



Review of High Performing Recycling Systems

Report for the Scottish Government

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E.1.1 Executive Summary

Eunomia was commissioned by Scottish Government to investigate and comment upon international evidence regarding the policies and practices that appear likely, whether individually or in combination, to lead to high household recycling performance. This work was undertaken through the production and analysis of international case studies regarding high-performing recycling systems. Key findings regarding practices that could be applied in Scotland to increase recycling are as summarised below.

Service Design

Providing as many households as possible with access to a full range of recycling services is a common feature of successful systems. In Scotland, this should involve kerbside collections of:

- A full set of common dry recycling materials (paper/card, plastic, metal, glass).
 - Wherever possible, a wider range of materials should be collected at kerbside (e.g. textiles, plastic films, small WEEE, batteries).
- Separate food waste collections, including for rural areas and communal bin properties.
- Garden waste collections for properties that require them, although home composting should be incentivised and measured.

Communal bin properties present a particular challenge, in particular because it is difficult to constrain access to residual waste capacity for these properties (see below) – this being a major driver for improved recycling. Wherever possible, communal bin collections should be avoided and where required (e.g. for flats), in addition to providing sufficient capacity to collect all target materials, should be supported by appropriate practices such as:

- engaging with building managers, where they are in place, to give them the necessary tools (e.g. communications materials, signage) to encourage proper use of recycling facilities.
- restricting access to containers (e.g. requiring residents to use a swipe card) to make individual users feel greater responsibility for how they manage their waste and recycling, and to allow data to be gathered that would enable communications to be targeted on households that produce the most residual waste.

These services should be complemented by recycling centres or other recycling service provision (such as mobile recycling centres, especially in dense urban and highly rural areas) to collect additional materials not collected door-to-door as well as making provision for unusually large volumes of material that is collected at the kerbside, e.g. cardboard, garden waste.

Alongside these services there is a need to incentivise effective participation, through the approach taken to residual waste and through the use of other incentives.

Residual Waste

Steps to disincentivise the production of residual waste are effective in increasing recycling rates. Within the current legal framework, the key measure by which this can be done is to restrict effective residual waste capacity. For door-to-door collections, this can be achieved by emptying residual waste containers less frequently or by reducing their size; for communal bin properties, it is more challenging, but can be achieved by limiting access to residual waste containers (e.g. through swipe card access, perhaps limiting the number of times residents can access the container each week). Pay as you throw for residual waste can also be an effective incentive.

Residual waste can be reduced after it is produced by implementing advanced mixed waste sorting. This may be especially useful in areas facing the greatest challenges with kerbside recycling collections.

Other Incentives

Incentives to increase recycling can be applied either to municipalities (to encourage them to adopt more effective recycling services) or to householders (to encourage them to make full use of the services provided). For local authorities, Scottish Government could consider setting binding targets, perhaps doing so in a way that takes account of authorities' current performance and any constraints on what they could reasonably be expected to achieve. It is likely that some such expectations will in any case be placed on authorities, at least in respect of packaging waste captures, as a condition for receiving their full Extended Producer Responsibility (EPR) payments. To make the targets effective, the Scottish Government should (a) make funding and practical support available to help authorities improve services and (b) financially incentivise authorities to reach the targets.

Communication and Engagement

A consistent feature of high-performing systems is the use of high-quality, frequent communication to remind householders how to use the system properly. EPR will assist with funding, but the Scottish Government may need to supplement this funding if it wishes to make progress prior to EPR coming on stream, and where a focus is required on non-EPR materials such as food waste.

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1.0 Introduction

Eunomia was commissioned to investigate and comment upon the mix of policies and practices that can lead to high recycling performance through the production and analysis of international case studies regarding high-performing recycling systems.

The information and discussion provided will be used to inform the Scottish Government's Route map, supported by Zero Waste Scotland, which will set out how Scotland's 2025 waste and recycling targets will be met, including a 70% recycling rate and 15% reduction in waste generation. The project extends a previous analysis of high-performing recycling systems commissioned by Zero Waste Scotland in 2019. The project had two phases as described below.

Phase 1 consisted of research into the policies and practices in 10 international locations that have high recycling performance and/or have particular similarities to one or more parts of Scotland. One-page summaries of each case study are provided in the Appendix and a summary of the key features (including reasons for selection) is provided in Table 1. Scotland has a highly diverse geography, ranging from very rural (e.g. the Highlands and Borders) to highly urban (e.g. Glasgow) and including remote island communities. These differences will certainly affect the waste collection practices that are appropriate to each area and the costs of providing services, but in this study we explore whether there are substantial differences in the policies and principles that are appropriate to bring about high performance. A large proportion of Scotland's waste and recycling tonnage comes from dense, urban areas and these areas currently have amongst Scotland's lowest household recycling rates. Therefore, there was a focus on including case studies that demonstrate high recycling performance in dense urban areas, especially those with a high proportion of communal collections. The Welsh case studies (Bridgend and Vale of Glamorgan) were selected because they are similar to the more suburban and rural areas of Scotland and achieve high performance with standard door-to-door collections, demonstrating that additional performance could be achieved even in the areas of Scotland that are currently the best performers. The case studies also include examples, such as Treviso, that feature a range of geographies from urban to very rural.

Phase 2 analysed the key policies and practices identified in the case studies and used information from these case studies (and wider examples where applicable) to assess which are likely to be most effective in Scotland. Where possible, the influence of certain practices/policies on recycling rate has been highlighted, but data limitations mean this is hard to do accurately and consistently. Policies were split into those that may improve recycling performance from properties with:

1. Shared waste containment (i.e. communal collections)
2. Individual containment (i.e. door-to-door collections).

This split reflects the observation that, regardless of the density of households receiving door-to-door collections, many of the same policies and practices appear to be effective. The focus of the commentary is on improving municipal recycling rate but also includes discussion of the carbon impact and relative cost (where known) of certain policies, as these are important additional criteria for the Scottish Government.

Table 1 Summary of the 10 case studies assessed in this report

| Location (municipality/region) | Country | Reason for short-listing | Reported recycling rate | Dry recycling collection method | Cost recovery system | Pay as you throw (PAYT) | DRS |
|-----------------------------------|----------|--|-------------------------|---|--|-------------------------|---|
| 1. Bridgend | Wales | Very high performing, most similar to Scotland (geography, culture, legal context), good data available and figures verified by Eunomia. Bridgend has particularly high food waste capture and very low residual whilst VoG has high dry recyclate captures. | 63.4% | Multi-stream* | Y – Council tax and some producer responsibility through PRNs ¹ | N | N |
| 2. Vale of Glamorgan (VoG) | Wales | High performance in urban area with high proportion of population living in apartments. | 64.7% | Comingled dry material for 95% in 2018/19 - rolling out multi stream collections* | Y – Council tax and some producer responsibility through PRNs | N | N |
| 3. Ljubljana | Slovenia | High performance across a range of different geographies from very urban to very rural, including different approach to collections in city centre | 69.0% ² | Multi-stream*#, glass through bring banks | Y - costs recovered through fees and national EPR scheme | Y | Y - plastic packaging and glass bottles |
| 4. Treviso | Italy | High food waste captures in an urban environment | 89.0% ³ | Multi-stream*# | Y - costs are recovered through fees charged and EPR on packaging | Y | N |
| 5. Milan | Italy | | | Multi-stream*# glass through bring banks | Y - costs are recovered through fees charged and EPR on packaging | Y | N |

¹ PRN: Packaging Recovery Note

² Separate collection rate not recycling rate

³ Separate collection rate not recycling rate

| Location (municipality/region) | Country | Reason for short-listing | Reported recycling rate | Dry recycling collection method | Cost recovery system | Pay as you throw (PAYT) | DRS |
|--------------------------------|---------|---|-------------------------|--|--|-------------------------|--|
| 6. Stavanger Region | Norway | Reasonably well performing and utilising DRS ⁴ and mixed waste sorting for high captures on plastics. Mix of urban, rural and islands. | 49.8% | Plastics collected in residual, glass and metal 40% door-to-door 60% bring | Y - costs are recovered through fees charged and EPR on batteries, WEEE ⁵ and packaging | Y | Y - metal cans, PET ⁶ bottles |
| 7. Copenhagen | Denmark | Reasonable recycling rate given urbanity and population density. | 45.0% | Multi-stream, glass through bring | Y - costs are recovered through fees charged. EPR only for WEEE, ELVs ⁷ , batteries | Y | Y - most beverage containers |
| 8. Seattle | US | Good recycling rate for a city with a number of multifamily properties | 65.0% ⁸ | Comingled | Y - costs are recovered through fees charged. EPR only for WEEE, paint, medicines | Y | N |
| 9. Leoben | Austria | Well performing industrial town with around 80% collections from communal bins. | 59.4% ⁹ | Multi-stream#, glass through bring and metals mostly bring | Y - costs are recovered through fees charged and EPR on packaging | Y | N |
| 10. Kempten | Germany | Well performing with majority of collections from communal bins | 59.8% ¹⁰ | Multi-stream#, glass through bring and metals mostly bring | Y - costs are recovered through fees charged and EPR on packaging | Y | Y - beverage packaging |

* plastic and metals mixed, # paper and card mixed

⁴ DRS: Deposit Return Scheme

⁵ WEEE: Waste Electrical and Electronic Equipment

⁶ PET: Polyethylene terephthalate

⁷ ELVs: End-of-Life Vehicles

⁸ Residential recycling rate

⁹ Calculated from arisings so no adjustments made for contamination etc.

¹⁰ Calculated from arisings so no adjustments made for contamination etc.

2.0 Measurement Method

Any discussion of recycling performance must start from an understanding of how performance is calculated. In this context, there is value in highlighting both that the international cases discussed in this study differ somewhat in their approach to calculating recycling performance; and that Scotland itself is likely to see a change in its recycling measurement method.

Recycling performance in Scotland is currently calculated in line with the NI192 indicator, which measures “the percentage of household waste arisings which have been sent by the Authority for reuse, recycling, composting or treatment by anaerobic digestion.” Within this, the material counted as recycled is based on the weight of materials that are:

- collected door-to-door;
- received at recycling centres or points; or
- extracted through sorting;

and sent for processing into new products or materials.¹ This weight of material collected or extracted is adjusted, to a greater or lesser degree, to take account of any material that is rejected at an initial MRF (or by a reprocessor, if sold directly to them), but does not fully account for all sorting and process losses throughout the recovery system.

In addition to dry recycling, biowastes make a substantial contribution to recycling performance. Food and garden waste are counted towards recycling figures when they are collected and treated in an open air windrow, in-vessel composter (IVC) or anaerobic digestion (AD) facility and where PAS 100 compost or as appropriate PAS 110 digestate is produced and subsequently used.

Scotland is aiming for a 70% recycling rate for all waste by 2025.¹ This target includes household and other local authority collected wastes, measured under the NI192 method; it also includes both Commercial & Industrial and Construction, Demolition & Excavation wastes, which are measured differently. The latter two waste streams have not been examined as part of this research, which focuses on household wastes as the priority waste stream.

The governments of all UK nations are currently working together on a new Extended Producer Responsibility (EPR) scheme for packaging. This will include the setting of packaging recycling targets for all packaging obligated under the EPR scheme. Whilst this

is currently subject to consultation¹¹ there are proposed minimum targets for six packaging materials which equate to a packaging recycling rate of 73% by 2030². According to section 4.19 of the March 2021 joint consultation on Extended Producer Responsibility for Packaging, the measurement method required for measuring this recycling rate will be aligned with the calculation method defined in Article 11a of the revised Waste Framework Directive for recycling targets.³ This means that material will only count as recycled when it enters the “final reprocessing operation”, i.e. when “all checking, sorting and other operations necessary to remove waste materials that are not targeted by the subsequent reprocessing operation” have taken place.⁴

It may prove confusing to operate different measurement method for different recycling targets in future, and there is likely to be a tendency to gravitate towards the new, stricter method that will apply to packaging. This will have the effect of reducing the recycling performance that Scotland reports compared with the level they would be at under the current NI192 recycling rate calculation.

Scotland has a public-facing commitment to increase its recycling rate to 70% under the NI192 method. If the new recycling calculation method is adopted, there are several options open to the Scottish Government in respect of this target:

- 1) *Maintain the 70% target, but report using the new measurement method.* This would make the target more challenging to achieve.
- 2) *Adjust the 70% target down to reflect the additional losses under the new measurement method and report using the new measurement method.* This would maintain the effect of current target, but could give rise to the appearance that the Scottish Government has diluted its ambitions.
- 3) *Maintain the 70% target and continue to report recycling rate progress using the NI192 method, whilst reporting under the new measurement method where EPR requires.* Maintaining two different recycling calculation methods could give rise to confusion and suspicion regarding what level of recycling performance is “really” being achieved.

Note that, within the case studies, the approaches taken locally to calculating recycling rates vary. We comment on the approach taken in each individual case study. The introduction of the new calculation method under the revised Waste Framework Directive will facilitate international comparisons in future.

¹¹ This report was written during and directly after the UK-wide consultation on Extended Producer Responsibility for Packaging, which was issued on 24 March 2021. Subsequently, a summary of consultation responses and the Government response was published on 26 March 2022. While the response to consultation revises some of the proposals presented in the consultation document, upon review these revisions do not materially affect this report’s analysis or conclusions.

3.0 Policies and Practices

In this section we describe the policies and practices that our research and wider experience indicate are associated with high recycling performance.

3.1 Collection Systems

Unsurprisingly, all of the municipalities discussed in the case studies have quite comprehensive separate collections of dry recycling and biowaste, although the exact way these are delivered varies based on location, geography and cultural expectations.

In almost all of the case studies, different collection methods are used for different material streams and/or different situations across the municipality. For example, in dense city centres there may be some use of communal bins or underground bring banks, whilst more suburban areas are served by door-to-door collections.

3.1.1 Door to Door, Communal and Bring Sites

Door to door collections appear to have higher typical and potential yields than where communal collections and bring sites are relied upon. Where communal bins are used, measures such as enforcement, restricted access or engagement with building supervisors can be used to achieve high recycling rates. The use of bring banks may result in lower yields, although they are a cost effective approach that may suit dense city centres.

The case studies selected (as discussed in 1.0) include examples of municipalities that predominantly collect recycling door-to-door and ones that predominantly rely on communal collections. While there are examples of reasonably good performance in areas that rely on communal and bring collections, our wider experience, including the process of shortlisting case studies for this project, indicates that areas with a high proportion of door-to-door collections:

- Are more strongly represented within any list of high performing municipalities; and
- Are capable of achieving higher recycling performance overall.

Communal and 'bring' schemes rely on waste generators to deposit waste at centralised locations, and recovery rates within such schemes are typically lower. However, they are generally cheaper and easier to operate. Their main attraction, though, is that they can be deployed easily in areas of high housing density, which face challenges with bin storage and day-of-collection bin placement. In practice, cities can use a combination of these strategies, with a combination of residential door-to-door collections, communal collections and drop-off schemes.⁵

It is challenging to specify an optimum density for bring sites, whether per capita or per square mile, because it is influenced by the extent of reliance on them and the

population density. If bring sites are the main collection method, then the optimum density would be much higher than if they are just supplemental. In cities that place less reliance on bring sites the density is generally under 100 per 100,000 people. Whereas in Ljubljana, which has a high reliance on bring sites for glass, the density is 850 per 100,000 people. Furthermore, in rural areas the optimum density is higher per capita due to the distances involved; whereas in cities the optimum density is higher per square mile due to the population density. If relying on bring sites in the countryside, distances needs to be considered as well as numbers of people. The highest bring site density in the UK in 2013 was one site to around 165 households.⁶ This is equivalent to around 250 per 100,000 people.

Door to door collections are typically the most costly option, due to the labour and capital investment involved in providing and collecting large numbers of containers. Gathering cost data is particularly challenging, but one source is a 2015 European Commission report, which assessed separate collections schemes in the 28 capitals of the EU and provided some comparative analysis of the costs of door-to-door (both separate collections and co-mingled) and bring sites.⁹⁰ However, this source does not clearly distinguish between communal and door to door collections, and does not take account of the different cost bases (e.g. labour costs) of different cities, making it difficult to place great reliance upon.

One would expect the cost of bring banks to increase in proportion to the density of containers; however, the report found that the two cities with the highest per capita annual running costs for their bring sites, Bratislava (€12) and Prague (€10) had quite different container densities. Prague has the highest bring point density among EU capitals, while Bratislava's was lower than the average. Meanwhile, average running costs for bring schemes across the cities were €5 per capita per year.

Many of the case studies where a significant proportion of the population is on communal collections cite the use of building supervisors or managers⁶ in supervising the interaction between the householders and the collection system. Supervisors or managers are typically, in the countries where this approach is taken, staff already employed by a building's owners, and it is not clear that this role necessarily exists in the same way in Scotland. However, local authority and registered social landlord owned buildings will generally have someone responsible for their upkeep (estate managers, caretakers, concierges), although they may be responsible for more than one building. The same will be true of larger private apartment blocks, but there may be greater challenges with smaller blocks, tenements and HMOs (houses in multiple occupation). The use of building supervisors in managing waste and recycling collections can increase compliance with the collection system as well as ensuring the communal collections are well managed e.g. sufficient capacity in recycling containers, encouraging recycling. Where obligations to manage waste and recycling can be placed on building management this is cost effective for municipalities.

While it is possible to achieve good performance from communal collections, or from very dense bring bank provision, doing so appears to be considerably more challenging than in door-to-door services. There are a number of examples where recycling

performance has increased substantially when door-to-door collections largely replaced a former communal bin system (e.g. Argentina, Spain and Treviso, Italy).

It would appear that recycling rates in Scotland could be improved if, wherever practicable, communal bin collections were to be replaced by door-to-door collections. This would be likely to have additional costs for municipalities, but a significant share of these might well be funded through EPR. Clearly there will be situations, such as high rise apartments, where this will be less practicable. In Hackney, door to door recycling collections of recycling were trialled in 2008, but were terminated when concerns were raised regarding fire safety in connection with waste containers being left in public areas.⁷ It might, however, be possible in some buildings to collect certain materials, such as food waste or card, door to door, while continuing to rely on communal bins for other waste streams.

3.1.2 Dry Recycling

3.1.2.1 Source Separation of Dry Recycling

To achieve a high recycling rate, it is important that a comprehensive dry recycling system is offered that covers all materials and suits the locality. These characteristics appear to outweigh any impacts of service configuration, although this may affect material quality.

Each of the case study areas has arrangements in place to allow the recycling of all of the core dry recycling materials, although these arrangements differ considerably.

With only two exceptions, the case study municipalities have some source separation of different dry material streams at the point of collection. The exceptions are Vale of Glamorgan (VoG) and Seattle, which have comingled systems, although VoG is moving to introduce a source-separated kerbside sort system in line with the Welsh Collections Blueprint.

Where collected door-to-door, metal and plastics are commonly collected mixed (Bridgend, Ljubljana, Treviso, Milan), as are paper and card (Ljubljana, Treviso, Milan, Leoben, Kempten). From the case studies, and from previous WRAP research,⁸ it appears that source separation does not have a substantial bearing on recycling rate, at least under current measurement methods. In some cases, these may not necessarily account fully for contamination and process losses, which are typically greater within fully comingled collections – although one of the highest performers (VoG) appears to account for contamination well.

These possible disparities in reporting will be reduced under the new EU measurement method.

Glass collections

Collection of glass by bring sites is prevalent across major European cities.⁹ Some of the case study municipalities rely heavily or exclusively on bring banks to collect glass (Ljubljana, Stavanger,¹⁰ Copenhagen, Milan, Leoben, Kempten) and metal (Stavanger,

Leoben, Kempten). It therefore seems that reliance on bring sites for glass is not necessarily a barrier to achieving reasonably good recycling rates. However, this finding is based on case studies of areas with a reasonably high density of bring banks; lower densities are likely to result in lower yields.

In addition, three of the case study areas that rely heavily on bring sites have a Deposit Return System (DRS) in place for glass bottles (Ljubljana, Copenhagen, Kempten) and four for metal beverage containers (Ljubljana, Copenhagen, Kempten, Stavanger). This helps to boost overall recycling performance for these material streams and reduces the volume of material for which municipal collection is required, making the relative inconvenience of bring banks less of an issue.

Analysis of whether glass yields are higher through door-to-door than bring sites would require a bigger dataset than is available to this project, and appropriate adjustment for DRS. We would speculate that, whilst glass captures are reasonable through bring banks, door-to-door collections will tend to have better captures. This trend would be particularly likely to arise where householders are attuned to expecting door to door collections.

Smaller Material Streams

Smaller streams such as WEEE (Waste Electrical and Electronic Equipment), batteries and textiles are most commonly collected through bring or recycling centres. However:

- in Bridgend, textiles and WEEE are collected door-to-door,
- in Copenhagen, WEEE and batteries are collected door-to-door,
- in Stavanger, hazardous wastes are collected door-to-door at a low frequency.

There is a mobile collection unit for WEEE and hazardous waste in Ljubljana.¹¹

Door to door collections of these materials can be cost effective when they are collected at the same time as other materials (e.g. on kerbside sort vehicles). While targeting these streams has a small impact on tonnage-based recycling rates, its impact on the carbon benefit of recycling can be disproportionately large. In Chichester, the Council is currently running a trial of a separate van pass for kerbside collections of WEEE and textiles, covering 75% of the authority's ~58,000 households. The council estimated that the costs of setting up and running the first 8 months of the pilot would be around £68,000, with ongoing costs of £20-45,000 per year.¹² However, some of the costs are now being met by Podback, and the service is also collecting coffee pods for recycling.¹³

3.1.2.2 Collection Frequency

Collection frequency should be tailored to the material stream, taking account of container size and yield.

