure hence shows that a further 1.8-3.5% could be added to the plastic packaging recycling rate from increasing the efficiency of mandatory mixed waste sorting, allowing plastic packaging recycling rates to exceed 60%.

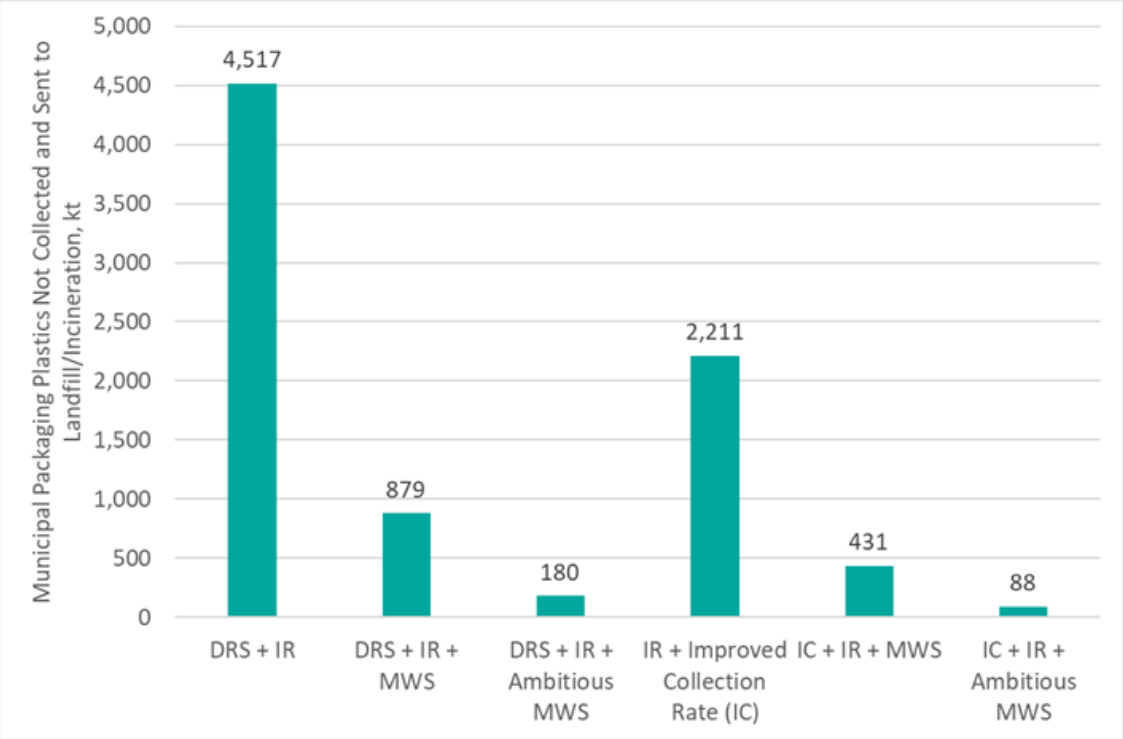
Figure 2-12: MWS and Ambitious MWS contributions to plastic packaging recycling rate



Although the potential for more ambitious MWS may look relatively small from a plastic packaging recycling rate perspective it is useful to also look at its potential from the perspective of the diversion of recyclable plastic waste from what would have otherwise been disposal or thermal recovery.

Figure 2-13 shows that in the case of no improvement in separate collection rates, MWS substantially reduces the amounts of plastics sent for disposal or thermal recovery by 3,638 kt per annum. However, "Ambitious MWS" could result in MWS sorting plants designed to divert an additional 699Kt of plastics per annum. In the case where separate collection improves substantially, there is less recyclable material leftover in the mixed waste fraction, so the contribution made by MWS is correspondingly lower, however, "Ambitious MWS" would still divert an additional 343kt of plastics from disposal or thermal recovery. This is associated with significant reductions of the GHG emissions currently associated with waste management, which is described in Section 3.0 of this report.

