Deliverable 2.4

Report on solutions for tackling systemic and technical boundary conditions

TASK 2.2: ASSESSMENT OF IMPLEMENTED SOLUTIONS IN THE 12 SELECTED CASE STUDIES FOR TACKLING SYSTEMIC AND TECHNICAL BOUNDARY CONDITIONS

Ive Vanderreydt, Dirk Nelen, Kévin Le Blevennec, Andrea Winterstetter (VITO)

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List of Acronyms

BSR	Berliner Stadtreinigungsbetrieben
BP	bring point
CAS	civic amenity site
CDW	construction and demolition waste
DtD	door to door
EPR	extended producer responsibility
EU	European Union
GDP	gross Domestic Product
IT	information technology (electronic devices)
LCA	life cycle assessment
MCDM	multiple-criteria decision making
PAYT	pay-as-you-throw
PMD	paper, metal and drinks cartons
PPW	paper and packaging waste
PRO	producer responsibility organisation
WCS	waste collection systems
WEEE	waste electrical and electronic equipment

Summary

This report focusses on the contribution of waste collection systems to improve circularity through recycling and on solutions implemented in waste collection systems that enable the recycler to produce more value, by producing better (qualitative) secondary materials.

The main boundary conditions for a waste collection system from a circular economy perspective that can improve the sorting and recycling process following the waste collection are:

- Traceability of the collected waste: what is exactly collected, and what not;
- Supply of collected waste: in order to be able to operate in a steady way, a minimum amount of waste must be supplied to the sorter and recycler;
- Quality of the waste: the (sorted) waste should meet some quality requirements to enhance recycling into marketable secondary materials.

So, the potential of a waste collection system to contribute to better recycling mainly lies in providing waste fractions as much as possible in line with the quality requirements for the corresponding secondary materials.
A selection of 12 case studies was analysed. For paper and packaging waste, data were compiled on the waste collection systems of 135 municipalities from 24 EU member states. For WEEE, 73 municipalities from 18 member states were considered. For CDW, 34 municipalities from 17 member states were considered.
In total, 5 PPW, 5 WEEE and 2 CDW case studies were selected from the municipalities sampled.
The information for the analysis of the case studies has been gathered through intensive contacts with local representatives for each of the case studies. Based on detailed questionnaires and contacts via e-mail and phone, relevant information on the waste recycling system and specifically on the waste collection system has been collected and processed. Where appropriate, this information has been complemented with desk research of available information in relevant literature and reports.

For paper and packaging waste, the analysis of the case studies learns that:

- For all PPW waste fractions, clear end applications requiring a high value recycling have been detected in the analysis of the case studies;
- A significant fragmented collection scope has been observed for glass waste and plastic waste;
- In the five cases, light packaging (plastic, metal, drink cartons) is collected together; collecting these easily sortable fractions together does not or hardly seem to influence the quality of the collected fractions, while there is definitely an economic benefit;
- The level of service provided to citizens, including the collection system and frequency, is extremely divers. Even within the same city, different collection systems can be applied for one waste stream as the waste collection is often tailored to the needs of specific areas within the city (e.g. multi-family houses versus detached houses);
- When researching specific information on the actors and eventual quality requirements at different steps of the recycling value chain, the organisation of the waste collection itself proved to be an essential parameter. The case studies analysis highlights that the organisation of waste collection is more and more being outsourced, either through public-private partnerships or through public authorities subcontracting private companies that might be horizontally integrated, so taking care of sorting and recycling as well;
- Changing or adapting waste collection habits needs a long term and case-specific approach: the role of citizens in waste collection is key, so their cooperation should be guaranteed at all times. Sometimes this might lead to areas where the waste collection itself is suboptimal in the perspective

of the subsequent sorting and recycling, but the benefits for further optimisation do not outweigh the risks of losing the involvement of citizens;
- When benchmarking urban mining (secondary materials) against geological mining (primary materials), it becomes clear that, seen the fragmented scope and the diverse methods applied for collecting the waste fractions, the current extraction of secondary materials from the urban mine is far way more complex and divers.

Systemic or technical solutions have been identified with respect to the waste collection to improve the recycling value chain. These solutions are:

- Collect easily sortable waste fractions together; this allows to reduce the costs for collection, without losing out on quality of the collected waste fractions;
- Limit the number of collected secondary materials in the scope of the collection (do's and don'ts); this allows to collect more homogeneous waste fractions, making them more suitable for high value recycling;
- Make sure that the configuration of the waste collection, sorting and recycling are adapted/aligned to each other; this will allow the recycling value chain to produce qualitative secondary materials in an efficient way, and can be done by:
    - Making clear agreements on the scope of the waste collection (do's and don'ts);
    - Securing transfer of relevant information between consecutive treatment steps such as collection, sorting and recycling, regardless if the responsible organization is the municipality, a private company or a PRO;
    - Creating clarity on standardized specifications for collection outputs, sorting outputs and recycling outputs, and harmonize them;
- Broaden collection scope from packaging waste to similar non-packaging waste fractions, resulting in a higher supply of collected waste;
- Collection in transparent recipients allows visual quality check during collection;
- Adapt the waste collection system to the local conditions (such as dominant type of housing).

For WEEE, a delta analysis was performed comparing the performance of the WEEE collection system for two points in time. Specific 'good practice actions' which were performed by the producer responsibility organization (PRO) in the case study and which resulted in increased WEEE collection quantity (or increased WEEE supply to recyclers) and quality were identified and analysed, such as transport optimization, increased pickup frequency, increased coverage of collection points, additional awareness campaigns, etc. , leading to more waste supply, of a better quality, to recyclers. As the analyses of those five case studies did not allow us to draw any conclusions on the quality of the materials due to the lack of data on the outputs of recycling plants, mainly because of confidentiality issues. While European waste management targets relate to the weight of waste, it is their quality that determines their value as secondary raw materials in the circular economy and may determine proper treatment. Therefore, it has been judged essential to contact and conduct interviews with PROs for obtaining complementary insights and evaluate how and to which extent WEEE collection systems could provide specific solutions to improve the quality of the collected waste in order to enable the sorter and/or the recycler to produce more qualitative secondary materials. The following observations were made:

- Clear and significant quality differences between WEEE collected through retail bring points and through municipal collection points are noticed. Having waste managed by trained professionals and concomitantly increasing the surveillance can reduce the number of broken appliances as well as the scavenging level. Increasing and homogenising the surveillance methods between municipal collection points can also reduce the scavenging level.

- Besides implementing specific containers for separately collecting the different WEEE categories there are almost no other measures implemented at collection points for facilitating the sorting (taking into consideration that the scope of the study is limited to three WEEE categories). It seems that the role of the waste collection system for facilitating the sorting is extremely limited and rather than focusing on “collection for sorting” is rather focusing on “collection for transport”.
- Qualitatively monitoring the presence of non-WEEE by identifying and classifying unwanted materials can be an incentive for improving the quality of collected WEEE. Partners in charge of the collection can be rewarded or penalized according to the quality of materials provided.
- No monitoring systems as such are being implemented to quantify the scavenging level at collection points. Increasing the surveillance in municipal collection points is nevertheless considered as essential for reducing the scavenging level and improving the quality of collected WEEE from public sources.
- There is currently no harmonization in the use (or not) of specific standards at collection points.
- It is considered essential to have trained professionals carrying out collection and logistics operations.
- Information and awareness campaigns, eventually combined with rewarding competitions can lead to an improvement in the quality of collected WEEE.
- According to an assessment performed in an additional shared research project, some implemented collection activities, being closer and increasing the convenience to the citizens, had a significant positive impact on the collection performance, both in quantitative and in qualitative terms.
- Economic compensations paid by PROs to collection points for improving the infrastructure of collection points against thefts or encouraging collection point for collecting WEEE in good condition, and compensations to increase the degree of WEEE separation were also identified.

For CDW, the analysis of the two case studies on CDW fractions shows that setting up a dedicated recycling value chain can be interesting for specific CDW fractions. The starting point for the collection of the CDW fractions in both case studies was the presence of a clear market for the end application, and the corresponding business case. The setup of the recycling value chain is both cases quite straightforward: starting from the market for the end application, the scope of the collected waste at the CAS is determined and a matching sorting process is selected.

1. Introduction

1.1 The importance of waste management

The EU's vision of sustainable economic growth and global competitiveness will be facilitated by the transition towards a circular economy, with its aim of extending the useful lifetime of materials by promoting recycling, whilst lowering resource use and environmental impacts (Tisserant, et al., 2017; Milios, 2018). About 500 kg of municipal waste per capita are generated every year in the EU. These wastes contain large volumes of valuable materials for Europe's industrial base. Proper collection of waste is a pre-condition for their optimal recovery.

Improving the collection performance of waste collection systems (WCS), thus diverting more recyclable material towards the appropriate material sorting facility and treatment processes, and away from sending it for disposal, is the obvious first step towards achieving the ambitious recycling targets proposed by the EU. For instance, common EU targets of recycling 75% of paper, 50% of plastic packaging, 50% aluminium, 70% ferrous metal and 70% glass by 2025 (increasing to 85%, 55%, 60%, 80% and 75% respectively by 2030) have been put in place (European Commission, 2018). Under the EU WEEE directive vendors have an obligation to recover end-of-life devices. A target of 85% (based on the average of electrical and electronic equipment put on the market in the last 3 years) or 65% of WEEE produced that year needs to be collected by 2025 (European Commission, 2012).

1.2 The COLLECTORS project

Good regional practices have the potential to serve as good practice examples for other regions. So far, however, results of existing studies and good practices have not been effective enough in supporting the implementation of better-performing systems elsewhere. The main objective of the COLLECTORS project is to overcome this situation and to support decision-makers in shifting to better-performing collection system.

The objectives of the COLLECTORS project are to:

1. Increase awareness of the collection potential by compiling, harmonising and presenting information on systems for Packaging and Paper Waste (PPW), Waste Electrical and Electronic Equipment (WEEE) and Construction & Demolition Waste (CDW) via an online information platform.
2. Improve decision-making on waste collection by the assessment of twelve good practices on their performance on:
   - (1) quality of collected waste;
   - (2) economics;
   - (3) environment;
   - (4) societal acceptance.
3. Stimulate successful implementation by capacity-building and policy support methods that will increase the technical and operational expertise of decision-makers on waste collection.
4. Engage citizens, decision-makers and other stakeholders throughout the project for validation of project results and to ensure the usability of COLLECTORS-output.

Thereby, the COLLECTORS project is specifically focussing on the following waste streams:

- **Packaging and Paper waste from private households (and similar sources):**
  - Paper & cardboard (both packaging and non-packaging);
  - Plastic packaging;
  - Metal packaging;
  - Glass packaging;

These materials represent all the paper and packaging materials targeted by different municipalities in accordance with the packaging and packaging waste directive (European Commission, 2018)

- **Waste Electrical and Electronic Equipment from private households and similar sources;**
  - Small household appliances;
  - Information technology (IT) equipment;
  - Light bulbs;

This is only a few categories of WEEE. These were considered due to the high quantities of these materials that are still being thrown in residual waste.

- **Construction and demolition waste with a focus on wastes that are managed by public authorities.**
  - Bricks
  - Insulation
  - Sanitary ceramics
  - Gypsum

1.3 Aim of this report

The objective of Work Package 2 (WP2, Boundary conditions and solutions for implementation of waste collection systems) of the COLLECTORS project is to identify the main boundary conditions for implementation of waste collection systems, and to gain insight into successful solutions and key elements for implementation via analysis of the twelve selected case studies. **The aim of this report is to analyse how and to which extent the waste collection systems as in the selection of case studies provide specific solutions to improve the quality of the collected waste in order to enable the sorter and the recycler to produce more qualitative secondary materials.** This report is a deliverable of Task 2.2 "Assessment of implemented solutions in the 12 selected case studies for tackling systemic and technical boundary conditions".

1.4 Approach

The analysis performed in this report focusses on the contribution of waste collection systems to improve circularity and on solutions implemented in waste collection systems that enable the recycler to produce more value, by producing better (qualitative) secondary materials.

The identification of the main boundary conditions for a waste collection system from a circular economy perspective at a generic European level showed us (see Deliverable 2.2[1]) that 3 factors can improve the sorting and recycling process following the waste collection:

[1] https://www.collectors2020.eu/wp-content/uploads/2019/06/COLLECTORS_D2.2_Analysis-of-boundary-conditions.pdf

- Traceability of the collected waste: what is exactly collected, and what not; the more information we have about the origin of products that have become waste, the more we know about the materials it is composed of and the higher the chance we can recycle it into high quality products;
- Supply of collected waste: in order to be able to operate in a steady way, a minimum amount of waste must be supplied to the sorter and recycler;
- Quality of the waste: the (sorted) waste should meet some quality requirements to enhance recycling into marketable secondary materials; additionally, the quality level should show stability in correspondence with the flexibility of the recycling and manufacturing infrastructure to able to absorb the waste and secondary materials.

The potential of a waste collection system to contribute to better recycling mainly lies in providing waste fractions as much as possible in line with the quality requirements for the corresponding secondary materials. Although this probably would decrease the effort for the respective sorting or recycling, there might be a trade-off with increasing effort for collection.

1.5 Case study selection

Data collection took the form of consultation with stakeholders and an extensive literature review of national reports and isolated case studies. The characteristics of the municipalities included in this study varied in terms of area size, population density, level of tourism, GDP and total waste generated. Data were collected on each of these characteristics, as well as on the performance of the WCS employed by each municipality with regards to each of the waste streams included within the scope of the study.

For PPW, data were compiled on the WCS of 135 municipalities from 24 EU member states. For WEEE, 73 municipalities from 18 member states were considered. For CDW, 34 municipalities from 17 member states were considered. In total, 5 PPW, 5 WEEE and 2 CDW were selected from the municipalities sampled (Figure 2-4). The selection of these 12 case studies was based on in-depth analyses in WP2 and dialogue with involved stakeholders as part of WP3. To do this, a participatory approach with local and regional authorities was used with the objective of building the methodology for a multiple-criteria decision making approach, from which all the case studies could be ranked (see COLLECTORS D1.3).

For PPW, the capture rates of each waste stream were weighted in relation to importance as concluded by the focus groups; all capture rates received similar weightings, with plastic being regarded as slightly more important than the others. For WEEE, the criteria deemed most important was the total WEEE collected per inhabitant and the share of WEEE in mixed residual waste. For CDW, the number of inhabitants per civic amenity site (CAS) was the most important factor. Case studies were then selected based on their high ranking and characteristics. Lastly, an assessment of data availability and willingness to cooperate was performed, in order to ensure cooperation and relevant data in the case studies (to this end we've had to drop and reselect some cases – which is discussed in Deliverable 7.1).

Figure 1: The PPW caste studies: Parma (IT), Tubbergen (NL), Ghent (BE), Berlin (DE) and Rennes (FR)

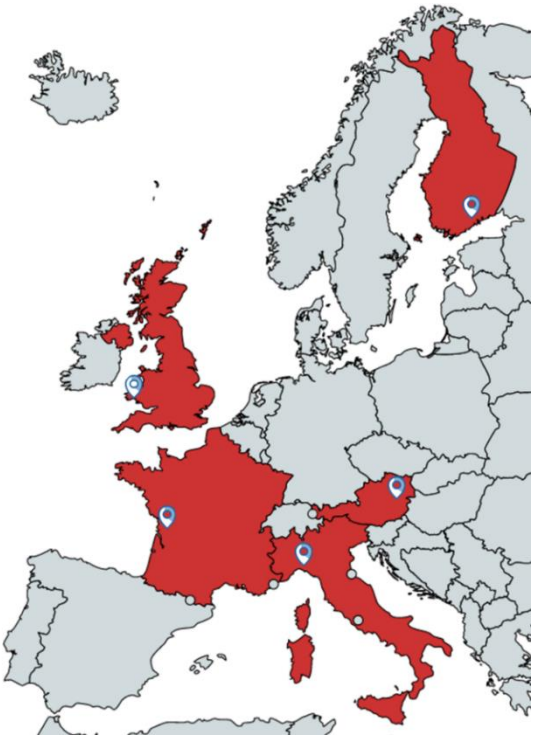

Figure 2: The WEEE case studies: Pembrokeshire (UK), Genova (Italy), Cyclad serviced area (France), Vienna (Austria) and Helsinki (Finland).

Figure 3: The CDW case studies: Odense (DK) and Reimerswaal (NL)

Local characteristics of the case studies

The non-performance related general parameters that describe the local context of the case studies, as in the database of WP1, are summarized in Table 1 for the PWW case studies and in Table 2 for the WEEE case studies. During the analysis of the case studies, where possible, observations have been included that could be linked to these parameters describing the local context. This has been done on a pragmatic and ad-hoc basis, and may not always provide statistical evidence enabling to extrapolate these observations, especially due to the small sample taken.

Case study	Area size [in km²]	Number of inh.	No. of inh. [per km²]	Detached and semi-detached houses [in %]	Multi-family houses: terraced houses, apartment buildings, housing blocks [in %]	GDP per inh. [in €]	Overnight stays per year	Total no. of commuters
Gent	156	256.262	1641	18	82	52.761	998.953	56.136
Parma	261	196.475	754	no information	no information	19.429	660.393	no information
Tubbergen	147	21.142	144	78	22	21.300	185.714	1.734.744
Berlin	892	3.537.100	3965	10	90	36.798	31.067.775	66.000.000
Rennes	711	438.865	617	36	64	30.770	1.613.810	no information

Table 1: Local context PPW case studies

Case study	Area size	Coastal area - remote	Coastal area - not remote	Number of inh.	Detached and semi-detached houses [in %]	Multi-family houses [in %]	Total no. of households	Ø size in persons per household	GDP per inh.	Overnight stays per year	Total no. of 1-day visitors	Total no. of commuters
Helsinki Capital region	1157	FALSE	TRUE	1.177.535	21	79	573.458	1,9	50741	5.300.000	no information	no information
Genova	240	FALSE	TRUE	580.097	no information	no information	293.251	1,97	20529	99.014	no information	no information
Pembrokeshire, UK	1590	TRUE	FALSE	124.711	no information	no information	54.754	2,23	23100	2.302.000	1.983.000	4.400
Vienna	415	FALSE	FALSE	1.867.582	60	40	911.869	2,06	47700	15.512.730	no information	59.690.025

Table 2: Local context WEEE case studies

As the relevance of publicly organised waste collection systems is very different for CDW compared to PPW and WEEE, it does not provide any added value to link the analyses of the CDW case studies with the local context parameters, and therefore this has not been done.

1.6 Case study backgrounds

1.6.1 Paper and packaging waste case studies

1.6.1.1 The city of Parma

Parma is a city located in Northern Italy at the foot of the Apennines with around 194,000 inhabitants. The region is Italy's top waste producer with 107,026 tonnes in 2016. Parma is leading the transition towards Zero Waste in the region (Zero Waste Europe, 2018). Currently Parma collects 78% of the generated PPW separately from residual waste and has an estimated recycling rate of 69%. Parma employs a "pay-as-you-throw" (PAYT) system, in which residents pay for the volume of paper, plastic, metal and composite materials and residual waste that is collected at the curb side. Residents are encouraged to place less PPW in the residual waste stream via a financial incentive (see D3.2 for more on PAYT in the cost benefit analysis).

The PPW collection in Parma can be described as a PMD commingling method. This means plastic, metal and composite material ("drinks cartons") are collected together and this is so called "light weight packaging waste" by the municipality. Paper and glass are collected separately. The residual waste, paper, and PMD are collected at the curb side, using home containers and bags. Several bring points (glass) and eight eco-stations (automated CAS where citizens can bring all waste except residual) are also available. The collected residual waste is transported to the sorting and incineration facility of Irens Ambiente, located in Parma. Paper waste is transported to the paper recycler Ghirardi in Parma. White and coloured glass is sent to Furlotti. The PMD stream is sent to the Oppimitti or Masotina recycling facility.

1.6.1.2 The municipality of Tubbergen

The municipality of Tubbergen is a small municipality (21,142 inhabitants) in the rural east side of the Netherlands, close to the border of Germany. 9,514 tonnes of MSW was generated in 2016. Tubbergen currently collects 94% of the generated PPW separately from the residual waste and has an estimated recycling rate of 85%.

The municipality effectively manages its waste by working together with the regional waste management company NV ROVA. This includes the collection and processing of different types of waste: organic waste (door-to-door collection), PMD, residual waste and paper (door-to-door collection, bring points, CAS) and glass (bring points). PMD, paper and cardboard and residual waste are all collected using either mini containers or shared containers. Glass is collected using 42 communal containers. PMD is transported to Attero in Wijster, the residual waste is transported to Twence in Hengelo.

Following "Afvalloos Twente" (waste-less Twente), Tubbergen has opted for the ambitious waste policy plan "Van Afval naar Grondstof, Van Idee naar Aanpak, Van Betalen naar Belonen" (from waste to raw material, from idea to approach, from payment to reward) to achieve a residual waste amount of only 50 kg per inhabitant per year by 2030. To achieve this, various measures were implemented in 2015 (facilitating the transition towards a complete PAYT system) which have resulted in a sharp decline in residual waste and a significant increase in separately collected waste (a decrease in residual waste from 200+ kg per inhabitant per year in 2015 to 63 kg in 2017, 65 kg in 2018) (Gemeente Tubbergen and ROVA, 2017). The achieved separation percentage in 2017 was already above the national standard of 75% for 2020.

1.6.1.3 The city of Ghent

Ghent is a port city in northwest Belgium with almost 250,000 inhabitants. 76,374 tonnes of MSW was generated in 2017. Currently Ghent collects 85% of the generated PPW separately from residual waste and has an estimated recycling rate of 77%.

The inter-municipality of IVAGO serves both the city of Ghent and the neighbouring municipality of Destelbergen. IVAGO has its own collection equipment but works together with private company SUEZ to complement the collection services. Since the introduction of the PAYT principle in 1998, the collection system for household waste in Ghent has remained practically unchanged (IVAGO, 2017). However, continuous improvements have been implemented over the years, which have resulted in large reductions in the amount of residual waste ('restafval') collected and the amount of illegal dumping ('sluikstorten'), while PMD, glass and paper capture rates have stayed fairly constant.

IVAGO collects residual waste, PMD, glass and paper and cardboard separately throughout the city and has defined three zones which each have their own collection approach:

- Zone C: Container-zone (waste collected in containers);
- Zone Z: Zakken-zone (waste collected in bags);
- Zone S: Sorteerpunten-zone (waste collected at a sorting point).

Depending on the zone the waste is collected in containers, bags or at bring points. In addition, Ghent has 6 civic amenity sites where citizens can discard of their waste.

The glass waste from Ghent is transported to High 5 Glass sorting and GRL Glass Sorting for sorting. Ghent's Paper waste is sorted by Stora Enso Paper Sorting. The residual waste is sent to IVAGO's incinerator. Lastly, PMD is sorted by Suez in the R&R BE North facility.