Most of the case study areas where materials are collected door to door have either weekly or fortnightly collections of most dry recycling streams. However, some of the case studies have less frequent collections for certain materials. In Kempten, the (mostly communal) paper/card bins are collected 4-weekly, whereas in other case study areas

(e.g. Bridgend) they are collected weekly. It is hard to directly correlate collection frequency with waste arisings given so many other influencing factors on arisings. Nevertheless, in Kempton the waste arisings of paper/card are 84kg/capita, whereas in Bridgend paper and card arisings are roughly half this (96kg/hhld which equates to around 40kg per capita).

In Stavanger where door-to-door collections are in place for glass and metals these are only every two to three months (on request). These low frequency collections are cost-effective for low volume materials, provided that households have adequate storage space. In Stavanger, annual waste arisings per capita are 14 kg of glass and 2.69kg of aluminium cans, whereas in Bridgend (with weekly glass collections) they are 27kg of glass and 1.25 of aluminium cans (assuming average household size of 2.4).

3.1.2.3 Mixed Waste Sorting

Mixed waste sorting is costly, but can make a modest - though important - contribution towards municipal recycling rates and has particular carbon benefits where plastics are extracted ahead of incineration in EfW facilities.

Mixed waste sorting (MWS) is being used to support recycling performance in European municipalities, including some of the case study areas.

- MWS contributes 4.6 percentage points to the recycling rate in Stavanger, but is able to achieve this in part because the collection system asks residents to place their non-deposit bearing plastic packaging in the residual waste stream.¹⁴ Where a comprehensive range of materials are collected at the kerbside and a deposit scheme is in place.
- The Regional Waste Management Centre that serves Ljubljana reports that it extracts a surprisingly large amount of recyclables (30,000 tonnes) from the 150,000 tonnes of mixed waste it processes each year, although we have not been able to identify an independent validation of this claim, or to distinguish how much of this is removed from Ljubljana's waste, as the facility serves several municipalities.
- Copenhagen is planning to introduce mixed waste sorting with an aim of capturing 14,055 tonnes of household recycling and increasing recycling by 6 percentage points. The costs of doing this are estimated in their Waste Management Plan at DKK37 million (≈£4.25m) across the period 2019-2024, including investment costs of DKK1 million and operating costs (net of residual waste treatment savings) of DKK36 million, which will be financed by a 20-year loan.

The amount of recyclables that can be extracted from mixed waste sorting depends upon the amounts collected by separate collection and the range of materials targeted in the mixed waste sorting facility. Prior to the introduction of MWS in Stavanger, the municipality operated a separate door-to-door collection of the plastic packaging that was not targeted by Norway's DRS. The plastic collection ceased when MWS was

introduced and the result was a substantial increase in captures of plastics (and also metals) from municipal solid waste.

In the UK, efforts at MWS in the form of mechanical and biological treatment (MBT) of residual waste have been associated with producing poor quality plastics; indeed, many facilities that had the capability to separate out plastics have opted not to do so due to poor end markets for the material making separation financially unattractive. This issue does not seem to arise with the latest advanced pre-treatment, with manufacturers claiming that around 65% of captured material is being reprocessed, with the greatest losses taking place at the washing stage.¹⁵ This lost material is likely to be food residues and other dirt; however, some plastics will also be lost during sorting and reprocessing, and this material is likely to be sent to some form of residual waste treatment in the absence of chemical recycling options.

Whilst the contribution to recycling rate may generally be modest for the investment required, MWS has the wider benefit of preventing plastics from being incinerated, which reduces greenhouse gas emissions. The investment will be easiest to justify in municipalities where:

- Captures of recycling – especially plastic and metals – through separate collections are low;
- There is a particular focus on achieving very high recycling rates
- There is a focus on reducing the carbon impacts of waste (e.g. because the municipality is aiming to reach net zero)

In the current Scottish context, where a major driver for authorities to recycle is to avoid disposal costs, the business case for MWS is challenging. However, EPR may change this by potentially introducing performance linked payments which encourages higher recycling of packaging. In Stavanger, packaging extracted from mixed waste sorting results in the operator receiving EPR payments, which help to support the business case. However, whether this will be the case in the UK will depend on the design of the new EPR scheme, and whether MWS can be treated as a “necessary cost” of meeting the packaging waste targets, whether in some or all municipalities. As noted above given the carbon benefits for local authorities and waste operators which are focused on reducing the carbon impacts of waste (e.g. through net zero targets), which an increasing number are, this strengthens the case for introducing MWS.

3.1.2.4 Deposit Return Schemes (DRS)

Deposit Return Schemes (DRS) can achieve much higher capture rates than other methods of collection and make notable contributions towards municipal recycling rates.

Deposit Return Schemes for beverage containers are a proven tool to yield high capture rates, allowing containers to either be reused or (more typically in modern systems) high-quality, closed loop recycling. These systems see customers pay a small deposit when they purchase a can or bottle, which they get back when they return the container to a collection point for recycling.¹⁶ DRS systems typically secure a return rate of over

85% (as proportion of materials placed on market that are in scope of the DRS), with Germany showing the best results globally at 98% returned (a figure which excludes the glass return rate, which is not reported).

Four of the 10 case study areas have some sort of DRS in place. These are outlined in Table 2 alongside a summary of which materials are included and information on capture rates (where available).

Table 2 Summary of case studies with DRS in place

| Case study | Materials included in DRS | DRS Capture rate |
|-----------------------------|---|--|
| Ljubljana (Slovenia) | Only a remnant of a DRS for reusable glass bottles and some group packaging exists. ¹⁷¹⁸ | No data available. |
| Stavanger (Norway) | Nationally, Norway operates a DRS for metal cans and plastic beverage packaging Glass bottles were formerly included in the DRS but have since been removed from its scope. | At a national level, Norway performs well with 89.4% of PET bottles placed on the market and 89.5% of metal cans being captured through the DRS in 2019. ¹⁹ |
| Copenhagen (Denmark) | Nationally, Denmark operates a DRS for most beverage containers, including those made from PET, metal, and glass. Cartons and pouches not included. | At a national level, Denmark is well performing with capture rates (as proportion of materials placed on market) of 94% for PET bottles, 90% for metal, and 88% for glass. ²⁰ |
| Kempton (Germany) | Nationally, Germany operates DRS schemes for most beverage containers, including those made from PET, metal, and glass. Cartons and pouches not included. | At a national level, Germany is extremely well performing with a return rate of 99% for metals and 97% for PET (on average 98% across both materials). The return rate for glass is unknown. This return rate is the proportion of materials within scope of the DRS placed on the market that are returned. ²¹ |

A DRS is planned in Scotland for beverage containers (for both soft and alcoholic drinks) made from PET plastic, steel, aluminium, or glass. ²² The high capture rate of DRS materials means that it has implications for the design of kerbside collection systems.

Where plastic bottles fall within the scope of a scheme, the high value PET bottles are mostly captured through DRS, leaving only lower grade plastics in the kerbside system. In Stavanger’s case, with a DRS for PET bottles in place the municipality opted to stop separate collections of the remaining plastics, which are instead placed in the residual waste and extracted through MWS. As already discussed in section 3.1.2.1, with a DRS system for glass there will be less glass in the household ‘mix’ and municipalities could consider collecting remaining glass through either a dense collection of bring banks or an

infrequent separate kerbside collection (4-weekly, for example) – or even mixed with other containers.

3.1.3 Food Waste

Collecting food waste for all property types is a precondition for a high municipal recycling rate. To achieve a high capture rate, a collection system must be supported by appropriate policies to drive captures. These may include: effective communications; restrictions on the volume and/or frequency of residual waste collections; and enforcement against disposal of food waste in residual bins. The frequency of food waste collections should be sufficiently high to avoid disamenity, especially odour issues; the frequency necessary to achieve this is influenced by local weather conditions. In the UK, weekly separate collections of food waste from kerbside properties have been found to be the most successful, and outperform fortnightly mixed food and garden to a significant degree.

Implementing comprehensive food waste collections is a precondition of high municipal recycling rate, as food waste makes up a substantial share (by weight) of municipal waste. No municipality, to our knowledge, has approached a 65% recycling rate without good captures of food waste.

However, merely offering a food waste service is not sufficient to achieve good capture rates. There are plenty of examples of areas with food waste collections that are not performing well (e.g. Sandwell, West Midlands, offers a weekly food waste collection service but collects only 25kg/hhld in 2019/20²³ – perhaps because it is offered alongside a weekly residual waste service).²⁴

In the case study areas, the municipalities almost all provide a food waste service, both for properties that receive door-to-door and communal collections. While communal bin properties tend to have lower yields of food waste, due to the challenges of encouraging participation when residents have effectively unlimited access to residual waste capacity, high capture rates are achieved in several case studies with a high proportion of communal collections. Most notable of these is Milan, where 75% of the population live in flats yet the food waste capture rates are high at 79%, which equates to 141kg per capita each year.

The high participation rates in Milan are largely attributed to:

- good communications with residents;
- a system of assigning responsibility for taking bins out within communal properties; and
- effective enforcement processes against food waste being placed in residual waste (further detail in 3.4.3)

Other measures used to increase participation in food waste recycling have been trialled across the UK. WRAP has funded the use of a “no food waste” residual bin sticker, a free supply of caddy liners, and information leaflets for residents for a number of local authorities. For the participating authorities, the use of this suite of measures increased

food waste yields by 12kg per household from 2013-2015, with Norwich achieving an even higher yield increase of 15.1kg.²⁵

Some of the case study municipalities provide 'free' food waste collections (VoG, Bridgend), while others include this service within a fixed fee portion of the local waste management charge (Copenhagen, Treviso, Milan, Stavanger), so that there is no additional cost for each kilo of food waste presented. Others charge based upon volume, although this typically occurs where food waste is combined with, and thus greatly outweighed by, garden waste (Seattle, Kempten, Leoben, and Ljubljana). In the UK, mixed food and garden waste collections appear to give rise to lower captures of food waste than separate food waste collections,²⁶ although it is not clear that this pattern is replicated in all municipalities around the world where such schemes are implemented.

The different fee structures do not seem to have a notable influence on yields. In order to have an effect, and provide a substantial incentive for food waste recycling, any charge for food waste needs to be substantially lower than any residual waste fee. Within the case study areas that charge for both, only Seattle seems to have a notable price differential between food and residual waste collections, and it therefore does not seem that in the cases of Kempten, Leoben and Ljubljana the price differential between organics and residual is a big influencer of recycling rates. Seattle's yield of organic waste is 123kg/household per year.

There frequency of food waste collections varies across the case study areas. In most cases, food waste collections are weekly, and WRAP has found that in the UK fortnightly mixed food and garden services are outperformed by weekly separate collections.²⁷ However, areas with a warmer climate, such as Treviso and Milan, collections are twice weekly, to reduce odour issues during warm weather. Both of these Northern Italian cases have particularly high food waste collection rates at 86kg/capita and 141kg/capita respectively, which might suggest more frequent collections are directly causing the higher capture rates.

However, there are other regions (including other areas of Italy) where, despite similar collection arrangements, food waste captures are lower.²⁸ There are also a number of case study areas where food waste is collected less frequently (as infrequently as fortnightly), yet capture rates are still high. For example, in Stavanger collections are fortnightly year-round and in Leoben and Kempten these are fortnightly in the cooler months and weekly in the warmer months. It should be noted all three of these examples have charges in place for residual waste disposal (see case studies for detail). This suggests that, rather than high frequency being a determinant of performance, what matters is that the frequency is sufficiently high to avoid disamenity from separate food waste collections, which will be greatly influenced by local weather conditions.

3.1.4 Garden Waste

Garden waste collections should be offered to households for which they are appropriate. Charging for garden waste collections is likely to reduce the amount of material captured in the kerbside system, with much of this diverted to Household Waste and Recycling Centres (HWRCs) and home composting.

The collection of large volumes of garden waste at the kerbside is not a necessary condition for a high recycling rate in urban areas where garden waste arisings are low. This is all the more true if material that is home composted is counted towards municipal recycling performance.

Four of the case study areas (Ljubljana, Seattle, Leoben²⁹ and Kempten) collect garden and food waste as a mixed stream. All of these have a 'Pay-As-You-Throw' (PAYT) fee for organic waste, as detailed in the case studies. Six of the case study areas offer separate collections of garden waste: Bridgend, VoG, Treviso, Milan, Stavanger, and Copenhagen. Of those with separate collections:

- two include the cost of this service in a flat waste management fee (Stavanger and Copenhagen);
- two make a discrete charge for it:
 - Bridgend charges £38.91 per household (£34.85 for pensioners);
 - Treviso requires an unquantified 'additional fee';³⁰ and
- Milan requires households to arrange collections with a private contractor.

The free garden waste collections offered by VoG produces greater yields of garden waste (137kg/household) than does Bridgend's charged for service (66kg/household). These figures take account both of garden waste collected at the kerbside and received at HWRCs, and the difference in garden waste collected between the two is therefore of the result of differences in local arisings per capita, the amount of garden waste disposed of in the residual waste and the amount that is home composted (or otherwise disposed of). However, it would not be reasonable to attribute the difference in yields solely to charging practice, when the municipalities also differ considerably in their geography and demographics.

In some case study areas, notably VoG and Treviso, separately collected garden waste makes a substantial contribution to recycling rates. However as demonstrated by Milan and Bridgend (which have relatively low garden waste arisings yet good recycling rates) the collection of large quantities of garden waste is not necessary for a good recycling rate.

Charging for garden waste can meet some of the costs associated with the service, but benchmarking work carried out by Eunomia indicates that it leads to some material being diverted to recycling centres, some to the residual waste stream and some no longer being set out for collection – presumably being home composted instead. Combining charging with encouragement for (and measurement of) home composting could be a way for authorities to continue to gain an income from garden waste while minimising the negative impact on recycling performance. Another approach taken by

some local authorities is to provide one bin free of charge, but to charge for additional bins; however, relatively few households generate sufficient garden waste to regularly require two bins.

Home Composting

Home composting provides a low cost way of managing organic waste in an environmentally responsible way, avoiding the need for the material to be collected and transported on (typically diesel) vehicles for composting. A number of local authorities in the UK have historically looked to encourage home composting by providing low cost home composting bins. Four of the case study areas (Treviso, Leoben, Stavanger and Kempten) provide an additional incentive by offering discounts on their charges for residual waste to households that indicate they are home composting and/or have received a home composter.

At present in the UK, garden waste that is composted at home will not be counted towards municipal recycling performance. However, in several EU Member States, an estimate of home composted material is included in recycling calculations.³¹ The European Commission's new guidance on the measurement method to be applied to calculating recycling performance attempts to bring more uniformity to such estimates, providing two methods that must be adopted by Member States wishing to report home composted garden waste – a simpler one for those wishing to claim up to 5% of municipal biowaste being home composted, and a more strenuous one to be applied where the amount exceeds 5%.³²

3.1.5 Residual Waste

Householders should be incentivised to minimise residual waste. This can be achieved relatively straightforwardly for households with door-to-door collections, whether through restricting effective weekly residual waste capacity (via smaller bins and/or less frequent collections) enforced volume limits (as in Wales), or through the use of an effective pay as you throw system. It is more challenging to achieve for households that use communal bins or bring arrangements, but has been done in some locations through the use of swipe card access and enforcement.

All the case study areas have policies that aim to incentivise householders to avoid putting recyclable materials in the residual waste. These either take the form of a capacity restriction or some form of financial incentive. Incentivising communal collections requires a slightly different approach to door-to-door collections. However, this is still ultimately achievable through limiting waste disposal capacity and/or charging by weight/volume. Communal collections require investment in different waste collection methods such as underground containers, perhaps with smart access. Therefore, increased emphasis on communal collections requires a clear investment plan and a determination to act on the part of the waste collector; these have been difficult for Scottish local authorities to provide.

The two Welsh case studies (VoG and Bridgend) have a capacity restriction, introduced in 2017. Each household is limited to two bags of residual waste per fortnight. It is hard to

determine the direct impact of this measure on recycling rates as it coincided with the introduction of increased capacity for recycling containers. The authorities also both began to offer separate containers for Absorbent Hygiene Products, although these were only sent for recycling by Bridgend. Following these three service changes, the recycling rate in Bridgend increased by 14.7 percentage points in just one year from 2016/17 to 2017/18. In VoG, the recycling rate increased by 6.7 percentage points between 2017/18 and 2018/19.

There are two types of Pay As You Throw (PAYT) systems found within the case study areas, although most would be more accurately described as a 'pay per container' volume charge. Either

- residents pay a variable fee proportionate to the exact weight or volume or waste they dispose of; or
- residents pay a variable fee based on container volume.

There are very few examples of the first type of PAYT and most regions with PAYT (including all the case study areas that use a charging system) use the second type because it is easier to implement, although arguably less effective. Some regions, such as Ljubljana and Stavanger, have implemented the first type of PAYT at container parks, where it is easier to implement the weighing equipment necessary for it to work.

There are many examples where PAYT systems seem to have contributed to high recycling rates. A 2016 assessment by the European Environment Agency concluded that "all countries with recycling rates above 45% employ a similar system [to PAYT], while most countries with recycling rates below 20% do not use them".³³ Time series data from Treviso offers evidence of the positive impact a PAYT system can have on recycling rates. PAYT was introduced into one district in the Treviso region in 2002, and an 8 percentage point increase in recycling rate occurred in the following two years.

However, there are examples where PAYT systems have not resulted in high recycling performance. For example, Poland has a PAYT system implemented uniformly across the country and comprehensive separate collections systems, yet the national recycling rate was just 34% in 2019.³⁴

It appears that, in order to be effective, PAYT fees must provide an adequate incentive to service users. PAYT will only drive behaviour change when improved recycling behaviour gives rise to meaningfully reduced costs. This means having a residual waste charge that is sufficiently high to be motivating; and where there are also volume-based charges for other streams (e.g. organics) there must be a meaningful differential between the residual waste charge and the recycling charge.

PAYT poses particular challenges for communal bin properties such as apartments, which are found in many of the case study areas. In many instances, such as in Ljubljana, PAYT fees are charged to residents based on the waste produced by the whole building unit, and so individual behaviour has less impact on the fees that a person pays. However, such systems can give rise to a level of social pressure to recycle, in order to avoid placing costs on one's neighbours.

Within the case studies there is one example of a more direct PAYT system. Ljubljana city centre has 67 bring sites with underground residual waste containers that are opened using a swipe card. Users are allowed to make a fixed number of deposits of residual and biowaste each year for a fixed monthly fee; above this, every additional deposit is separately charged. There is no charge to use the containers for dry recyclables. A local contact described this as a relatively expensive system to operate, but one that works well within the city centre.

A 'pay per container' volume/collection frequency system can be implemented more cheaply than a system where residents pay for the exact weight / volume of waste disposed of.

In addition to direct charging for waste, some of the case study areas also apply fines for incorrect waste sorting (as discussed further in section 3.3) to provide a further financial incentive for residents to recycle more and thereby reduce residual waste volumes.

3.1.6 Recycling Centres

To encourage high recycling rates, door to door/communal or bring bank collection systems should be supplemented by recycling centres to provide facilities for a wider variety of materials. These should be accessible, both in terms of location and opening hours. If residual waste is collected, measures should be put in place to avoid undermining any restrictions on kerbside residual waste collections.

Household Waste Recycling centres (HWRCs) are facilities where residents can bring their waste for recycling or disposal. Typically, recycling centres provide the opportunity to recycle materials not collected through door-to-door collections or bring banks, such as rubble, wood, furniture, oils, batteries and light bulbs. Many also provide facilities for materials that are collected door-to-door materials – for example, providing facilities for people who need to dispose of a large volume of garden waste. Some of the case study areas have recycling centres which collect a very wide range of different materials. Leoben, for example, provides facilities for 70 different fractions to be collected. Collecting this range of low volume materials at the kerbside would be costly and impractical, making recycling centres a critical part of the overall recycling infrastructure.

All of the case study areas provide one or more recycling centres. Some ensure ease of access by providing multiple facilities:

- Copenhagen has five large recycling centres and 12 smaller local recycling hubs, four of which have been recently added. Annually, they receive 45,000 tonnes of waste (around a quarter of the city's household waste), of which 90% is recycled, which helps to boost the overall recycling rate.
- Kempten and Bridgend both have three recycling centres.
- Vale of Glamorgan and Ljubljana have two recycling centres, with Ljubljana noting that once centre is used by 1,000 residents per day.

Leoben takes a different approach to ensuring access. While it has just one recycling centre, it is located on a well-connected road at the edge of the town.

A further approach, which can be useful in ensuring access in areas where many residents do not have cars, or where the population is dispersed over a wide area, is to use mobile recycling centres. In France, mobile household recycling centres are set up temporarily at convenient locations.³⁵ In Birmingham, the city council is putting in place a fleet of mobile recycling centres as part of a £7.2m package of measures to achieve cleaner streets.³⁶

Where recycling centres may also collect residual waste, measures need to be put in place to ensure this does not undermine any measures taken to deter excess use of the door-to-door residual waste disposal system. Where charges are applied for residual waste, this could involve ensuring that equivalent charges are put in place for material taken to the recycling centre. In the Vale of Glamorgan, the approach taken is to require that residual waste sacks brought to the recycling centre are opened and inspected for recyclables before disposal is allowed. This type of intervention requires investment of staff resources, but can lead to savings on disposal costs.

3.2 Extended Producer Responsibility (EPR)

EPR provides a mechanism by which to meet the costs of managing the wastes that it covers. This can allow improved services to be put in place without additional expenditure by the municipality.

In some of the case study areas, the fees collected through EPR schemes contribute significantly to meeting the costs of running municipal waste services. Extended producer responsibility schemes are in place for packaging in six of the case study areas (Ljubljana, Treviso, Milan, Stavanger, Kempten and Leoben), while the UK's more limited form of producer responsibility for packaging applies to the two Welsh case study areas.

Reform of the producer responsibility system for packaging in the UK is currently in prospect, with the results of a recent consultation expected to be published in late 2021¹². The relevant primary legislation is now in place through the Environment Act (2021), with further secondary legislation to follow and the scheme expected to become operational for household waste in 2023. Its introduction will change who pays for waste management costs: currently the financial burden for household waste and recycling collection and processing is borne by local authorities, and thus paid for largely through Council Tax, Business Rates and General Revenue Grant. With the introduction of packaging EPR, the full net costs of managing packaging will be funded by producers.