Figure 2-13: Plastics not separately collected and sent for landfill /incineration



2.2 Other Materials – Packaging Targets

The above sections focus on recycling rates for plastic packaging since these are likely to be the most challenging to meet, and plastics are also the material for which MWS is anticipated to have the greatest impact. However, the full implementation of MWS prior to incineration and landfill will enable greater capture rates for materials other than plastics as well (metals, glass and paper/ card). Therefore, in Table 2-7, we also examine the reported recycling rates for these packaging materials, and the impact that planned improvements will have on these, as well as the role that MWS could play.

For glass, aluminium and steel, the 2030 recycling targets are attainable through the rollout of DRS across the EU 27, alongside some improvements in separate collection rates (as shown by the figures highlighted in green in the table). MWS is therefore not necessary to achieve the 2030 target, but will certainly become relevant in the future as targets continue to rise as the circular economy develops.

Note that we have not included any non-packaging glass, aluminium or steel in the MWS. There is little or no data on the tonnage of this arising in the waste stream, and that which does arise is not the right type of material to be targeting by MWS, so it has been excluded from the modelling.

Table 2-7 Recycling rates for other packaging materials under all scenarios

Material	2030 Target	2019 Reported	Baseline Modelled	Improved Recyclability (IR)	DRS + IR	DRS + IR + MWS	IR + Improved Collection Rate (IC)	IR + IC + MWS
All Packaging	70%	64%	47%	48%	53%	68%	66%	71%

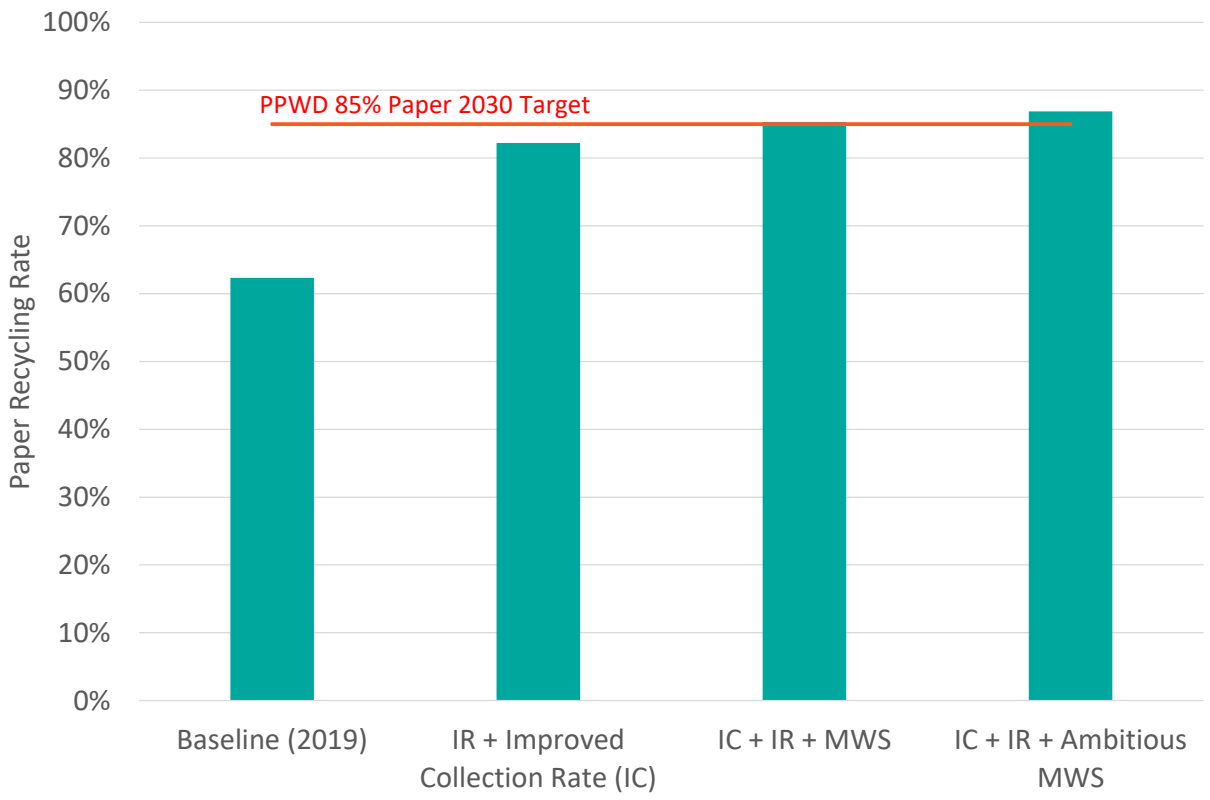
Paper and cardboard	85%	82%	62%	62%	62%	81%	82%	85%
Glass	75%	75%	63%	63%	82%	92%	85%	93%
Ferrous metals	80%	77%	60%	60%	62%	90%	85%	93%
Aluminium	60%	77%	47%	47%	59%	75%	68%	77%