1.6.1.4 The city of Berlin

Berlin is a large capital city with over 3.5 million inhabitants. 1,350,457 tonnes of MSW was generated in 2016. Currently Berlin collects 59% of the generated PPW separately from residual waste and has an estimated recycling rate of 54%.

Berlin has implemented a PAYT-based waste collection system focused on the separate collection of PPW. The waste collection is organised and carried out by the Berliner Stadtreinigungsbetrieben. This includes the waste materials considered for the so-called Dual Systems (German producer responsibility scheme for the packaging waste): paper, cartons, glass and light packaging. Glass is collected separately (white, green, brown) and Berlin has 1,467 bring points for glass waste. Berlin also employs a PMD commingling method; PMD is collected in yellow shared containers and wheelie bins at 27,600 bring points throughout the city. Additionally, it is possible to get specific household waste bags (6€ per bag) at civic amenity sites, which can be ordered in case of an unusual higher amount of waste. Berlin has 15 civic amenity sites. Co-mingled waste is collected using household waste bins ('Hausmülltonne'). There are 5 different sizes available, which can be ordered depending on the amount of household waste arising in a specific household (varying from 60 – 1100 litres) (Senatsverwaltung für Stadtentwicklung und Umwelt Berlin, 2015). The frequency of collection is bi-weekly. Berlin also has a deposit scheme; whereby plastic bottles can be returned to machines in exchange for store credit.

The first entry point for paper waste is the sorting facility WUB Wertstoff-Union Berlin GmbH, where the collected paper is sorted. Different material types are for example carton board, mixed paper and de-inking capable paper. During this step, all non-paper material is removed. Plastic waste from the PMD entry point is sorted at the ALBA Recycling GmbH sorting facility, providing the material to the market for subsequent recycling steps

1.6.1.5 The city of Rennes

Rennes is a city in the east of Brittany in north-western France with 438,865 inhabitants. 204,552 tonnes of MSW was generated in 2017. Currently Rennes collects 55% of the generated PPW separately from residual waste and has an estimated recycling rate of 44%.

Waste is managed by "Rennes Métropole", operated by various subcontractors: Sita Ouest and La Feuille d'érable (Household and recyclable waste collection), Tribord (Door-to-door vegetable waste and bulky waste collection). The collection method used is PMD + Fibres commingling. Thus plastic, metal, composite materials and paper are collected together; residents put these items in yellow recycling bins and bring points. Glass is collected separately at bring points, but the different colours are mixed.

1.6.2 Waste electrical and electronic equipment case studies

1.6.2.1 The county of Pembrokeshire

Pembrokeshire is a coastal county in the south-west of Wales and therefore part of the UK, with around 125,000 citizens living on 1,590 km2, i.e. 79 inhabitants/km2. In Wales the GDP per capita amounted to £19,002 (Pembrokeshire County Council, 2019). Wales follows UK legislation in terms of recycling and waste collection. The United Kingdom in turn follows the European WEEE directive introduced in 2012 on WEEE collection (European Commission, 2012). The directives main concern was the introduction of the "Producer Responsibility" principle, obliging producers (importers, producers, retailers) to have a capture rate of 85%

(based on the average of electrical and electronic equipment put on the market in the last 3 years) or 65% of electrical and electronic waste produced that year by 2025. Also, they are to be financially responsible for at least the transport of WEEE from the communal collection points to the sorting facilities.

The collection of WEEE in the county of Pembrokeshire, in contrast to a common approach elsewhere in Europe, is not organized via a Producer Responsibility Organisation (PRO); no WEEE is collected from households directly. REPIC is the contracted PRO for the region and is in charge of bringing the waste from the collection points to the material recovery plants. Residents are obliged and encouraged to bring their potential electronic waste to one of 8 collection sites. The capture rate of small WEEE, IT and lamps have increased in the last couple of years by more than 30%. Investments into school education programs, research and development funding, as well as public awareness campaigns ("Don't bin it, bring it") have likely contributed to this increase. These programs have been established in cooperation with WRAP, a charity organization dedicated to improving circular economy (My Recycling Wales, 2018). Recently, reuse centres such as "The green shed" and "Pembrokeshire Remakery" have been built.

1.6.2.2 The Helsinki Capital Region

Finland has 5.43 million inhabitants with an average population density of less than 18 inhabitants/km2. The distance between the southernmost to the northernmost points of Finland is almost 1,200 km. Most Finns live in the southern and western parts of the country. The most populous area is the Helsinki Capital Region, including the cities of Helsinki, Espoo, Vantaa, Kauniainen and Kirkkonummi in the southern coast, with about 1.2 million inhabitants in total covering 1,157 km2, i.e. 1,037 inhabitants/km2. 79% of the population lives in multi-family houses, 21% in (semi)detached houses. The average household size is 1.9 persons. The GDP amounts to 50,741 €/cap.

In Finland, the collection of WEEE is arranged mainly as a permanent collection; in 2011, approximately 450 collection points existed around the country. Permanent collection points are in most cases collectively financed by the producer associations, provided by the municipality and, in some cases, by private companies or social enterprises. Private users and households can bring their end-of-life products to the collection points free of charge (Ylä-Mella, et al., 2014).

However, permanent collection systems are not always efficient, due to e.g. long distances and low quantities of returned devices. Therefore, WEEE collection in Finland is also organized as a mobile collection in the 50 smallest or least populous municipalities. In the Helsinki region, mobile collection of small WEEE is organized twice a year, in addition to the permanent bring points and civic amenity site (CAS). While one round is organized by the regional waste management company HSY, the other one is organized by the regional recycling centre (Kierrätyskeskus). The recycling centre collects only functional devices (169 tons/year).

In addition, the amounts of WEEE received in retail stores have also increased. Since 2007, the overall WEEE capture rate in Finland has exceeded 9 kg/inhab/year ranking third best in the European Union. The transportation of WEEE from reception points and registered stores to the regional treatment plants is managed by the producer associations. The logistics services are typically sourced from private regional operators. At the collection points, the WEEE is divided into four different categories with lamps and batteries being collected separately: cooling devices (fridge and freezers), large domestic appliances, small WEEE and IT. Lamps are collected separately by FLIP Association, a producer organization responsible for the producer responsibility of lamps falling within the scope of the WEEE directive.

At the regional sorting plants, WEEE is separated based on brands, not on product categories or source, for different product cooperatives, weighed, and sorted into reusable and not reusable materials. Functional devices are manually separated and directed for preparation for reuse. The rest of the WEEE is sorted out according to WEEE categories and is pre-treated before sending to the various treatment plants for final treatment. The companies offering sorting and dismantling services to producers' associations are typically social economy enterprises, but a few private companies also exist in the field. Some of the dismantling and pre-treatment plants provide final treatment services for particular WEEE categories; however, most of the sorted and pre-treated WEEE is forwarded to detached recovery and/or final treatment plants located mainly in Finland. While all WEEE of a certain brand is treated at the same pre-treatment stations, all WEEE of the same category are sent to the same final recycling plants.

The main challenges of WEEE collection in the Helsinki Capital Region are related to the size of permanent collection points. In the smallest, the physical space for collection cages is limited and the amounts of returned devices is low. Therefore, mobile collection and retail stores as WEEE bring points were introduced in 2013. The use of the retailers take-back option has been very limited in Finland due to strong resistance the from Finnish retail businesses. However, in accordance with the Directive 2012/19/EU, the retailer take-back option has been extended throughout Finland. Since 2013, electrical and electronic devices can also be returned to the retailers in association with buying a new, corresponding device. Furthermore, small WEEE and lamps (all dimensions no more than 25 cm) can also be returned with no purchase obligation to electronics shops with area larger than 200 m2 or to grocery shops of 1000 m2 minimum. Additionally, fluorescent lamps and LEDs, as well as portable batteries and accumulators, can also be returned to the retail shops with no purchasing obligations.

There are no exact guidelines for the implementation of in-store reception, however, shops are required to finance and organise the place, the requisites, and the work contributions needed to receive WEEE. Distributors may forward the received WEEE to the reception points of official collection networks by themselves or, alternatively, they may enrol in a distributors register in order to obtain free unloading services financed by producers' associations.

4,126 tonnes of WEEE (3.5 kg / cap) are collected at the CAS and 8,957 tonnes of WEEE (7.6 kg / cap) are collected at 2,000+ retail bring points. Another reason for the increased collection quantities is the improved reporting and reporting accuracy thanks to new treatment operators.

1.6.2.3 The city of Genova

Genova is the capital of the Italian region Liguria and the sixth-largest city in Italy. It is located in Northern Italy on the Gulf of Genoa in the Ligurian Sea, covers 240 km2 and has 580,097 inhabitants (2017) with an average population density of 2,417 inhabitants /km2. The GDP in 2012 amounted to 20,529 €/cap. In 2017 a total of 3,533 tonnes of WEEE were collected, i.e. 6.1 kg / cap. The non-retail bring points receive 706 tonnes of WEEE (1.2 kg/cap), while the civic amenity sites (CAS) receive 2,825 tonnes (4.9 kg/cap).

With the launch of the WEEENMODELS project, the WEEE collection system in Genova has been completely revised. AMIU created 47 new mobile collection points for small WEEE and 4 "ecological islands", i.e. collection and recycling areas, distributed all over the territory, where citizens can bring their WEEE. The mobile collection system operates daily in different parts of the city. In practice the mobile collection system operates through a system of two equipped vans (ECOVAN+ and ECOCAR), which stop at different stations

at scheduled times and locations, and where citizens can deposit their small WEEE and lamps. Small WEEE and IT can be brought to the ecological islands and to the ECOVAN+.

The WEEENMODELS project involved the testing of a mobile collection system of WEEE in 6 locations (all located to the western side of Genova) for 5 months (September 2015 - February 2016) to understand if citizens would appreciate such collection system. Of the 6 collection stations, 2 have received very positive results, 2 were moderately used by citizens, and other 2 were almost not used. In total 1,172 kg of small WEEE were collected, out of which 377 kg could be reused.

The retailers who joined the WEEENMODELS project have a free platform, a container for collecting small WEEE, which is provided by AMIU, a low-cost collection service and the possibility to take WEEE to the AMIU Collection Centre, renovated for that purpose.

The communication campaign, carried out by AMIU, has increased awareness about the separate collection of WEEE. Workshops and laboratories were organized for young participants to increase their knowledge on the concept of circular economy.

1.6.2.4 The Cyclad serviced area

The Cyclad Mixed Syndicate ensures the collection, treatment and recovery of waste produced by households in the region of the north-east of Charente-Maritime, France. It also organizes awareness campaigns for sorting and reducing waste. The syndicate's formation shows the political will of a rural area to make use of synergies for an efficient waste management system in a sparsely populated area. The average GDP in Charente-Maritime was 20,919 €/cap in 2005, being below the national average of 27,811 €/cap.

For waste collection, treatment and final land disposal, Cyclad provides services to 6 intermunicipal associations, namely to the Aunis Atlantique, Aunis Sud, Vals de Saintonge, and Coeur de Saintonge, Gémozac and Saintonge Viticole, comprising 188 communes with 148,659 habitants covering an area of 2,704 km2 (55 inhabitants / km2). Further, they provide waste treatment services, but no collection, to Ile de Ré and Agglomeration of Saintes.

The recycling of WEEE is financed by the Eco-participation fee paid with each purchase of new equipment. More and more communities are offering this line to their waste treatment centres to facilitate sorting and promote recycling. This is the case for Cyclad, offering the collection in partnership with the PRO Eco-systèmes. Together they collect about 90% of the local WEEE. Lamps and batteries are collected separately by CorePile and Recyclum. At the big civic amenity sites (CAS), there are normally two containers for small WEEE & IT, and two for large WEEE. These containers are shared with Eco-systèmes and once they are full, Cyclad contacts Eco-systèmes to pick it up and transport it to the recycling facilities.

Cyclad also cooperates with a number of retailers. When the retailers' storage space is full, they call Eco-systèmes to pick up the WEEE. In addition, supermarkets provide drop off points for lamps, batteries and mobile phones. There are 5 social economy shops in the area, where people can drop off WEEE and buy second hand upcycled/recycled WEEE objects, i.e. the Emmaüs and Envie networks.

The biggest problem related to WEEE collection in the past was theft. In 2011 France introduced a legal ban on cash transaction for metals, to avoid WEEE leakage at borders and to include scrap dealers in the system and avoid WEEE non-compliant treatment. In order to protect metals, WEEE

and batteries, Cyclad bought containers (20ft) with special locks. In addition, they introduced video surveillance at all sites. They also painted the containers that are shared with Eco-systèmes in orange to make them easier to recognize. Further they have a special contract with the police, who regularly check the site to make sure that the employees are safe. Thanks to these measures the stealing decreased significantly and the WEEE flow is better under control. Further measures that increased the collected WEEE quantities include awareness raising campaigns to mobilize small WEEE that people keep at home in their drawers. Since there was a hoax in France that all WEEE is going to India, some campaigns have been launched to inform the general public on where the WEEE goes.

1.6.2.5 The city of Vienna

Vienna, being the capital of Austria, covers 415 km2 and has 1.87 million inhabitants (2017) with an average population density of 4,502 inhabitants /km2. 40% of the population lives in multi-family houses, 60% in (semi)detached houses. The average household size is 2.06 persons. The GDP in 2017 amounted to 47,700 €/cap.

In Austria, around 80,000 tonnes of WEEE are collected every year; the ARA service group (specifically, the ERA compliance service) accounts for 40% of this amount. Every Austrian resident collects around 9.5 kg of WEEE per year. Consumers and businesses can drop off WEEE and used batteries at around 2,100 collection points across the country. In addition, people can also return WEEE to retailers/distributors when they purchase a new, equivalent device which fulfils the same functions as the old one, provided that the shop's sales area is greater than or equal to 150 m2. Batteries can always be returned to vendors free of charge without a need of purchase. In Vienna, there are 16 recycling centres (Mistplätze). The Austrian coordination body is called "Elektroaltgeräte- Koordinierungsstelle".

Measures to improve the cost efficiency ratio include: public relation schemes, restrictions to informal-collection, reduction of expenses for logistics costs, increase revenue in marketing, improved collection pickup coordination with partners/recyclers. 3 WEEE categories are collected in containers: 30m3 (small WEEE); lattice boxes (IT-monitors / display devices); 240l bins (gas-discharge lamps; w/ 120l bag, if broken).

1.6.3 Construction and demolition waste case studies

1.6.3.1 The city of Odense

Odense is the 3rd largest city in Denmark with a population of 204,200 (Statbank Denmark, 2019). Odense is the commercial hub of Funen, and has a notable shopping district with a diversity of stores. Several major industries are located in the city, including the Albani Brewery and GASA, Denmark's major dealer in vegetables, fruits and flowers. Odense has 8 recycling stations (CAS), with over 40 containers for collecting different waste materials. The vast majority of containers will be found at all the recycling stations in Odense. However, the smallest ones do not have space for all 40 containers. The CDW materials that are collected separately at the recycling stations include:

- Window glass with frames
- Window glass without frames
- Double glazing with Polychlorinated biphenyl (PCB)

- Asbestos and Ethernite
- Roofing board
- Gypsum
- Concrete and Bricks
- Mineral wool
- White toilets and washbasins
- Building waste with PCB
- Bricks only

Odense is a good example of a municipality involved in innovative CDW management schemes, leading the way in the reuse of old bricks which are being refurbished in Odense Renovation A/S's recycling centres. Previously, when bricks were delivered to Odense Renovation A/S, they were crushed and reused in construction projects, just like concrete and slate, but discarded bricks now have their own dedicated containers at the recycling centres (Gamble Mursten, 2019). When a container is full, it is driven to the Gamle Mursten factory in Svendborg on Funen, where they are cleaned and sorted before being stacked on pallets ready for reuse in new constructions. Odense also aims to collect both waste mineral wool insulation and waste ceramic sanitary ware separately in order to repurpose this material.

1.6.3.2 The municipality of Reimerswaal

Reimerswaal is a municipality in the province of Zeeland in the south-western Netherlands on Zuid-Beveland, named after the lost city. The municipality had a population of 22,432 in 2017, and has a surface area of 242 km2 of which 140 km2 is water. The municipality of Reimerswaal was established in 1970, from the aggregation of the municipalities Krabbendijke, Kruiningen, Rilland-Bath, Waarde, and Yerseke.

The municipality is responsible for the collection and management of household waste and has this outsourced to private scheme The Zeeuwse Reinigingsdienst (ZRD). ZRD does the collection of all household waste (residual, organic, plastics and beverage cartons) as well as the management of all the CAS in Zeeland, where all CDW materials are collected.

2. Paper and Packaging Waste

2.1Structure of the analysis of the case studies

The information for the analysis of the case studies has been gathered through intensive contacts with local representatives for each of the case studies. Based on detailed questionnaires and contacts via e-mail and phone, relevant information on the waste recycling system and specifically on the waste collection system has been collected and processed. Where appropriate, this information has been complemented with desk research of available information in relevant literature and reports.

The analysis of the case studies has the following structure for each case:

- Case study background;
- Flow Scheme;
- Recycling value chain.

Additionally, per waste fraction a meta-analysis (over all cases studies) is provided.

Case study background

For each of the selected case studies, we first provide a short description of the case including the regional characteristics and of the organisation of the local waste collection system.

Flow scheme

In a next step an overview of the waste collection and subsequent treatment steps is given in the format of a flow scheme.

The scope of the flow scheme is the separately collected PPW. This scope is complemented with the residual waste flow as this is the alternative destination for the PPW if not collected selectively. The flow scheme not only represents the waste generation and collection, but also the subsequent treatment steps as sorting and recycling, and any logistical steps (as transport, storage, …).

Based on this flow scheme some specific highlights for the case are described, and the organisation of the collection is described (such as the involved organisations and their relation).

Recycling value chain

A schematic presentation for each collected waste stream is given on the role of the waste collection system in the recycling value chain. Based on the matrix with all possible collection methods, collection, sorting and recycling outputs (see previous report[2] and illustrated in Figure 4), the role of the waste collection system to tune waste into a secondary material is presented in a schematic overview.

[2] https://www.collectors2020.eu/wp-content/uploads/2019/06/COLLECTORS_D2.1_Methodology-report.pdf

For each PPW waste fraction (glass waste, paper and cardboard waste, plastic waste and metal waste) for the specific case is shown how it fits into the matrix of possible categories for collection methods, collection outputs, sorting outputs and recycling outputs. In the background all categories are shown. The specific situation of the case is shown in **black and bold.**

Container glass waste				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Transparent glass	• CAS • Bring point • Door-to-door • **Bring points + CAS** • Door-to-door + bring points • Door-to-door + bring points + CAS • Bring points + CAS + other	• Clear container glass • **Coloured container glass** • Mixed container glass • Mixed container glass co-mingled with other wastes	• **Clear container glass cullet** • **Brown container glass cullet** • **Green container glass cullet** • Mixed container glass cullet	• **Container glass (flint, brown, green)** • Insulation mineral wool (short glass fibre) • Ceramic sanitary ware • Fluxing agent in brick manufacture • Sports turf and related applications • Water filtration media • Abrasive • Aggregate in construction materials • Reflective highway paint

Figure 4: Illustration of recycling value chain

The collection methods are ranked according to their (perceived) level of service to the citizens, with the best service level at the bottom of the list. For this ranking, we used the average transport distance to the collection point for citizens as proxy for the service level, so ranking door-to-door collection over bring points, and bring points over CAS. Additionally, we scored multiple collection methods over single collection methods.

The recycling output categories are ranked according to their market value as a proxy for their perceived quality (although this is difficult to prove and will not always be the case), with the highest quality at the top of the list.

Where available, this overview is complemented with information of the case studies on the scope of the waste collection system (What is allowed? What is prohibited?), the collection frequency, the destination and both generic and specific quality requirements and/or specifications corresponding with the collected waste and the respective output fractions from sorting and recycling, as illustrated in Figure 5. The structure for presenting this information is based on the generic overviews of quality requirements per waste fraction as in Annex.

Container glass waste				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Quality requirements: **Transparent glass bottles and jars;** Not: • **lids or caps** • **heat-resistant glass** • **porcelain and earthenware** • **stone bottles and jugs** • **glass or crystal crockery** • **flat glass (windows, mirrors, etc.)** • **fluorescent and incandescent lamps** • **ampoules and vials of medicines** • **milky white glass**	Frequency: - **DtD and BP: monthly** - **CAS: as needed**	Generic criteria Soda-lime-silicate container glass with: Bulk density < 500 kg/m³ Ferrous metals < 0,3% Destination: - **Glass recycler company** Quality requirements: - **Purity:** **Clear glass: max. x% of other colours;** - **Contamination:** **Ceramic-Stone-Porcelain: max. 1 w%**	Generic criteria BSI/WRAP PAS 101 Untreated cullet A: Whole or broken containers, colour separated. B: Whole or broken containers, colour separated but to a lesser standard. … Destination: **Sibelco Green Solutions** Quality requirements: No information available	Generic criteria BSI PAS 102 Specifications for processed glass for selected secondary end markets Total contaminant (organic, inorganic, ferrous/nonferrous metals) Particle size distribution Colour requirements Other requirements

Figure 5: Illustration of quality requirements and destination

The background of the fields of the matrix is different for each field, and corresponds with the colours that will be used in the flow scheme to delineate respectively the scope, the waste collection, the collection output and the sorting output.

Based on this recycling value chain overview and specific background information per case, we described the highlights with respect to good practices when it comes to efficient and effective cooperation along the value chain and to the role of the collection system to improve the quality of the waste and the corresponding secondary materials.

Meta-analysis

Besides the analysis of the individual cases for the different PPW fractions, the meta-analysis provides an overview per PPW fraction benchmarking how the different cases relate to each other for that specific waste stream. On top of that, per waste fraction a summary of observations is given related to the cooperation within the recycling value chain and specifically the role of collection therein.

2.2Results of the analysis of the cases

2.2.1 The city of Ghent

Case study background

Ghent is a port city in northwest Belgium with almost 250.000 inhabitants. The intermunicipal association of IVAGO serves both the city of Ghent and the neighbouring municipality of Destelbergen. Since the introduction of the PAYT principle in 1998, the collection system for household waste in Ghent has remained practically unchanged[3]. However, continuous improvements have been implemented over the years, which result in the continuous downward trend of collected residual waste ('restafval') (see Figure 6) and illegal dumping ('sluikstorten'), while plastics/metals/drinking cartons (PMD), glass and paper collection rates stay fairly constant.