¹² This report was written during and directly after the UK-wide consultation on Extended Producer Responsibility for Packaging, which was issued on 24 March 2021. Subsequently, a summary of consultation responses and the Government response was published on 26 March 2022. While the response to consultation revises some of the proposals presented in the consultation document, upon review these revisions do not materially affect the report's analysis or conclusions.

Local authorities may respond to the newly available resources by looking to improve services, and will be encouraged to do this by producers (or the schemes set up to discharge their responsibilities). However, local authorities may be reticent to commit independently to making changes before they become sufficiently comfortable that their costs will be met by producers. This presents an opportunity for the Scottish Government to lead. It could do this by considering requiring local authorities to introduce collection services that might previously have been seen as unaffordable when local authorities were meeting the cost. These might include:

- Improved services for packaging materials already collected (e.g. greater source separation, greater density of bring sites where these are relied on);
- Introducing collections or drop-off arrangements for packaging materials that are not currently collected (e.g. plastic films, composite plastics, EPS¹³);
- Greater use of communications; and/or
- The use of mixed waste sorting.

The introduction of EPR may also affect the composition of the packaging waste stream, as the financial incentives provided by EPR will encourage producers to make their packaging more readily recyclable. As producers adapt to the new financial incentives, the choices they make to reduce the costs they bear are likely to influence the recycling rate for packaging that can be achieved.

3.3 Motivation of Municipalities

Municipalities are most likely to prioritise improvements in recycling performance if they are motivated to do so. In the past, escalation of disposal costs (e.g. through a landfill tax) has been an incentive to invest in measures to divert waste. There are also examples of targets being used to improve recycling rates, but these are most effective when addressed to the organisations that can bring about required changes, when backed by financial and practical support for those looking to make changes and when they have negative consequences where they are not met.

Municipalities have tended to require some form of incentive to motivate them to introduce measures to encourage recycling. Across the case study areas, and our wider experience, two main incentives have been deployed, either separately or in combination.

3.3.1 Targets and Strategy

Setting a local or national recycling target can encourage local (or indeed national) governments to implement policies to improve recycling rates. The need to measure progress towards the target, and to assess whether particular interventions have been

¹³ EPS: Expanded Polystyrene

effective, can also incentivise improvements in waste and recycling data collection and analysis. This approach is exemplified by the EU's introduction of increasingly challenging recycling targets for its member states to meet, by the national targets set in Scotland, and by the targets set for local authorities by the Welsh Government.

Six of the case study areas are subject to some kind of local or national target for recycling performance, while the remaining four are within Member States where the EU targets apply. Of the six:

- Four have set their own municipal targets, some expressed in terms of recycling rate and some in terms of material separately collected for recycling:
 - Copenhagen – aiming for 70% recycling by 2024
 - Ljubljana – aiming for 78% of material separately collected by 2025
 - Treviso – aiming for 96.7% of material separately collected by 2022
 - Seattle – aiming for 70% citywide recycling rate by 2025

Since these are self-imposed targets, there are no direct negative consequences for the municipalities if they fail to meet the targets. To the extent that they carry force, it is because either (a) there are financial costs associated with having more waste to dispose of or (b) the commitments they express would be embarrassing or otherwise politically problematic for the municipality to renege upon – or a combination of the two.

- The two Welsh municipalities (Bridgend and Vale of Glamorgan) are required to meet their share of Wales's national targets, which have direct application to councils. The Welsh targets apply equally to all Welsh councils and have escalated periodically and predictably since they were introduced under the Waste (Wales) Measure 2010.³⁷ The authorities are now aiming to achieve 70% recycling by 2025.

These are statutory targets, and Welsh authorities that fail to meet them are liable for a fine from the Welsh Government of £200 for each tonne of residual waste above the level implied by the target. However, the Welsh Government has not, to date, imposed fines on authorities that have missed the targets.³⁸

In some of the case study areas, and in other municipalities we are aware of, waste management goals are becoming part of wider strategies. Some of these encompass wider circular economy principles, including exploring how municipalities can encourage the use of products and systems that are designed to eliminate waste. For example, Wales has done this in its 'Beyond Recycling Strategy',³⁹ which proposes the introduction of a statutory preparation for reuse target for local authorities, while Copenhagen has set its waste management goals in a wider circular economy context in its 'Circular Copenhagen - Resource and Waste Management Plan 2024'.⁴⁰

Meanwhile, many local authorities that have declared climate emergencies have been led to examine how they can change their approach to waste management to minimise CO₂ emissions. The Mayor of London's Emissions Performance Standard is an early example of an attempt to drive improvements in waste management based on an appreciation of its impact on climate change.⁴¹

Although setting targets can help incentivise the implementation of policies to improve recycling, there are examples of municipalities that have set targets that they have not been met. For example, Bristol's Zero Waste Strategy set a target of a 50% recycling rate by 2020;⁴² in fact, the authority progressed from 43.6% in 2015/16 to 47.1% in 2019/20. While the authority undertook a number of measures to encourage recycling, including improving its food waste collection services and implementing a number of communication programmes, it has not opted for any more radical measures, such as moving to three-weekly residual waste collections. Because the target was set locally, there were no substantial implications when they were not met.

In contrast with Wales, England and Scotland have not chosen to translate their national recycling targets into specific goals for municipalities. This may have been a factor in Wales making greater progress towards its targets than have its neighbours, although the Welsh Government also invested very significant resources in providing support to authorities to implement infrastructure and service changes.

The introduction of packaging EPR requirements creates a new set of targets that indirectly influence municipalities.

The track record of targets is therefore somewhat mixed, and they appear to have proved most effective when (1) they are addressed to organisations that are in a position to bring about the changes necessary for compliance, (2) they are supported by the availability of financial and practical support to assist in making the necessary changes and (3) they are backed by the credible prospect of negative consequences for failure.

3.3.2 Cost of Disposal

None of case study areas has "low cost" disposal routes for residual waste. This creates a financial incentive for municipalities to minimise residual waste through increasing recycling. A number of case study areas have made a concerted effort to increase recycling rates due to financial pressure to avoid unusually high disposal costs.

- For the Welsh municipalities, this pressure comes from the combination of disposal costs around the level of Landfill Tax, combined with the prospect of fines of £200/t fine for every tonne of residual waste beyond the level implied by the recycling rate target.
- In Seattle, the absence of an affordable nearby landfill option (combined with local objections to incineration) means that disposal costs have been high since the 1980s, which is recognised as the primary driving force behind the City's recycling programme.⁴³
- In Copenhagen, while incineration costs are not highlighted as a driver for improving resource management, the City's 2018 Resources and Waste Strategy highlights that a move away from incineration as a source of energy is underway, implying that there will be less incineration capacity in future:

"Energy recovered through incineration has been used in the district heating network of the City. However, in connection with the conversion of Copenhagen's

energy supply into more sustainable energy... the time has now come to find alternative solutions with resource consciousness in focus."⁴⁴

In the UK, the average gate fee for local authorities per tonne of waste sent for Energy from Waste (EfW) is £93 (£95 for facilities built after 2000, £62 for facilities built before 2000). The average gate fee for per tonne of waste sent for landfill is £113 (inclusive of Landfill Tax and the site's gate fee).⁴⁵

The threat of high disposal costs under the Landfill Allowance Trading Scheme led to many UK local authorities accelerating efforts to divert waste from landfill.⁴⁶ The Landfill Tax escalator during the early 2010s was also effective in driving up recycling performance, as it provided a financial case for investments in improved collections and measures to reduce residual waste, as well as incentivising authorities to enter into contracts for thermal treatment of their remaining residual waste. However, the success of the Landfill Tax in diverting waste means that further increases in its real terms value would be unlikely to be effective – there is insufficient local authority waste going to landfill.

Some of the local authorities that have made relatively slow progress on recycling have been those that had invested in incinerators at an early stage and thereby secured unusually low disposal costs and avoided the effects of Landfill Tax.

In the Netherlands, concerns about the CO₂ emissions from incinerators have led to their being included in the country's Carbon Tax, which will also have the effect of increasing the cost of waste disposal, providing an additional incentive to improve recycling rates.⁴⁷

Seattle is the only case study example that disposes of the majority of its residual waste via landfill, making use of a site in Oregon. Almost all the other case studies are located in countries whose landfill disposal rates are below the EU-28 average in 2017 of 23.5% of waste to landfill,⁴⁸ implying the majority of residual waste is disposed of via EfW.

Historically, areas that face high disposal costs have been particularly incentivised to increase recycling. There may still be potential to increase recycling by driving up disposal costs, especially in areas that enjoy unusually low gate fees. However, to the extent that EfW has taken over from landfill for active waste, financial incentives that target landfill are becoming less effective and it may be necessary to focus on EfW costs of disposal instead. It should also be borne in mind that the role of disposal costs in motivating recycling performance may change once EPR takes full effect since local authorities will be motivated not only to avoid disposal costs but also to increase packaging recycling rates to meet the requirements for EPR. The exact details of how EPR payments will be made and the incentives are still to be agreed. While further EPR schemes are in prospect for materials such as WEEE and textiles, there is little prospect of EPR being extended to certain important to non-packaging streams such as food waste. While the introduction of EPR for packaging should release funds that could be spent on improving other aspects of waste management, such as food waste collections, the Scottish Government should consider how authorities can be incentivised to invest in measures to increase food waste recycling. Examples might include support for communications or other measures to promote uptake, funding research or pilot

projects for food waste services in communal bin properties, or meeting the capital costs of introducing food waste for the few authorities without food waste, as England is proposing to do. Measures that increase the cost of residual waste disposal would also indirectly incentivise authorities to promote separate food waste collections. As noted in 3.1.2.3 net zero ambitions are increasingly a driver for local authorities' behaviour alongside costs.

3.4 Driving Public Engagement

The use of enforcement measures where recyclable material is placed in residual waste has been shown to be effective and should be considered where composition studies show recyclables are still placed in residual waste.

One method by which to encourage members of the public to recycle is to provide them with clear incentives to use the recycling system correctly, and to the maximum extent that is feasible. Four main methods have been adopted.

3.4.1 Communications

Communications are cited by many high performing municipalities as vitally important for high recycling rates, although quantifying their impact is challenging. Investing in communications may be supported in Scotland by upcoming reformed EPR payments.

Communications are an integral part of any local authority recycling service as, to participate fully, residents need to understand what they need to do in order to use the service as intended. Communications also give the opportunity to provide information to motivate residents, such as explaining what happens to their recycling after it is collected and what the benefits of recycling are.

Common communication channels are physical collateral (such as leaflets), webpages and apps, social media, and face to face communications (whether visits from staff employed to assist residents, or inviting residents to visit facilities). In addition to more targeted communications campaigns, many of our local contacts cited access to basic information like collection schedules and use of apps reminding residents of collection days as important, and often underestimated.

In Treviso, the waste management company Contarina places substantial emphasis on its communications and this was cited as a key reason for achieving high recycling rates. The Contarina system has enabled good integration of communications campaigns at both provincial and municipal levels. Contarina has a branch office in almost every town within Treviso that residents can contact/visit. It publishes its own magazine twice a year, which is distributed to all residents. It runs education programmes in schools and makes extensive use of social media, including an app for reporting litter. Twice a year it opens its head office and recycling plants so that people can see what happens to their waste after it is collected.⁴⁹

In some case study areas with high levels of communal properties, mobilising building supervisors as a go-to point for information has been successful. In Seattle, building managers in multi-family properties are responsible for providing recycling guidance to residents. They are provided with sample letters to issue to new residents at the point when they move in, along with advice on signage and how to set up containers.

In both Leoben and Kempten, each Regional Waste Council has a 'waste consultant' available to support residents with waste and recycling queries. The municipalities also provide training at schools.

Quantifying the exact impact of communication measures on recycling rate is difficult and none of the case study areas were able to provide data on this point. However, in many of the case study areas, communications are cited by local contacts as key to contributing towards good recycling rate. In the UK, the extent of municipal recycling communications has reduced due to constraints on resources, but with the introduction of EPR in the UK there is likely to be more funding available to improve communications to the extent necessary to meet national packaging targets. With EPR payments likely to be performance-linked, local authorities will be incentivised to use the funding they receive to implement measures to improve packaging recycling performance, ranging from service changes to communications (which could have incidental benefits in promoting food waste collections). There has been no suggestion to date that EPR funding would in any way be seen as "replacing" the funds local authorities currently receive as a block grant from Scottish Government which covers around 85% of expenditure⁵⁰, 80% in 2019-20⁵¹, with the remainder mostly from Council Tax. If this is genuinely additional funding, it should release funds for other purposes, which could include improving non-EPR waste collections. However, if the Scottish Government wishes to ensure rapid progress, it may need to consider providing additional support.

3.4.2 Control over Communal Bins

It is widely recognised that achieving high levels of recycling through communal bin collections is more challenging than with door-to-door collections. A particular focus of the selection of case studies was to include areas with a relatively large number of households in apartments, where communal bins would typically be relatively prevalent.

Within the case study areas, there are two main approaches to controlling the use of communal bins to assist in increasing recycling rates:

- Use of building management/supervisors to manage the use of waste and recycling containers including: ensuring building residents know how to recycle, maintaining signage, ensuring sufficient recycling capacity is available and setting up containers to make recycling as easy as possible. This approach is used in Ljubljana, Seattle, and Leoben, and is being introduced in Copenhagen.
- Regulation of who can access communal bins through swipe card access. This is used in Stavanger, while in Ljubljana it is combined with a pricing system that enables people who dispose of larger quantities of waste to be charged additional waste fees.

Both of these approaches entail some additional costs, but appear to have an effect in reducing the amount of potentially recyclable material that is lost to the residual stream.

3.4.3 Fining for recyclable materials in residual waste

Two of the case study areas (Milan and Seattle) fine residents for placing recyclable materials in the residual waste stream.

Milan has a strict system of enforcement. The waste management company that undertakes collections for the city is called “AMSA” (Azienda Milanese Servizi Ambientali); its parent company is partly owned by the city, partly by the nearby municipality of Brescia, and partly by private shareholders. AMSA employs a team of inspectors who can fine residents upwards of €50 if they are found to have put waste in the wrong bin (or to have put bins out at the wrong time). About 50,000 fines are issued each year.⁵² For the 80% of residents that live in multi-unit dwellings with shared bins, the fine system creates social pressure – rather than great direct financial pressure – to correctly sort waste because if one person puts their waste in the wrong place, the costs are borne collectively by the residents.^{53,54} Furthermore, a municipal law states that residual waste must be presented in clear bags to help make the presence of recyclables more obvious, which one article claims has led to a 2% reduction in residual waste.⁵⁵

In 2015, Seattle became the first city in the United States to fine homeowners for not properly sorting their waste.⁵⁶ Residents are required to sort paper, cardboard, glass, plastic, aluminium, tin, food waste, and compostable paper for separate collection.^{57,58} Any violation of this by “residential curbside or backyard customers” results in fine of \$1 per bin collection. Any violation of this “by detachable container and drop box customers” results in a fine of \$50 per detachable or drop box collection. Multifamily structures that do not have adequate storage space for recyclable materials may be eligible for an exemption, if agreed by the Director of Seattle Public Utilities.

Although not one of our case studies, Rhondda Cynon Taf (RCT) was the first council in the UK to adopt fines for residents that place recyclable material in their residual waste bags, using powers under the Environmental Protection Act 1990.^{59,60} While some other authorities had introduced “compulsory recycling” systems (e.g. Barnet, Basildon, Carmarthenshire, Derbyshire Dales, East Lindsey, Gwynedd, Horsham, Isle of Wight, Malvern Hills, St Helens and Waltham Forest),⁶¹ those that have imposed fines have generally done so when residents have contaminated their recycling.⁶² The RCT fines system is claimed to have been the first to be adopted in the UK explicitly as a policy to improve recycling rates. The policy was adopted in April 2018, and allowed residents who ignored an initial warning to be fined £100. At the same time, residents on sack collections had their black bin fortnightly residual waste allowance reduced from four bags to two, while a “no side waste” policy was introduced in areas where wheeled bins are used. Despite these changes the recycling rate in RCT only increased by 1 percentage point from 64% in FY16/17 to 65% in FY 19/20, although it is not clear how many fines have in practice been issued,⁶³ as the council says that fines will only be issued as a last resort.⁶⁴ The council’s target recycling rate is 80% by FY24/25, while the Welsh Government’s target for that year is 70%.⁶⁵

The evidence base for fines in the UK is not currently strong, but this appears to be in part due to reticence on the part of local authorities to make use of powers when they have been made available. RCT's view that fines should only be used as a last resort is widely held; and authorities that have looked to apply fines have received negative publicity, even when fines have clearly been issued correctly.⁶⁶ The UK government has not generally encouraged councils to use their powers to issue waste-related fines.⁶⁷ Perhaps as a result, authorities have not been eager to advertise the number of fines they have issued or to talk about their effectiveness, although when it was made more difficult for English authorities to apply fines, waste managers expressed concerns.⁶⁸ Thus the lack of evidence regarding the effectiveness of fines should not be viewed as showing that fines are ineffective; rather that there has rarely been a credible threat backed by publicity regarding cases where fines have been applied, giving them little chance to have the required deterrent effect over time.

4.0 Application to Scotland

In this section, we analyse how the findings in the previous sections of this report might be applied in the context of Scotland. There are a number of waste and recycling requirements local authorities are already required to meet and voluntary commitments, the most relevant of these to this work are:

- **The Waste (Scotland) Regulations 2012** which make the following provisions⁶⁹:
 - All businesses, public sector and not-for-profit organisations are required to present metal, plastic, glass, paper and card (including cardboard) for separate collection from 1 January 2014.
 - Food businesses (except in rural areas) which produce over 50 kg of food waste per week to present that food waste for separate collection from 1 January 2014.
 - Food businesses (except in rural areas) which produce over 5 kg of food waste per week to present that food waste for separate collection from 1 January 2016.
 - Local authorities to provide a minimum recycling service to householders.
 - Waste contractors to provide collection and treatment services which deliver high quality recycling.
 - A ban on any metal, plastic, glass, paper, card and food collected separately for recycling from going to incineration or landfill from 1 January 2014.
 - All new incinerators must ensure that metals and dense plastics have been removed from residual municipal waste prior to incineration.
 - A ban on biodegradable municipal waste going to landfill from 1 January 2021. Subsequently extended to 31st December 2025⁷⁰
- **Household Recycling Charter and Code of Practice on Household Recycling in Scotland**⁷¹, setting out the basis for a consistent approach to the provision of

recycling services by local authorities in Scotland. There are 21 commitments made and each commitment has both essential and desirable elements.

- Despite these, recycling performance by local authority across Scotland varies widely. In 2019 the Scottish household recycling rate was 44.9%, with a maximum and minimum local authority recycling rate of 67.8% and 17.1%, respectively.

4.1 Service Design

There are opportunities for services to be designed differently, particularly in the context of the introduction of EPR and Scotland's DRS over the next few years.

- The DRS will reduce the volume of dry recycling material being presented by householders, changing the mix of materials and potentially opening up some capacity on vehicles, unless authorities quickly reconfigure their services.
- EPR should provide access to new resources for packaging waste collections.

From the example provided by the case studies, the following changes might be considered.

Dry Recycling

Three stream collections are common in the case studies, with higher levels of source separation being the exception (although highly successful across Wales and does help to minimise processing and sorting losses). The three stream approach is aligned with the Code of Practice: Household Recycling in Scotland,⁷¹ namely:

- mixed fibres (paper and card)
- plastic and metal containers
- glass containers

With the reduction in glass waste likely to result from the DRS, local authorities could consider using a less frequent collection system (e.g. 4-weekly collections), or even moving to a bring bank system, so long as the network was of sufficient density to be convenient for service users. A bring bank system which is not adequate to meet local needs risks a reduction in recycling rate.

Consideration should be given to widening the range of materials that are routinely collected at the kerbside, especially with the prospect of UK-wide EPR being introduced for additional materials over the course of the next five years. Possible target materials include:

- textiles
- plastic films
- small WEEE
- batteries

As Scottish Government has committed to implementing the requirements of the EU's Circular Economy Package (CEP) there is a requirement for textiles to be separately collected by 2025. For the majority (7) out of the 10 case studies, there is no kerbside collection in place for any of these materials. Instead, these materials must be taken to

bring banks or recycling centres. Bridgend and VoG have weekly kerbside collections for textiles and small WEEE (but not batteries). Copenhagen has kerbside collections for small WEEE and batteries and kerbside collections are being planned for textiles.

There is also interest from producers in ensuring that their specialist products are recycled. A current example is coffee pods, which producers are willing to pay local authorities to collect, although no Scottish authority has yet taken up this offer.

While none of these additional materials is likely to yield a large additional tonnage contribution to the recycling rate individually, their combined effect could add several percentage points to overall performance.

Organics

Ubiquitous separate food waste collections, including for rural areas and communal bin properties, are required for high recycling rates. Most Scottish authorities (other than the most rural areas) have already introduced food waste collections, but there have been issues in some areas with contamination and poor utilisation⁷² and these issues are often more frequent in urban areas. To address this, authorities will need to consider measures to incentivise effective participation (see section 4.2). While many authorities in Scotland collect food and garden waste as a mixed stream, WRAP's research and Eunomia's benchmarking work with local authorities has found that mixed food and garden waste services generally have substantially lower yields than do separate weekly collections. WRAP's findings regarding typical yields were:

- Separate weekly collections: 1.5 kg/hh served/week;
- Weekly mixed food and garden waste collections: 0.8 kg/hh served/week; and
- Fortnightly mixed food and garden waste collections: 0.5 kg/hh served/week.⁷³

Even these yields do not match some of the highest performing authorities in England and Wales, which capture 100kg or more of food waste per household per year in their separate weekly collections. Unless yields of food waste from Scottish authorities' mixed food and garden services are close to 1.5kg per household per week, they should be encouraged to implement separate collections in order to maximise food waste yields.