Note: Figures highlighted in green show scenarios in which the 2030 target for the relevant packaging material is met

For paper and card, on the other hand, we do include non-packaging paper and card found in the municipal waste stream. These estimates are based on tonnages reported by CEPI in their key statistics[40] scaled to cover the EU-27. Non-packaging municipal paper and card waste is equivalent to around half the total tonnage of paper and card packaging and has therefore been added over and above the paper/ card packaging waste tonnage estimates.

The recycling rates for paper/card packaging have been displayed for clarity in the bar graph below. The recycling rate resulting from improved recyclability and separate collections of paper/ card packaging alone is slightly short of the target, however not significantly so. The addition of MWS does increase the recycling rate to above the target level, but again, very minimally so. It is therefore not clear whether further interventions are needed, and if so, whether MWS is the correct solution in this case.

Figure 2-14: Paper Packaging Recycling Rate Under Different Scenarios



[40] https://www.cepi.org/wp-content/uploads/2022/07/Key-Statistics-2021-Final.pdf

2.3 Municipal Waste Recycling Targets

The European Commission's Waste Framework Directive[41] sets out mandatory targets for EU Member to recycle (or prepare for reuse) 60% by weight of municipal waste generated by 2030 and 65% by 2035. These targets will need to be met using the new measurement method. Member States are allowed to continue reporting compliance against the 2020 target until 2024 using the historic measurement method, but can voluntarily choose to do so using the new measurement method.[42] At present, not all MS have chosen to implement the new measurement method in full, and the resulting municipal waste recycling rate in the EU 27 averaged 49% in 2021, which indicates that there is a substantial increase in recycling needed in many member states within a relatively short time period if the targets in 2030 and 2035 are to be met.

Whilst collection rates for recycling may improve there will almost certainly be recyclable materials left in waste destined for disposal/incinerations. MWS can capture the recyclables in mixed waste and divert them from incineration/ landfill to recycling, thereby contributing to the municipal waste recycling rate. This study therefore considered what the likely contribution to the municipal waste recycling rate would be through a full roll-out of MWS across the EU 27 and against several different separate collection scenarios.

Underlying all the scenarios is an assumed improvement in the recyclability of the key recyclable materials by 2030 (IR). Two collection scenarios were considered to show a range of plausible changes to collection rates within this timeframe:

- Only minor improvements to collection via DRS implementation for beverage containers "DRS+IR"; and
- The highest likely collection rates derived from the case studies (Section 2.1) above "IC+IR"

The modelling considered what MWS could achieve by further separating from the residual fraction;

- Papers (Packaging and non-Packaging);
- Plastics
- Metals
- Packaging Glass
- Polyester rich textiles (for chemical recycling)

The results were considered two ways; existing performance based on examples of sorting efficiency shown by the more efficient existing MWS plants; and "ambitious MWS" which shows what could be technically achieved if the right regulatory and economic incentives were in place to increase sorting efficiencies in these plants.

These sorting efficiencies were used to calculate (using the new measurement method approach) an estimate of kg/inhabitant of municipal solid waste that would additionally be recycled if MWS was rolled out. This was compared against the current estimated waste generation of 505 kg/inhabitant in Eurostat[43] to provide an estimate of the contribution of MWS to the relevant recycling rates as shown in Figure 2-15.