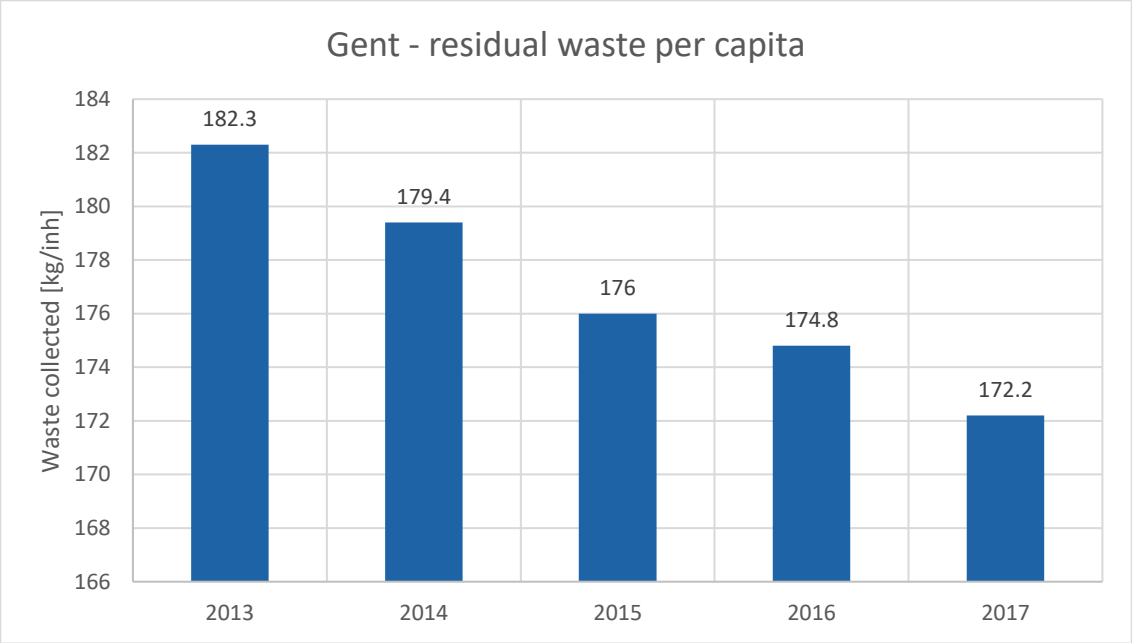

Figure 6: Performance of residual waste collection Ghent[3]

IVAGO collects residual waste, PMD, glass and paper and cardboard separately throughout the city and has defined zones with each their own collection approach. Depending on your address or type of building, the waste is collected in one of the following fashions:

- In the so-called C-zone (Container zone) waste is collected using containers. The containers are equipped with electronic chips, that register every time the container is emptied. Citizens pay in advance for the waste collection.
- In the Z-zone ('Zakken' or bag zone) waste is collected using bags. IVAGO uses different colour bags per waste streams; yellow bags for residual waste, blue bags for PMD, and glass and paper and cardboard in a box.
- High-rise buildings have their own waste containers, for residual, PMD, glass and paper and cardboard waste. Again, citizens pay for their residual and PMD waste. The arrangement for payments is made at building level.

[3] Activiteitenverslag IVAGO, 2017

- Throughout the city waste can be brought to underground waste containers, called 'sorteerpunten'. Citizens need their IVAGO card to open the container, and pay for residual, PMD and organic waste. Bringing glass and paper and cardboard waste is free.

Fee system: Ghent has a PAYT system with a fixed fee. Citizens pay a fixed 'deposit' fee depending on their housing situation and container size[4]; e.g. in 2018 households that use a >120L container pay € 50 and get five free uses, and households that use a bring bank pay a fixed fee of € 25 and get five free uses as well. Households that make use of the door to door residual waste collection pay € 17.50 for 10 60L/15kg yellow waste bags, or a subsequent € 3.5 for a 120L container (after first five uses). Collection of paper and cardboard and glass is for free. 20 blue 75L bags for PMD collection cost € 6.

Flow scheme

Ghent already has a PAYT-based waste collection system since 1998. The intermunicipal association of IVAGO serves both the city of Ghent and the neighbouring municipality of Destelbergen. Their system remained largely unchanged over the last years and focuses on the separate collection of paper and cardboard; glass; and plastic, metals and composites. In Ghent the waste management company has identified different zones for collection approaches; C-zones, Z-zones and Apartments and S-zones. Depending on the zone the waste is collected in containers, bags or at bring-points. The collection approaches per zone are also presented in the figure below. In case of door-to-door collection, citizens need to use a specific yellow bag for residual waste; and a blue bag for PMD waste. In addition, Ghent has six civic amenity sites were citizens can discard of their waste. To be noted that at this moment, there is no standardized recipient for collecting glass and P&C, this also reflected in Figure 7. The glass waste from Ghent transported to High 5 Glass sorting and GRL Glass Sorting for sorting. Ghent's Paper waste is sorted by Stora Enso Paper Sorting. The residual waste is sent to IVAGO's incinerator. Lastly, light weight packaging is sorted by Suez in the R&R BE North facility. The flowchart for the collection of PPW in Ghent is presented in Figure 8.

Figure 7: Different collection methods in Ghent (Yellow bag=residual waste; Green container = organic waste; Blue = PMD)[5]

[4] https://stad.gent/system/files/regulations/2018_RE_IVAGO_huisvuil.pdf
[5] Glass and paper and cardboard don't have a specific container or bag.

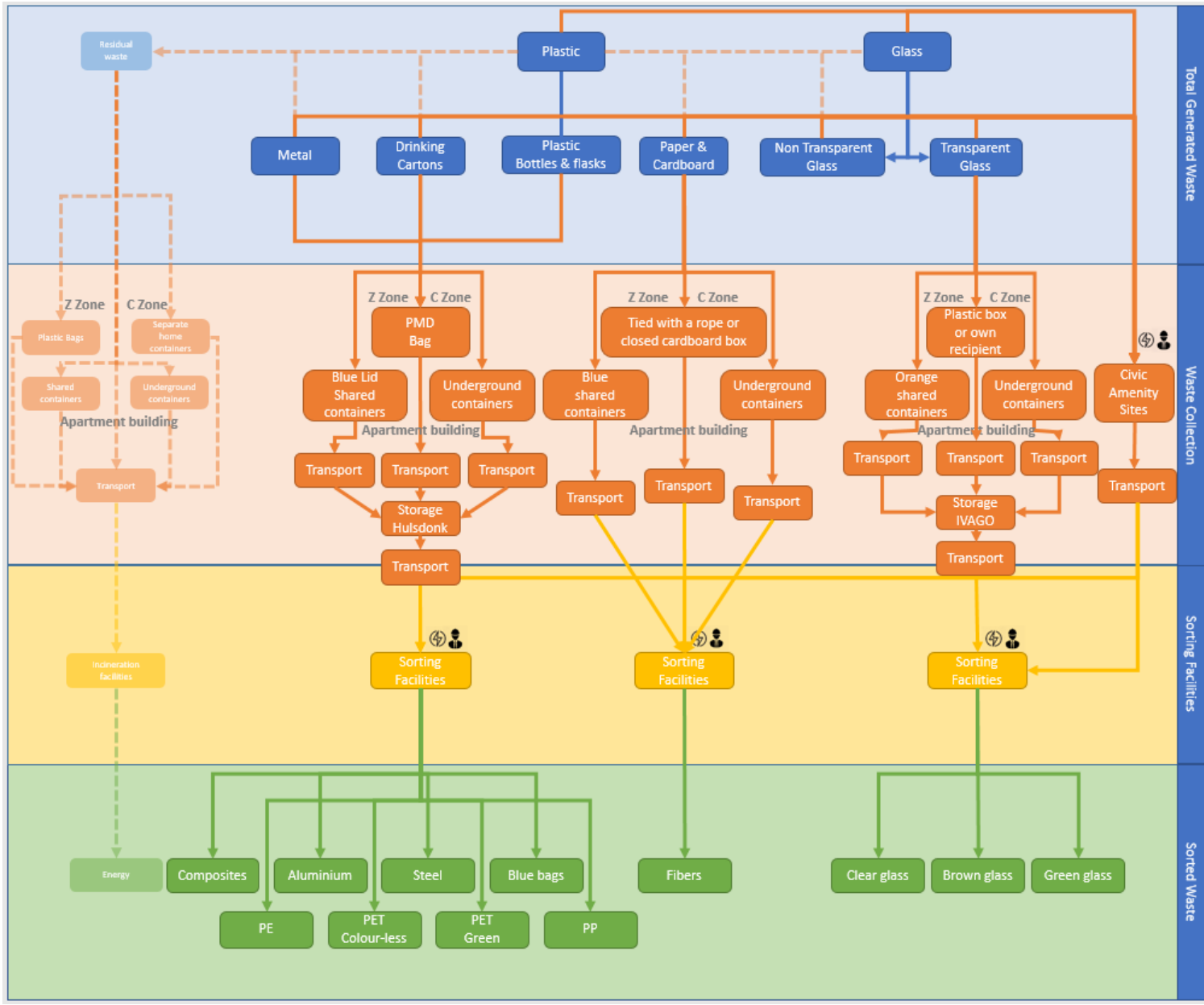

Figure 8: Ghent waste collection flow scheme

To better understand the responsibilities of the municipality with respect to the waste collection, an overview of the financial responsibilities is given in the next paragraph (as in D3.2).

Financial responsibilities: Since the PAYT system has already been in place for a long time, no relevant investments have been identified and included in the assessment.

Since IVAGO owns the waste management equipment and fleet, operational costs and potential investments in equipment are directly made by IVAGO. IVAGO is a mixed intermunicipal association. The city of Ghent and the municipality of Destelbergen are the government partners. ECOV, a partnership between SUEZ and Indaver, is the private partner. Every year, IVAGO charges Ghent and Destelbergen for the collection, transport and treatment of the household waste. Revenues from material streams and incineration are collected by IVAGO. Revenues from the Belgian EPR Fostplus for packaging waste are collected by IVAGO. Lastly, the municipality collects the waste fee from the citizens[6].

[6] Beleidsnota 2014-2019, IVAGO

Highlights

- Ghent is a densely populated city, with 3 collection types per waste stream according to the accommodation type (commercial zone, apartment building, regular houses); the accommodation type determines the waste collection method;
- (some) dry and easily sortable recyclables are collected together (PMD); this enhances the waste collection, limits the costs for waste sorting and guarantees a high quality of sorting output;
- PRO FostPlus is responsible for management of PMD on a national level, so throughout Belgium; the city of Ghent only collects PMD for FostPlus (the Belgian packaging PRO);
- The waste collection is a PPP (public-private participation) between IVAGO (an intermunicipal companies) and ECOV (a private company) (and 2 other intermunicipal companies, IVLA and IDM); where the waste collection used to a public service and private companies were only involved for waste treatment (including sorting and recycling), there is now a horizontal integration of waste management companies in public services/waste collection;

Recycling value chain

Container glass waste				Ghent
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Transparent glass (both clear, brown, green and blue)	• CAS • Bring point • Door-to-door • Bring points + CAS • Door-to-door + bring points • **Door-to-door + bring points + CAS** • Bring points + CAS + other	• Clear container glass • **Transparent container glass** • Coloured container glass • Mixed container glass • Mixed container glass co-mingled with other wastes	• **Clear container glass cullet** • **Brown container glass cullet** • **Green container glass cullet** • Mixed container glass cullet	• **Container glass (flint, brown, green)** • Insulation mineral wool (short glass fibre) • Ceramic sanitary ware • Fluxing agent in brick manufacture • Sports turf and related applications • Water filtration media • Abrasive • Aggregate in construction materials • Reflective highway paint
Quality requirements: **Transparent glass bottles and jars;** Not: • **lids or caps** • **heat-resistant glass** • **porcelain and earthenware** • **stone bottles and jugs** • **glass or crystal crockery** • **flat glass (windows, mirrors, etc.)** • **fluorescent and incandescent lamps**	Frequency: - **DtD and BP: monthly** - **CAS: as needed**	Generic criteria Soda-lime-silicate container glass with: Bulk density < 500 kg/m³ Ferrous metals < 0,3% Coloured glass < 5% (for clear glass only) Ceramics, stones and porcelain < 0,4% Plastic bottles < 2,5% Non-ferrous metals < 0,2% Organic materials < 0,5% Flat glass < 1%	Generic criteria BSI/WRAP PAS 101 Untreated cullet A: Whole or broken containers, colour separated. B: Whole or broken containers, colour separated but to a lesser standard. C: Whole or broken containers, mixed. D: Compacted glass. Contamination limits per grade for ferrous metals, non-ferrous metals and organic material	Generic criteria BSI PAS 102 Specifications for processed glass for selected secondary end markets Total contaminant (organic, inorganic, ferrous/nonferrous metals) Particle size distribution Colour requirements Other requirements

• **ampoules and vials of medicines** • **milky white glass**		Destination: - **High5Recycling;** - **GRL Glasrecycling** Quality requirements: - **Purity:** **Clear glass: max. 5% of other colours;** **Coloured glass: max. 10% clear glass** - **Contamination:** **Ceramic-Stone-Porcelain: max. 0,5 w%** **Other (labels, caps, lids, …): max. 2,5 w%** Quality specifications: No information available	Inorganic contamination (ceramics, porcelain and stones) subject to negotiation between suppliers and reprocessor CEN/TC 261/SC 4/WG 3 Material recovery All contaminants < 5% Ceramics, porcelain and stones <10mm < 0,01% Total ceramics, porcelain and stones < 0,25% US Institute of Scrap Recycling Industries (ISRI) container glass cullet specification (GC-208) Destination: **Sibelco Green Solutions** Quality requirements: No information available	

The scope of the glass waste collection in Ghent is quite particular: all transparent container glass, regardless of the colour, is collected together and transported to two sorting installations, each receiving 50% of the collected waste on annual basis. These sorting companies are equipped to sort the glass waste in three main fractions (colourless, brown and green) that are delivered to a glass manufacturer processing it in container glass applications again.

Highlights

- Despite the high specific weight of glass waste, a high service level (being door-to-door collection on a monthly basis) is offered to all citizens;
- After collection, the glass waste is brought to a transfer station, from where is further distributed to the 2 sorting companies that are located about 75 and 125 km from Ghent;
- The sorting is in line with the collection: the sorting process is configured to be able to sort the collected waste in pre-defined sorting outputs;
- The specifications for the sorting outputs are defined by the recycler and therefore allow high-value recycling of the sorted fractions;
- End application focusses on high-value recycling (closed loop);

Paper and cardboard waste				Ghent
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Packaging and non-packaging paper and cardboard	• Door-to-door • Bring point • CAS • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • **Door-to-door + bring points + CAS** • Bring points + CAS + other	• Newspapers & magazines • Cardboard • **Mixed paper & cardboard** • Paper & cardboard co-mingled with other wastes	• **mixed paper & cardboard** • **corrugated and kraft** • **newspapers & magazines** • **other and special grades**	• **Newsprint** • **Other graphic papers** • **Case materials** • **Carton board** • Wrappings and other packaging • Sanitary and household • Other paper and board • Construction materials (insulation, bricks and furniture) • Animal beddings or compost • Fibre applications in construction and manufacturing (in concrete, asphalt, brake linings)
Do's: - **newspapers** - **Magazines** - **letters and envelopes** - **old books** - **advertising brochures (without plastic)** - **printing paper** - **folded cardboard** - **paper and cardboard packaging** - **egg cartons** - **toilet rolls** Don'ts: - **dirty or greasy paper** - **paper handkerchiefs** - **paper tablecloth** - **kitchen roll paper** - **carbon paper** - **self-adhesive paper** - **milk cartons, fruit juice ...**	Frequency: - **DtD and BP: monthly** - **CAS: as needed**	Generic criteria Natural fibre based paper and board suitable for recycling: Paper and board in any shape Products made predominately from paper and board, which may include coatings and laminates, spiral bindings, etc. Destination: **Stora Enso**	Generic criteria CEPI Classes I to IV Mixed grades Corrugated and kraft Newspapers & magazines Other grades **EN 643 - European List of Standard Grades of Paper and Board for Recycling** **Group 1: ordinary grades, such as mixed paper and board;** **Group 2: medium grades, such as sorted office paper;**	Generic criteria

- **wallpaper** - **plastic bags** - **styrofoam**		Quality requirements: **According to EN643** Group 1: ordinary grades, such as mixed paper and board; Group 2: medium grades, such as sorted office paper; Group 3: high grades, such as white newsprint; Group 4: kraft grades, such as unused corrugated kraft; Group 5: special grades, such as used beverage cartons	**Group 3: high grades, such as white newsprint;** **Group 4: kraft grades, such as unused corrugated kraft;** **Group 5: special grades, such as used beverage cartons.** Destination: **Stora Enso (Ghent)** Quality requirements: **According to EN643**	

The collected paper and cardboard waste is transported immediately to the sorter/recycler (being Stora Enso), as the transport distance between Ghent and Stora Enso is limited (10-15 km).

Highlights

- Both sorting and recycling are covered by one company (Stora Enso);
- Stora Enso focusses on high-value recycling, being newsprint and magazine paper from 100% recycled material;
- EN643 is applied to sort the waste in specified fractions allowing high-value recycling;

Plastic waste (together with metal waste and drink cartons)				Ghent
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Plastic bottles and flasks	• Door-to-door • Bring point • CAS • Other • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • **Door-to-door + bring points + CAS**	• **Plastic packaging co-mingled with other packaging waste** • Plastic packaging only, co-mingling all polymers • Single type of packaging (e.g. only bottles) and/or a single polymer (e.g. PET) • Mix of two or more target polymers (e.g. PET, HDPE, LDPE, PE, PP) and/or packaging types (e.g. bottles and foils)	• **Mono-colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)** • Mixed colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)	• **Mono-colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)** • Mixed colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)
Do's: - **plastic bottles of water, soft drinks, milk ...** - **plastic bottles of detergent, shampoo, bath or shower foam, washing-up liquid** Don'ts: - **all other plastic packaging and items that are not bottles or flasks. (e.g. yoghurt cups, butter and margarine dishes, plastic wrap ...)[7]** - **injection needles** - **styrofoam**	Frequency: - **DtD and BP: bi-weekly** - **CAS: as needed**	Generic criteria Plastic bottles and flasks that contained: water and soft drinks milk washing-up and maintenance products washing powder water softeners bath and shower products distilled water bleaches Destination: **Transfer station Suez (Hulsdonk) + Sorting installation Suez (Brugge)** Quality requirements: No information available/provided	Generic criteria US Institute of Scrap Recycling Industries (ISRI) baled recycled plastic commercial guidelines (P-2018) Plastics Recyclers Europe Bales Characterization Guidelines HDPE Bales PET Coloured Bales PP Film Bales PET Clear-blue Bales PET Light blue Bales PE Film Bales PET Clear Bales	Generic criteria EN 15342 - Characterization of polystyrene (PS) recyclates EN 15345 - Characterisation of Polypropylene (PP) recyclates EN 15346 - Characterisation of polyvinyl chloride (PVC) recyclates EN 15347 - Characterisation of plastics wastes EN 15348 - Characterization of polyethylene terephthalate (PET) recyclates EN 15344 - Characterisation of Polyethylene (PE) recyclates

[7] As from 01/01/2020 the scope of the plastic packaging waste collection will be extend with these fractions, and the sorting and recycling process will be adapted accordingly

			Specifications Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe (DKR) PET (DKR 328-1) PE (DKR 329) PP (DKR 324) Film (DKR 310) EPS (DKR 340) Mixed plastics (DKR 350) Destination: **-PET: PET recycling installation (outside of Flanders)** -PE: unknown -PP: unknown Quality requirements: No information available/provided	

Plastic waste is collected together with drinking cartons and metal waste and transported to a transfer station before going to a sorting company.

Highlights

- The collected waste is a combination of easy to sort dry recyclable fractions (plastic-drinking cartons-metals); these fractions have totally different intrinsic characteristics which makes them easy to sort;
- With respect to plastic packaging, focus is on bottles and flasks, limiting the heterogeneity of the composition (bottles= PET; flasks= PE/PP) and making the separation easier which improves the quality of the sorting output;
- The waste is collected in blue transparent bags; the transparency allows to reject waste that does not with the defined scope;
- The collection of the waste is offered as a service to the PRO (being FostPlus); the PRO remains proprietary of the waste and decides on the (final) destination of the waste;

Metal waste (together with plastic waste and drinking composites)				Ghent
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Metal packaging	• Door-to-door • Bring point • CAS • Other • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • **Door-to-door + bring points + CAS**	• **Aluminium and steel packaging co-mingled with other packaging waste, often including drinking cartons** • Aluminium beverage cans only • Metal packaging • Metal packaging co-mingled with other dry recyclables	• **Baled or briquetted aluminium cans and/or aluminium meal trays, rigid containers, aerosol cans, screw closures and caps** • **Baled steel drums and cans** • **Baled drinking cartons**	• **3000-series wrought aluminium alloys** • **Low carbon steel** • **Fibres**
Do's: - **metal cans of soft drinks, beer ...** - **food cans** - **aluminium saucers and trays** - **metal lids and caps** - **metal boxes and buses** - **spray cans of food or cosmetics** Don'ts: - **aluminium foil** - **packaging with a child-proof closure** - **packaging of dangerous products (insecticide, weed killer, moss suppressor, rat poison ...)** - **packaging of motor oil, paint, varnish and varnish**	Frequency: - **DtD and BP: bi-weekly** - **CAS: as needed**	Generic criteria Beverage cans Food cans Bottle caps Lids Aerosol cans of food and cosmetics Aluminium trays Destination: **Transfer station Suez (Hulsdonk) + Sorting installation Suez (Brugge)** Quality requirements: No information available	Generic criteria EN 13920-10:2003 for baled aluminium beverage cans Maximum moisture and volatile substance levels Limited concentrations of silicon and a series of metallic impurities Metal yield > 88 % Free from burnt or oxidized cans and aluminium foil EN 139205-14:2003 and EN 139205-15:2003 for used aluminium packaging < 5 % of steel packaging Free from plastic, paper and blister packs < 60 % of volatile components Council Regulation (EU) No 333/2011 End-of-Waste aluminium scrap Maximum levels of combustible non-metallic materials Free from polyvinyl chloride (PVC) in form of coatings, paints, plastics	Generic criteria American National Standard Alloy and Temper Designation Systems for Aluminium 2017 ANSI H35 standards Aluminium 3004 Specifications ASTM B209 ASTM B221 ASTM B313 ASTM B547 ASTM B548 SAE J454 UNS A93004

			End-of-Waste iron and steel scrap: Technical proposal on tin-coated packaging scrap Excessive moisture, metallic copper, tin devices (and alloys) and lead (and alloys) Minimum concentrations of free iron or alloy, or of metallic packaging European Steel Scrap Specifications Standard classifications of national industry associations US Institute of Scrap Recycling Industries (ISRI) non-ferrous scrap guidelines (NF-2018) US Institute of Scrap Recycling Industries (ISRI) ferrous scrap guidelines (FS-2018) ASTM E 1134 : 1986 Specification for source separated steel cans <u>Destination:</u> **Metal recycling company** <u>Quality requirements:</u> **Steel: max. 8% impurities, max. 5% moisture; Aluminium: max. 30% impurities, max. 10% moisture**	

Highlights

- Focus for collection is on metal packaging, which limits the alloys present in the collected fraction to steel and aluminium; these alloys are easy to separate;
- High level of impurities allowed for aluminium at the sorting step

2.2.2 The city of Berlin

Case study background

Berlin is a large capital city with over 3.5 million inhabitants for an area of 892 km² (3,965 inhabitants per km²). Berlin is counting 90% of multi-family houses (terraced houses, apartment buildings, housing blocks) and subsequently 10% of detached and semi-detached houses. GDP per inhabitant was 38,798 euros in 2016. Another highlight in this case study is the large numbers of tourists and commuters. Indeed, 8.8 tourist overnight stays per inhabitant and 29.9 one-day visitors per inhabitant have been noted in 2016. In Berlin in 2017, it is estimated that 300,000 persons are commuting every day.