Garden waste collections should be made available to households that are likely to require them. As Scottish Government has committed to implementing the requirements of the EU's Circular Economy Package (CEP) there is a requirement for garden waste to be separately collected by 2023. If garden waste collections continue to be charged for, the Scottish Government should explore options to estimate material processed through home composting and add this to municipal recycling performance. Local authorities should then look to encourage home composting as far as possible, for

Recommendation: Scottish Government should continue to mandate for weekly separate food collections, including looking at how this can be rolled out to currently exempt areas, noting Scottish Government has already committed to consult on removing rural exemption for food waste collections. Scottish Government should explore how the EU method for calculating recycling can include home composting and encourage home composting appropriately.

example by providing subsidised home composting bins and undertaking communication work regarding what can safely be composted at home and the benefits of composting food waste for use in residents' own gardens.

Communal Bin Properties

Communal bin properties are widely recognised to pose a particular challenge. Wherever it is feasible, communal bins should be avoided and individual households should be provided with their own containers. However, in many settings, such as tenements and high rise blocks of flats, this will not be feasible.

In order to achieve the highest recycling rates possible for communal bin properties, authorities need to offer them a comprehensive recycling collection system, providing sufficient capacity to collect all target materials. To achieve high yields, the collection system needs to be supported by appropriate policies, such as:

- engaging with building managers, where they are in place, or appropriate alternatives tailored to the local context, to give them the necessary tools (e.g. communications materials, signage) to encourage proper use of recycling facilities.
- restricting access to containers (e.g. requiring residents to use a swipe card). This could be used to make individual users feel greater responsibility for how they manage their waste and recycling, and to allow data to be gathered that would enable communications to be targeted on households that produce the most residual waste. More ambitiously, it could be used to restrict the number of residual waste deposits each person makes, similar to residual restrictions applied on door to door collections through reduced volume/frequency collections. Such a system would certainly be needed if Scotland were to introduce PAYT.

Since not all buildings will have managers, it will not be possible to rely on them in all cases. Local government officers within functions such as estate management could be tasked with managing waste from a portfolio of communal bin properties within the council estate, or even across privately owned buildings; but they would not necessarily have the benefit of familiarity with the residents, or have the same role in resolving their other property-related problems that engenders trust and makes this system effective where it is employed elsewhere. There could be the possibility of more community focused approaches, but these may be perceived as having less authority and there are no known successful cases of such an approach. The greatest challenges to this approach may well arise with smaller blocks, tenements and HMOs (House in Multiple Occupation), where the landlord may not play an active role in building management. In these cases, Scotland may wish to focus on steps such as encouraging the adoption of model clauses for tenancy agreements and clear licencing conditions relating to waste for HMO landlords, as has been recommended in London.⁷⁴

Restricting access might therefore be the more promising option in Scotland. This approach could be combined with PAYT, were Scotland to go down that path, to further

incentivise waste reduction. While each of the options has costs, the case studies indicate that they can be effective in increasing yields.

As regards sequencing, the most promising starting point would be the introduction of local authority recycling targets (4.3.1), as this will provide the incentive and rationale for subsequent interventions. The use of initial trials, especially for novel or controversial measures, would help give confidence regarding the effectiveness of interventions ahead of wider roll-out. Trials and full roll out should be accompanied by communications monitoring before and after to verify their effectiveness, identify problems and solutions, and encourage other local authorities to take interventions up. These interventions should also be supported by appropriate enforcement to minimise any unintended consequences such as fly tipping.

Recommendation: As improving recycling rates in properties which require a communal collection is vital for increasing Scotland's overall recycling rate, it is recommended that the Scottish Government looks to initiate trials on how the use of swipe cards to access communal bin stores and engagement with a building supervisor type model could be used in properties in Scotland to improve recycling rates. Other actions which could be trialled include ensuring clear bin signage and moving in guidance to those in apartment blocks.

Recycling Centres / Other Recycling Service Provision

Recycling centres should complement the door-to-door service by receiving materials that are not collected door-to-door, as well as making provision for unusually large volumes of material that is collected at the kerbside e.g. cardboard, garden waste.

Recycling centres should be made easily accessible to service users, both in terms of location and opening hours. The service offered should also tie up with the door-to-door service. For example, if there are restrictions on residual waste at the kerbside, these should be mirrored at the recycling centres to avoid undermining the impact of the policies.

In areas where recycling centres are not as accessible to residents (e.g. rural areas where recycling centres are some distance away or urban areas with low car ownership), it may be worthwhile considering the use of mobile recycling centres to provide residents with access to the opportunity to recycle a wider range of items at relatively low frequency, thereby helping to divert waste from the residual stream.

Recommendation: Scottish Government should encourage local authorities to review their provision of recycling centres and other recycling services to ensure residents have sufficient opportunities to recycle a wider range of items than offered at kerbside, recognising that reaching higher recycling rates may require targeting of a wider range of materials.

4.2 Residual Waste

One measure that is highly effective across the case study areas is to take steps to drive down residual waste generation. This is principally achieved through capacity restrictions

and PAYT. The former has been deployed by many Scottish local authorities to a greater or lesser degree, but the evidence from the Welsh case studies suggests that moving towards an effective capacity of 60-70 litres for a typical kerbside household can be effective in encouraging people to maximise their recycling. When restricting residual waste capacity, authorities should take steps to address householders' reasonable concerns and avoid evasion of the restrictions. For example:

- An assessment should be made of any households that may justifiably generate a larger than normal amount of residual waste, and residents should be able to apply for a larger bin.
- Separate collections of absorbent hygiene products should be offered, even if this material cannot be recycled.
- An assessment should be made of typical recycling container needs, and additional capacity provided if the existing containers are likely to be inadequate.
- Householders should be able to obtain larger/additional recycling containers if they require them

PAYT for residual waste is not currently permitted in Scotland. This approach to deterring the production of residual waste is discussed further in section 4.3.

Especially in areas facing the greatest challenges with kerbside recycling collections, consideration should be given to a requirement to introduce advanced mixed waste sorting of residual waste before it is sent for incineration or landfill. This will yield a moderate boost in recycling performance, as well as avoiding emissions of CO₂ from the combustion of plastics in incinerators.

4.3 Incentives

The case studies illustrate that incentives can be applied both to municipalities (to encourage them to adopt more effective recycling services) or to householders (to encourage them to make full use of the services provided).

4.3.1 Incentives for Local Authorities

Authorities in Scotland are not currently subject to statutory recycling targets like those applied to Welsh authorities. The Scottish Government could consider setting targets, perhaps doing so in a way that takes account of authorities' current performance and any constraints on what they could reasonably be expected to achieve. Indeed, with the introduction of EPR, it is likely that there will be expectations placed on authorities, at least in respect of packaging waste captures, as a condition for receiving their full EPR payments. It might be relatively uncontroversial for the Scottish Government to set an overall recycling target for each authority, taking account of non-packaging stream performance, once these EPR targets are in prospect.

The Scottish Government would then need to consider whether to back the targets with the force of fines in the way that the Welsh Government has. Scottish authorities already face reasonably expensive gate fees for residual waste; and the prospect of reduced EPR payments would already offer a strong incentive to reach the packaging performance

requirements of the EPR system. However, the importance of recycling non-packaging streams to the overall recycling rate combined with the experience of the Welsh case indicates that the possibility of fines could be highly effective. When combined with the EPR system, the fines may not need to be as high as those in Wales in order to prove highly motivating. However, as in Wales it would then be reasonable for the Scottish Government to make funds available to support authorities in achieving the targets (although again, if combined with EPR payments, the funding needed to make progress against recycling of other materials may not need to be as great as the amount that Wales has invested).

To be effective recycling targets should be announced with as much advance notice as possible, and should proceed in steps. Different targets may be appropriate for different authorities. Funding should be put in place alongside the targets, so that local authorities know they will be supported in improving recycling rates. In addition to direct financial support, it will be important that authorities continue to have access to advice through Zero Waste Scotland (e.g. to look at collection options, to advise on more innovative approaches to collection, to support with implementation management). Recognising the limitations of local authorities' annual operating budgets, any changes required to reach recycling targets are likely to need to be funded through a combination of EPR money and direct support from the Scottish Government, although there may be opportunities for local authorities to find efficiencies to help reduce the cost of service improvement.

Recommendation: To improve recycling rates, Scottish Government should consider introducing statutory recycling targets for local authorities. If introduced these targets are more likely to be effective if supported by funding (which could come partly from EPR) and if there is a financial penalty for authorities that fail to achieve them. Targets should be tailored to reflect local authorities' starting position and realistic potential to increase recycling rates (e.g. recognising areas which need communal collections will be more challenging and take longer). Targets should also be stepped to encourage incremental improvements towards and ultimate target and allow monitoring and possibly the funding of further interventions for those authorities struggling to meet targets.

4.3.2 Incentives for Householders

Assuming that good collection systems are in place that allow householders to maximise their recycling, the case studies suggest that the use of high-quality, frequent communication to remind householders how to use the system properly is likely to be beneficial. Again, the introduction of EPR will help to make resources available to support this. The Scottish Government could, however, research and provide recommendations on the frequency and content of communications to support authorities in deciding how best to use these resources. If it wishes to make progress before the introduction of EPR, the Scottish Government could provide financial support to local authorities to undertake communications campaigns in the interim.

Scottish Government could allow powers, similar to in Wales, for local authorities to impose fines for householders that contaminate their recycling bins, or (as in Rhondda

Cynon Taf (RCT)) who place recyclable material in the residual waste bin. However, there is no clear indication that this fines policy has made a significant difference to recycling in RCT. In cases where fines do appear to have played a significant role, such as Milan, the investment in staff resources to deliver an enforcement system has been significant. However, it is clear that there are issues with some households not participating in recycling and enforcement is one of the few tools available to local authorities to change this. The Scottish Government could therefore consider encouraging, or even supporting (e.g. by providing training or funding) the introduction of additional enforcement staff by local authorities. It would be important to maintain data to ensure that the effectiveness of enforcement is measured, and to consider how enforcement could be applied in the case of communal bin properties within the Scottish system. As a first step Scottish Government may want to review with local authorities what powers are lacking and what needs to change to allow local authorities to enforce effectively. For example, some English authorities (e.g. Wigan, Islington)⁷⁵ take the view that, in the case of recycling contamination in communal bin properties, they are able to enforce against landlords – who will then pass on costs to residents – while others do not. The Scottish Government could provide a clear position for Scottish authorities facing such issues.

When considering funding, the Scottish Government may also want to consider different funding models. For example, it might be possible for waste enforcement to become a self-funding role, as is the case for litter and fly-tipping enforcement in areas such as Blaenau Gwent Enfield, Broxbourne, Hertfordshire and Maidstone.⁷⁶

Recommendation: To improve recycling rates Scottish Government should look at how enforcement powers could be used, particularly for communal properties where currently enforcement actions are limited. To be able to effectively enforce against communal properties, changes in law or guidance should be considered. A business case for additional enforcement should be developed, which may find that enforcement officers will effectively pay for themselves, through a combination of fines income and the improvements in recycling seen as a result of their activity. The Scottish Government may want to show some ‘proof of concept’ trials that this does work to encourage local authorities to employ additional enforcement officers.

4.3.3 Implementation of PAYT

‘Pay As You Throw’ (PAYT) for household waste is not currently lawful in Scotland, except for certain materials (e.g. garden waste) where a charge is allowed under the Controlled Waste Regulations 1992. However, it may be within the powers of the Scottish Government to introduce. As discussed in section 3.1.5, in order to be effective PAYT needs to be well designed, so as to create a sufficiently strong incentive for service users to recycle, and would need to be applied to both door-to-door and communal bin collections. In order to achieve the latter, a swipe card system, like that seen in Ljubljana, would need to be introduced.

In order to make PAYT politically and publicly palatable, its introduction might need to be combined with a reduction in Council Tax payments, so that the waste management charge could not be portrayed as “additional”. It might also be necessary to make some support available to those that might be adversely and unavoidably affected (e.g. large families where the parents are living on benefits), or to make free bins available for items that might otherwise add considerably to the volume of residual waste a household produces (e.g. absorbent hygiene products).

Whilst a weight-based system might provide the strongest PAYT incentive, the costs and technological issues associated with it may make it unattractive. A volume-based system would be likely to be more practical, although it may then be necessary to ensure that households are able to choose the size, or frequency of collection, of their residual waste bin in order to give them control over their costs.

A number of the case studies deploy a system in which there is a fixed component to cover cost of managing recyclables and other administrative charges and then a variable portion depending on volume of collection. The variable element could be responsive just to the volume of residual waste capacity required, or could also vary based on the volume of recyclables, provided that there was a substantial differentiation between the costs of the two, so as to ensure that there was an incentive to recycle.

Alternatively, Scotland could deploy a system of PAYT where the fixed charge element is £0, with the costs still met through Council Tax. There might also be no charge for a minimal residual waste service – perhaps set at the equivalent of 60 litres per week (the volume offered by Bridgend and VoG), or even less. Residents that require more capacity than this could then be subject to charges for the additional capacity. Given the current context in Scotland, the introduction of PAYT would be a substantial and controversial change. It might best be considered a ‘last resort’ to be used if other approaches are not effective in meeting the recycling rate targets. If PAYT is to be introduced, it will require legislation; this in turn would require consultation, and an impact assessment evidencing that PAYT is required (i.e. other methods have not worked or not to a sufficient extent) and likely to be effective. It may be possible to put legislation in place more quickly if it is solely to allow trials to take place to assess the effectiveness of PAYT, as was the case in England and Wales under the (now repealed) S.72 of the Climate Change Act 2008.⁷⁷ Any trials should include exploration of how PAYT can effectively be applied to communal properties where its introduction is more challenging, but where the gains to be made are potentially greater. A staged introduction should be used with plenty of notice and guidance for householders.

Recommendation: Scottish Government should look to actively encourage greater restriction of residual waste, predominantly for more suburban local authorities where collections are door to door and this can be implemented quickly and effectively but also for communal bin properties through measures such as the use of swipe card access. If these do not prove to have the desired effect on recycling performance then PAYT options may need to be trialled, which would require a change in law; and (if trials are successful) introduced more widely.

APPENDICES: Case studies

A.1.1 Bridgend, Wales

Bridgend has a recycling rate, geographic similarities to Scotland (rural, small towns, steep topography), good data available and figures verified by Eunomia. It has achieved particularly high food waste capture and very low residual waste arisings following the introduction of residual waste restrictions.

Population: 147,049 (mid-2019)⁷⁸, 62,405 households.

Geography/Demographics: Bridgend is a relatively rural county in the Valleys of South East Wales that covers around 285 square kilometres.⁷⁹ Located adjacent to the Vale of Glamorgan and midway between Swansea and Cardiff, Bridgend includes rural areas, coastal communities, and towns.⁸⁰ Bridgend is the largest town, with around 40,000 people. The county's population has grown quite rapidly, by 12% from 2001-2017, during which time an average of 491 homes were built each year.⁸¹ The South Wales Valleys area is generally considered one of the least wealthy regions in Wales. The Welsh Index of Multiple Deprivation (WIMD) identifies small areas of high deprivation (called Lower Super Output Areas or LSOAs) and in 2019 49% of these LSOAs were found in South East Wales.⁸² However, Bridgend is on the outskirts of the Valleys and in 2014 the household income in Bridgend was only marginally lower than the Welsh average.⁸³

Recycling rate: In 2019/20, the recycling rate for household waste was 63.4%, making it the authority with the 5th highest recycling rate in Wales for this year.⁷⁸ Their NI192 equivalent recycling rate in 2019/20 was 63.08%.

Definition of waste: Includes municipal waste (household waste and waste from small business) collected at kerbside and HWRCs, and the reported recycling rate excludes contamination.⁸⁴

Pattern of waste arisings/recycling rate over time: A time series graph of recycling rate is included as Figure 3 in the Appendix. Bridgend's recycling rate has increased from 53.5% in 2012/13 to 63.4% in 2019/20. However, performance has varied across that period. A separate food waste collection was introduced in 2010 and a separate garden waste collection introduced in 2013, the recycling rate decreased by 11.9 percentage points between 2012/13 and 2015/16 due to a change in recycling rate calculation. In June 2017, the council introduced three new measures: (1) a two bin bag limit on the amount of residual waste that residents can throw out each fortnight. Prior to this, the amount of bin bags that could be put out was unlimited; (2) the separate collection of Absorbent Hygiene Products (AHP) on request; (3) residents received new recycling containers with greater capacity for cardboard, paper and glass.⁸⁴ These three service changes resulted in a notable increase (14.7 percentage points) in the year from 2016/17 to 2017/18. The recycling rate has remained relatively steady over the last three years.

Waste arisings and composition: Of all waste collected at the kerbside for 2019/20, 191kg/hhld was residual waste, 141kg/hhld was separately collected food waste and 235kg/hhld was dry recycling.⁷⁸ Of the kerbside collected dry recycling in 2019/20, the major components were mixed glass (28%), card (27%), mixed plastics (15%) and paper (13%). The smaller fractions were: AHPs (8%), steel cans (2%), aluminium cans (1%) and small amounts of non-automotive batteries, textiles and footwear, and small WEEE.⁸⁵

Approach to collection and treatment of municipal waste:

- **Separate kerbside collections:** The following materials are collected: 1. Cardboard (orange fabric sack); 2. Paper (white fabric sack); 3. Plastics and metals (blue fabric sack); 4. Glass (35L black caddy); 5. Textiles and footwear (separate carrier bag); 6. WEEE – small domestic appliances (separate carrier bag); 7. Food waste (23L brown caddy); 8. Residual waste (2 blue bags) 9. Garden waste (two reusable charged for sacks collected March-November) AHP (purple sacks).^{86,87}
- **Bring banks/recycling centres:** At present, there are three recycling centres in Bridgend, these take a wide variety of items including paper & cardboard, plastics, cans, large & small WEEE, scrap metal, batteries, and garden waste.⁸⁸ Residual waste is collected but won't be accepted if there if bags contain any material that can be recycled.
Collection coverage: All households in the county receive waste collection services. Approx. 2,000 properties are on communal collections.⁸⁹
- **Frequency:** Weekly for all dry recycling and food waste; fortnightly for residual, AHP (on request) and garden waste (March-November).⁸⁹
- **DRS/EPR:** EPR is due to be phased in from 2023, taking over from the current PRN system. A DRS is due to be introduced in 2024.⁹⁰ These are both expected to have implications for the kerbside composition with a substantial reduction in glass and metal at kerbside and a smaller reduction in plastics, although Wales is

exploring digital DRS options that would allow deposit-bearing materials to still be collected via the kerbside. If DRS materials are removed, paper/card will become an even bigger share of the kerbside recycling stream.

- **PAYT:** There is no PAYT. To encourage residual waste minimisation, a limit of two bags (approx. 70-80 litres capacity per bag) per household per fortnight was introduced in 2017. There is a garden waste charge of £38.91 per household per year, or £34.85 for pensioners. Each household that registers receives two garden sacks for collecting and storing their garden waste ready for their collection day. Additional sacks can be purchased for an additional annual fee of £5.08.⁹¹
- **Waste treatment:** Residual waste is currently sent to Neath Port Talbot energy from waste (EfW) plant. Plastics and cans are sorted at local waste transfer station Tondy. Food waste is treated at Agrivert Anaerobic Digestion facility locally and garden waste is composted locally at Cowbridge. AHP is treated by Natural UK and their NappiCycle facility.⁹²
- **Waste collection management costs:** Collections are carried out by Kier, who have a contract with the council up to 2024.⁹³ Bridgend had the lowest combined cost of any Welsh authority for kerbside dry recycling and composting per household in 2018/19 of ≈£35/hhld/year⁹⁴ whilst residual waste costs are the second highest at ≈£90/hhld/year⁹⁴.

Key policies and practices of interest: The authority has long offered comprehensive recycling services including separate food and garden waste. However, the recent increase in recycling has occurred following the introduction of a two-bin bags per fortnight limit on the amount of residual waste that residents can present, alongside an increase in recycling container capacity and the introduction of separate AHP collections. Soon after these changes, there was an almost 15 percentage point increase in recycling rate.

A.1.2 Vale of Glamorgan, Wales

Vale of Glamorgan has the highest municipal waste recycling rate in Wales, and is unusual in having some co-mingled collections, although a source separated service is gradually being rolled out. It is a relatively rural county, especially in the West.

Population: 133,587 (mid-year 2019)⁷⁸, 56,050 households.⁹⁵

Geography/Demographics: The Vale of Glamorgan (VoG) is a county in Wales that covers around 331 square kilometres.⁹⁶ It includes rural areas, coastal communities and towns. Overall, VoG is a wealthy county with a relatively high standard of living but there are areas of deprivation, mostly in the Southeast. VoG is considered just outside the South East Valley region and often grouped with nearby Cardiff. From 2012-2014 household income rates in Cardiff & Vale were about 6 percentage points higher than Bridgend.⁸³ Barry is the administrative centre of the county and is the largest town both in the county and in Wales.⁹⁷

Recycling rate: In 2019/20, the recycling rate for household waste was 64.7%, making it the authority with the second highest household recycling rate in Wales for this year.⁹⁸ Their NI192 equivalent recycling rate in 2019/20 was 61.39%

Definition of waste: Includes household and non-household local authority collected waste, collected at kerbside and HWRCs, and excludes contamination (i.e. recycling rate excludes contamination).