With existing sorting performance, it can be seen that MWS could contribute as much as 6.1% to the overall municipal waste recycling rate if there is minimal improvement to collections (just DRS implementation).

[41] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0098-20180705
[42] https://ec.europa.eu/eurostat/documents/342366/351811/Guidance+on+municipal+waste+data+collection/
[43] 2020 MSW reported to Eurostat

This drops to 2.9% if separate collections are performing at the highest current level in the EU 27. The likely actual contribution that MWS would make lies somewhere between these two estimates. Even with high end separate collection performance, if the sorting efficiency of MWS plants was improved (as shown in the ambitious MWS scenario), the lower range of contribution of MWS to municipal waste recycling rates would increase from 2.9% to 3.9%. The higher range of contributions in the ambitious MWS scenario is estimated to be 8.2%.

Further detail of how these contributions have been calculated are shown in Table 2-8.

Figure 2-15 - Contribution of MWS to municipal waste recycling targets

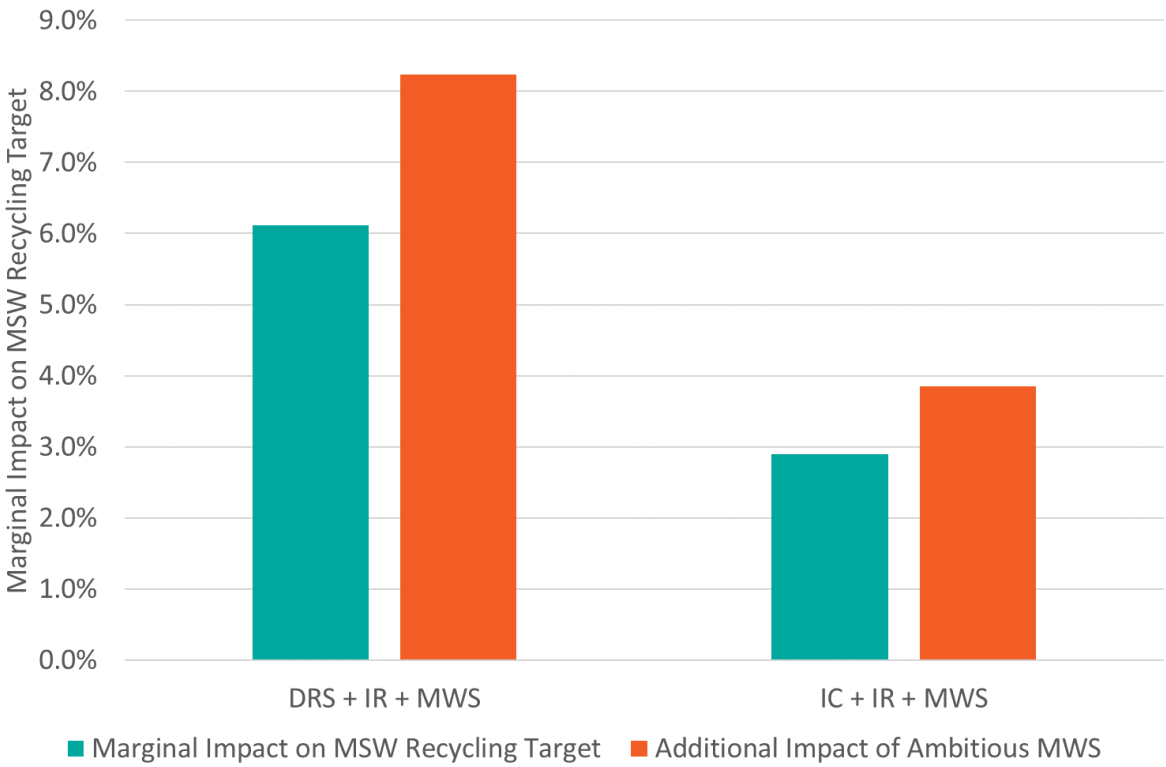


Table 2-8 Material added to recycling from MWS

	DRS+IR+MWS		DRS+IR+Ambitious MWS		IC+IR+MWS		IC+IR+ambitous MWS	
Material	Tonnes (k)	Kg/inhab	Tonnes (k)	Kg/inhab	Tonnes (k)	Kg/inhab	Tonnes(k)	Kg/inhab
Plastic	3,230	7.2	3,844	8.6	1,587	3.5	1,890	4.2
Paper / Board	7,031	15.7	10,547	23.6	2,988	6.7	4,482	10.0