Based on the 'Kreislaufwirtschafts- und Abfallgesetz Berlin', it is the public authority's responsibility to collect waste from households and other sources. The waste collection is organised and carried out by the Berliner Stadtreinigungsbetrieben (BSR), an institution under public law owned by the municipality (Land Berlin). Residual waste is collected using grey household waste bins ('Hausmülltonne'). There are five different sizes available, which can be ordered depending on the amount of household waste arising in a specific household (varying from 60 – 1.100 litres)[8]. Citizens pay a waste fee based for collection of residual waste depending on their bin size for the door-to-door collection and quantities delivered to the civic amenity sites. Glass, paper and cardboard and lightweight packaging material is collected separately. Paper and cardboard is collected separately using door-to-door collection via blue wheelie bins, occasionally "bundled" collections by various organisations; and bring systems such as the BSR civic amenity sites which are located throughout the city. Since 2013 PMD, or light weight packaging (plastic, metal, or composite materials) is collected in 190.000 yellow and orange bins throughout the city. Glass is collected separately throughout the city via door-to-door collection, green and brown wheeled containers for apartment buildings (90.000) and ca. 6.000 bottle bank containers (bring systems)[9]. Collection of glass, paper and cardboard and light weight packaging waste is largely financed by the dual systems.

Figure 9 below shows the decrease in waste quantities from households (including all waste streams) in the period 2009 – 2015.

Figure 9: Evolution of the volume of household waste 2009 - 2015 in Berlin[8]

[8] Senatsverwaltung für Stadtentwicklung und Umwelt Berlin, Abfalbilanz des Landes Berlin 2015

[9] Municipal waste management in Berlin | Titel der Broschüre | Berlin's municipal waste, 2013, https://www.berlin.de/senuvk/umwelt/abfallwirtschaft/downloads/siedlungsabfall/Abfall_Broschuere_engl.pdf

Fee system: Berlin has a PAYT system with a fixed fee. Every quarter, each unit that is part of the general collection scheme, pays a mandatory base fee ('Ökotarif') of € 6.39 (2018). Citizens pay a fixed quarterly fee for residual waste depending on the container fee: e.g. 60L - €55.38; 240L - € 82.30. In addition, there is a cost structure in place that considers the distance and steps a waste collection worker has to take to get to the waste bin. For example, for a distance of 50 - 100m or 16 - 20 steps, an additional fee of € 33.80 per quarter can be charged. Collection of recyclables (plastic, metal and drank carton packaging) is collected free of charge. Collection of glass is free as well. Collection of paper and cardboard is € 2.38 per emptying of a 120L container.

Flow scheme (Berlin)

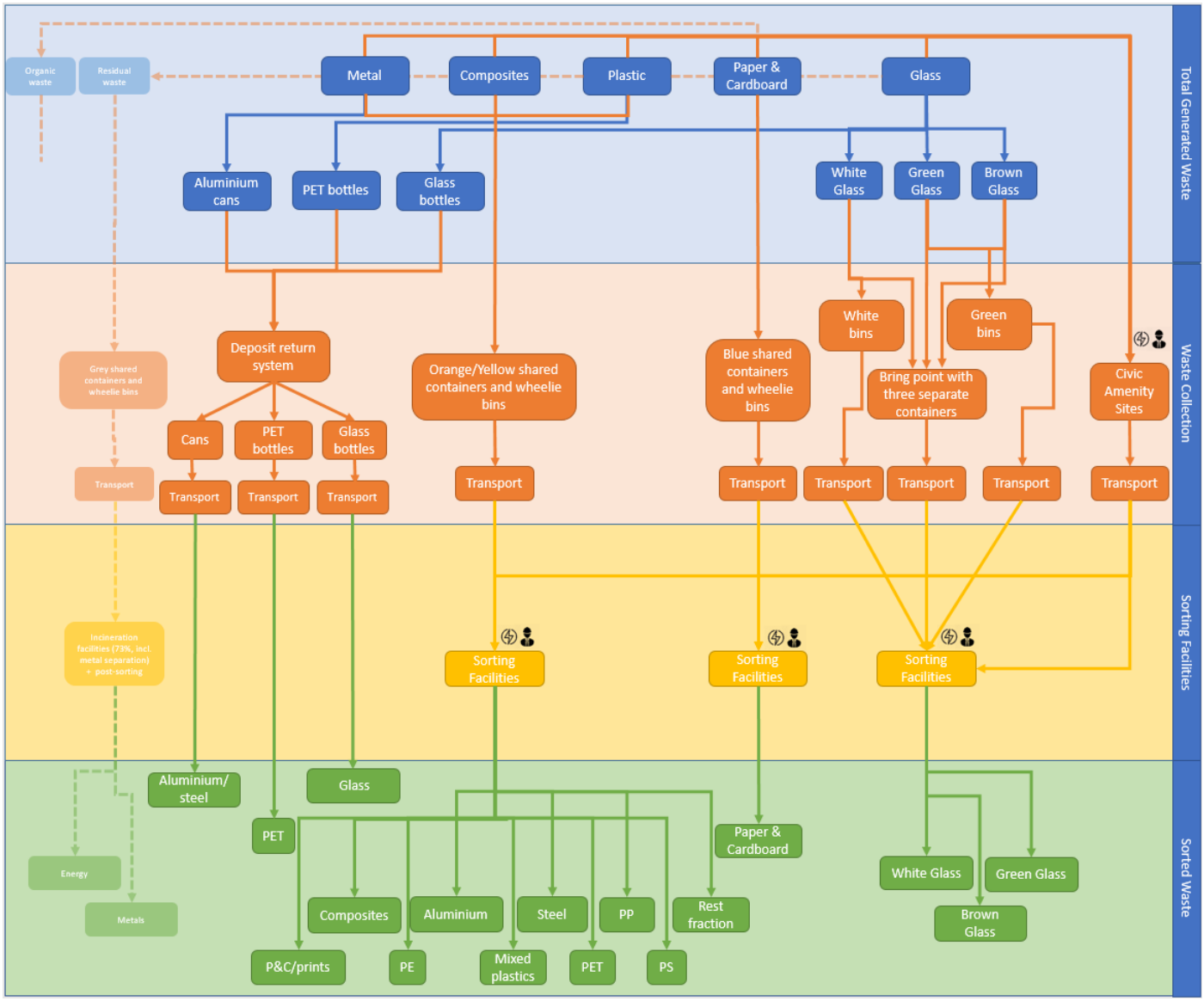

Figure 10: Flow scheme waste collection in Berlin

Highlights

- Mixed situation for collection of glass waste: houses with backyard are serviced through door-to-door collection of bins, while houses without yard are serviced through bring points[10];

[10] Our local contact point clarified that 'the companies collecting the waste prefer a bringpoint system, while citizens prefer door-to-door collection'

- Dry recyclables such as metal-plastic-drinking cartons are collected together; this collection system comes on top of the existing deposit return system for cans and drinking bottles (both for glass and PET);
- Paper and cardboard collection (and recycling) outsourced to private company completely (both type and method of waste collection);

Recycling value chain

Container glass waste [Berlin]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Clear and coloured glass is collected separately. In some areas for coloured glass distinction is made between green and brown glass	• CAS • Bring point • Door-to-door • Bring points + CAS • Door-to-door + bring points • **Door-to-door + bring points + CAS** • Bring points + CAS + other	• **Clear container glass** • **Coloured container glass** • Mixed container glass • Mixed container glass co-mingled with other wastes	• **Clear container glass cullet** • **Brown container glass cullet** • **Green container glass cullet** • Mixed container glass cullet	• **Container glass (flint, brown, green)** • Insulation mineral wool (short glass fibre) • Ceramic sanitary ware • Fluxing agent in brick manufacture • Sports turf and related applications • Water filtration media • Abrasive • Aggregate in construction materials • Reflective highway paint
Do's: - **Mason jars** - **Non-refundable beer and wine bottles** - **Oil and vinegar bottles** - **Perfume bottles** - **Empty glass pharmaceutical bottles** Don'ts: - **Non-glass packaging with a Green Dot** - **Broken glass** - **Ceramics** - **Crystal** - **Pottery** - **Flower pots** - **Drinking glasses** - **Christmas ornaments** - **Light bulbs**	Frequency: - **DtD: 2-weekly** - **Bring points and CAS: as needed**	Generic criteria Soda-lime-silicate container glass with: Bulk density < 500 kg/m³ Ferrous metals < 0,3% Coloured glass < 5% (for clear glass only) Ceramics, stones and porcelain < 0,4% Plastic bottles < 2,5% Non-ferrous metals < 0,2% Organic materials < 0,5% Flat glass < 1% Destination:	Generic criteria BSI/WRAP PAS 101 Untreated cullet A: Whole or broken containers, colour separated. B: Whole or broken containers, colour separated but to a lesser standard. C: Whole or broken containers, mixed. D: Compacted glass. Contamination limits per grade for ferrous metals, non-ferrous	Generic criteria BSI PAS 102 Specifications for processed glass for selected secondary end markets Total contaminant (organic, inorganic, ferrous/nonferrous metals) Particle size distribution Colour requirements Other requirements

- **Neon lighting** - **Mirrors**		**Berlin Recycling and Karl Mayer GmbH**[11] <u>Quality requirements:</u> No information available <u>Quality specification:</u> - **Contamination: ± 10 w%**	metals and organic material Inorganic contamination (ceramics, porcelain and stones) subject to negotiation between suppliers and reprocessor CEN/TC 261/SC 4/WG 3 Material recovery All contaminants < 5% Ceramics, porcelain and stones <10mm < 0,01% Total ceramics, porcelain and stones < 0,25% US Institute of Scrap Recycling Industries (ISRI) container glass cullet specification (GC-208) <u>Destination:</u> No information available/provided <u>Quality requirements:</u> No information available <u>Quality specifications:</u> No information available	

[11] Subcontractor responsible for the waste collection at the time of the project (2019)

Highlights

- Mixed situation for collection method of glass waste: houses with backyard are serviced through door-to-door collection of bins, while houses without yard are serviced through bring points; on top of that, the companies collecting the waste prefer a bring point system, while citizens prefer door-to-door collection;
- The scope of the waste collection is not uniform throughout the entire city: for some areas brown and green glass is collected together via door-to-door collection and for other areas these are collected separately via bring points; it is not clear if (and how) this affects the subsequent sorting; in the ideal case, the sorter should be able to capitalize on the effort of citizens already sorting brown and green glass;
- The contract of the city with the sorter is to be renewed in the medium term (between 3-10 years);
- As end application is focussed on high-value recycling (closed loop);

Paper and cardboard waste [Berlin]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Old newspapers, magazines, catalogues, office paper, packing paper, cardboard and card	• Door-to-door • Bring point • CAS • Door-to-door + bring points • **Door-to door + CAS** • Bring points + CAS • Door-to-door + bring points + CAS • Bring points + CAS + other	• Newspapers & magazines • Cardboard • **Mixed paper & cardboard** • Paper & cardboard co-mingled with other wastes	• **mixed paper** • **cardboard** • corrugated and kraft • **newspapers & magazines** • other and special grades	• **Newsprint** • **Other graphic papers** • **Case materials** • **Carton board** • Wrappings and other packaging • Sanitary and household • Other paper and board • Construction materials (insulation, bricks and furniture) • Animal beddings or compost • Fibre applications in construction and manufacturing (in concrete, asphalt, brake linings)
Do's: - **Magazines** - **Newspapers** - **Flyers** - **Egg cartons** - **Corrugated cardboard** - **Carton used for packaging** Don'ts: - **Drink cartons → yellow bin** - **Waxed paper → grey bin** - **Carbon paper → grey bin** - **Paper towels → grey bin**	Frequency: - **Dtd: twice a week, weekly, 2-, 4- or 8-weekly** - **CAS: as needed**	Generic criteria Natural fibre based paper and board suitable for recycling: Paper and board in any shape Products made predominately from paper and board, which may include coatings and laminates, spiral bindings, etc. Destination: **Wertstoff-Union Berlin GmbH**[12]	Generic criteria CEPI Classes I to IV Mixed grades Corrugated and kraft Newspapers & magazines Other grades EN 643 - European List of Standard Grades of Paper and Board for Recycling Group 1: ordinary grades, such as mixed paper and board; Group 2: medium grades, such as sorted office paper; Group 3: high grades, such as white newsprint;	Generic criteria

[12] Subcontractor responsible for the waste collection at the time of the project (2019)

		Quality requirements: No information available Quality specification: contamination level= ± 10 w%	Group 4: kraft grades, such as unused corrugated kraft; Group 5: special grades, such as used beverage cartons. Destination: No information available/provided Quality requirements: No information available/provided Quality specification: No information available	

For paper and cardboard, the collection is outsourced to an external company. This company may keep the revenues of the sorting and recycling of the paper and cardboard waste in return for a collection scheme agreed with the city.

Highlights

- Focus is on high-value recycling (newsprint and magazine paper from 100% recycled material);
- Collected mixed waste is sorted into 3 fractions: cardboard, mixed paper and paper requiring deinking (graphic, newspaper and magazines)

Plastic waste (collected together with metal waste and drink cartons) [Berlin]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Collection of light packaging and equivalent nonpackaging waste, meaning any objects made of plastics (and/or metal, or composite materials), e.g. including watering cans, flower pots, plastic bowls, toys, pots and pans, tools, cutlery, etc. Deposit Return System in place for PET drinking bottles (and drinking cans)	• **Door-to-door** • Bring point • CAS • Other • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • Door-to-door + bring points + CAS	• **Plastic packaging co-mingled with other packaging waste** • Plastic packaging only, co-mingling all polymers • Single type of packaging (e.g. only bottles) and/or a single polymer (e.g. PET) • Mix of two or more target polymers (e.g. PET, HDPE, LDPE, PE, PP) and/or packaging types (e.g. bottles and foils)	• **Mono-colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)** • Mixed colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)	• **Mono-colour rPET** • **Mono-colour rHDPE** • **Mono-colour rLDPE / rLLDPE** • **Mono-colour rPP** • Mixed plastic pellets
Do's: - **Plastic packaging** - **Non-refundable plastic bottles** - **Condiment bottles** - **Yoghurt containers** Don'ts: - **Styrofoam from food packaging → grey bin** - **Wood → recycling centre, grey bin** - **CDs → grey bin** - **Cassette tapes → grey bin** - **Textiles → donation bins, grey bin and partially return in shops**	Frequency: - **Weekly or bi-weekly**	Generic criteria Plastic bottles and flasks that contained: water and soft drinks milk washing-up and maintenance products washing powder water softeners bath and shower products distilled water bleaches Destination: **Alba** Quality requirements: No information available Quality specification: **Rough estimate:** - **metals ~16 %**	Generic criteria US Institute of Scrap Recycling Industries (ISRI) baled recycled plastic commercial guidelines (P-2018) Plastics Recyclers Europe Bales Characterization Guidelines HDPE Bales PET Coloured Bales PP Film Bales PET Clear-blue Bales PET Light blue Bales PE Film Bales PET Clear Bales	Generic criteria EN 15342 - Characterization of polystyrene (PS) recyclates EN 15345 - Characterisation of Polypropylene (PP) recyclates EN 15346 - Characterisation of polyvinyl chloride (PVC) recyclates EN 15347 - Characterisation of plastics wastes EN 15348 - Characterization of polyethylene terephthalate (PET) recyclates EN 15344 - Characterisation of Polyethylene (PE) recyclates

		- **plastic ~50 %** - **composite materials & paper/cardboard ~ 10 %** - **“miss-sorting” ~ 24 %**	Specifications Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe (DKR) PET (DKR 328-1) PE (DKR 329) PP (DKR 324) Film (DKR 310) EPS (DKR 340) Mixed plastics (DKR 350) Destination: **Alba sorts and recycles the collected waste into outputs for the plastic industry** Quality requirements: **According to customer’s specific needs**	

Highlights

- Combined collection of easy to sort dry recyclable fractions (plastic-drink cartons-metals);
- Scope of plastic includes all types of plastics and not only packaging, so the scope is very broad;
- Most valuable fractions, such as PET bottles, are out of scope (because of the deposit return system); still the remaining collected plastics are being sorted and recycled as much as possible;
- The impurity rate (24% sorting residue) of the collected fraction is quite high;
- Also the recycling residue is high, resulting in more than half of the collected waste ending up in energy recovery operations;

Metal waste (collected together with plastic waste and drink cartons) [Berlin]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Collection of light packaging and equivalent non-packaging waste, meaning any objects made of metal (and/or plastics, or composite materials), e.g. including watering cans, flower pots, plastic bowls, toys, pots and pans, tools, cutlery, etc. Deposit Return System in place for PET drinking cans (and drinking bottles)	• **Door-to-door** • Bring point • CAS • Other • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • Door-to-door + bring points + CAS	• Aluminium and steel packaging co-mingled with other packaging waste, often including drinking cartons • Aluminium beverage cans only • Metal packaging • **Metal packaging co-mingled with non-packaging metals and other dry recyclables**	• **Baled or briquetted aluminium cans and/or aluminium meal trays, rigid containers, aerosol cans, screw closures and caps** • **Baled steel drums and cans** • Baled drinking cartons	• **3000-series wrought aluminium alloys** • **Low carbon steel** • Fibres
Do's: - **Metal** - **Non-refundable cans** - **Metal cans** Don'ts: - **Batteries → special recycling (see above)**	Frequency: - **Weekly or bi-weekly**	Generic criteria Beverage cans Food cans Bottle caps Lids Aerosol cans of food and cosmetics Aluminium trays Destination: **Alba** Quality requirements: No information available Quality specification: **Rough estimate:**	Generic criteria EN 13920-10:2003 for baled aluminium beverage cans Maximum moisture and volatile substance levels Limited concentrations of silicon and a series of metallic impurities Metal yield > 88% Free from burnt or oxidized cans and aluminium foil EN 139205-14:2003 and EN 139205-15:2003 for used aluminium packaging < 5 % of steel packaging Free from plastic, paper and blister packs < 60 % of volatile components Council Regulation (EU) No 333/2011 End-of-Waste aluminium scrap	Generic criteria American National Standard Alloy and Temper Designation Systems for Aluminium 2017 ANSI H35 standards Aluminium 3004 Specifications ASTM B209 ASTM B221 ASTM B313 ASTM B547 ASTM B548 SAE J454 UNS A93004

		- **metals ~16 %** - **plastic ~50 %** - **composite materials & paper/cardboard ~ 10 %** - **"miss-sorting" ~ 24 %**	Maximum levels of combustible non-metallic materials Free from polyvinyl chloride (PVC) in form of coatings, paints, plastics End-of-Waste iron and steel scrap: Technical proposal on tin-coated packaging scrap Excessive moisture, metallic copper, tin devices (and alloys) and lead (and alloys) Minimum concentrations of free iron or alloy, or of metallic packaging European Steel Scrap Specifications Standard classifications of national industry associations US Institute of Scrap Recycling Industries (ISRI) non-ferrous scrap guidelines (NF-2018) US Institute of Scrap Recycling Industries (ISRI) ferrous scrap guidelines (FS-2018) ASTM E 1134 : 1986 Specification for source separated steel cans <u>Destination:</u> No information available/provided <u>Quality requirements:</u> No information available/provided	

Highlights

- Scope of metals includes all types of metal, not only packaging;

2.2.3 The municipality of Tubbergen

Case study background

The municipality of Tubbergen is a small municipality (21.142 inhabitants) in the rural east side of the Netherlands, close to the border of Germany. The municipality works together with the regional waste management company NV ROVA for the execution waste management. ROVA collects municipal waste for 23 municipalities in a working area of ca. 850.000 inhabitants. ROVA is responsible for the collection, treatment and processing of household waste, as well as the operation of bring banks and Civic Amenity Sites.

Following the ambition "Afvalloos Twente" (: waste-less Twente), Tubbergen has opted the ambition in their waste policy plan “Van Afval naar Grondstof, Van Idee naar Aanpak, Van Betalen naar Belonen” to achieve a residual waste amount of only 50 kg per inhabitant per year in 2030. To achieve this, various measures were implemented in 2015 (transition to a complete PAYT system) which have resulted in a sharp decline in residual waste and significant increase in separately collected waste (see Figure 11 below). The green line indicates the performance of Tubbergen. As shown in the graph a decrease in residual waste from 200+ kg per inhabitant per year in 2015 to 63 kg in 2017 was realised. In addition, the achieved separation percentage in 2017 is at 81%, already above the national standard of 75% for 2020[13].

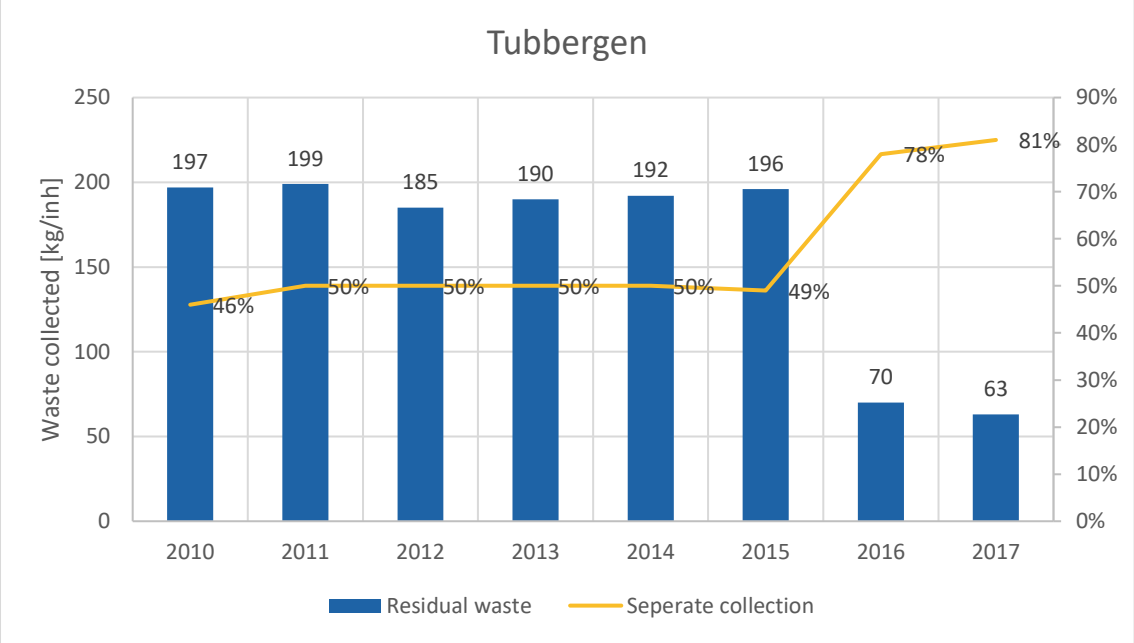

Figure 11: Performance of PPW collection Tubbergen

Fee system: Tubbergen charges her citizens with a basic tariff of € 80 per year per household[14]. Emptying a 140L residual waste container costs € 5.60, and € 9.20 for a 240L container. The door to door collection of PMD is organised every four weeks, and can be used free of charge. Paper and cardboard and glass is free of charge as well.