Pattern of waste arisings/recycling rate over time: Vale of Glamorgan has seen a steady increase in its recycling rate from 54.4% in 2012/13 to 64.7% in 2019/20. The greatest increases were between 2014/15 and 2015/16 (9.7%) and between 2017/18 and 2018/19 (6.7%). From September 2018, the council limited the amount of residual waste households can put out to two bags per fortnight (approx. 70-80L capacity per bag).⁹⁹ The council communicated the change in advance through a variety of methods including social media posts, newspaper adverts, a waste helpline, and the temporary deployment of waste wardens.¹⁰⁰ At the same time, the Vale of Glamorgan introduced black bag splitting at its two HWRCs, with residents asked to open their black bags to confirm they did not contain recyclable materials. Residents were also required to present a proof of residence to reduce the misuse of the HWRCs.¹⁰¹ Before the introduction of these requirements, residents were asked to complete an online survey on the changes, the aims of which were to raise awareness about the changes and to get feedback on how the changes could best be introduced.¹⁰⁰ The double approach of limiting residual waste and bag splitting ensured that potentially recyclable

waste wasn't diverted from the kerbside residual waste to HWRCs and that it instead brought about real behaviour change amongst residents.¹⁰¹

Waste arisings: Of all waste arisings for 2018/19, 582/kg/hhld was residual waste, 113/kg/hhld was food waste and 354/kg/hhld was dry recycling. In 2019/20, 95% of kerbside dry recycling collected was still co-mingled but the council is moving over to a separate collection system.

Approach to collection and treatment of municipal waste:

- **Separate kerbside collections:** The Vale of Glamorgan is in the process of moving from co-mingled recycling to separate collection of materials (detailed below) for all households (including flats). This was introduced in the Rural Vale in October 2019, in Barry in October 2020 and is due to be rolled out in Penarth, Dinas Powys, Sully and surrounding areas in 2022.^{102,103} Until then, there is co-mingled recycling in most of the authority. The following materials are collected in co-mingled recycling: paper, glass, cans, cardboard, plastic, foil, aerosols and cartons. Where there are separate collections, cardboard is collected in an orange fabric sack, paper is collected in a white fabric sack, plastics and metals are collected in a blue fabric sack, and glass is collected in a 35L black caddy. Food waste is collected separately in all areas in a 23L brown caddy. Garden waste is collected in a green fabric sack from March to November and can be collected on request December – February. Two reusable garden waste sacks are provided as standard but residents can request extra (£2/bag). Residual waste is collected in blue bags with residents able to put out a maximum of two bags per collection.
- **Bring banks/recycling centres:** There are two HWRCs in Vale of Glamorgan; Barry Recycling Centre and Llandow Recycling Centre.¹⁰⁴ The HWRCs accept items not suitable for kerbside collection, such as larger WEEE items, scrap metal, mattresses, carpet, cooking oil, hard plastics, and batteries.
- **Collection coverage:** All households in the county receive waste collection services.
- **Frequency:** Dry recycling and food waste are collected weekly, while residual waste and garden waste are collected fortnightly.
- **DRS/EPR:** *As above for Bridgend*
- **PAYT:** There is no PAYT. To encourage residual waste minimisation, a limit of two bags per household per fortnight was introduced in 2018. Garden waste is collected free of charge with two reusable bags provided as standard, additional bags can be purchased for £2 each.
- **Waste treatment:** Separate recycling is taken to the council's processing centre near Cowbridge. From here, glass waste is taken to Cwmbran, where it is re-processed into glass fibre or aggregate, aluminium is crushed into bales and then smelted in Cardiff, and food waste is managed under a joint venture with Cardiff Council and is placed into a sealed skip and transported to an anaerobic digestion plant in Cardiff under a 15-year contract.¹⁰⁵ Garden waste is sent to a compost facility in Cardiff Bay.¹⁰⁰ With co-mingled recycling, the council has had around 25-30% contamination, which cannot be recycled and so is sent to incineration. Along with contamination, residual waste is also incinerated at Cardiff ERF.¹⁰⁶ Vale of Glamorgan, along with Cardiff, Newport, Monmouthshire and Caerphilly make up the Prosiect Gwyrdd (Project Green) partnership which has a 25-year contract with Cardiff ERF and uses a regional approach to the management of residual waste. A new waste transfer station is being built adjacent to Barry Recycling Centre to allow capacity for the introduction of multistream recycling collections.¹⁰⁰
- **Waste collection management costs:** Vale of Glamorgan cites its waste management service is low cost compared to other authorities in Wales.¹⁰⁰ However, even before the introduction of multistream collections, their kerbside dry recycling and composting costs for 2018/19 were 7th highest per household of the 22 Welsh authorities at ≈£90.⁹⁴ The council's residual waste costs are the third lowest at ≈£38/household.⁹⁴

Key policies and practices of interest: The restriction of collections of residual waste to two bags per fortnight and bag splitting at HWRCs were introduced at the same time and were supported by various communications. The high levels of contamination associated with the council's co-mingled collections mean that it is expected there may be an increase in recycling rates in moving to separate collections.

A.1.3 Ljubljana, Slovenia

Ljubljana has a recycling rate over 60%, high performance in a location where residents mainly live in flats and apartments.

Population: 380,287 in 2014 (including nine suburban municipalities),¹⁰⁷ and ~154,588 households (based on average household size of 2.46 for Slovenia in 2018).¹⁰⁸

Geography/Demographics: Urban. In 2014 the population density was 1,125 inhabitants per km².¹⁰⁹ 72% of residents lived in apartments with communal collection for their building. Most communal buildings are managed by a building supervisor. The metropolitan area of Ljubljana is relatively wealthy. It accounts for 37% of national GDP and 31% of employment. Between 2000 and 2016 it generated 49% of national GDP growth. In terms of GDP per capita, Ljubljana is above the median OECD metropolitan area, ranking 144th among the 329 OECD metropolitan areas.¹¹⁰

Recycling rate: No recent published figure is available. In an interview, our contact reported that 69% of waste was source separated in 2019.¹¹¹ However, this does not fully account for contamination, which Eunomia estimated for a previous study would account for at least 5 percentage points of the total, reducing the real recycling rate to no more than 64%.

Definition of waste: Waste from offices and small businesses is included in the definition of municipal waste. Waste from these customers is co-collected with householder waste and data is not separately recorded. Wood from household (not commercial) sources is also included. Material is recorded as being recycled after it has been subject to initial sorting.^{111,108,112,113,114}

Pattern of waste arisings/recycling rate over time: Separate kerbside collection for dry recyclables was set up in 2002. There has been a gradual increase in source separation since 2004 (~6% source separated) to 2014 (~61% source separated).¹⁰⁸ with rates now reaching 69% (2019)¹¹¹. The city is aiming for 75% recycling rate by 2025. In 2014, Ljubljana became Europe's first capital to commit to becoming a 'zero waste' city.

Waste arisings: In 2014 total waste arisings were 320kg/capita total of which 190kg/cap was separately collected (incl. 77kg/cap biowaste, 43kg/cap metal and plastics, 41kg/cap paper and card and 17kg/cap glass) and 130kg/cap was residual waste¹¹³. Note the separate collection rate has increased from 60% in 2014 to 69% in 2019.

Approach to collection and treatment of municipal waste:

- **Separate kerbside collections:** There are kerbside collections for: (1) residual; (2) co-mingled metal & plastic packaging; (3) organics (including both food and garden waste);¹¹⁵ (4) paper & cardboard. The frequency of collection for individual and communal buildings differs, as outlined below. Separate collection is mandated by a National Decree but commitment to this is voluntary and local.
- **Bring points /recycling centres:** There are 2,628 bring points around the city consisting of three separate containers for paper, glass, and packaging. Glass is only collected at bring points or civic amenity sites.¹¹³ Each bring point serves ~117 inhabitants. In the city centre, underground bring points have been introduced in an attempt to maximize public space and make the recycling process easier on the eye. There are currently 67 underground units in Ljubljana used in city centre areas where space for communal bins is limited. For these units, paper and packaging bins can be accessed without charge whilst residual and biowaste bins require a swipe card to access and operate on a PAYT basis. The underground containers are more expensive but well suited for the tourist areas.¹¹¹ There are also two recycling centres. 1,000 residents per day use one of these two centres. Ljubljana also has mobile collection units for hazardous waste and WEEE, which have been in place since December 2010. The vehicles are equipped with a multimedia information system used for retrieving and transmitting data, user identification, waste weighing and storing information.¹¹⁶
- **Collection coverage:** 99% of the city population (307,446 residents) receive door-to-door collections for residual waste and plastic/metal packaging. 82% of households receive door-to-door collections for organic waste (and 18% of the population compost their biowaste). 100% of the population have access to paper & cardboard collections, but this includes bring points. A separate value for door-to-door collections is not provided.^{113,111}
- **Frequency:** Residual: three times a week (city centre), once a week (areas of mainly high-rise housing), or once every three weeks (areas of mainly individual houses). Biowaste – twice a week (city centre), weekly all year round (areas of mainly high-rise), weekly Mar-Nov, bi-weekly Dec-Feb (areas of mainly individual houses). Paper and cardboard and co-mingled packaging – weekly (areas of mainly high-rise housing); every 3 weeks (areas of mainly individual houses).¹¹⁷
- **DRS/EPR:** Only a remnant of a DRS for glass bottles and some group packaging exists.¹¹¹ There are three EPR schemes on the national level that therefore apply to Ljubljana. These are for batteries and accumulators, electronic and electrical equipment, packaging (cardboard, glass, plastic and metal).¹¹⁸
- **Pay as you throw:** A tariff system was implemented in 2013, in line with the "polluter pays" principle. Residents are charged directly for organic (food and garden) waste collection and residual waste collection depending on

the size of containers used and the collection frequency. The packaging waste collection is free for users. The PAYT pricing system is complicated and does not create a large price differential between organic recycling and residual. Therefore, it is unlikely the PAYT scheme is a substantial incentive to engage with organic recycling.¹¹¹ The charging system for residents living in apartments is usually set up by building stewards and normally based upon the number of residents per unit i.e. it does not create a strong direct incentive to reduce residual waste.

- **Treatment of waste:** In 2015, the Ljubljana Regional Waste Management Centre (RCERO) was established. This comprises an anaerobic digestion plant for separately collected organic waste, and a MBT where mixed waste is sorted to extract plastic, paper, aluminium and other recyclable materials, with the remainder being converted into a SRF with a calorific value similar to brown coal. Of 150,000 tonnes of mixed waste 30,000 tonnes of recyclables are extracted.¹¹⁹ Around 5% is sent to landfill.

Key policies and practices of interest:

- DRS, ubiquitous bring infrastructure, high-tech mixed waste sorting and reduced residual waste collection frequencies.
- Use of chipped bin access in city centre.
- Frequency of collection of all waste streams is higher for the city centre and areas of mainly high-rise housing.
- Strong media communication campaigns and educational programmes in schools have helped create an 'eco-conscious cultural shift'.¹¹¹

A.1.4 Province of Treviso, Northern Italy

The province of Treviso has a wide range of different geographies including the very urban (and hard to navigate) Treviso City centre, small towns, and very rural areas. Treviso nevertheless has one of the highest recycling rates in Europe.

Population: 554,000¹²⁰ – this is the population served by publicly owned company Contarina. This equates to around 240,869 households (based on the average household size of 2.3 in the wider Veneto region in 2019).¹²¹

Geography/Demographics: The province of Treviso is around 1,300 km² and includes large rural areas, small and medium-sized communities and the city of Treviso. In 2017, around 3,000 inhabitants lived in the compact historic centre.¹²² The GDP per capita for Treviso in 2015 was \$40,813 US PPP. This placed it 24th out of 110 provinces in Italy in terms of GDP per capita.¹²³

Recycling rate: In 2019, 89% of municipal waste was source separated.¹²⁴ This is compared to a national average recycling rate of 51.3% across Italy in 2019.¹²⁵

Definition of waste: Municipal waste includes residential and trade waste from SMEs. 95% of the collections carried out by Contarina, the municipal waste company, are residential, with the remaining 5% being from small business such as bars and restaurants.¹²⁶

Pattern of waste arisings/recycling rate over time: The separate collection is currently 89% and the province has set a target to reach at least 96.7% by 2022. Time series for two sub-districts within the province are shown in Figure 8 (in the Appendix).¹²⁴ This graph also indicates the timings of introducing separate kerbside collection and PAYT.¹²⁶ Kerbside collection was implemented in 2000 for both districts and led to increases of 38 and 13 percentage points respectively over the following two years. PAYT was introduced into one district in 2002 and led to an 8 percentage point increase in the following two years. In the other district, PAYT was introduced in 2010 when the recycling rate was already high at 79%. Nevertheless, this still led to an increase of just under 5 percentage points in the following two years. The recycling rates of both districts converged at around 85% in 2014.¹²⁴ The recycling rate of the City of Treviso increased from 52% to 85% from 2013-2014 as a direct result of service changes initiated when public company Contarina took over collections in 2014.¹²² The company provided more frequent and flexible door-to-door collections and charged variable PAYT fees.¹²²

Waste composition: 58kg of annual residual waste per inhabitant in 2014 (of which 43kg is from door-to-door collection).¹²² In 2020, annual per inhabitant generation rates were: residual waste 42kg (10%); organic 86kg (21%); yard waste 49kg (12%); paper 54kg (13%); glass, cans and plastic 79kg (20%); other collections 92kg (23%).¹²⁷ In 2020 the majority of material (98%) is collected at kerbside with 2% collected through ecobuses and ecostops (described below).¹²⁷

Approach to collection and treatment of municipal waste:

- **Separate kerbside collections:** There are kerbside collections for: (1) Non-recyclable dry (grey bin), (2) Organics (food scraps), (3) Garden waste, (4) Paper and cardboard, (5) Glass, (6) Plastic and cans. In some municipalities glass is collected mixed with plastic and cans. These waste streams are placed in colour-coded bins, these bins are collected at the kerbside, provided free of charge (charges for emptying of residual waste containers explained in PAYT section below) and are readily available.¹²⁶
- **City centre collections:** In less populated areas, the collection containers are large bins, whereas in more highly populated (such as the historical city centre) the containers are small bins and bags reserved for users with limited space (see Figure 7).¹²⁶ Furthermore, in the old part of the city, Contarina responded to complaints from residents about the number of bins in the streets by trialling a new model, which it has now adopted. There are now four 'ecobuses', which run on six set routes and spend half an hour at each stop collecting two different types of waste at a time. Residents can bring waste to the vehicles. The schedules are published and include evening and weekend routes, to fit with people's work patterns. Complementing the ecobus are 'ecostops', which are portable containers taking four types of waste, with two routes and one hour stops at fixed places, again with residents taking their waste to the facilities. Ecostops are largely the same as ecobuses but collect four (rather than two) waste streams at a time and stop for longer.
- **Bring banks/recycling centres:** The ecobus and ecostops collection model approximates to a bring bank system in the historic centre of Treviso, but there are no permanent bring banks for waste streams that are collected at the kerbside. Municipalities have recycling centres for materials that are not collected at the kerbside (e.g. WEEE, clothes, C&D etc).¹²⁴
- **Collection coverage:** In 2014, Contarina served 554,000 inhabitants which was 100% of the population at the time.¹²⁶ The majority of the population (~98%) is served by kerbside collections.¹²⁷
- **Frequency:** Food waste is twice a week (the typical standard for northern Italy) and residual waste fortnightly. However, for residual waste there is a PAYT scheme based on number of set-outs (typical for Italian PAYT schemes which have become fairly widespread). Most households set out residual waste between five and 10 times a year.¹²⁴ Paper, green waste and other recyclables are collected between once and three times per week.
- **DRS/EPR:** No DRS; collectors receive around half of the producer responsibility fees collected by the current schemes in Italy, which do not yet reach the full extended producer responsibility requirements of the revised waste framework directive.¹²⁸ There is one packaging recovery organisation in Italy, Corepla, that is responsible for plastic packaging. It is part of the CONAI EPR System. If a municipality signs an agreement with Corepla then they must ensure that the material collected ends up with a Corepla. Although it is not mandatory to do this, Corepla serves 92% of municipalities in Italy, including Treviso.¹²⁹
- **PAYT:** Charges in Treviso are made up of two components, a fixed fee based on the number of people in a household and a variable fee calculated depending on (1) the amount and frequency of residual waste emptied, (2) whether a household home composts, which results in a 30% reduction in the variable fee and (3) whether or not the household chooses to have a garden waste collection (a fixed price but included within the variable fee).^{122,126} The fixed annual fee covers the cost of the service and services such as street sweepings whereas the variable covers cost of collection and treatment of waste.¹³⁰ The variable rate applied to non-recyclable dry waste is €1.05/kg but the cost is calculated based on cost of emptying containers based on their volume and a specific weight of the waste equal to 0.0986kg/litre.¹³⁰
- **Waste treatment:** There are no incinerators or landfill sites in the province, so long haulage distances lead to a greater financial incentive to recycle as much as possible. There are also no contractual commitments to a minimum tonnage to be delivered to a waste.^{122,126} In 2015, Contarina outlined plans for a Material Recovery and Biological Treatment (MRBT) plant to provide some mixed waste sorting to help recover recyclable materials from residual waste¹²⁶. However, construction has still not begun as Contarina still need to get regional approval.^{124, 126}
- **Waste collection management costs:** Over the last 15 years, Contarina's waste management costs have increased only 8%, while local sources state that at a national level these costs have grown 70%, and the general cost index has grown around 30% (see Figure 9 in the Appendix). Contarina spends around €1 per inhabitant per year on communications, around €550,000 total.¹²⁷

Key policies and practices of interest:

- The success of Treviso's recycling system is often attributed to the way that Contarina operates. It is owned by a consortium that represents the 50 municipalities in the province, with all key decisions taken collectively by the mayors of the municipalities.
- Good communications are considered a key aspect contributing to high performance,¹²⁷ and the Contarina system has enabled good integration of communications campaigns at both provincial and municipal levels.¹²⁴ Contarina has a branch office in almost every municipality that residents can contact/visit. It publishes its own magazine twice a year, which is distributed to all residents. It runs education programmes in schools and makes extensive use of social media, including an app for reporting litter. Twice a year it opens its head office and recycling plants so that people can see what happens to their waste after it is collected.

A.1.5 Milan, Italy

Milan is an urban area with a high recycling rate (60%) compared to other cities in Europe, and has a very high capture rate for food.

Location: Consiglio Comunale Milan (i.e. the City Council of Milan) is a municipality within the region of Lombardy which is situated in Northern Italy.

Population: Milan has a population of around 1.4 million (as of 2019) and is the second largest city in the country.¹³¹ Based on the average household size (2.2) in the region of Lombardy, this is around 636,363 households.¹²¹

Geography/Demographics: Milan is an urban area with the highest population density in Italy at 7,700/km², compared with a national average density of 206/km². 75% of the population live in flats.¹³² In 2015, the Metropolitan City of Milan was the wealthiest province in Italy based on GDP per capita (\$68,381 US PPP).¹²³

Recycling rate: Milan had a reported recycling rate of 59.5% in 2018. The system that contributes the most to the recycling rate is separate collections, which is largely made up of food waste, papers and packaging glass, with small contributions from plastic and metal packaging. Milan has one of the best recycling rates of any large city across Europe and food waste captures are very high at 79%.¹³²

Definition of waste: This excludes unmanaged litter, household garden waste (as this is mainly collected by private collection contractors), and any waste not considered household waste under Italian law, however it does include bulky waste, street sweepings and wood waste.

Pattern of waste arisings/recycling rate over time: In 2011, Milan had a separate collection rate of 35%.¹³³ The introduction of household food waste collections in 2012 was the start of a sharp increase in recycling, as well as in collection coverage, which rose to 100% by Jun 2014.¹³⁴ Food waste now has a capture rate of 79%, which is exceeded by the rate for glass (82%).

Waste arisings: In 2019, arisings per household were as follows: 487kg residual, 281kg food and green waste, 128kg glass, 125kg paper, 91kg plastics and metal, 40kg street sweepings, 38kg bulky waste, 32kg cardboard, 14kg wood, 10kg mixed packaging, 8kg textiles, 8kg C&D, 6kg WEEE, 6kg from other ferrous, hazardous and other.¹³⁵

Approach to collection and treatment of municipal waste:

- **Separate kerbside collections:** door-to-door collections for 80% of the population, communal collection points for the remaining 20%.¹³² Paper and card are placed in white bags, glass in green bags, plastics and metals in yellow bags, food waste in a 35L caddy or 120L brown wheeled bin, and residual waste in clear bags.^{132,134,136}
- **Bring banks/recycling centres:** There are 230 communal collection points for paper and glass, and six container parks (one of which is mobile) for bulky waste, aggregates, paper and card, glass, plastic and metal, sheet glass, garden waste, iron, wood, textiles, car batteries, portable batteries and accumulators, paint, cooking oil, waste cartridges and toner, tyres and WEEE. These are free to use but there are limits on material quantities and visit frequencies for certain materials.¹³⁷ From container parks, 8.8kg per capita of municipal waste is collected, of which 86% is eventually recycled. Container parks contribute 1.6 percentage points to the recycling rate, with non-packaging metals and reusable/recyclable textiles making up the largest proportion of this.¹³²

- **Collection coverage:** 80% of residents receive a door-to-door service for paper, card and cartons, glass, metals and plastics, food and organic waste, and residual waste. 20% of residents use a communal collection points for these materials. All residents have access to bulky waste collections.¹³²
- **Frequency:** Plastic and metal, glass, paper and cardboard, and residual waste are collected weekly. Organic waste is collected twice weekly.¹³⁸
- **DRS/EPR:** There is no DRS and all the material recycled is collected separately, either by door-to-door collections, at communal collection points or in container parks.¹³² The packaging recovery organisation Corepla serves Milan (see details on Treviso above).¹²⁹
- **PAYT:** There is a PAYT element to the cost of waste management which is related to the amount of non-recyclable solid waste disposed of. The remaining amount is covered by a fixed fee paid by citizens to the municipality. Households can arrange for a private contractor to collect garden waste (or use collection points).
- **Waste treatment:** residual waste is disposed via Energy from Waste (EfW) at the Silla2¹³⁹ waste-to-energy plant, located in the north-west area of the city near Figino. There is no mixed waste sorting in place. Organic waste is sent to a privately owned anaerobic digestion plant in Montello.¹³⁵
- **Waste collection management costs:** Waste management costs per inhabitant in Milan are €150¹²⁴-€220.¹⁴⁰

Key policies and practices of interest:

- There are very few litter bins in Milan, with most situated in tourist areas. The aim is to get residents to return packaging home, where it will be recycled.¹³²
- When food waste collections were introduced, households were given compostable bags, 10L ventilated kitchen caddies (for individual households and flats) and a 120L wheeled bin (for blocks of flats), or 35L bin (for families living in smaller dwellings, provided on request).¹⁴¹ AMSA (Milanese Environmental Services Company), which is responsible for Milan's waste management, also sent trained officers to households to give out leaflets, posters and stickers, and set up public meetings between residents, AMSA and the municipality.¹³⁴
- A municipal law, introduced in 2011,¹⁴² requires residual waste to be presented in clear sacks. This facilitates inspections by AMSA, and residents can be fined upwards of €50 for poor sorting of waste.¹³⁴ No data is available on the amount of recyclable material that remains in the residual waste, but despite a team of 20 enforcement officers, fines are relatively rare (around 50,000 per year across all streams¹⁴³) which suggests that less than 0.04% of containers presented contained an amount of the wrong material sufficient to result in a fine. These measures have been associated with a 2% reduction in residual waste.¹³⁴
- Property managers or nominated residents are responsible for taking bins and bags out into the street and bringing them back into the property. Assigning this responsibility is considered a key success factor.
- According to law, all new buildings must have a dedicated space for waste containers.¹³⁴

A.1.6 Stavanger Region, Norway

The Stavanger region achieves a reasonably high recycling rate (50%) and uses DRS and mixed waste sorting to achieve high captures of plastics and metals. Recycling rate is also notably better than the average for Norway, despite relatively poor food waste captures.