Glass	1,729	3.9	2,074	4.6	1,337	3.0	1,605	3.6
Steel	1,033	2.3	1,136	2.5	301	0.7	331	0.7
Alu	225	0.5	260	0.6	131	0.3	151	0.3
Textiles	557	1.2	725	1.6	188	0.4	245	0.5

3.0

GHG Emissions

Addressing climate change, decarbonisation and the sustainable management of municipal waste are pivotal societal challenges, as recognised by the Paris Agreement. The EU recently adopted a 55% net emissions reduction target by 2030, in line with the objective of achieving climate neutrality by 2050. The waste sector is listed among the largest contributors to Greenhouse Gas Emissions (GHG) emissions in the EU, emitting 112 $MtCO_2e$ (million tonnes of CO_2 equivalent) in 2020 [44]. As such, managing these sectoral emissions is a key factor of the EU decarbonisation effort and is highly contingent on early legislative decisions.

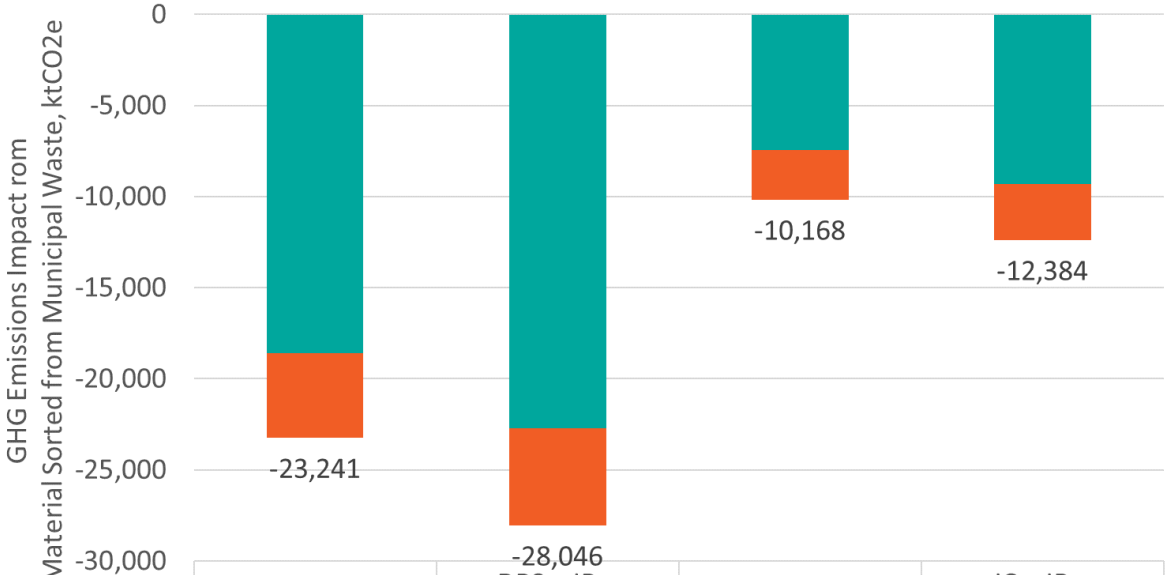
The end-of-life management of waste is directly linked to its GHG emissions and increasing the amount of recycled waste naturally leads to a lower final impact, not just thanks to avoided emissions related to virgin materials production but also by reducing the amount of waste that is incinerated. This is also relevant in the context of ongoing revisions to the EU Emissions Trading System (ETS)[45] and the Renewable Energy Directive (RED III)[46], both of which are considering regulating the incineration of waste such that, for example, associated emissions could be counted in the ETS and subject to mandatory pre-treatment using MWS in RED III.