[13] Grondstoffen Monitor Tubbergen, 2017, Gemeente Tubbergen & ROVA
[14] https://www.tubbergen.nl/afvalstoffenheffing

Flow scheme Tubbergen

In 2015, Tubbergen shifted to a PAYT based waste collection system. Light weight packaging, paper and cardboard and glass are collected separately. Light weight packaging, paper and cardboard and residual waste are all collected using either mini containers or shared containers. Glass is collected using 42 communal containers. In Tubbergen, ROVA[15] collects all four waste streams and transports the light weight packaging and metal to Attero in Wijster, the residual waste to Twence in Hengelo, and the paper and cardboard to Remondis and Peute in Rotterdam. The flowchart for the collection of PPW in Tubbergen is presented in the figure below.

[15] ROVA is a public service provider and works for 23 municipalities with a working area of approximately 850,000 inhabitants.

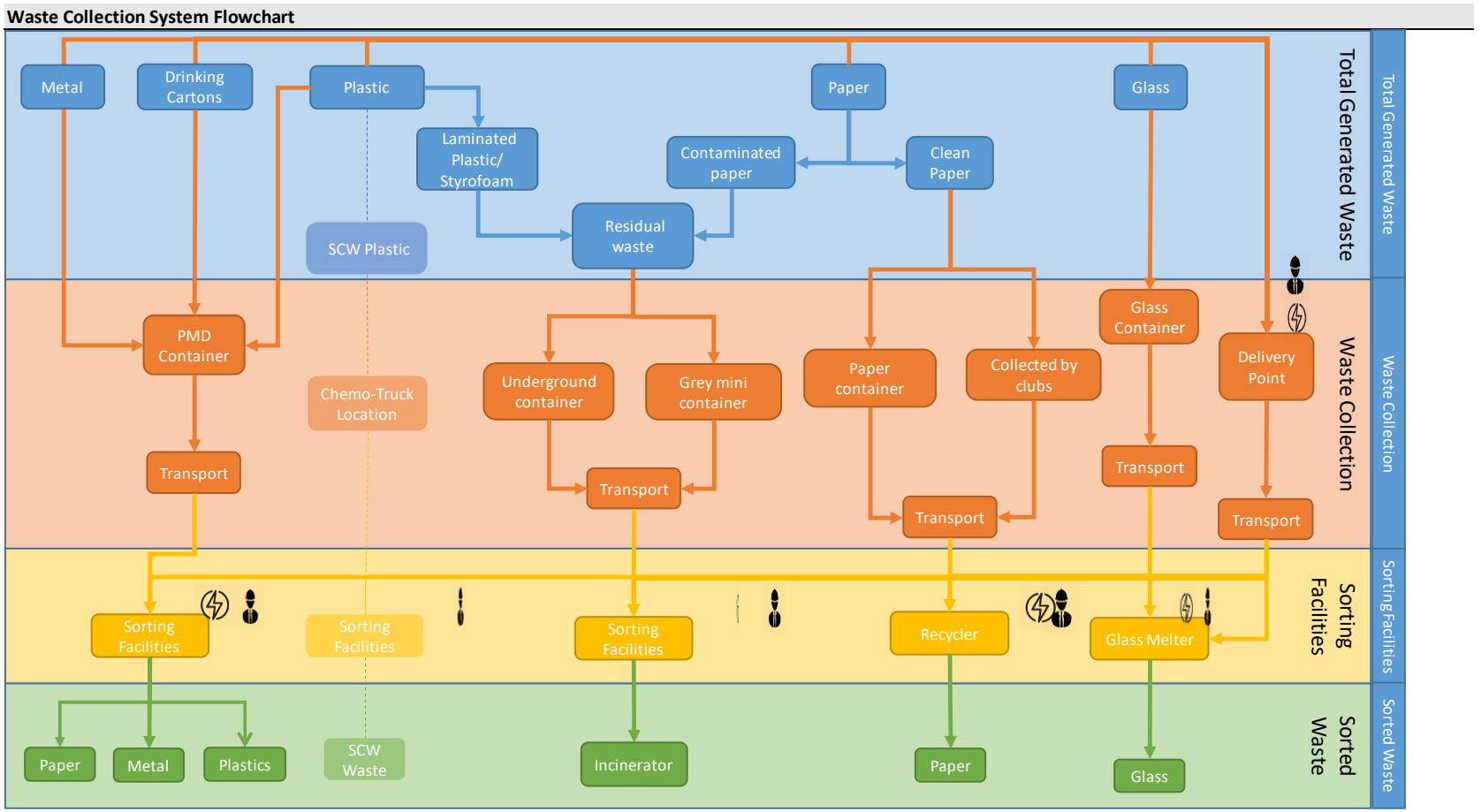

Figure 12: Flow scheme of waste collection in Tubbergen

To better understand the responsibilities of the municipality with respect to the waste collection, an overview of the financial responsibilities is given in the next paragraph (as in D3.2).

Financial responsibilities: ROVA is an intermunicipal association, owned by the 23 municipalities it is serving. ROVA owns the waste management equipment and fleet, therefore operational costs and potential investments in equipment are directly made by ROVA. Since ROVA has been operating in Tubbergen for quite some time, the required investments in equipment were very limited. The municipality Tubbergen invested mainly in communication campaigns, and in new (electronic) containers. Both the citizen waste fees and EPR compensation from Afvalfonds Verpakkingen is paid to the Tubbergen municipality. Revenues

from material streams and incineration are collected by ROVA. ROVA charges Tubbergen for a waste management and organisation fee; covering the collection, transport, treatment and analysis of the waste for the PAYT system.

Highlights

- Paper and cardboard collection is outsourced to local organisations; these organisations may keep the revenues of selling the collected paper and cardboard on the market, as long as they also collect the paper and cardboard according to the agreed collection method/scheme;
- Collection of (some) dry and easily sortable recyclables is done together (PMD);
- NV ROVA is subcontracted by the municipality to execute waste management (collection and corresponding processing);

Container glass waste [Tubbergen]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Clear and coloured glass is collected separately. In some areas for coloured glass distinction is made between green and brown glass	• CAS • **Bring point** • Door-to-door • Bring points + CAS • Door-to-door + bring points • Door-to-door + bring points + CAS • Bring points + CAS + other	• **Clear container glass** • **Coloured container glass** • Mixed container glass • Mixed container glass co-mingled with other wastes	• Clear container glass cullet • Brown container glass cullet • Green container glass cullet • Mixed container glass cullet	• Container glass (flint, brown, green) • Insulation mineral wool (short glass fibre) • Ceramic sanitary ware • Fluxing agent in brick manufacture • Sports turf and related applications • Water filtration media • Abrasive • Aggregate in construction materials • Reflective highway paint
Do's: - **Glass bottles for juice, beer and wine;** - **Glass jars (vegetables, sauces)** - **Parfum bottles** - **Deodorant rollers** - **Empty medicine bottles** - **Jars for creme** Don'ts: - **Flat glass such as windows and mirrors;** - **Drinking glasses** - **Lamps**	Frequency: - Monthly	Generic criteria Soda-lime-silicate container glass with: Bulk density < 500 kg/m³ Ferrous metals < 0,3% Coloured glass < 5% (for clear glass only) Ceramics, stones and porcelain < 0,4% Plastic bottles < 2,5% Non-ferrous metals < 0,2% Organic materials < 0,5% Flat glass < 1% Destination: **ROVA** Quality requirements: No information available	Generic criteria BSI/WRAP PAS 101 Untreated cullet A: Whole or broken containers, colour separated. B: Whole or broken containers, colour separated but to a lesser standard. C: Whole or broken containers, mixed. D: Compacted glass. Contamination limits per grade for ferrous metals, non-ferrous metals and organic material Inorganic contamination (ceramics, porcelain and stones) subject to negotiation between suppliers and reprocessor	Generic criteria BSI PAS 102 Specifications for processed glass for selected secondary end markets Total contaminant (organic, inorganic, ferrous/nonferrous metals) Particle size distribution Colour requirements Other requirements

			CEN/TC 261/SC 4/WG 3 Material recovery All contaminants < 5% Ceramics, porcelain and stones <10mm < 0,01% Total ceramics, porcelain and stones < 0,25% US Institute of Scrap Recycling Industries (ISRI) container glass cullet specification (GC-208) Destination: Maltha Glass Recycling Quality requirements: No information available	

Highlights

- No uniform scope for the waste collection: depending on the area where you live brown and green glass waste is collected together or separately; this makes it hard for the sorter to align his process to the collected waste;
- Information on the destination and the fate of the sorted outputs and the final application for the secondary materials is not available;

Paper and cardboard waste [Tubbergen]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
All paper and cardboard	• Door-to-door • Bring point • CAS • Door-to-door + bring points • Door-to door + CAS • **Bring points + CAS** • Door-to-door + bring points + CAS • Bring points + CAS + other	• Newspapers & magazines • Cardboard • **Mixed paper & cardboard** • Paper & cardboard co-mingled with other wastes	• mixed paper & cardboard • corrugated and kraft • newspapers & magazines • other and special grades	• Newsprint • Other graphic papers • Case materials • Carton board • Wrappings and other packaging • Sanitary and household • Other paper and board • Construction materials (insulation, bricks and furniture) • Animal beddings or compost • Fibre applications in construction and manufacturing (in concrete, asphalt, brake linings)
Do's: - **Everything made from paper and cardboard, such as** o **Newspapers;** o **Magazines** o **Packaging** o **Boxes** Don'ts: o **Drinking cartons** o **Pizza boxes**	Frequency: - **Monthly**	Generic criteria Natural fibre based paper and board suitable for recycling: Paper and board in any shape Products made predominately from paper and board, which may include coatings and laminates, spiral bindings, etc. Destination: **Remondis and Peute** Quality requirements: No information available	Generic criteria CEPI Classes I to IV Mixed grades Corrugated and kraft Newspapers & magazines Other grades EN 643 - European List of Standard Grades of Paper and Board for Recycling Group 1: ordinary grades, such as mixed paper and board;	Generic criteria

			Group 2: medium grades, such as sorted office paper; Group 3: high grades, such as white newsprint; Group 4: kraft grades, such as unused corrugated kraft; Group 5: special grades, such as used beverage cartons. Destination: No information available Quality requirements: No information available	

Highlights:

- Information on the destination and the fate of the sorted outputs and the final application for the secondary materials is not available;
- Collection of both packaging and non-packaging paper and cardboard together;
- Collection outsourced to external company (on short term basis);
- Horizontal integration of collection, sorting and recycling in one company;

Plastic waste (together with metals packaging and drink cartons) [Tubbergen]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
All plastic packaging	• Door-to-door • Bring point • CAS • Other • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • **Door-to-door + bring points + CAS**	• **Plastic packaging co-mingled with metal packaging waste and drinking cartons** • Plastic packaging only, co-mingling all polymers • Single type of packaging (e.g. only bottles) and/or a single polymer (e.g. PET) • Mix of two or more target polymers (e.g. PET, HDPE, LDPE, PE, PP) and/or packaging types (e.g. bottles and foils)	• Mono-colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS) • **Mixed colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)**	• **Mono-colour rPET** • Mono-colour rHDPE • Mono-colour rLDPE / rLLDPE • Mono-colour rPP • Mixed plastic pellets
Do's: - **All plastic packaging** Don'ts: - **Non-plastic items** - **Non-packaging items**	Frequency: - **Every 4 weeks**	Generic criteria Plastic bottles and flasks that contained: water and soft drinks milk washing-up and maintenance products washing powder water softeners bath and shower products distilled water bleaches Destination: **Attero, Wijster** Quality requirements: No information available/provided	Generic criteria US Institute of Scrap Recycling Industries (ISRI) baled recycled plastic commercial guidelines (P-2018) Plastics Recyclers Europe Bales Characterization Guidelines HDPE Bales PET Coloured Bales PP Film Bales PET Clear-blue Bales PET Light blue Bales PE Film Bales PET Clear Bales	Generic criteria EN 15342 - Characterization of polystyrene (PS) recyclates EN 15345 - Characterisation of Polypropylene (PP) recyclates EN 15346 - Characterisation of polyvinyl chloride (PVC) recyclates EN 15347 - Characterisation of plastics wastes EN 15348 - Characterization of polyethylene terephthalate (PET) recyclates EN 15344 - Characterisation of Polyethylene (PE) recyclates

			Specifications Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe (DKR) PET (DKR 328-1) PE (DKR 329) PP (DKR 324) Film (DKR 310) EPS (DKR 340) Mixed plastics (DKR 350) <u>Destination:</u> No information available/provided <u>Quality requirements:</u> No information available/provided	

Highlights

- Scope of plastic includes all types of plastics packaging (and excludes non-packaging);
- Only very limited information available on sorting and recycling;

Metal waste (together with plastic waste and drink cartons) [Tubbergen]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Metal packaging	• Door-to-door • Bring point • CAS • Other • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • **Door-to-door + bring points + CAS**	• **Aluminium and steel packaging co-mingled with other packaging waste, often including drinking cartons** • Aluminium beverage cans only • Metal packaging • Metal packaging co-mingled with other dry recyclables	• Baled or briquetted aluminium cans and/or aluminium meal trays, rigid containers, aerosol cans, screw closures and caps • Baled steel drums and cans • **Mixed bales with metal packaging** • Baled drinking cartons	• 3000-series wrought aluminium alloys • Low carbon steel • Fibres
Do's: - **Food and drink packaging cans** - **Aluminium foil** - **Metal lids** Don'ts: -	Frequency: - **Every 4 weeks**	Generic criteria Beverage cans Food cans Bottle caps Lids Aerosol cans of food and cosmetics Aluminium trays Destination: **Attero, Wijster** Quality requirements: No information available/provided	Generic criteria EN 13920-10:2003 for baled aluminium beverage cans Maximum moisture and volatile substance levels Limited concentrations of silicon and a series of metallic impurities Metal yield > 88% Free from burnt or oxidized cans and aluminium foil EN 139205-14:2003 and EN 139205-15:2003 for used aluminium packaging < 5 % of steel packaging Free from plastic, paper and blister packs < 60 % of volatile components Council Regulation (EU) No 333/2011 End-of-Waste aluminium scrap Maximum levels of combustible non-metallic materials Free from polyvinyl chloride (PVC) in form of coatings, paints, plastics	Generic criteria American National Standard Alloy and Temper Designation Systems for Aluminium 2017 ANSI H35 standards Aluminium 3004 Specifications ASTM B209 ASTM B221 ASTM B313 ASTM B547 ASTM B548 SAE J454 UNS A93004

			End-of-Waste iron and steel scrap: Technical proposal on tin-coated packaging scrap Excessive moisture, metallic copper, tin devices (and alloys) and lead (and alloys) Minimum concentrations of free iron or alloy, or of metallic packaging European Steel Scrap Specifications Standard classifications of national industry associations US Institute of Scrap Recycling Industries (ISRI) non-ferrous scrap guidelines (NF-2018) US Institute of Scrap Recycling Industries (ISRI) ferrous scrap guidelines (FS-2018) ASTM E 1134 : 1986 Specification for source separated steel cans <u>Destination:</u> No information available/provided <u>Quality requirements:</u> No information available	

Highlights

- Scope focusses on metal packaging, so broader than steel and aluminium cans;

2.2.4 The city of Parma

Case study description

Parma is a city located in Northern Italy at the foot of the Apennines with ca. 194,000 inhabitants. Well known for their food and quality of life, the region produced significant amounts of waste, 636 kg of waste per capita in 2014. This is roughly 150 kg above the Italian average, and 160 kg above the EU average. By that time, the region recycled 58.2% of the municipal waste, meaning that significant quantities are still sent to disposal, to be landfilled or incinerated. Fortunately, the situation is changing, and Parma is leading the transition towards Zero Waste in the region[16].

Parma started its zero-waste strategy by improving the separate collection of waste through door-to-door collection, introducing eco-stations and eco-wagons. Currently, the PPW collection in Parma can be described as PMD commingling method, meaning plastic, metal and composite material ("drinks cartons") are collected together. Paper and glass are separated separately. The residual waste, paper, and PMD are collected at the kerb, using home containers and bags. Also, several bring points (glass) and eight eco-stations (automated CAS where citizens can bring all waste except residual) are available. By providing citizens ample and easy opportunities to separately discard their waste, Parma performance rates have increased significantly (see Figure 13 below).

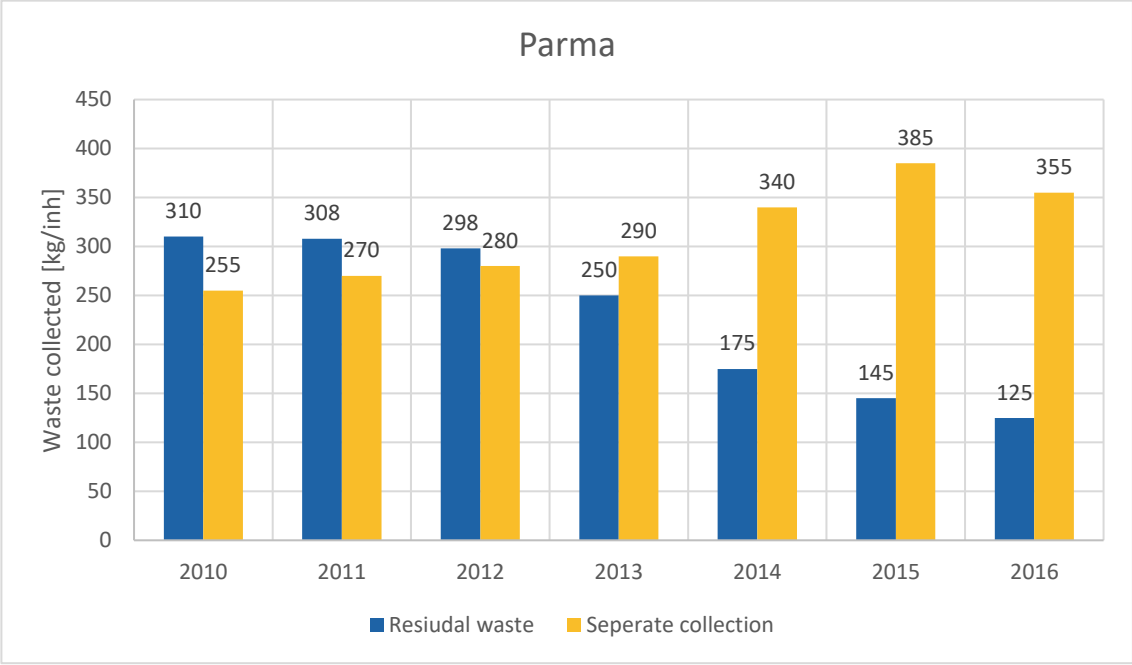

Figure 13: Performance of PPW collection in Parma 2010 - 2016[16]

Parma's historical centre, food-scene and mountainous suburbs all pose various challenges regarding to the waste collection. In order to collect the waste as good and efficient as possible, Parma uses different collection zones, with different collection frequencies and pickup times. The map below shows the Parma region, with four different zones. E.g. to avoid blockage and nuisance, the waste collection in the historical centre happens mainly in the evening.

[16] Zero Waste Europe, Casestudy 'The story of Parma', 2018.

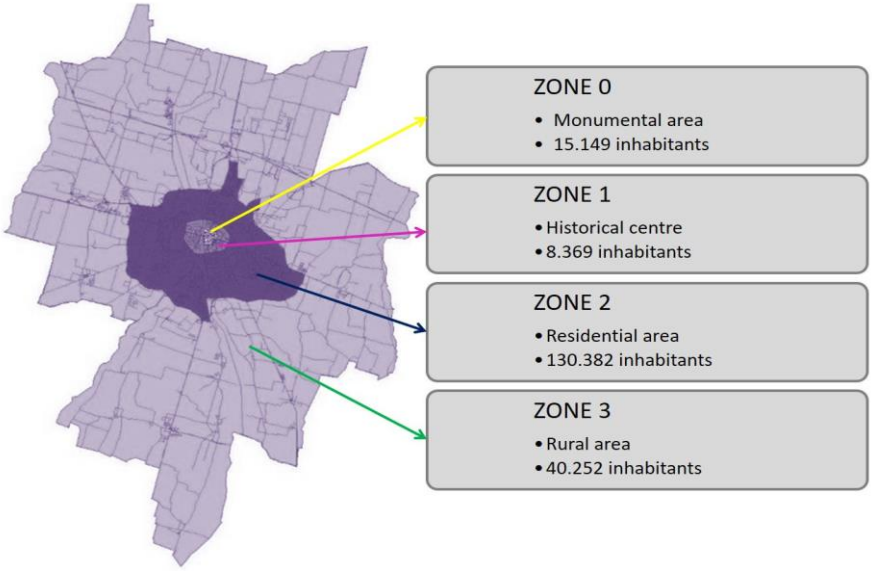

Figure 14: Various zones in Parma

For the waste collection, treatment and disposal, Parma works together with Iren Ambiente[17]. Iren Ambiente performs collection services for more than 2.3 million residents, amongst others in the provinces of Parma, Piacenza and Reggio Emilia. Iren Ambiente manages waste from collection to treatment, disposal and recovery and has 30 treatment plants that yearly process over 2 million tonnes of waste.

Fee system: Parma implemented a PAYT system with a fixed fee. Citizens pay the fixed fee (€ 244 for 3person and 100m2 household in 2017) and can collect eco-points; a discount on their waste bill for the following year. Eco-points are collected for brining e.g. electronic waste, hazardous waste and medical waste and depend on the quantity and sort waste. Disposing packaging waste is for free, but yields no eco-points. Each eco-point is worth a discount of € 0.15, and citizens can receive a maximum discount of € 20.

Flow scheme

In 2013, Parma implemented a PAYT-based waste collection system focused on the separate collection of paper and cardboard; glass; and plastic, metals and composites. In the new collection system, the residual waste, paper and cardboard, glass and light weight packaging waste streams are collected at the kerb, using home containers and bags. For glass collection, 1.304 bell containers are available throughout the city. Parma has four civic amenity sites run by Iren Ambiente, and thirteen automatic eco-stations where citizens can bring their waste (ca. one bring point per 11.557 inhabitants).