Location: Rogaland Region, Southwest Norway

Population: 322,000 (population of the 10 municipalities whose waste is managed by IVAR), which equates to 151,173 households based on the average household size (2.13 people) in Norway in 2021.¹⁴⁴

Geography/Demographics: Mixture of urban and rural areas, with two islands (Rennesøy and Kvitsøy). The Rogaland Region is moderately wealthy with a GDP per capita in 2019 of €37,100 PPS, compared to a Norwegian average of €47,300 PPS.¹⁴⁵

Recycling rate: The current recycling rate is 49.8%. The contributions each recycling “route” makes to the overall rate is as follows.¹⁴⁶ Eunomia has calculated this recycling rate and it is equivalent to the new EU measurement method.

| Stream | DRS | Separate Collection | Container Park | Mixed Waste Sorting | Streets/Litter | Incinerator Bottom Ash |
|-------------------|-----|---------------------|----------------|---------------------|----------------|------------------------|
| Percentage points | 1.4 | 33.1 | 10.5 | 4.6 | 0.1 | 0.1 |

Definition of waste: excludes unmanaged litter, home composting and any waste not considered household waste under Norwegian law.

Waste arisings: In 2019 each inhabitant generated 372kg of household waste each year of which 100kg/cap is dry recycling (excl. contamination) and 79kg/cap is organic waste.¹¹⁴

Approach to collection and treatment of municipal waste:

- Separate kerbside collections:** Kerbside collections of residual waste, paper, card and aseptic cartons and food waste are provided to ~63% of residents, with glass and metal packaging collected from 40% of residents. Glass and metals are mostly collected via bring banks but door-to-door collections can be requested.¹⁴⁷ Plastics used to be collected separately, but this service stopped when the new mixed waste sorting (MWS) facility (IVAR) became operational in 2019 – residents are now directed to place plastics in the residual waste. At the same time residual waste collection frequencies were increased to provide additional capacity for plastics, which the MWS would separate for recycling. Until 2018, food waste was collected together with garden waste in a ‘mixed biowaste’ collection. Separate collections of food waste are currently being rolled out but are not complete.¹³²
- City centre collections and frequency:** In Stavanger: green bin for paper, collected once every four weeks; brown wheelie bin for food waste collected fortnightly; red bin for hazardous waste, need to book a collection; black bin for other residual municipal waste including plastic, collected fortnightly. Garden waste is collected up to three times per year. Where door-to-door collections have been requested for glass and metals the frequency of collection is once every two to three months. Private households in Stavanger municipality can order collections of bulky waste, garden waste, hazardous waste, glass packaging and clothes.¹⁴⁸ The main difference between Stavanger and the other municipalities is the amount of communal properties that are served by underground containers. The majority of these are in Stavanger with a few in the surrounding slightly more urban municipalities. These containers have no set frequency, they have sensors which resulted in bespoke scheduling of collections when the sensor registers 80% fill. Access to these communal bins is regulated by use of a swipe card. Waste from other communal bins is collected as needed.¹³²
- Bring banks/recycling centres:** There are six container parks in the region, all of which are operated by IVAR. The materials collected are wood, garden waste, WEEE, metal, paper, card, glass and metal, batteries, textiles, boats, hazardous waste, and construction and demolition waste.¹³²
- Collection coverage:** Kerbside collections of residual waste, paper and card and organic waste are provided to ~63% of residents, with glass and metal packaging collected from 40% of residents. The remainder is covered by either communal underground containers (27%) or other communal collections (10%), which are mostly large, wheeled bins, including for biowaste.¹³²
- DRS/EPR:** Nationally, Norway operates a Deposit Return Scheme that covers metal cans, large PET bottles, and small PET bottles. Glass bottles were formerly included in the DRS, but have been removed from its scope. This appears to be due to the relatively small market for glass in Norway, which makes it more cost-effective collect glass via communal bring sites.¹³² Norsirk is the leading EPR scheme in Norway and handles the management of waste batteries, WEEE and packaging.¹⁴⁹
- PAYT:** Residual waste is charged for, and charges are variable depending on container size. There is no charge for garden waste collections for up to three collections per household per year. Maximum volume of garden waste per collection per household is 3m³.¹⁵⁰
- Waste treatment:** Residual waste is all sent through the IVAR mixed waste sorting (MWS) facility, where plastics and any remaining metals and recyclable paper are extracted for recycling. IVAR is owned by 13 municipalities and manages the waste treatment of 10 municipalities, including Stavanger. IVAR does not have responsibility for any waste collections in these municipalities. The IVAR MWS also has a bespoke paper

sorting facility and polyolefins reprocessing facility (both for rigid HDPE/PP and for PE film) on site. All collected papers and polyolefins go to these facilities. All remaining material is sent to one of two EfW plants that provide combined district heating and power. IVAR also runs the container parks within the Rogaland region. Materials from the container parks are separated for recycling, and waste without recycling markets is sent to either landfill or to an EfW plant. These facilities have different technology and so slightly different performances. Both have little capacity to store heat so some is lost. Food waste is mechanically sorted before being treated at a wet AD facility, which produces gas to grid and digestate. Garden waste is sent to open air windrow for composting.¹³²

- **Waste collection costs:** In 2021 the average annual waste fee in Stavanger was 2,888 NOK (which is around £236). This is based on the most common annual fee.¹⁵¹

Key policies and practices of interest:

- Through a combination of DRS and mixed waste sorting, high captures of plastics and metal are achieved.
- High captures of target papers are achieved from extraction in mixed waste sorting in addition to separate collections.
- Reasonably high recycling and reuse of textiles are also achieved. The captures of plastics and textiles contribute towards good performance in GHG terms.
- Currently doing a trial where recycling points have a camera activated voice if waste is left outside recycling point instructing that waste must be taken to the recycling centre or can be collected free of charge. This has significantly reduced clean ups required.¹⁵²

A.1.7 Copenhagen, Denmark

Densely populated city dominated by multi-family properties achieving reasonably good recycling rate for a city (45%) considering that there is little contribution from garden waste.

Population: 639,000 people (April 2021, municipality of Copenhagen)¹⁵³ occupying 384,845 housing units.¹⁵⁴

Geography/Demographics: Copenhagen is the capital and largest city of Denmark, located on islands in the south of the country. The population is around 10% of the national total, with a density of 6,800 people per square kilometre, 45 times denser than the national average. 72% of the population is Danish.¹⁵⁵ Copenhagen consistently ranks highly for quality of life, although the cost of living is high. Around 90% of homes are flats.¹⁵⁶ Copenhagen remains one of the most productive cities in Europe, and the wider Copenhagen region accounts for 39% of Denmark's output and has enjoyed stable growth over the long term.¹⁵⁷ Copenhagen is a wealthy city with a GDP per capita of 487,000 DKK in 2016, which is around £55,950 at today's exchange rate.¹⁵⁸ Between 1993 and 2011, GDP per capita growth in the Copenhagen region averaged 2% per year.¹⁵⁷

Recycling rate: The reported rate was 45% in 2018.¹⁵⁹

Definition of waste: The Danish definition of municipal waste is similar to that used in the UK. It includes waste from households (except construction waste) and commercial waste that is collected in municipal schemes.¹⁶³

Pattern of waste arisings/recycling rate over time: The recycling rate in Copenhagen increased 18 percentage points between 2010 and 2018 (from 27% to 45%). This is attributed to new schemes being introduced so that most of the population now has access to separate collections for biowaste, cardboard, paper, glass, metal plastic and small electronics. The latest Waste Strategy is aiming for 70% recycling by 2024.¹⁵⁹ Waste generation has decreased by 10% in the last 10 years despite a 20% increase in population. The percentage of organic waste in residual waste has decreased from 41% in 2016¹⁶⁶ to 34% in 2019¹⁶⁰ as food waste captures increase (see Figure 11).

Waste arisings: In 2017 waste arisings from private households were ≈300kg/inhabitant.¹⁶⁶

Approach to collection and treatment of municipal waste:

- **Separate kerbside collections:** separate kerbside collections for food, plastics, metal, cardboard, paper, glass, garden waste (collected Mar-Nov), bulky waste, batteries, electronics (large and small) and hazardous waste. New collections of textiles and composite packaging are planned.¹⁵⁶ These are a mix of mandatory and voluntary

provision of door-to-door collections as described below – this describes whether the property must have a collection system:

- Mandatory for all residential properties: paper, residual waste, plastics, cardboard, metals, food waste (houses can opt out) and hazardous waste.
- Mandatory for multi-storey residential properties: batteries, large and small electronics.
- Mandatory for houses, voluntary for multi-storey: bulky.
- Voluntary: garden waste, glass (collected through street “igloos” and communal kerbside containers)
- **Bring banks/recycling centres:** Where there is no door-to-door collection (as described above), residents are still under an obligation to recycle recyclable waste at recycling centres/hubs, this is a requirement stated for Copenhageners rather than national legislation. There are five large recycling centres that take over 35 different fractions and 12 smaller local recycling hubs, four of which have been recently added.¹⁶¹ These contribute significantly to high recycling with 45,000 tonnes of waste delivered here annually with 90% recycled.¹⁵⁹ These include swap stands for reusable items to be donated and collected.¹⁵⁹
- **Collection coverage:** Most of the population has access to separate door-to-door collections as described above – there are a few exceptions are principally due to lack of space.
- **Frequency:** For multifamily apartment buildings cardboard and residual waste are collected twice a week, food, plastics and metals weekly and paper and small electronics fortnightly. Garden waste (collected March-Nov), hazardous, large electronics, glass and bulky emptied on request.¹⁶² For properties without the space for this number of containers, there is a new initiative planned to place 750 collection points in public spaces to supplement near access containers.¹⁵⁶
- **DRS/EPR:** In Denmark, most beverage containers are subject to DRS via reverse vending machines in most supermarkets, return rates are very high at 89%.¹⁶⁶ EPR schemes are in place for WEEE, ELVs, batteries and accumulators.¹⁶³ There is no producer responsibility scheme for packaging,¹⁶⁴ but one is in development to meet the requirements of the 2018 revision to the Waste Framework Directive.¹⁶⁵
- **PAYT:** Property owners are charged for waste services via a property tax bill which includes access to recycling stations. The costs are passed to tenants via their rent.¹⁶² There is a flat fee to cover recyclables and residual waste is charged based upon volume, for single family households in 2017 a 140L bin was charged at €318 compared to €435 for a 240L bin. For flats in 2017 there is a fixed fee of €31-52 and emptying charge of €0.7/litre/week.¹⁶⁶ Garden waste collections are included in the flat free to cover recyclables unless you have large amounts and require a large container.
- **Waste treatment:** residual waste is predominantly sent to EfW with <2% to landfill,¹⁶⁷ whilst separately collected recyclables are treated in dedicated facilities. There are plans for residual waste sorting: the latest resource and waste management plan includes objectives for increasing post-sorting of household waste for recycling which it says has the potential to yield a 6 percentage point increase in recycling rate.¹⁵⁹
- **Waste collection/management costs:** In 2017 waste management budget was €83 million/year, €138/inhabitant.¹⁶⁶

Key policies and practices of interest:

- Recent roll out of biowaste, most households receive door-to-door collections of food waste even with high proportion multifamily properties.
- Comprehensive network of recycling centres and recycling hubs which recycle most (90%) of the waste delivered.
- For biowaste “bio buckets” (caddies) and bio bags are provided for free to both houses and apartments.
- Driven by a Resources and Waste Management Plan aiming for 70% recycling rate. The plan outlines specific actions, anticipated increase in recycling from each action and investments required to achieve this.
- Focus on public attitudes, including linking waste and climate change.

A.1.8 Seattle, USA

The city achieves a high overall recycling rate of ~65%, while having a substantial and increasing proportion of its population living in multifamily properties that present greater challenges for achieving a high rate.

Population: 747,000 (in 2019),¹⁶⁸ and 331,836 households (in 2019).¹⁶⁹

Geography/Demographics: Seattle is a seaport city on the West coast of the US and is one of the largest (if including the metropolitan area) and most affluent cities in the country. The Seattle-Tacoma-Bellevue Metropolitan Area had the third highest GDP per capita of the 100 'leading metro areas' in the United States in 2019.¹⁷⁰ It has experienced population growth of 23% in past 10 years. Of 350,000 households, just 167,000 are single family¹⁷¹ and the multifamily residential sector has been a particular area of growth in recent years.

Recycling rate: The residential municipal solid waste (MSW) recycling rate for 2019 is around 65%.¹⁷¹

Definition of waste: 'Residential MSW' includes only waste collected from single and multifamily residential properties. 'MSW' includes residual, recyclables, and food/garden waste from four sources: single-family residential, multifamily residential, commercial, and self-haul to Seattle's two transfer stations. Self-haul includes non-municipal waste such as C&D; the residential MSW recycling rate is therefore the focus for this case study. Recycling rates exclude contamination but do not account for any other losses during sorting and processing.

Pattern of waste arisings/recycling rate over time: The recycling rate has steadily increased since 2000, but the rate of increase has somewhat levelled off since 2015,¹⁷¹ which is attributed partly to the influx of new multifamily residents and population growth with the "Amazon boom".

Waste composition: The largest components of residential waste in Seattle in 2014 were organics (53.8%), paper (20.3%) and plastic (11.5%). The smaller components included 'construction, demolition and land clearing' (CDL) wastes (4.6%),¹⁷² metal (3.1%), fines and miscellaneous materials (2.8%),¹⁷³ glass (2.3%), hazardous waste (0.5%) and appliances and electronics (0.9%).¹⁷⁴ This breakdown is shown in Figure 13 in the appendix. In 2015, the waste arisings per household were 778kg/hhld of which 210kg were dry recyclables (excl. contamination) and 253kg of compostable material.

Approach to collection and treatment of municipal waste:

- **Separate kerbside collection:** Seattle operates a co-mingled collection service collecting paper and card (incl. tetrapaks), plastic, glass and metal. A compost service is operated for mixed food and garden waste and also accepts food soiled paper/cardboard. Commercial businesses have a choice of using the City contract or open market.
- **Bring banks/recycling centres:** There are two transfer stations in Seattle, one in the north and the other in the south, that accept recyclable material and residual waste from residents. Recyclables can be deposited free of charge whilst residual waste, yard waste, wood and appliances are charged for.¹⁷⁵
- **Single vs multifamily apartments:** Single-family households have a kerbside service whilst multi-family apartments (generally 5+ housing units) have a communal "dumpster" bin. Apartments and condominiums must provide convenient food and garden ('yard') waste service and recycling service for their residents. Since 2011, building landlords have been required to manage the collection accounts for garbage, recycling, and food and yard waste disposal at multi-family properties.
- **Collection coverage:** All households have access to kerbside or communal collections covering the same range of materials.
- **Frequency:** for single-family residences, residual and compost is collected weekly and dry recycling fortnightly in a 96 gallon (~420L) container. For multifamily residences, residual, dry recyclables and organics are all collected once per week, with an option of up to twice a week if needed. However, the municipality prefers to add more containers instead of increasing collection frequency.¹⁷⁶
- **DRS/EPR:** No DRS is in place. EPR takeback schemes are in place for: paint, solar PV, electronics, lighting and medicine.
- **Pay as you throw:** Residual waste collection is considered relatively expensive. A 32 gallon (~140L) can collected weekly is \$41/month compared to \$82/month for a 64 gallon (280L)¹⁷⁷ bin; food and yard waste

are collected together in City-provided containers. The costs are \$10 for a 32 gallon container or \$13 for 96 gallon container; other recycling collections are free. Extra yard waste that doesn't fit in these containers is then charged at an extra \$6.55 per bundle (max weight 60 pounds). There is a special pickup fee of \$50 for collection of one extra container. Extra yard waste fees are not charged in November, when customers are asked to keep fall leaves out of drains to reduce the risk of flooding. Households can put out up to 10 bags of extra yard waste per collection day for free from November 1 to 30.¹⁷⁸

- **Law:** Seattle Municipal Code specifies which materials must be recycled and the law stipulates that compostable and recyclable materials aren't allowed in residual waste. Business owners and property managers are required to provide convenient food, yard waste and recycling services. Seattle Public Utilities issues warning notices if residual waste containers hold recyclables or compostables; after 2 warnings, a \$50 fine can be issued.
- **Treatment of waste:** Seattle's waste is rail hauled 257 miles south to the Columbia Ridge Landfill in Arlington, Oregon.¹⁷⁹ Most of Seattle's recyclables go to a MRF in the SODO area of the city, with 28% reprocessed in Seattle, 38% elsewhere in North America and 34% in Asia.¹⁸⁰ Organics are sent to composting.

Key policies and practices of interest:

The high costs of residual waste disposal due to a lack of local disposal facilities has helped make the economic case for investing in diverting waste into recycling since the late 1980s. Policies and practices in place to facilitate high levels of recycling include:

- Comprehensive "three stream" recycling collections to all households
- A pricing system that incentivises recycling over disposal
- A legal framework that forbids the disposal of recyclables, which is backed by enforcement
- Consistent colour coding and signage
- Regular communications with residents including in person, regular mailings, use of 'Recycle It' app
- Education and outreach programmes
- Focus on improving performance in multifamily properties, including making building managers responsible for managing recycling and providing guidance to help them increase recycling, e.g. sample letters to issue to new residents on move in, advice on signage and how to set up containers¹⁸¹

A.1.9 Leoben, Austria

Leoben is a town with similarities to Scotland in terms of geography and socioeconomic structure, in a federal state that is known for high standards in waste separation, particularly state wide well-developed and user friendly system of recycling yards.

Population: 28,016 (2020)¹⁸² and 14,367 households (based on the average household size in Leoben).¹⁸³

Geography/Demographics: A typical industrial town, on a main rail and road intersection and the second largest town in the federal state (Styria). Surrounded by hills with 80% of the area covered with forests.¹⁸⁴ Both its industrial background and topography are reasons for residential structures with 'communal bins' (including high rise buildings). With 228 inhabitants per square kilometre Leoben is the densest populated municipality in the Urban Region Upper Styria, average: 100 inh./m².¹⁸⁵ The population has decreased slightly in the last two decades, about 5% since 2001.¹⁸⁴ In 2018, Styria was ranked sixth of the nine Austrian states in terms of GDP per capita (€40,000).¹⁸⁶

Recycling rate: In 2020, the recycling rate for household waste was 59%, calculated based upon arisings per inhabitant.

Definition of waste: includes household waste, collected at kerbside, via depot containers and at one recycling yard, includes bulky waste and wood. Includes contamination, for paper and cardboard collected at kerbside the contamination is known to be 4.1%.¹⁸⁷

Pattern of waste arisings/recycling rate over time: Relatively stable over the last years, with a drop in disposal and rise of streams to be reused or recycled. Residual waste saw a decrease in 1990 and has been relatively stable since 1994 (Figure 15). Note EPR was introduced in Austria for packaging in 1990.

Waste composition: The major components of the dry waste stream are card (36%), wood (25%), glass (12%), plastic packaging (11%) and scrap metal (9%) with metal cans included. The remaining 17% is comprised of textiles and footwear, WEEE (small domestic appliances), reuse materials and other recyclables such as sheet glass (see Figure 14).

Waste arisings: 198 kg/inhabitant per year of residual waste (of which 34kg is bulky waste), 91kg of biowaste, and 199kg of dry recycling.