Figure 3-1 shows the GHG emissions savings achievable through recycling of all materials sorted through MWS and ambitious MWS compared to the scenarios without sorting. . Removing high carbon content material from municipal waste, such as plastic, through increased sorting provided by MWS has a significant impact in terms of reducing emissions associated with incineration and increasing the total credits associated with recycling.

Considering the scenario with improved recyclability but only minor improvements to collection rates (DRS+IR), with a full roll-out of effective MWS a saving of 23.2 $MtCO_2e$/annum would be achieved, or 28.0 $MtCO_2e$/annum through a roll-out of ambitious MWS. Considering the ambitious scenario of improved collections to the best examples in the EU (IC+IR), then the corresponding MWS would lead to a saving in emissions of 10.2 $MtCO_2e$/annum, and ambitious MWS would lead to a saving of 12.4 $MtCO_2e$/annum. It is therefore reasonable to conclude that MWS would contribute a saving of between 10.2 and 23.2 $MtCO_2e$/annum, and ambitious MWS would contribute a saving of between 12.4 and 28.0 $MtCO_2e$/annum, with the range dependent on the success of separate collection improvements. This equates to a saving of between 9% and 21% of the total 2020 waste sector emissions thanks to MWS. An ambitious MWS instead could bring a saving of between 11% and 25% of the total 2020 waste sector emissions.

[44] https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer.
[45] https://oeil.secure.europarl.europa.eu/oeil/popups/summary.do?id=1708651&t=e&l=en
[46] https://resource.co/article/zwe-responds-european-parliament-s-new-position-red-iii

Figure 3-1 Greenhouse gas emissions saving from material sorted from municipal waste



	DRS + IR + MWS	DRS + IR + Ambitious MWS	IC + IR + MWS	IC + IR + Ambitious MWS
Residual	-4,652	-5,329	-2,726	-3,084
Recycling	-18,589	-22,717	-7,442	-9,299
Total	-23,241	-28,046	-10,168	-12,384

4.0

Conclusions

This report considers the current and likely performance of packaging and municipal recycling in Europe and concludes that a full roll-out of effective MWS is likely to be necessary to meet existing targets and almost certainly is important if climate change impacts of waste management are to be minimised and more ambitious recycling rates to be achieved in the future.

With respect to the current plastic and paper packaging rates it appears highly likely that even if the best examples of improved collection rates (which includes a full roll out of effective DRS) were to be achieved, which is perhaps a highly ambitious scenario, that the average EU recycling rates and individual case study results in Belgium, Germany and Sweden will still result in these targets being missed in 2030.

Although improvements to plastic packaging recyclability are likely, even when we overlay an ambitious improvement to recyclability over and above the ambitious improvements in collection rates then it still seems highly likely that the EU average recycling rates and those in Germany and Sweden will fall short of the targets. Only in Belgium does this combination of assumptions result in the plastic packaging target being met but this is based on a number of official assumptions around placed on the market figures and loss rates prior to input into the final recycling operation which are not very transparent. Sensitivity analysis on these variables illustrates the potential for this target to also be missed in Belgium in these scenarios.

Only when effective mixed waste sorting is fully rolled out across the EU and the case study countries is there any degree of confidence that the respective plastic and paper packaging recycling targets will be consistently met. This would also provide a useful contribution to the municipal waste recycling targets of between 2.9% (in a scenario in which separate collection rates are already highly improved) and 6.1% (if there are only minor improvements in separate collection).

Perhaps the most important contribution from MWS would be the reduction in GHG emissions associated with waste, as it is an effective method for ensuring that energy intensive materials are not lost to landfill and energy recovery but can be recycled and displace the need for virgin materials. It is reasonable to conclude that MWS would contribute a saving of between 10.2 and 23.2 $MtCO_2e$/annum, with the range dependent on the success of separate collection improvements. This equates to a saving of between 9% and 21% of the total 2020 EU waste sector emissions. This increases to a saving 28.0 $MtCO_2e$/annum equivalent to 25% of EU waste sector emissions if ambitious MWS is rolled out.