[17] Iren Ambiente, 2019 https://www.gruppoiren.it/en/ambiente

Figure 15: Eco-station in Parma

In Parma, the waste is collected and processed by Iren Ambiente. Iren Ambiente is subcontracted by the municipality to execute waste management (collection and corresponding processing). The collected residual waste is transported to the post sorting and incineration facility of Irens Ambiente, located in Parma. Paper waste is transported to the paper recycler Ghirardi in Parma and both the clear and coloured glass stream are sent to Furlotti. The light weight packaging stream is post-separated in paper from the beverage cartons (Ghirardi); plastics; and metals, which are both send to the Oppimitti or Masotina recycling facility. The flowchart for the collection of PPW in Parma is presented in the figure below.

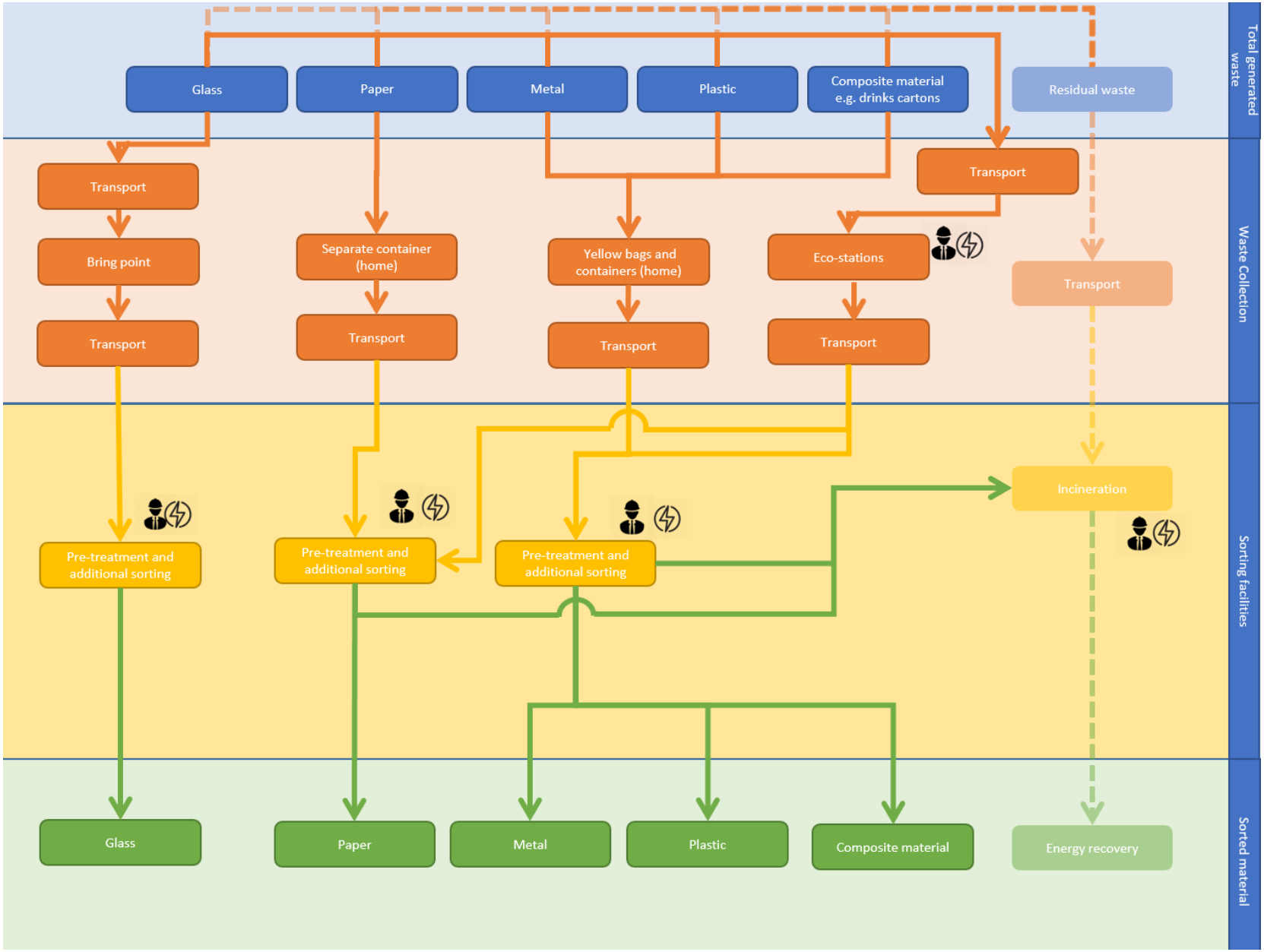

Figure 16: Flow scheme waste collection in Parma

In order to better understand the responsibilities of the municipality with respect to the waste collection, an overview of the financial responsibilities is given in the next paragraph (as in D3.2).

Financial responsibilities: In 2015 the collection system was expanded with four eco-stations; these are automated CAS where citizens can bring all waste except residual waste. In 2017 four additional eco-stations were installed, followed by five mini eco-stations in 2018. These investments were done by the municipality of Parma. In addition, Parma invested in large information campaigns in the period of 2012 – 2015. Since Iren Ambiente owns the waste management equipment, operational costs and potential investments in equipment are directly made by Iren Ambiente. Iren Ambiente charges municipalities based on the quantities of waste collected. Revenues from material streams and incineration are collected by Iren Ambiente, and partly transferred to the municipality. Revenues from the EPR CONAI are collected by the municipality. Lastly, the municipality collects the waste fee from the citizens.

Highlights

- Implementation of an innovative waste collection method, being the ecostation; an ecostation is an automated collecting station for different waste types accessible with badge;
- The combined collection of glass and plastics has been switched some years ago to the combined collection of plastics and metals; since then, glass is collected separately;
- IREN Ambiente is subcontracted by the municipality to execute waste management (collection and corresponding processing)

Recycling value chain

Container glass waste [Parma]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Mixed glass	• CAS • Bring point • Door-to-door • Bring points + CAS • Door-to-door + bring points • **Road containers + CAS** • Bring points + CAS + other	• Clear container glass • Coloured container glass • **Mixed container glass** • Mixed container glass co-mingled with other wastes	• **Clear container glass cullet** • **Brown container glass cullet** • **Green container glass cullet** • Mixed container glass cullet	• **Container glass (flint, brown, green)** • Insulation mineral wool (short glass fibre) • Ceramic sanitary ware • Fluxing agent in brick manufacture • Sports turf and related applications • Water filtration media • Abrasive • Aggregate in construction materials • Reflective highway paint
Quality requirements: No information available/provided Not: No information available/provided	Frequency: - **Road containers, CAS: as needed**	Generic criteria Soda-lime-silicate container glass with: Bulk density < 500 kg/m³ Ferrous metals < 0,3% Coloured glass < 5% (for clear glass only) Ceramics, stones and porcelain < 0,4% Plastic bottles < 2,5% Non-ferrous metals < 0,2% Organic materials < 0,5% Flat glass < 1% Destination: **Furlotti Luigi, San Polo di Torrile** Quality specification:	Generic criteria BSI/WRAP PAS 101 Untreated cullet A: Whole or broken containers, colour separated. B: Whole or broken containers, colour separated but to a lesser standard. C: Whole or broken containers, mixed. D: Compacted glass. Contamination limits per grade for ferrous metals, non-ferrous metals and organic material	Generic criteria BSI PAS 102 Specifications for processed glass for selected secondary end markets Total contaminant (organic, inorganic, ferrous/nonferrous metals) Particle size distribution Colour requirements Other requirements

		- **Purity:** - **Contamination: 1-3 w%**	Inorganic contamination (ceramics, porcelain and stones) subject to negotiation between suppliers and reprocessor CEN/TC 261/SC 4/WG 3 Material recovery All contaminants < 5% Ceramics, porcelain and stones <10mm < 0,01% Total ceramics, porcelain and stones < 0,25% US Institute of Scrap Recycling Industries (ISRI) container glass cullet specification (GC-208) <u>Destination:</u> **CoReVe** <u>Quality requirements:</u> No information available	

Highlights

- Until a few years ago glass was collected co-mingled with lightweight packaging such as plastics and drinking composites; now, glass is collected separately, leading to a higher quality collected material and to lower contamination levels for both collected fractions;

Paper and cardboard waste [Parma]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Mixed paper and cardboard	• Door-to-door • Bring point • CAS • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • **Door-to-door + ecostations + CAS** • Bring points + CAS + other	• Newspapers & magazines • Cardboard • **Mixed paper & cardboard** • Paper & cardboard co-mingled with other wastes	• mixed paper & cardboard • corrugated and kraft • newspapers & magazines • other and special grades	• Newsprint • Other graphic papers • Case materials • Carton board • Wrappings and other packaging • Sanitary and household • Other paper and board • Construction materials (insulation, bricks and furniture) • Animal beddings or compost • Fibre applications in construction and manufacturing (in concrete, asphalt, brake linings)
Do's: - Don'ts: -	Frequency: - **Dtd: weekly**	Generic criteria Natural fibre based paper and board suitable for recycling: Paper and board in any shape Products made predominately from paper and board, which may include coatings and laminates, spiral bindings, etc. Destination: **Ghirardi srl** Quality specifications:	Generic criteria CEPI Classes I to IV Mixed grades Corrugated and kraft Newspapers & magazines Other grades EN 643 - European List of Standard Grades of Paper and Board for Recycling Group 1: ordinary grades, such as mixed paper and board;	Generic criteria

		- **Contamination: 1-2 w%**	Group 2: medium grades, such as sorted office paper; Group 3: high grades, such as white newsprint; Group 4: kraft grades, such as unused corrugated kraft; Group 5: special grades, such as used beverage cartons. <u>Destination:</u> No information available/provided	

No highlights identified

Plastic waste (collected together with metal waste and drink cartons) [Parma]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
All plastic packaging	• Door-to-door • Bring point • CAS • Other • **Door-to-door + ecostations** • Door-to door + CAS • Bring points + CAS • Door-to-door + bring points + CAS	• **Plastic packaging co-mingled with other packaging waste** • Plastic packaging only, co-mingling all polymers • Single type of packaging (e.g. only bottles) and/or a single polymer (e.g. PET) • Mix of two or more target polymers (e.g. PET, HDPE, LDPE, PE, PP) and/or packaging types (e.g. bottles and foils)	• **Mono-colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)** • Mixed colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)	• Mono-colour rPET • Mono-colour rHDPE • Mono-colour rLDPE / rLLDPE • Mono-colour rPP • Multi-colour per polymer • Mixed plastic pellets
Do's: - Don'ts: -	Frequency: - **Dtd: weekly**	Generic criteria Plastic bottles and flasks that contained: water and soft drinks milk washing-up and maintenance products washing powder water softeners bath and shower products distilled water bleaches Destination: **50% Oppimitti, 50% Masotina** Quality specifications: **17% non-compliant plastic packaging;** **2 % paper/cardboard** **2% glass**	Generic criteria US Institute of Scrap Recycling Industries (ISRI) baled recycled plastic commercial guidelines (P-2018) Plastics Recyclers Europe Bales Characterization Guidelines HDPE Bales PET Coloured Bales PP Film Bales PET Clear-blue Bales PET Light blue Bales PE Film Bales PET Clear Bales	Generic criteria EN 15342 - Characterization of polystyrene (PS) recyclates EN 15345 - Characterisation of Polypropylene (PP) recyclates EN 15346 - Characterisation of polyvinyl chloride (PVC) recyclates EN 15347 - Characterisation of plastics wastes EN 15348 - Characterization of polyethylene terephthalate (PET) recyclates EN 15344 - Characterisation of Polyethylene (PE) recyclates

			Specifications Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe (DKR) PET (DKR 328-1) PE (DKR 329) PP (DKR 324) Film (DKR 310) EPS (DKR 340) Mixed plastics (DKR 350) Destination: Corepla Quality requirements: No information available/provided	

Highlights

- Combined collection of easy to sort dry recyclable fractions (plastic-drinking cartons-metals);

Metal waste (collected together with plastic waste and drink cartons) [Parma]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Metal waste	• Door-to-door • Bring point • CAS • Other • **Door-to-door + ecostation** • Door-to door + CAS • Bring points + CAS • Door-to-door + bring points + CAS	• **Aluminium and steel packaging co-mingled with other packaging waste, often including drinking cartons** • Aluminium beverage cans only • Metal packaging • Metal packaging co-mingled with other dry recyclables	• Baled or briquetted aluminium cans and/or aluminium meal trays, rigid containers, aerosol cans, screw closures and caps • Baled steel drums and cans • Baled drinking cartons	• 3000-series wrought aluminium alloys • Low carbon steel • Fibres
Do's: - Don'ts: -	Frequency: **Dtd: weekly**	Generic criteria Beverage cans Food cans Bottle caps Lids Aerosol cans of food and cosmetics Aluminium trays Destination: Seems like Oppimitti and Masotina only do plastic waste; who sorts the collected metal+plastics? Quality specifications: **17% non-compliant plastic packaging;** **2 % paper/cardboard** **2% glass**	Generic criteria EN 13920-10:2003 for baled aluminium beverage cans Maximum moisture and volatile substance levels Limited concentrations of silicon and a series of metallic impurities Metal yield > 88% Free from burnt or oxidized cans and aluminium foil EN 139205-14:2003 and EN 139205-15:2003 for used aluminium packaging < 5 % of steel packaging Free from plastic, paper and blister packs < 60 % of volatile components Council Regulation (EU) No 333/2011 End-of-Waste aluminium scrap Maximum levels of combustible non-metallic materials Free from polyvinyl chloride (PVC) in form of coatings, paints, plastics	Generic criteria American National Standard Alloy and Temper Designation Systems for Aluminium 2017 ANSI H35 standards Aluminium 3004 Specifications ASTM B209 ASTM B221 ASTM B313 ASTM B547 ASTM B548 SAE J454 UNS A93004

			End-of-Waste iron and steel scrap: Technical proposal on tin-coated packaging scrap Excessive moisture, metallic copper, tin devices (and alloys) and lead (and alloys) Minimum concentrations of free iron or alloy, or of metallic packaging European Steel Scrap Specifications Standard classifications of national industry associations US Institute of Scrap Recycling Industries (ISRI) non-ferrous scrap guidelines (NF-2018) US Institute of Scrap Recycling Industries (ISRI) ferrous scrap guidelines (FS-2018) ASTM E 1134 : 1986 Specification for source separated steel cans <u>Destination:</u> No information available/provided <u>Quality requirements:</u> No information available	

Highlights

- Combined collection of easy to sort dry recyclable fractions (plastic-drinking cartons-metals);

2.2.5 The city of Rennes

Case study background

Rennes Métropole is an intercommunal organisation located in Brittany (France), gathering 43 municipalities taking a census of 438,865 inhabitants in 2017. Those inhabitants are living on a territory of 654 km² (617 inhabitants per km²) counting 36% of detached and semi-detached houses and subsequently 64% multi-family houses (terraced houses, apartment buildings, housing blocks). In 2016, the tourist overnight stays per inhabitants was 3,7. The GDP per inhabitant was about € 30,770 in 2012.

With regards to waste management, Rennes Métropole was selected by the French ministry ("ministère de l'Ecologie, du Développement Durable et de l'Energie) as pilot areas of the national programme on zero waste ("Zéro déchets, zéro gaspillage"). In Rennes, waste collection is managed by Rennes Métropole ("Direction des déchets et des réseaux d'énergie") and operated in collaboration with various subcontractors such as Sita Ouest for household and recyclable waste, Tribord for door-to-door vegetable and bulky waste and La Feuille d'erable for paper and cardboard from businesses. The Métrople operates 18 civic amenity sites (24.381 inhabitants per CAS). Concerning recyclable waste, glass is collected separately at bring points. Paper, newspapers and magazines from households are collected co-mingled with plastic, metal and composite packaging. Yellow bins collected door to door or bring points have been implemented for collecting those recyclables ("Multi-matériaux"). In July 2017, the list of recyclables to be included in those yellow bins or bring points was extended to all plastic packaging and small aluminium. Important communication campaigns followed this scope extension. As shown in the graph, 466 kg of waste per capita were collected in 2017, with 93 tonnes collected separately.

The national waste programme set a 10% reduction of waste generated per inhabitants from 2010 to 2020. The objective of Rennes Métropole is thus to reduce the waste generated per capita to 437 kg by 2020. Also reflected in the graph, in 2014 inhabitants from Rennes Métropole were already generating 70 kg of waste per year less than average national inhabitants (460 kg/capita compared to 560 kg/capita in average in France).

The figure below shows the downwards trend in total waste, both in total, residual and recyclable waste.

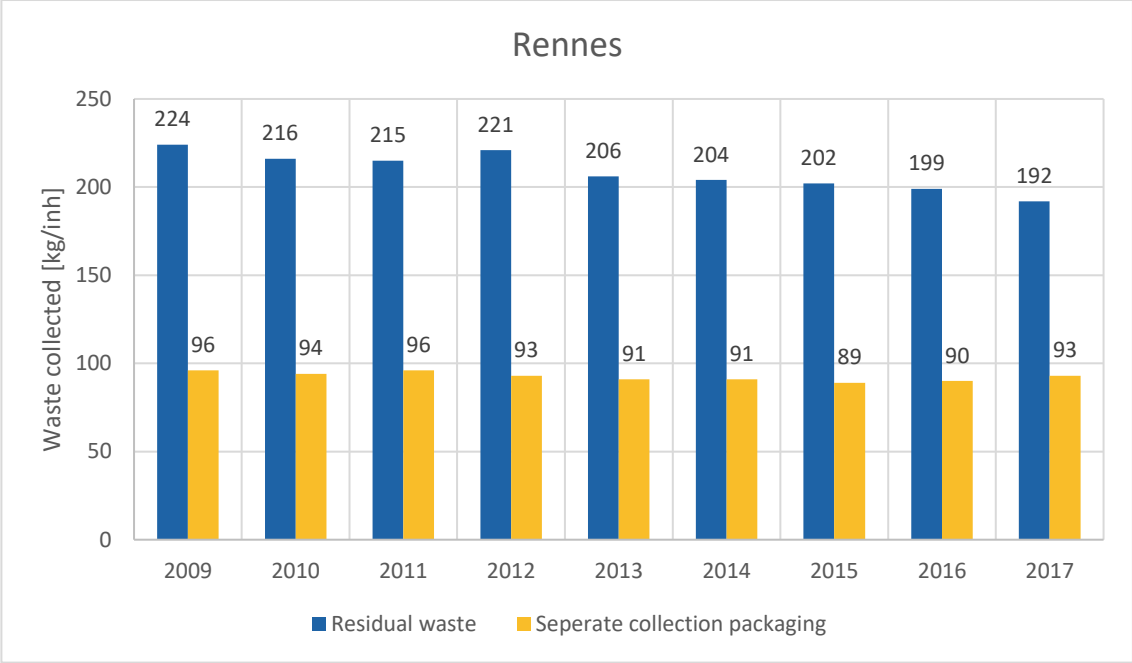

Figure 17: Downwards trend in residual waste in Rennes

Fee system: The citizen waste tax in Rennes is based on the property value. The legal responsibility for the provision of the waste service resides with the local municipality, although rural domestic services are generally run on an inter-communal basis. Most municipalities charge for the service through a tax, called the Taxe d'Enlèvement des Ordures Ménagères (TEOM), which is collected with the annual property rates bill, the taxe Foncière[18]. However, the TEOM is a discretionary tax, and some councils simply decide to fund the service through the general budget. In 2017, the Rennes metropole collected a total TEOM of € 64.50 per inhabitant.

[18] https://www.french-property.com/guides/france/finance-taxation/taxation/local-property-taxes/waste-rubbish-collection

Flow scheme

Rennes has been selected by the French ministry as one of the pilot areas for the national programme on zero waste. The national waste programme sets a 10% reduction of waste generated per inhabitants from 2010 to 2020. During this time Rennes reorganised their waste collection system, participated in the LIFE+ Miniwaste project to reduce biowaste, and invested largely in communication campaigns on reducing waste as well as additional containers and bring points.

Rennes collects glass separately at bring points. Paper, newspapers and magazines from households are collected co-mingled with plastic, metal and composite packaging. Yellow bins collected door to door or bring points have been implemented for collecting those recyclables (“Multi-matériaux”). The Métrople operates 18 civic amenity sites (24.381 inhabitants per CAS). In July 2017, the list of recyclables to be included in the yellow bins or bring points was extended to all plastic packaging and small aluminium. Important communication campaigns followed this scope extension. The flowchart for the collection of PPW in Rennes is presented in shown in the figure below.

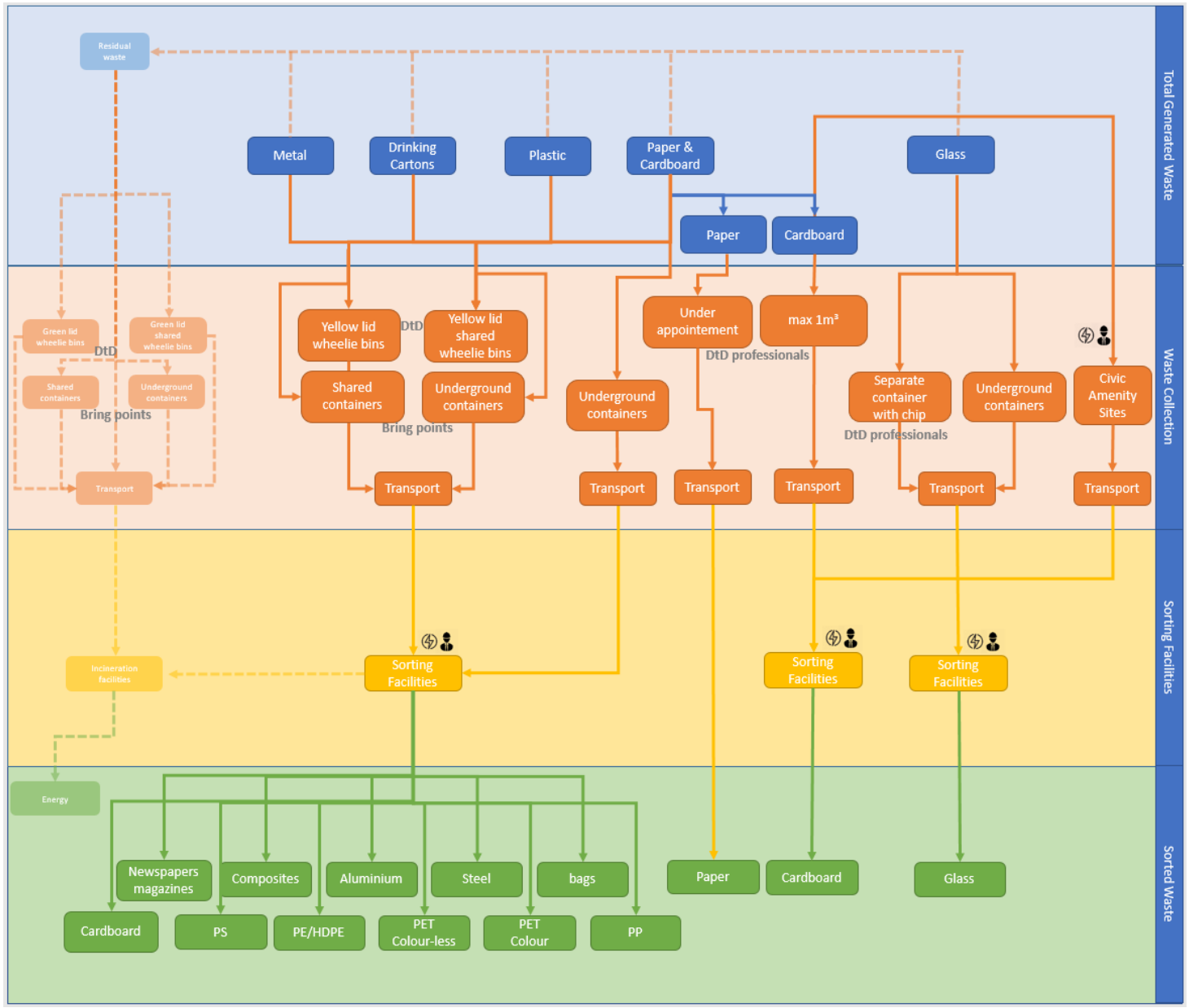

Figure 18: Flow scheme waste collection in Rennes

In order to better understand the responsibilities of the municipality with respect to the waste collection, an overview of the financial responsibilities is given in the next paragraph (as in D3.2).