Approach to collection and treatment of municipal waste:

- **Kerbside collections:** kerbside collections of: residual waste, biowaste, paper & cardboard, plastic packaging (via bin or bag, in 'communal bin' areas via containers), and, for a small % of the population metal packaging. An estimated 80 % of the population are on communal collections.
- **Bring banks/recycling centres:** depot containers are used for bottle glass (two colours), textiles and footwear, and metal packaging. About 70 fractions are collected at one *recycling yard* (ASZ Altstoffsammelzentrum Leoben) located on a well connected road on the edge of the town.
- **Collection coverage:** Estimated 95%+ of the population receives waste collection services, those with difficult access conditions are required to transport their bin to a "service area" and are charged a reduced rate. "Self-disposers" transport their bin to a location within the legally defined "service area"; there a reduced tariff applies. For communal bins the building janitor will normally provide this service.
- **Frequency:** residual waste collection frequency is flexible with the minimum frequency for single households of four weeks for a 120L container (an 80L container is available in request). Communal bin areas for up to 19 households are served fortnightly, with 20 households and more weekly. Biowaste bins are emptied weekly between mid March-mid November and fortnightly over winter. Paper/cardboard is collected weekly and plastic packaging fortnightly.
- **DRS/EPR:** EPR for packaging is implemented nationwide since 1990. There is no DRS yet.
- **PAYT:** A combined waste tariff is applied (typical in Austria): a base fee per housing unit plus a variable fee depending on size and emptying frequency of the residual waste bin. In cases where home composting is proven to be practiced (11% of all households), discounts are given on the base fee. For communal properties the impact of the variable charging is negligible due to how costs are divided per flat/household. Collection of garden waste is free: well shredded and chopped garden waste should be composted; light garden waste should be in organic waste bin or in separate 110L paper sacks (which can be bought from ASZ recycling centre); larger volumes of waste such as branches or twigs can be collected for free or taken to the ASZ Recycling Centre – again free of charge.
- **Waste treatment:** Residual waste (including bulky waste) is currently sent to a nearby mechanical treatment plant (Mayer Recycling GmbH, St. Michael) where it is processed into raw Solid Recovered Fuel (SRF) for the cement industry and a fraction forwarded to an incinerator in a Styrian paper factory. Waste paper is sorted nearby by 'Papyrus Altpapierservice', a private company 25km away supplying the paper industry in and beyond). Plastic packaging and cans are sorted by a private company 'Saubermacher' in Graz. Biowaste and green waste is composted in three nearby private compost plants.
- **Waste management costs:** A typical example referring to an apartment building (20 flats)¹⁸⁸

| | |
|---|---------------------------------|
| - Base fee with "partial service" ¹⁸⁹ | 20 x € 110,35 = € 2 207,00 p.a. |
| - Variable fee: Emptying an 1100L container 52 times a year | € 1 564,86 p.a. |
| - Total fee | € 3 771,86 p.a. |
| - Total fee per flat / household | € 188,59 p.a. |

No further cost is applied for biowaste, paper & cardboard, bulky & green waste, packaging, or use of the recycling yard. The only exception is if additional volume is requested in residential areas. Collection of residual & bulky & green waste, biowaste, and paper/cardboard is carried out by the municipality, other services are by private contractors.

Key policies and practices of interest:

- "Easy" access (by Austrian standards) to waste related information, with standard information also available in English.¹⁹⁰
- A tariff structure that supports separate collection, and home composting where applicable to an appropriate extent.

- A well-managed free to access recycling yard (including a reuse shop), open six days / 59 hours a week
- One “waste consultant” staff equivalent (employed by a Regional Waste Council) available five days a week to support residents e.g. providing training at schools.

A.1.10 Kempten, Germany

A typical mid-sized Bavarian city with a high portion of ‘communal bins’ and a waste separation system which has been performing well for many years. Waste management includes a focus on public awareness and introduction of waste fees to influence reduced disposal as well as investing in waste treatment technology

Population: 70,724 (30 June 2021).¹⁹¹

Geography/Demographics: A wealthy German city (GDP per capita 2016: €53,400, compared to €33,200 for state of Bavaria and €38,200 for Germany in the same year¹⁹²) bordering Austria with an economy driven by SMEs. High population density ($\approx 1,100$ inhabitants/km²) and a high proportion $\approx 95\%$ “apartment buildings”¹⁹³ which differs from the norm for this area of Germany, which is dominated by single-family houses.

Recycling rate: In 2020, the recycling rate for household waste was 60% based upon per capita arisings.

Definition of waste: includes household waste, collected at kerbside, via depot containers and via several recycling yards, and includes contamination (for related considerations in Germany – numbers refer to packaging only – 10% are reported for glass, 15-30% for paper and board, 5-20% for steel metal cans and c.25% for composite cardboard¹⁹⁴).

Pattern of waste arisings/recycling rate over time: Quite stable over the last years, with a significant dropping of streams to be disposed of and rise of streams to be reused or recycled in the early 1990s.

Waste composition: The dry waste stream is comprised by paper and cardboard (36%), wood (27%), scrap metal (13%), glass (12%), plastic packaging (8%) and WEEE (4%).

Waste arisings: 139kg/inhabitant per year of residual waste, 48kg of bulky waste (incl. in residual for recycling rate calculation), 46kg of biowaste, and 232kg of dry recycling.

Approach to collection and treatment of municipal waste:

- **Separate kerbside collections:** kerbside collections for residual waste, biowaste (including garden waste¹⁹⁵), and paper and cardboard.
- **Other collections:** depot containers are used to separately collect: glass (by three colours), paper and cardboard and ‘consumer packaging’ which is divided into plastic, metal and composite materials and about 30 fractions at three recycling yards.
- **Collection coverage:** 100% of the population receives waste collection services. It is estimated that 95% of the population are on communal collections.¹⁹³
- **Frequency:** residual waste is collected fortnightly (can be weekly on request), biowaste weekly May and September and fortnightly otherwise and paper and cardboard 4-weekly.¹⁹⁶
- **DRS/EPR:** EPR for packaging is implemented nationwide since 1991, DRS for beverage packaging since 2005.
- **PAYT:** The tariff applies a clear PAYT component but has little effect in residential structures “apartment” or “high-rise” compared to a single-family house. A combined tariff is applied; a base fee per housing unit (€2.50/month)+ a variable fee de-pending on size and emptying frequency of the residual waste as well as the biowaste bin. The variable fee in respect to different container volumes is strictly linear, a receptacle twice as large also costs twice as much with a PAYT concept applied. For residual waste a 240L container is €22.80 per emptying and a 40L organic bin €2.40.¹⁹⁷
- **Waste treatment:** Residual waste (including bulky waste) is disposed of in a small sized (by German standards¹⁹⁸) incinerator located in Kempten. The operator of this plant also operates a fermentation plant for biowaste and a composting plant for green waste, both in Kempten.
- **Waste management costs:** The annual waste fee for a two-person household is currently €104.40 (the same level as in 2008, and with an overall decline in costs over the last 25 years¹⁹⁹), which excludes EPR costs which would result in an extra €100 being added.

Key policies and practices of interest:

- Waste separation is important to the city, recycling yards collect an extensive range of items (down to bottle corks, CDs and cooking oil).
- Reuse system including items collected at doorstep.
- Special advice offered to architects how to design for waste and recycling in residential structure.
- Good access (by German standards) to waste related information includes alerts on upcoming collection dates and extensive information on the “fate” of collected recyclables.²⁰⁰
- A tariff structure that supports the separate collection, and home composting where applicable to an appropriate extent.
- Three recycling yards (and three more in the nearby area which Kempten citizens can access without restriction) open six days / + 20 hrs a week, two reuse shops.
- A half “waste consultant” staff equivalent available five days a week providing customized information²⁰¹ based on 30 years’ professional experience.

A.1.11 Case Study Figures

Figure 1: Bridgend Proportion of Recycled and Reused Materials Collected at Kerbside⁷⁸

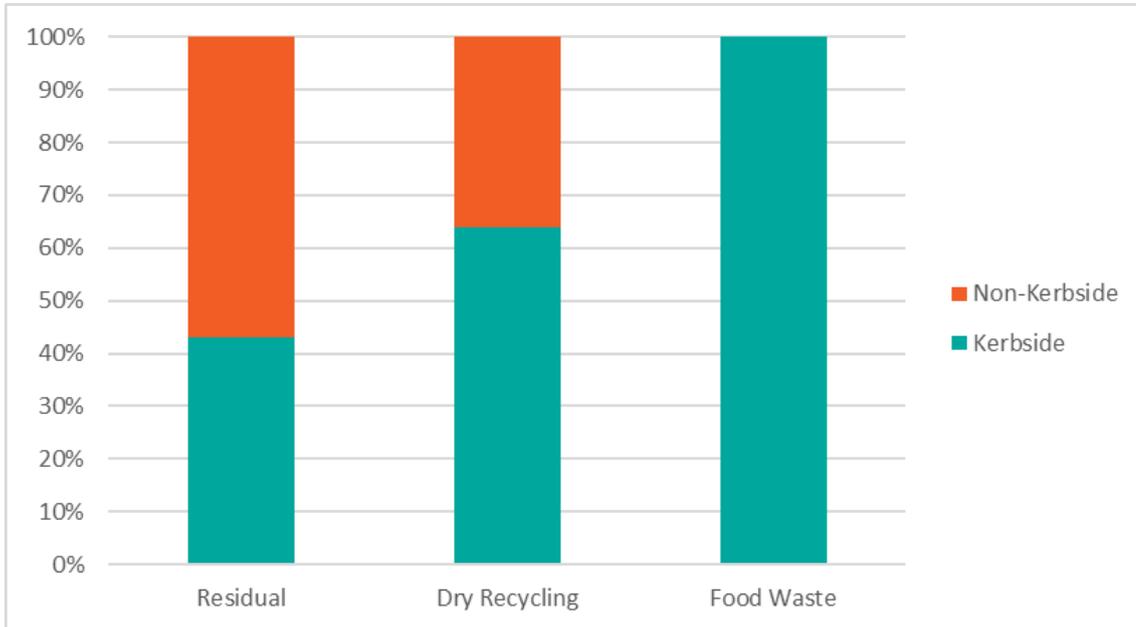


Figure 2: Bridgend Split of Recycled and Reused Materials Collected at Kerbside

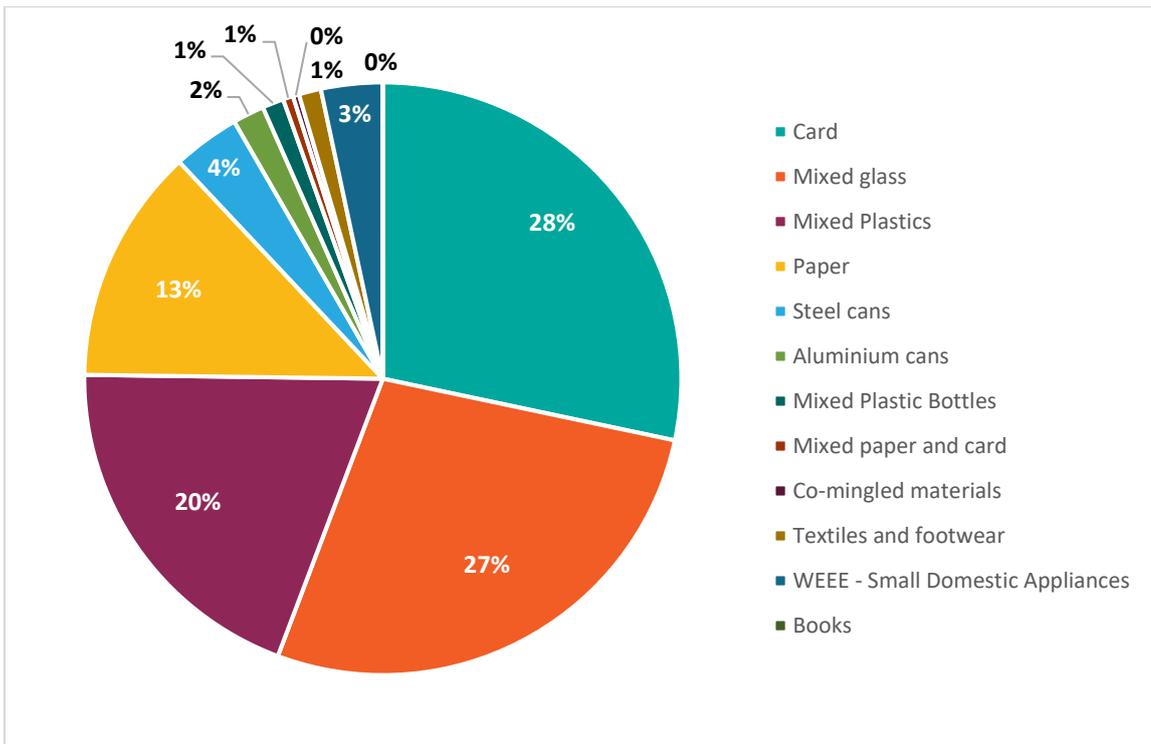


Figure 3: Bridgend Waste arisings and recycling rate

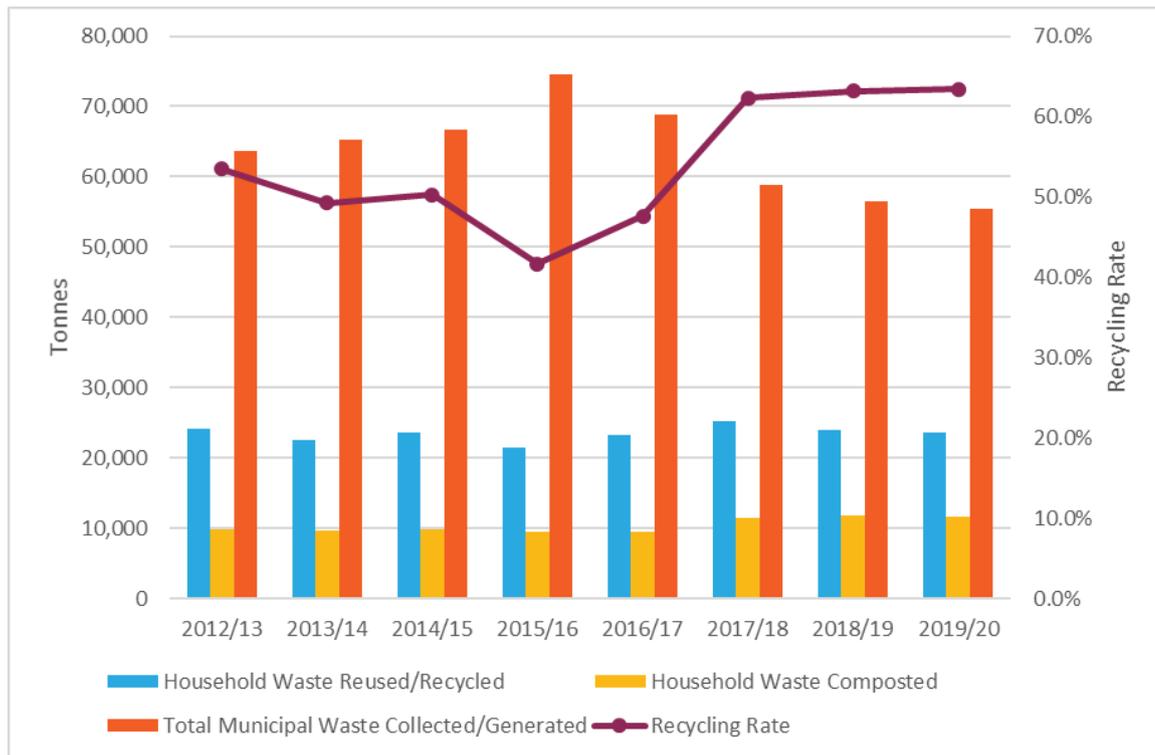


Figure 4: Vale of Glamorgan Percentage of municipal waste collected at kerbside

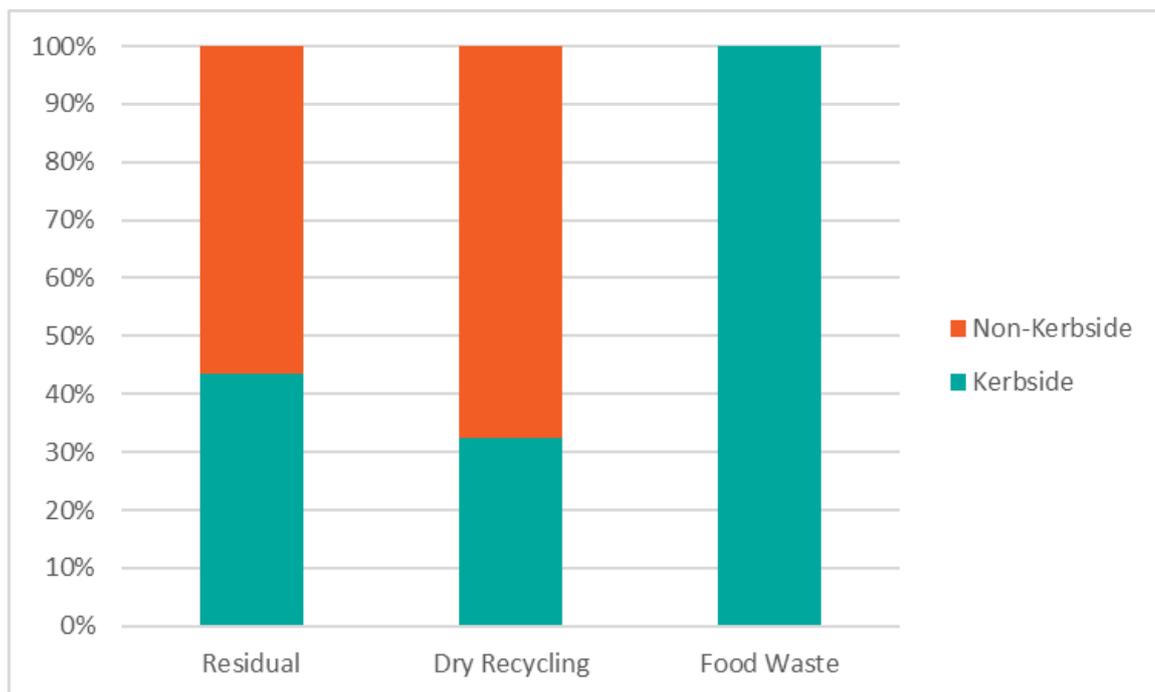


Figure 5: Vale of Glamorgan waste arisings and recycling rate

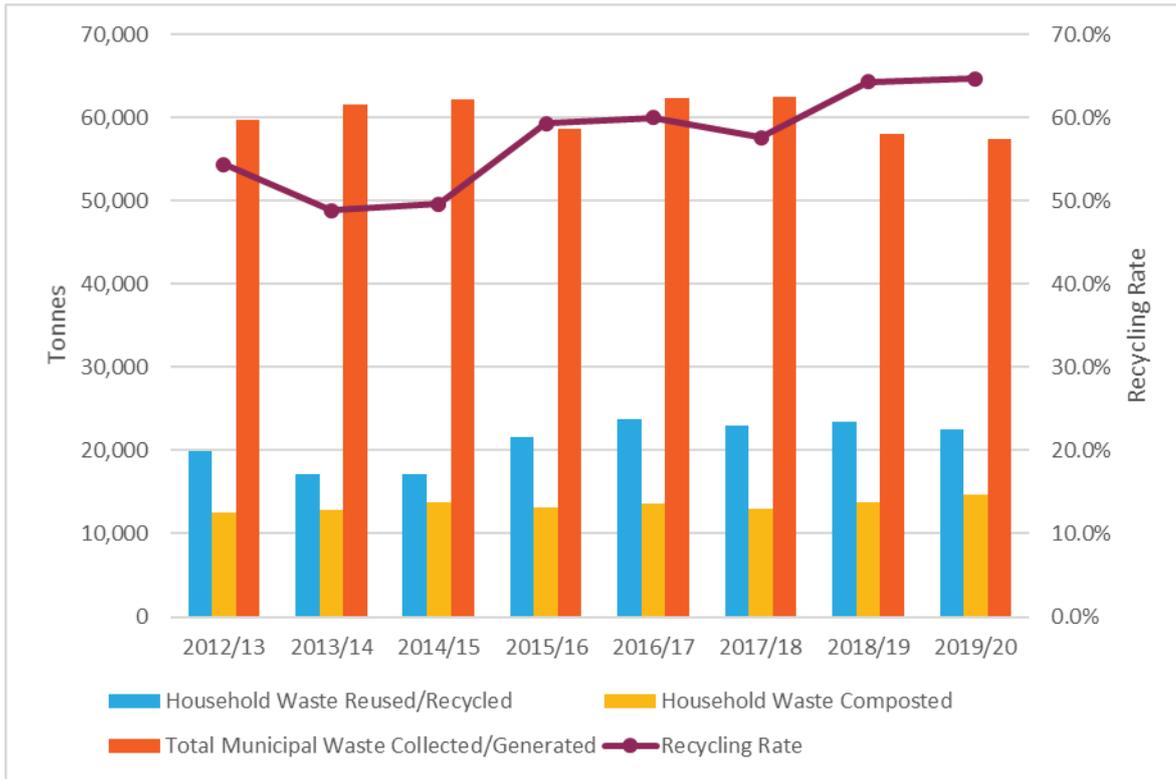


Figure 6: Ljubljana Increase of separate collection and decrease of residuals 2004-2014 (kg/person/year)¹⁰⁸

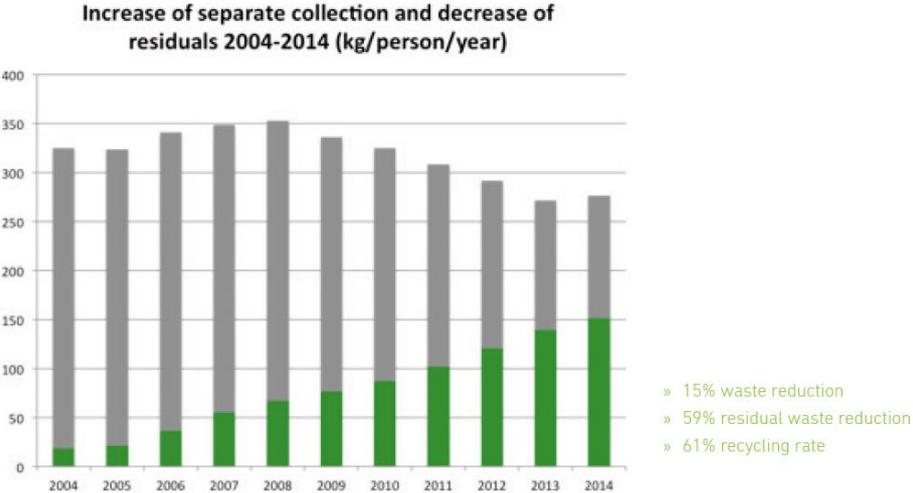


Figure 7: Treviso types of collection containers for household kerbside collections¹²⁶



Figure 8: Recycling rates from two sub-districts in Treviso 2000-2014¹²⁶

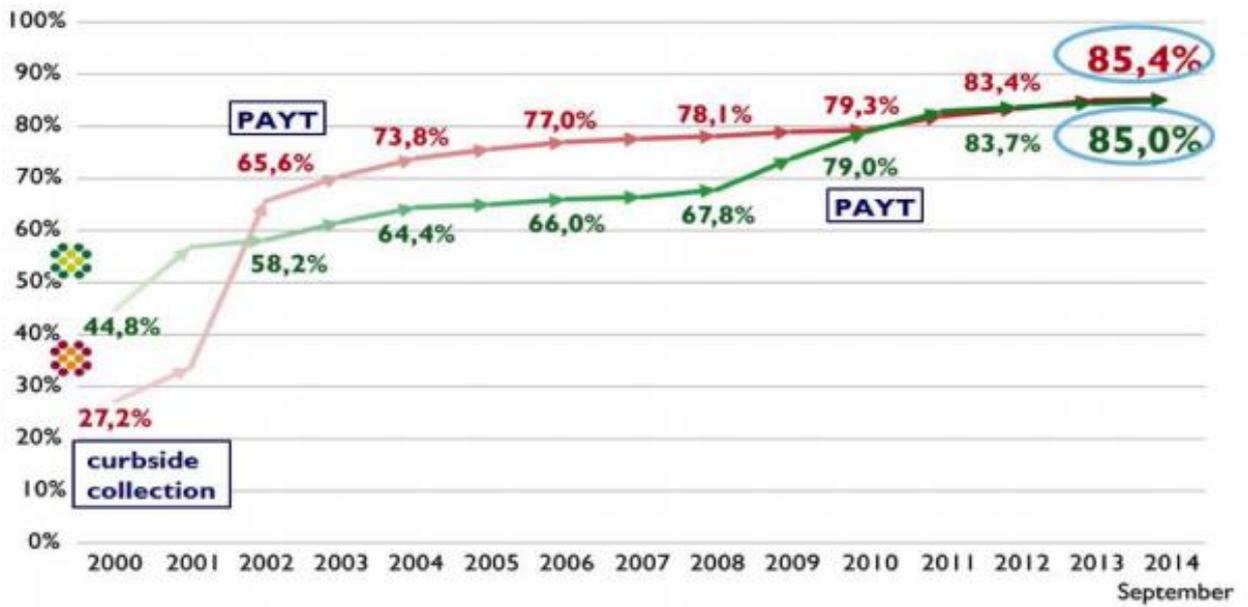


Figure 9: Contarina (Treviso) management costs compared to those in Italy in 2013¹²⁶

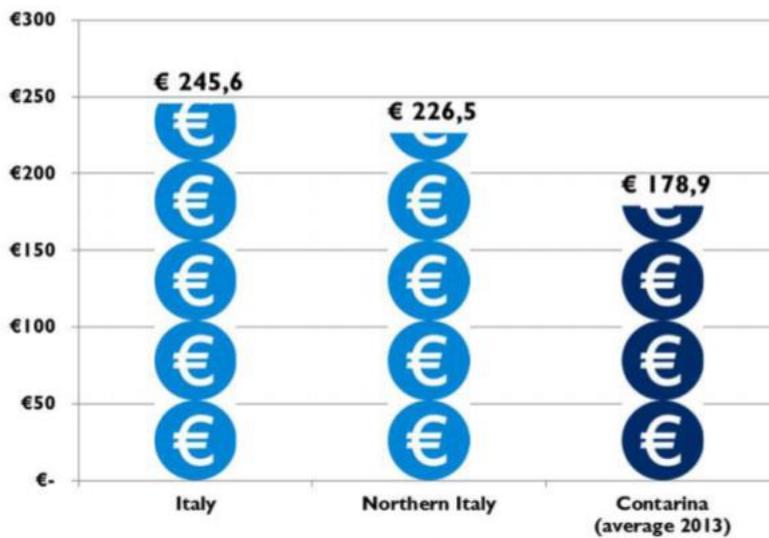


Figure 10: An ecobus in the city centre of Treviso¹²²



Figure 11: Composition of residual waste in Copenhagen²⁰²

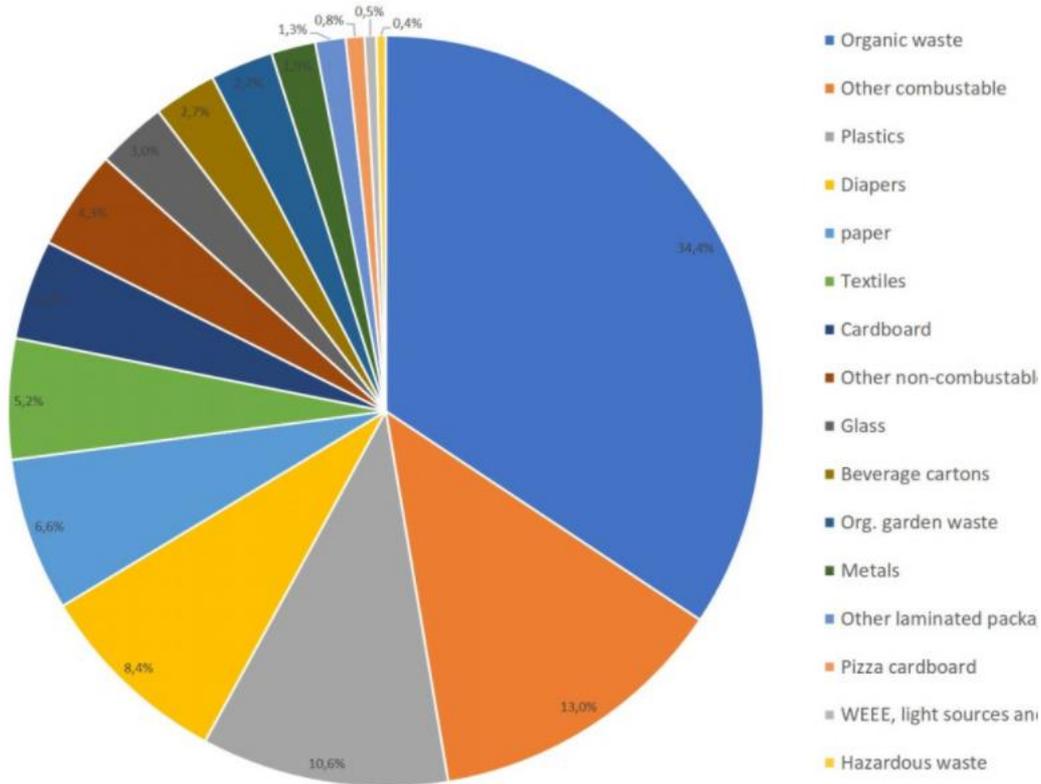


Figure 12: Population and Residential Municipal Solid Waste (Generated = Disposed + Recycled + Composted)¹⁷¹

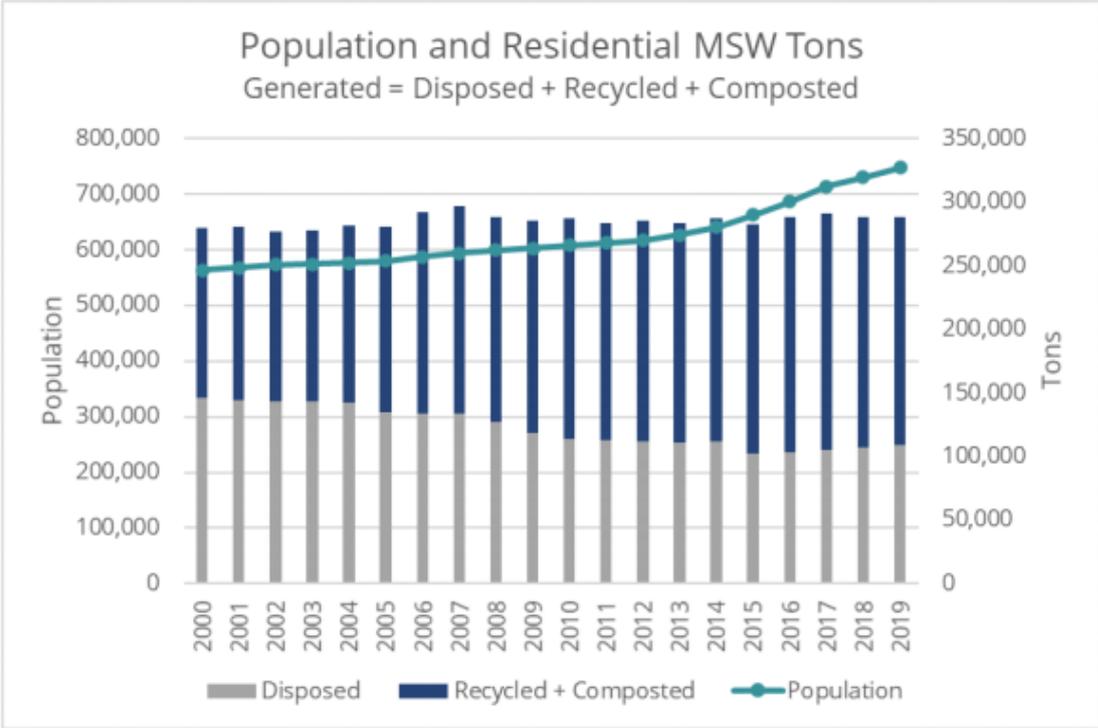


Figure 13: Waste composition summary - overall residential (Jan-Dec 2014)

203 204

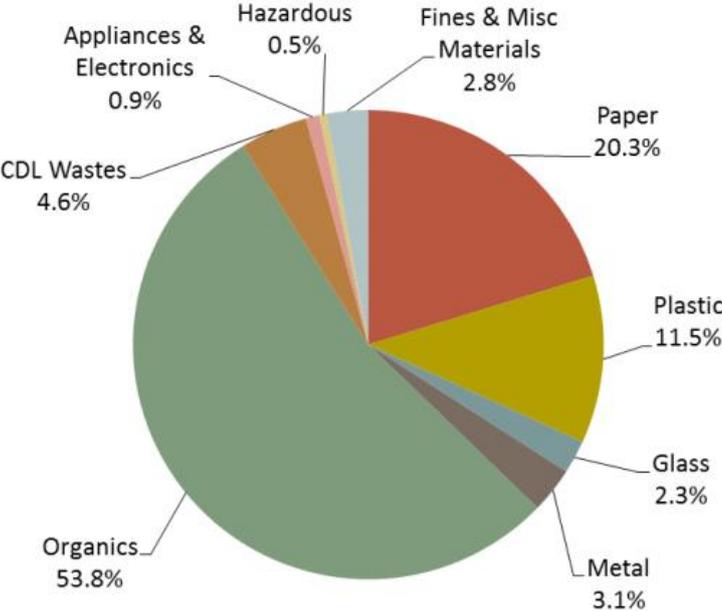


Figure 14: Composition of the total waste volume in the municipality of Leoben in 2020

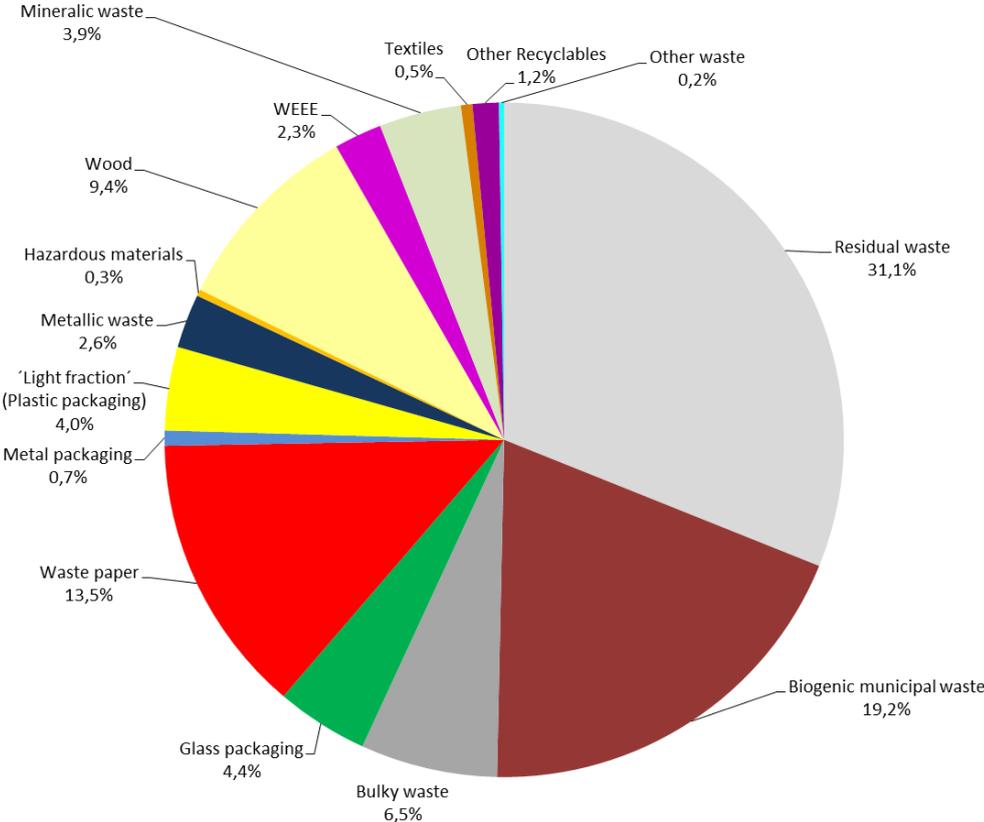


Figure 15: Timely development of residual waste (“Kommunaler Restabfall”) in Styria ²⁰⁵

Kommunaler Restabfall (Restmüll)

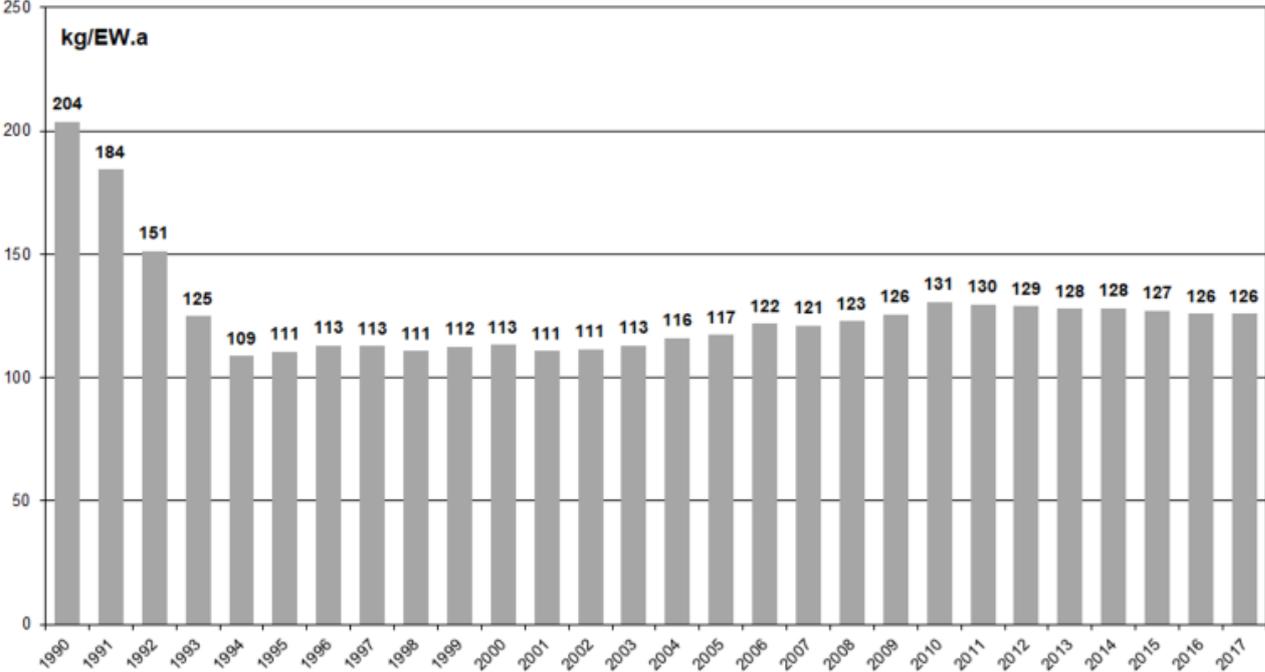


Figure 16: Household waste arisings for Kempton, recyclable material is shown in green and residual in yellow

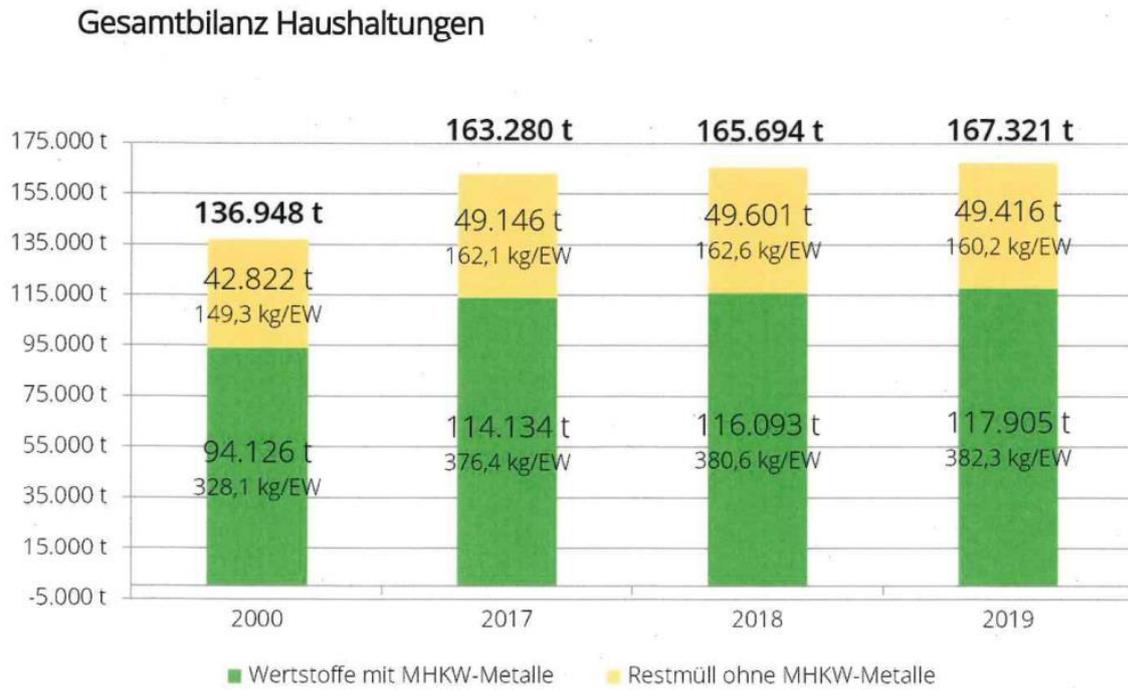
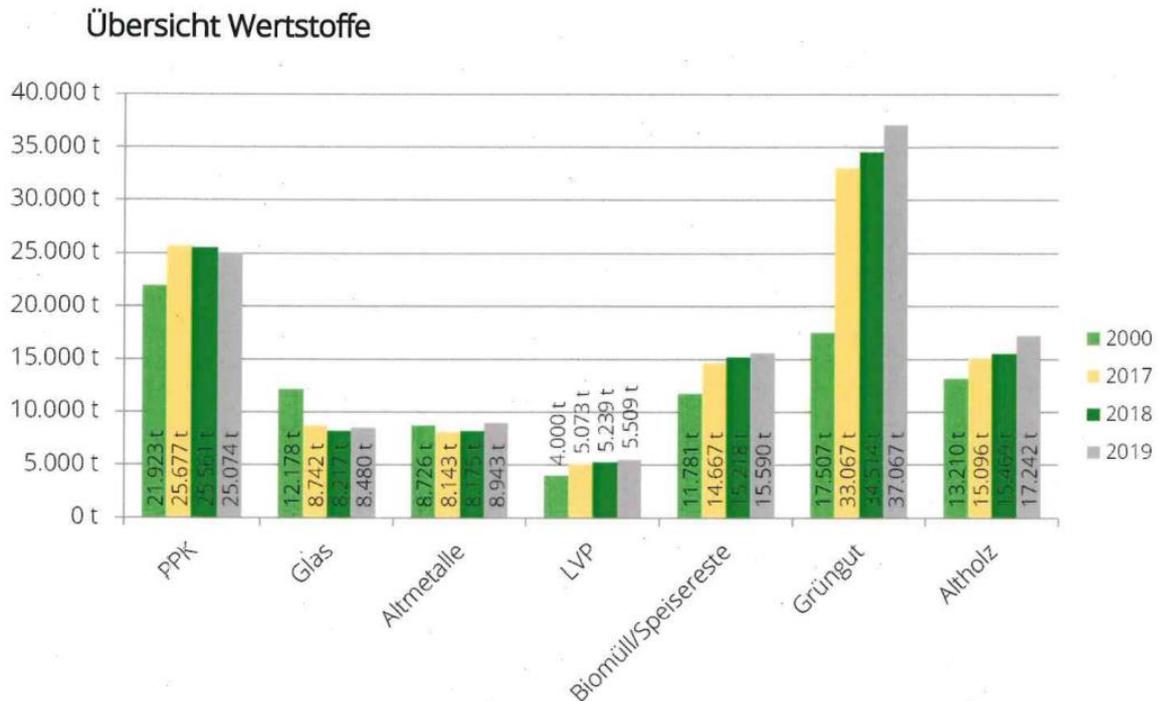


Figure 17: Recyclables collected for Kempton (Packaging, Glass, Scrap metal, light packaging, Food waste, green waste, wood waste)



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