Financial responsibilities: In Rennes, waste collection is managed by Rennes Métropole ("Direction des déchets et des réseaux d'énergie") and operated in collaboration with various subcontractors such as Sita Ouest for household and recyclable waste and Tribord for door-to-door vegetable and bulky waste. Specific equipment investments can be done by both Rennes Metropole and the subcontractors. In 2013, Rennes Metropole invested in the acquisition of new containers, bring points and underground waste containers and construction of new waste disposal centres new equipment for treatment such as grinders and shredders. The citizen waste fee (TEOM) is collected by Rennes Metropole, as well as potential government or industry (EPR) support.

Highlights

- Waste collection is managed by Rennes Métropole ("Direction des déchets et des réseaux d'énergie") and operated in collaboration with various subcontractors;
- Paper and cardboard from businesses is collected separately (as 2 separate fractions) and outsourced to private company completely (both type and method of waste collection);
- Co-mingled collection of PMD + paper and cardboard for households implemented;
- In some areas, fibres (paper and cardboard, from households) are collected separately;

Recycling value chain

Container glass waste [Rennes]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Mixed glass	• CAS • Bring point • Door-to-door • Bring points + CAS • **Door-to-door + bring points** • Road containers + CAS • Bring points + CAS + other	• Clear container glass • Coloured container glass • **Mixed container glass** • Mixed container glass co-mingled with other wastes	• **Clear container glass cullet** • **Brown container glass cullet** • **Green container glass cullet** • Mixed container glass cullet	• **Container glass (flint, brown, green)** • Insulation mineral wool (short glass fibre) • Ceramic sanitary ware • Fluxing agent in brick manufacture • Sports turf and related applications • Water filtration media • Abrasive • Aggregate in construction materials • Reflective highway paint
Quality requirements: **Bottles and jars** **Emptied, but no need to clean** Don'ts: No information available/provided	Frequency: - **DtD: once a week to once a month, depending on area**	Generic criteria Soda-lime-silicate container glass with: Bulk density < 500 kg/m³ Ferrous metals < 0,3% Coloured glass < 5% (for clear glass only) Ceramics, stones and porcelain < 0,4% Plastic bottles < 2,5% Non-ferrous metals < 0,2% Organic materials < 0,5% Flat glass < 1% Destination: **Sibelco Green Solutions** Quality specification:	Generic criteria BSI/WRAP PAS 101 Untreated cullet A: Whole or broken containers, colour separated. B: Whole or broken containers, colour separated but to a lesser standard. C: Whole or broken containers, mixed. D: Compacted glass. Contamination limits per grade for ferrous metals, non-ferrous metals and organic material Inorganic contamination (ceramics, porcelain and stones) subject to negotiation between suppliers and reprocessor	Generic criteria BSI PAS 102 Specifications for processed glass for selected secondary end markets Total contaminant (organic, inorganic, ferrous/nonferrous metals) Particle size distribution Colour requirements Other requirements

		- Purity: - Contamination:	CEN/TC 261/SC 4/WG 3 Material recovery All contaminants < 5% Ceramics, porcelain and stones <10mm < 0,01% Total ceramics, porcelain and stones < 0,25% US Institute of Scrap Recycling Industries (ISRI) container glass cullet specification (GC-208) Destination: **OI Manufacturing (Reims)** Quality requirements: No information available/provided	

Highlights

- Collection and sorting are aligned; the configuration of the sorting installation is adapted to the mixed composition of the collected output, and therefore allows to get sorting outputs according to the colour;
- Focus on high-value recycling (closed loop);

Paper and cardboard waste (for most households together with PMD, for some separate bring points) [Rennes]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Households: paper and cardboard together Professionals: paper (from offices) and cardboard (from shops) separately	• Door-to-door • Bring point • CAS • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • **Door-to-door + bring points + CAS** • Bring points + CAS + other	• **Newspapers & magazines** • **Cardboard** • **Mixed paper & cardboard** • **Paper & cardboard co-mingled with other wastes**	• **mixed paper & cardboard** • **corrugated and kraft** • **newspapers & magazines** • other and special grades	• **Newsprint** • **Other graphic papers** • **Case materials** • **Carton board** • **Wrappings and other packaging** • **Sanitary and household** • **Other paper and board** • Construction materials (insulation, bricks and furniture) • Animal beddings or compost • Fibre applications in construction and manufacturing (in concrete, asphalt, brake linings)
Do's: - **Papers** - **Newspapers** - **Magazines** - **Envelopes** Don'ts: -	Frequency: - **Door-to-door: Rennes city centre 2 times per week; outside once a week** - **All bring points are equipped with a monitoring system allowing to detect the filing and thus optimize the collection transport**	Generic criteria Natural fibre based paper and board suitable for recycling: Paper and board in any shape Products made predominately from paper and board, which may include coatings and laminates, spiral bindings, etc. Destination: **NCI Environnement Bretagne**	Generic criteria CEPI Classes I to IV Mixed grades Corrugated and kraft Newspapers & magazines Other grades EN 643 - European List of Standard Grades of Paper and Board for Recycling Group 1: ordinary grades, such as mixed paper and board; Group 2: medium grades, such as sorted office paper; Group 3: high grades, such as white newsprint;	Generic criteria - **Sorted newspapers & magazines are sent to Norske Skog by train and train coming back contain recycled paper sent to "Ouest France" newspaper editor based in Rennes** - **Recycled P&C from Paprec 40% France, 40% Europe, 20% Asia**

		Quality specifications: No information available	Group 4: kraft grades, such as unused corrugated kraft; Group 5: special grades, such as used beverage cartons. Destination: - **Newspaper and magazines: Norske Skog (Vosges)** - **Cardboard: Paprec** - **Paper from businesses: European Products Recycling - EN 643**	

Highlights

- Paper and cardboard from businesses is collected as 2 separate fractions, which enter a specific sorting and recycling line for respectively paper (Norske skog) and cardboard (Paprec); however, it is not clear if this also leads to more or better high value recycling;
- The collection for professionals is outsourced to a private company completely (both type and method of waste collection);
- Co-mingled collection of PMD + paper and cardboard for households implemented;
- In some areas, fibres (paper and cardboard, from households) are collected separately
- EN643 is applied for all collected paper and cardboard waste fractions;

Plastic waste (collected together with metals and drink cartons, and for some households together with fibres) [Rennes]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
All plastic packaging	• Door-to-door • Bring point • CAS • Other • **Door-to-door + bring points** • Door-to door + CAS • Bring points + CAS • Door-to-door + bring points + CAS	• **Plastic packaging co-mingled with other packaging waste** • Plastic packaging only, co-mingling all polymers • Single type of packaging (e.g. only bottles) and/or a single polymer (e.g. PET) • Mix of two or more target polymers (e.g. PET, HDPE, LDPE, PE, PP) and/or packaging types (e.g. bottles and foils)	• **Mono-colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)** • Mixed colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)	• Mono-colour rPET • Mono-colour rHDPE • Mono-colour rLDPE / rLLDPE • Mono-colour rPP • Multi-colour per polymer • Mixed plastic pellets
Do's: - **All plastic packaging;** - **Not nested;** - **Emptied well, no need to clean;** Don'ts: - **Non-packaging**	Frequency: - **Door-to-door: Rennes city centre 2 times per week; outside once a week** - **All bring points are equipped with a monitoring system allowing to detect the filing and thus optimize the collection transport**	Generic criteria Plastic bottles and flasks that contained: water and soft drinks milk washing-up and maintenance products washing powder water softeners bath and shower products distilled water bleaches Destination: **NCI Environnement Bretagne (sorting facility) for household waste** Quality specifications: No information available/provided	Generic criteria US Institute of Scrap Recycling Industries (ISRI) baled recycled plastic commercial guidelines (P-2018) Plastics Recyclers Europe Bales Characterization Guidelines HDPE Bales PET Coloured Bales PP Film Bales PET Clear-blue Bales PET Light blue Bales PE Film Bales PET Clear Bales	Generic criteria EN 15342 - Characterization of polystyrene (PS) recyclates EN 15345 - Characterisation of Polypropylene (PP) recyclates EN 15346 - Characterisation of polyvinyl chloride (PVC) recyclates EN 15347 - Characterisation of plastics wastes EN 15348 - Characterization of polyethylene terephthalate (PET) recyclates EN 15344 - Characterisation of Polyethylene (PE) recyclates

			Specifications Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe (DKR) PET (DKR 328-1) PE (DKR 329) PP (DKR 324) Film (DKR 310) EPS (DKR 340) Mixed plastics (DKR 350) Destination: **Valorplast** Quality requirements: No information available/provided	

Highlights

- Combined collection of easy to sort dry recyclable fractions (plastic-drinking cartons-metals), together with paper and cardboard for households;

Metal waste (collected together with plastic waste and drink cartons, and for most households together with fibres) [Rennes]				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
All metal packaging	• Door-to-door • Bring point • CAS • Other • **Door-to-door + bring points** • Door-to door + CAS • Bring points + CAS • Door-to-door + bring points + CAS	• **Aluminium and steel packaging co-mingled with other packaging waste, often including drinking cartons** • Aluminium beverage cans only • Metal packaging • Metal packaging co-mingled with other dry recyclables	• **Baled or briquetted aluminium cans and/or aluminium meal trays, rigid containers, aerosol cans, screw closures and caps** • **Baled steel drums and cans** • **Baled drinking cartons**	• **3000-series wrought aluminium alloys** • **Low carbon steel** • Fibres
Do's: - Don'ts: -	Frequency: - **Door-to-door: Rennes city centre 2 times per week; outside once a week** - **All bring points are equipped with a monitoring system allowing to detect the filing and thus optimize the collection transport**	Generic criteria Beverage cans Food cans Bottle caps Lids Aerosol cans of food and cosmetics Aluminium trays Destination: **NCI Environnement Bretagne** Quality specifications: No information available/provided	Generic criteria EN 13920-10:2003 for baled aluminium beverage cans Maximum moisture and volatile substance levels Limited concentrations of silicon and a series of metallic impurities Metal yield > 88% Free from burnt or oxidized cans and aluminium foil EN 139205-14:2003 and EN 139205-15:2003 for used aluminium packaging < 5 % of steel packaging Free from plastic, paper and blister packs < 60 % of volatile components Council Regulation (EU) No 333/2011 End-of-Waste aluminium scrap Maximum levels of combustible non-metallic materials	Generic criteria American National Standard Alloy and Temper Designation Systems for Aluminium 2017 ANSI H35 standards Aluminium 3004 Specifications ASTM B209 ASTM B221 ASTM B313 ASTM B547 ASTM B548 SAE J454 UNS A93004

			Free from polyvinyl chloride (PVC) in form of coatings, paints, plastics End-of-Waste iron and steel scrap: Technical proposal on tin-coated packaging scrap Excessive moisture, metallic copper, tin devices (and alloys) and lead (and alloys) Minimum concentrations of free iron or alloy, or of metallic packaging European Steel Scrap Specifications Standard classifications of national industry associations US Institute of Scrap Recycling Industries (ISRI) non-ferrous scrap guidelines (NF-2018) US Institute of Scrap Recycling Industries (ISRI) ferrous scrap guidelines (FS-2018) ASTM E 1134 : 1986 Specification for source separated steel cans <u>Destination:</u> - **Aluminium: Netra** - **Steel: Guy Dauphin** - **Drink cartons: Revipac** <u>Quality requirements:</u> No information available	

Highlights:

- Scope for collection includes all metal waste, so both packaging and non-packaging;

2.3Meta-analysis

In the next paragraphs and based on the analysis of the individual cases, an overview is made per PPW fraction that illustrates how the different cases relate to each other for that specific waste fraction. As for the individual analysis of the case studies, the subsequent steps of the recycling value chain and corresponding categories are used to provide an overview of the individual cases, by using a different colour code for each case.

In the analysis of the individual case studies additional information is added on the scope of the collection and relevant quality requirements for the respective value chain step (collection, sorting, recycling).

Based on this information per PPW fraction, a description is included of the main findings related to the cooperation within the value chain on the one hand and to the waste collection system and its relation to the quality of the waste specifically on the other hand.

2.3.1 Glass waste

Container glass waste				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Transparent glass Clear versus mixed coloured glass Clear versus green versus brown glass Mixed glass	• CAS • Bring point • Door-to-door • Bring points + CAS • Road containers + CAS • Door-to-door + bring points • Bring points + CAS + other • Door-to-door + bring points + CAS	• Clear container glass • Coloured container glass • Mixed container glass • Mixed container glass co-mingled with other wastes	• Clear container glass cullet • Brown container glass cullet • Green container glass cullet • Mixed container glass cullet	• Container glass (flint, brown, green) • Insulation mineral wool (short glass fibre) • Ceramic sanitary ware • Fluxing agent in brick manufacture • Sports turf and related applications • Water filtration media • Abrasive • Aggregate in construction materials • Reflective highway paint
Ghent	**Berlin**	**Tubbergen**	**Parma**	**Rennes**

Highlights

- Although glass waste is commonly considered as an obvious waste stream when it comes to collection, both the scope of the collected waste and the collection method varies considerably between the case studies;
- The service level related to the collection method seems to increase with the population density and/or the type of housing (higher service level for multi-family houses);
- Despite of the varied scope and collection methods, the sorting process is able to produce the same sorting output fractions for all cases;
- Sorting glass waste is widely spread and proven technology; the differentiating characteristic to sort glass waste is the colour;
- Both the sorting and the recycling process provide the functionality to deal with impurities, at least to some extent;
- Although the scope of the waste collection is very fragmented, and a variety of collection methods is implemented to collect the glass waste, all cases focus on the same end application, being container glass, so striving for high value recycling;

2.3.2 Paper and cardboard waste

Paper and cardboard waste				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Packaging and non-packaging paper and cardboard Paper (from offices) and cardboard (from shops) separately	• Door-to-door • Bring point • CAS • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • Door-to-door + bring points + CAS • Bring points + CAS + other	• Newspapers & magazines • Cardboard • Mixed paper & cardboard • Paper & cardboard co-mingled with other wastes	• mixed paper & cardboard • mixed paper • cardboard • corrugated and kraft • newspapers & magazines • other and special grades	• Newsprint • Other graphic papers • Case materials • Carton board • Wrappings and other packaging • Sanitary and household • Other paper and board • Construction materials (insulation, bricks and furniture) • Animal beddings or compost • Fibre applications in construction and manufacturing (in concrete, asphalt, brake linings)
Ghent	**Berlin**	**Tubbergen**	**Parma**	**Rennes**

Highlights

- In most cases paper and cardboard are collected together; this does not seem to affect the quality of the corresponding secondary materials;
- The sorting process is proven and able to easily sort the collected waste in several fractions;
- In several cases EN643 categorisation is applied, leading to clearly defined sorting outputs which can be easy put/sold on the recycling market;
- In all cases packaging and non-packaging waste is collected to together;
- For the cases with a differentiated scope (paper and cardboard separately) it is not clear if this enhances the recycling process; in any way, it does allow to skip part of the sorting process;
- In most cases (except for households in Rennes) paper and cardboard is not collected co-mingled with other waste fractions; experiences in the past have learnt that this leads to (too) high levels of contamination of the paper and cardboard fraction; especially contamination of paper and cardboard with wet or fatty materials should be avoided;

2.3.3 Plastic waste

Plastic waste				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Plastic bottles and flasks Plastic packaging and non-packaging All plastic packaging	• Door-to-door • Bring point • CAS • Other • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • Door-to-door + bring points + CAS	• Plastic packaging co-mingled with other packaging waste • Plastic packaging only, co-mingling all polymers • Single type of packaging (e.g. only bottles) and/or a single polymer (e.g. PET) • Mix of two or more target polymers (e.g. PET, HDPE, LDPE, PE, PP) and/or packaging types (e.g. bottles and foils)	• Mono-colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS) • Mixed colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)	• Mono-colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS) • Mixed colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)

Ghent	Berlin	Tubbergen	Parma	Rennes

Highlights

- The scope for plastic waste is quite differentiated, ranging from plastic bottles & flasks to all packaging and non-packaging plastics; in practice, this means that the composition ranges from a rather well known mixture (bottles & flasks = large pieces of PET and PE/PP) over a mixture of all sorts of plastics, and a mixture of all sorts of plastics and non-plastics without PET bottles to a random mixture of all polymers, all sizes and appearances (packaging and non-packaging);
- The service level of the collection ranges from only door-to-door collection to a combination of door-to-door, bring points and CAS;
- In all cases door-to-door collection is offered for plastic waste;
- In all cases plastic waste is collected co-mingled with other dry recyclable fractions (drinking cartons-metals) that have completely different characteristics as density and chemical composition, which makes them quite easy to sort;

- When the scope of the collection is limited, the subsequent sorting process is easy and robust and the level of impurities in the sorting outputs is limited; the broader the scope of the plastic waste collection, the more challenging the sorting becomes, including higher costs and/or lower efficiencies and/or lower quality output materials;
- Not all municipalities are aware of the end application of their plastic waste; for the cases where this information is available, closed-loop/high-value recycling is aimed for;
- All cases are able to realize closed-loop recycling, at least to some degree: based on the scope of the collected waste and the sorting applied, the quality of the secondary materials will vary; this quality level can be expressed as the percentage of virgin materials needed to produce new products, as these virgin materials will have to compensate for the lower quality of the secondary materials;

2.3.4 Metal waste

Metal waste				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Metal packaging Metal packaging and any objects made of metal	• Door-to-door • Bring point • CAS • Other • Door-to-door + bring points • Door-to door + CAS • Bring points + CAS • Door-to-door + bring points + CAS	• Aluminium and steel packaging co-mingled with other packaging waste, often including drinking cartons • Aluminium beverage cans only • Metal packaging • Metal packaging co-mingled with other dry recyclables	• Baled or briquetted aluminium cans and/or aluminium meal trays, rigid containers, aerosol cans, screw closures and caps • Baled steel drums and cans • Mixed bales with metal packaging ?	• Aluminium alloys • Low carbon steel ? ?

Ghent	Berlin	Tubbergen	Parma	Rennes

Highlights

- In all cases different metals used for packaging are collected together, even co-mingled with other waste fractions with different characteristics (like plastic waste and drinking cartons) as these fractions are easy to separate;
- The differentiating characteristics of metals (both packaging and non-packaging) allows an easy and robust sorting, and therefore they are collected together;

2.4 Conclusions

The meta-analysis per waste fraction allows detecting eventual similarities or discrepancies between the cases. The main conclusions from this meta-analysis are:

- For all PPW waste fractions, clear end applications requiring a high value recycling have been detected in the analysis of the case studies;
- A significant fragmented collection scope has been observed for glass waste and plastic waste;
- In the 5 cases light packaging (plastic, metal, drink cartons) is collected together; collecting these easily sortable fractions together does not or hardly seem to influence the quality of the collected fractions, while there is definitely an economic benefit;
- The level of service provided to citizens, including the collection system and frequency, is extremely divers. Even within the same city, different collection systems can be applied for one waste stream as the waste collection is often tailored to the needs of specific areas within the city (e.g. multi-family houses versus detached houses). It was found that four waste packaging streams (glass, plastics, metal and cardboard) are collected employing 29 collection methods (different points of collection and combinations of them), resulting in 16 different waste material combinations of different levels of impurities and co-mingled with different other waste stream, to be sorted in 12 different material flows. These numbers illustrate how difficult it is to come to conclusions on the performance of European collection systems, and to provide estimates on how much irrecoverable quality losses occur on the way and at which point, and how much of each material is recovered and reused in new applications.
- 135 paper & packaging waste systems were analysed, that pretend to 'separately' collect the very same packaging products and materials, within an EU-wide regulatory framework, in a global materials market, but with different scopes, objectives and drivers, operating in different contexts. Such approach results inevitably in highly fragmented value chains derived from the collected waste, that often are disconnected from consumers and local authorities
- Often, collection practices do not link with material value chain drivers. This makes their optimization towards obtaining higher material values challenging and waste push based. On the other hand, the difficulty of pushing collection practices towards higher quality secondary raw materials, might result in calls for minimum recycled content regulations, attempting to enforce the use of substandard quality recycled materials.
- Waste collection ('urban mining') as sourcing practice for secondary materials presents analogies with mining and quarrying operations for primary materials: they are often resource and cost intensive, with the corresponding environmental impacts.
- Not many waste collection systems seem to have taken into account yield-versus-purity trade-offs in their design. Citizens and authorities believe that technology will solve most, if not all, material quality challenges.
- Consumers and local authorities seem to have high expectations on the value of recycled materials. In practice however, household waste management always comes with a cost, that can be compensated only partly by revenues from the obtained secondary materials.
- When researching specific information on the actors and eventual quality requirements at different steps of the recycling value chain, the organisation of the waste collection itself proved to be an essential parameter. The case studies analysis highlights that the organisation of waste collection is more and more being outsourced, either through public-private partnerships or through public authorities subcontracting private companies that might be horizontally integrated, so taking care of sorting and recycling as well;
- Changing or adapting waste collection habits needs a long term and case-specific approach: the role of citizens in waste collection is key, so their cooperation should be guaranteed at all times.

Sometimes this might lead to areas where the waste collection itself is suboptimal in the perspective of the subsequent sorting and recycling, but the benefits for further optimisation do not outweigh the risks of losing the involvement of citizens;
- When benchmarking urban mining (secondary materials) against geological mining (primary materials), it becomes clear that, seen the fragmented scope and the diverse methods applied for collecting the waste fractions, the current extraction of secondary materials from the urban mine is far way more complex and divers.

The analysis of the individual case studies allows to identify several systemic or technical solutions that have been applied with respect to the waste collection to improve the recycling value chain. These solutions and their link to the boundary conditions (supply, quality and traceability, as in D2.2[19]) are:

- Collect easily sortable waste fractions together; this allows to reduce the costs for collection, without losing out on quality of the collected waste fractions;
- Limit the number of collected secondary materials in the scope of the collection (do's and don'ts); this allows to collect more homogeneous waste fractions, making them more suitable for high value recycling;
- Make sure that the configuration of the waste collection, sorting and recycling are adapted/aligned to each other; this will allow the recycling value chain to produce qualitative secondary materials in an efficient way, and can be done by:
    - Making clear agreements on the scope of the waste collection (do's and don'ts);
    - Securing transfer of relevant information between consecutive treatment steps such as collection, sorting and recycling, regardless if the responsible organization is the municipality, a private company or a PRO;
    - Creating clarity on standardized specifications for collection outputs, sorting outputs and recycling outputs, and harmonize them;
- Broaden collection scope from packaging waste to similar non-packaging waste fractions, resulting in a higher supply of collected waste;
- Collection in transparent recipients allows visual quality check during collection;
- Adapt the waste collection system to the local conditions (such as dominant type of housing).

In order to set up a waste collection and recycling framework that responds to a materials market pull approach, the following steps might be considered:

- Define what would for you constitute a successful system;
- Decide the EoL products' **scope** of your collection;
- Check for **existing experiences** in other cities (successful and failed);
- Build your own collection – sorting – recycling chain: check possible **pathways and available players;**
- Explore your potential **market** for collected, sorted, recycled material outputs;
- Look for opportunities for **collaboration** with neighbouring municipalities and **upscaling;**
- **Monitor** your results and **share** them with the world in order to generate confidence in your actions!

[19] https://www.collectors2020.eu/wp-content/uploads/2019/06/COLLECTORS_D2.2_Analysis-of-boundary-conditions.pdf

3. Waste of Electric and Electronic Equipment

3.1 Structure of the analysis of the case studies

The data and information necessary to analyse the case studies were collected through intensive contacts with local representatives for each of the case studies. Based on detailed questionnaires and follow-up contacts via e-mail and phone, relevant information on the waste recycling system and specifically on the waste collection system was gathered. Where required, this information was complemented with desk research of available information in relevant literature and reports.

The analysis of the case studies has the following structure for each case:

- Flow Scheme;
- Case Study Background;
- Circular Economy (CE) Analysis;

Additionally, conclusions for all cases studies are provided. Because of the lack of specific economic data both for the WEEE cases and for WEEE management in the EU in general, an alternative approach than the one applied for the PPW cases (and as described in Deliverable 2.2) is used to analyse the WEEE cases.

The European Directive 2012/19/EU changed the categorisation of WEEE from into 6 categories for which collected quantities are to be reported:

1. Temperature exchange equipment
2. Screens and Monitors
3. Lamps
4. Large equipment
5. Small equipment
6. Small IT and telecommunications equipment

Due to its increasing potential for recovery of valuable materials and their rapid increase in numbers, this report focusses on the following 3 streams: Lamps, Small equipment and Small IT and telecommunications equipment (henceforth: small IT). These streams were chosen due to their similar challenges at collection level. The three streams can be characterized by their small size, which makes it easy to dispose e.g. a lamp, cable, or an old mobile phone in the residual waste. In addition, it is known that many appliances within these streams are kept at home or exit countries via illegal export routes and are not being reported to the official registers.

Furthermore, small IT is an interesting and fast-growing waste stream containing valuable secondary raw materials, small household equipment represents a significant part of the household waste stream and largely overlaps with IT (more and more appliances become ‘smart’) therefore also containing valuable SRM’s, and for Lamps there is large room for improving collection (average EU collection of 40%).

Flow scheme

For each of the selected cases, an overview of the waste collection and subsequent treatment steps is presented in the format of a flow scheme.

The flow scheme covers three selected separately collected WEEE fractions, as described above. The flow scheme not only shows the waste generation and collection, but also the subsequent treatment steps, such as sorting and recycling, and any logistical steps (e.g. transport, storage).

Based on the flow scheme some specific highlights as well as the way the collection is organized are described for each case, e.g. the involved organisations and their relation.

Case Study Background

For each of the selected case studies, a description of the case including the regional characteristics (e.g. GDP, number of tourists) and the organisation of the local waste collection system is provided.

Circular Economy Analysis

For the circular economy analysis, we performed a delta analysis meaning that the performance of the WEEE collection system is compared for two points in time. Specific 'good practice actions' which were performed by the producer responsibility organization (PRO) in the case study and which resulted in increased WEEE collection quantity and quality were identified and analysed, such as transport optimization, increased pickup frequency, increased coverage of collection points, additional awareness campaigns, etc.

Specifically for the CE analysis, we answer questions like 'What changes were introduced to improve WEEE collection and how did it impact the collected quantities and quality?', 'Do these changes also provide a better service e.g. frequency or convenience or diversified collection points?', 'Did the changes in the collection mode allow to capture additional quantities, e.g. separate collection of phones? ' and 'Were new and innovative awareness raising and education campaigns introduced?'.

Based on these questions we then draw conclusions on a) how these measures relate to the specific boundary conditions in each case study, i.e. with respect to population density, urban vs remote areas, GDP per inhabitant and b) what measures rather targeted / resulted in increased quality, traceability and a more constant waste supply.

3.2 Results of the analysis of the cases

3.2.1 The county of Pembrokeshire

Flow scheme

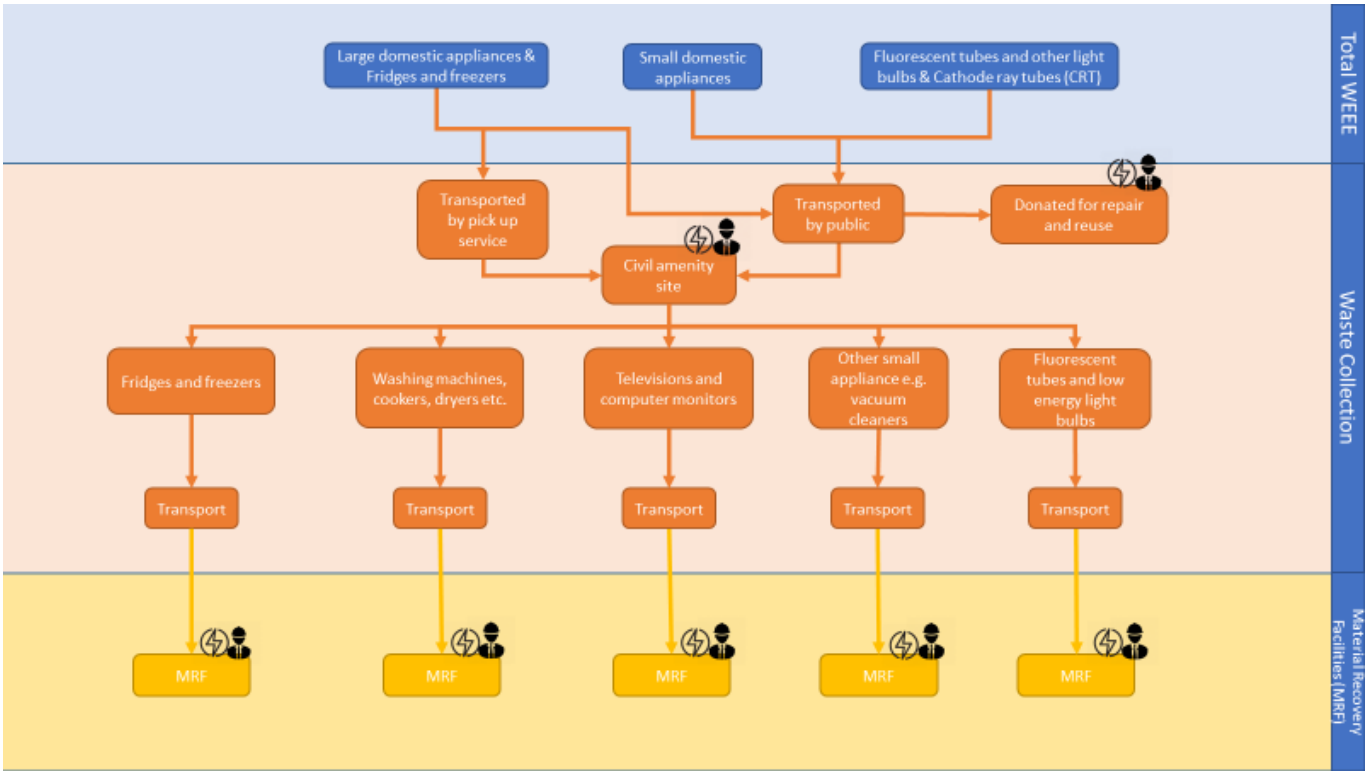

Figure 19: Flow scheme for waste collection in Pembrokeshire

Highlights (based on Figure 19):

- 6 civic amenity sites (CAS) serve as bring points, with 1 CAS covering 20,800 inhabitants in average
- Retail stores can serve as bring points, but have the possibility to opt out and have therefore no major role in the system
- No WEEE collection from home

Case Study Background

Pembrokeshire is a coastal county in the south-west of Wales and therefore part of the UK, with around 125.000 citizens living on 1,590 km^2, i.e. 79 inhabitants per km^2. In Wales the GDP per capita amounted to £19,002 (2015)[20].

The industry is focused on agriculture, oil and gas, and tourism. Many of Pembrokeshire's beaches have won awards and in 2015 4.3 million tourists visited the county, staying for an average of 5.24 days.

[20] Source: https://www.pembrokeshire.gov.uk/performance-and-statistics/data-and-statistics). So both the population density and GDP are low.

With respect to WEEE, the WEEE directive 2012/19/EU of 2012 applies to the whole of the UK implemented by UK wide regulations[21]. Wales, however, has devolved powers with respect to municipal waste management and has its own waste management plan as described under the Waste Framework Directive.[22]

The WEEE directive's main concerns was the introduction of the "Producer Responsibility" principle, obliging producers (importers, producers, retailers) to have a collection rate of 85% (based on the average of EEE POM of last few 3 years) or 65% of actual put on market that year by 2025. Also, they are to be financially responsible at least for the transport of WEEE from the communal collection points to the sorting facilities.

The collection of WEEE in Pembrokeshire, in contrast to a common approach elsewhere in Europe, is not organized via a PRO in a way that the electronics are collected from households directly. REPIC is the only contracted PRO for the region and is in charge of bringing the waste from collection point to material recovery plant. Residents are expected and encouraged to bring their potential electronic waste to one of 6 CAS, with one CAS covering 20,833 inhabitants in average. Retail stores can serve as bring points, but have the possibility to opt out and have therefore no major role in the system. Some CAS offer repair or second-hand shops where certain products can be fixed and resold, or donated to a charitable organization.

The Welsh 'Towards Zero Waste' strategy aiming at all waste being reused or recycled with no landfill or incineration by 2050. A report titled 'Preparing for re-use: A roadmap for a paradigm shift', recommends introducing a national reuse target within the wider recycling target, in order to drive activity up the waste hierarchy away from disposal and establishing national reuse hubs and collection points.[23]

Circular economy analysis

The collection rate of small WEEE/IT electronics and lighting has increased in the last couple of years by more than 30%, as shown in Table 3 and Figure 20. The WEEE is in most cases considered as waste and recycled, however, when possible it is refurbished and reused.

It is believed that the improvements made during this time can be attributed to investments into school education programs and research and development funding as well as local public awareness campaigns run by REPIC. These programs have been established in cooperation with the Waste and Resources Action Program (WRAP), a charity organization dedicated to improving circular economy[24] [25]. In July 2018, "Green Shed" reuse centres opened; whilst it is unclear if these centres made an impact to the results over the time frame, it is thought that these should increase collection rate of small WEEE, IT & lamps in the coming years.

Table 3: WEEE collected in Pembrokeshire between 2012 – 2018 (own data from questionnaire)

	Amount collected 2012 -2013	Amount collected 2017 - 2018	Absolute increase 2012 - 2018
Small household appliances & IT			
[t/a]	399	537	+17%
[kg/cap/a]	3.2	4.3	
Capture rate (waste generated / waste collected)	32%	40%	
Lamps			

[21] https://www.gov.uk/guidance/regulations-waste-electrical-and-electronic-equipment
[22] https://gov.wales/sites/default/files/publications/2019-05/towards-zero-waste-our-waste-strategy.pdf
[23] https://resource.co/article/reuse-next-step-welsh-zero-waste-strategy-12745
[24] https://myrecyclingwales.org.uk/local_authorities/pembrokeshire/WEEE
[25] http://www.wrap.org.uk/

[t/a] [kg/cap/a] Capture rate (waste generated / waste collected)	3 0.24 12%	4 0.32 30%	+ 33%

Figure 20: WEEE collection data Pembrokeshire

One of the main goals of these campaigns is to make the fate of waste as transparent as possible to the general public. As shown on myrecyclingwales.org.uk WEEE collected in Pembrokeshire, is processed mainly in Wales (63 %) and England (37 %)[26]. In Newport, Gwent, for instance, a state-of-the-art recycling facility was opened in 2009 for 12 million pounds (11 million euro). It has the capacity to recycle 100,000 ton of appliances a year and is home of the then biggest refrigerator recycling plant in the world.

Summary

Although WEEE is only collected at 6 CAS serving as bring points and there is no direct collection from home, the capture rate for small WEEE & IT has increased from 32 % to 40 % and for lamps from 12 % to 30% between 2012 and 2018. This is mainly due to the building of new reuse centres, school education programs and research and development funding as well as extensive campaigns in cooperation with charity organizations to create public awareness and to promote waste diversion strategies, such as preparation for reuse.

[26] https://myrecyclingwales.org.uk/local_authorities/pembrokeshire

3.2.2 The Helsinki Capital Region

Flow scheme

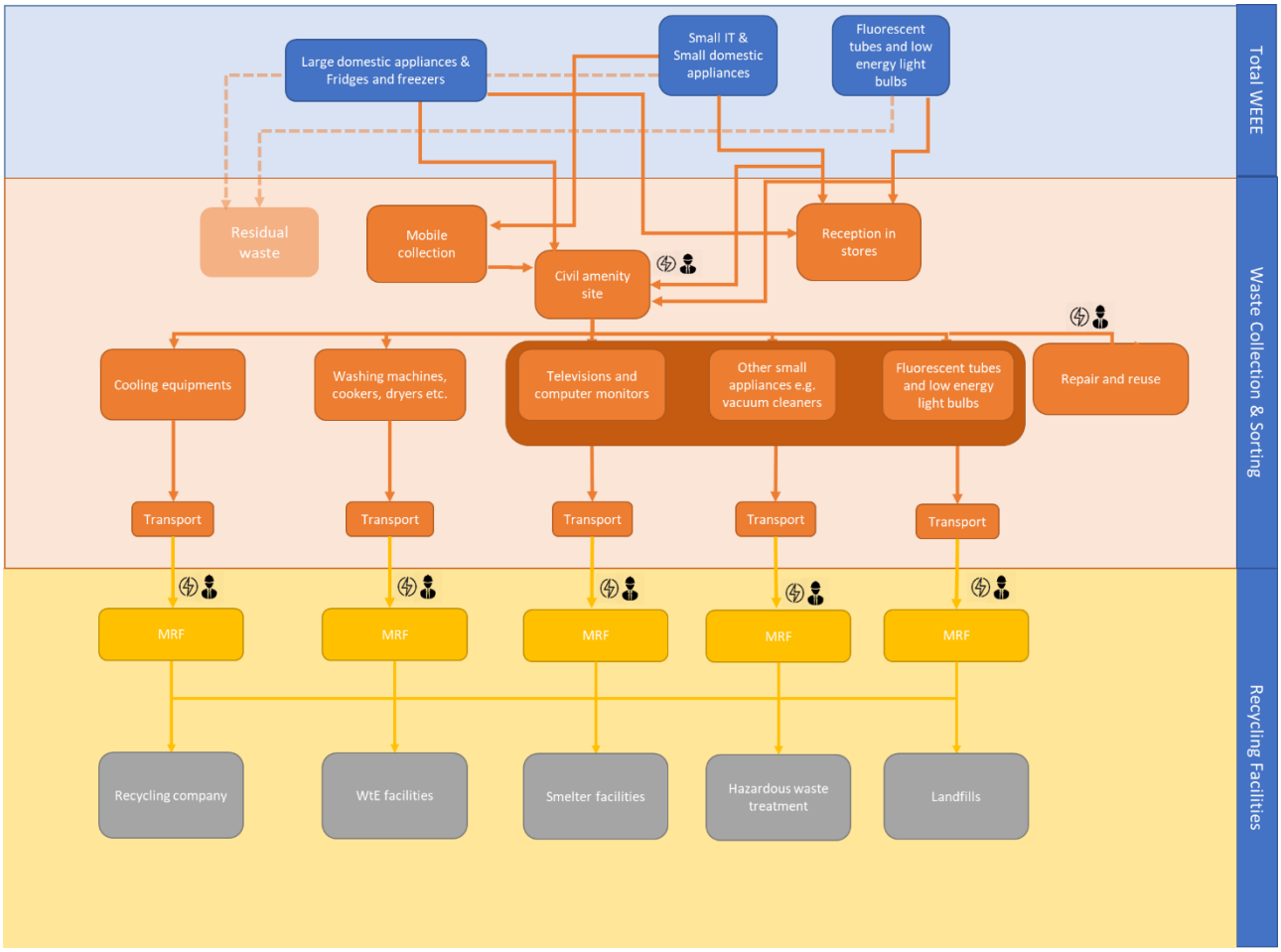

Figure 21: Flow scheme for waste collection in Helsinki Capital Region

Highlights (based on Figure 21):

- Over 2000 retail bring points all over Finland received 68 wt. % of all collected WEEE
- Permanent collection points, mainly civic amenity sites, account for 31 wt. % of all collected WEEE
- Semi-annual mobile collection to account for long distances and low quantities of returned devices (about 1 wt. % of all collected WEEE)
- 1 bring point covers 2,445 inhabitants in average

Case Study Background

Finland has 5.43 million inhabitants with an average population density of less than 18 inhabitants/km^2. The distance between the southernmost to the northernmost points of Finland is almost 1200 km. Most Finns live in the southern and western parts of the country. The most populous area is the Helsinki Capital Region including the cities of Helsinki, Espoo, Vantaa and Kauniainen and Kirkkonummi in the southern coast, with about 1.2 million inhabitants in total covering 1157 km^2, i.e.1037 inhabitants / km^2. 79 % of the population lives in multi-family houses, 21 % in (semi)detached houses. The average household size is 1.9 person. The GDP amounts to 50,741 EUR / cap[27].

[27] HSY (2017) Jätehuollon vuositilasto 2017; https://www.hsy.fi/sites/Esitteet/EsitteetKatalogi/Jatehuollon_vuositilasto_2017.pdf

To fulfil the requirements set in the WEEE Directive, a recovery infrastructure needed to be built in Finland after 2003. In Finland, most electronic devices sold on the market are imported. Most of the representatives of foreign and domestic producers have transferred responsibility for discarded electronics to producers' associations.

At the moment, there are five producers' associations providing centralized services to manage practical affairs related to the obligations set out in the WEEE Directive and to fulfil the corresponding obligations of Finnish legislation, as shown Table 4.

Table 4: Overview of WEEE collection in Helsinki Capital Region[28]

Legislation	Directive 2002/96/EC implemented in 2004, no exemptions. Finnish Waste Act revised in 2011 and amended in 2014 to comply with the Directive 2012/19/EU
Financing method	Recycling fee included in the EEE prices
Launch of the separate collection	2004, in consequence of the WEEE Directive
Operators	5 producer associations (i) FLIP ry, (ii) ICT-tuottajaosuuskunta, (iii) SELT ry, (iv) SERTY ry, (v) ERP Finland ry (Elker Ltd. is founded by Flip, ICT and SELT).
Total WEEE collected (2018)	13250 t (11.2 kg / cap)
Total WEEE collection rate (2018)	52 %

In Finland, the collection of WEEE is arranged mainly as a permanent collection; in 2011, approximately 450 collection points existed around the country. Permanent collection points are, in most cases collectively financed by the producer associations, provided by the municipality and, in some cases, by private companies or social enterprises. Private users and households can bring their end-of-life products to the collection points free of charge.

However, permanent collection systems are not always adapted to the local needs and context, due to e.g. long distances and low quantities of returned devices. Therefore, WEEE collection in Finland is also organized as a mobile collection in the 50 smallest or least populous municipalities. In Helsinki Capital Region, mobile collection of small WEEE is organized twice a year, in addition to the permanent bring points and civic amenity site (CAS). While one round is organized by the regional waste management company HSY, the other

HSY(2017) Vuosikertomus 2016;
HSY (2016) Pääkaupunkiseudun seka- ja biojätteen koostumus

[28] Ylä-Mella, J., Poikela, K., Lehtinen, U., Tanskanen, P., Román, E., Keiski, R. L., & Pongrácz, E. (2014). Overview of the WEEE Directive and its implementation in the Nordic countries: national realisations and best practices. Journal of Waste Management, 2014.

one is organized by the regional recycling centre (Kierrätyskeskus). The recycling centre collects only functional devices (169 tons/a).

In addition, the amounts of WEEE received in retail stores have also increased. Since 2007, the overall WEEE collection rate in Finland has exceeded 9 kg/inhab./year ranking third best in the European Union. The transportation of WEEE from reception points and registered stores to the regional treatment plants is managed by the producer associations. The logistics services are typically sourced from private regional operators. At the collection points, the WEEE is divided into four different fractions with lamps and batteries being collected separately: COOLS, large domestic appliances (LDA), small domestic appliances (SDA) (WEE 4-10, WEEE 5 separately) and IT (WEEE 3 separately). All kind of lamps are collected separately of other SDA by FLIP Association, a producer organization responsible for the producer responsibility of lamps falling within the scope of the WEEE directive.

At the regional sorting plants, WEEE is separated based on brands (all devices from the same brand together rather than all devices from the same product category), not on product categories or source, for different product cooperatives, weighed, and sorted into reusable and not reusable fractions. Functional devices are manually separated and directed for preparation for re-use. The rest of the WEEE is sorted out according to WEEE categories and is pre-treated before sending to the various treatment plants for final treatment. The companies offering sorting and dismantling services to producers' associations are typically social economy enterprises, but a few private companies also exist in the field. Some of the dismantling and pre-treatment plants provide also final treatment services for particular WEEE fractions; however, most of the sorted and pre-treated WEEE is forwarded to detached recovery and/or final treatment plants located mainly in Finland. While all WEEE of a certain producer is treated at the same pre-treatment stations, they are all sent to the same final recycling plants [29].

Circular Economy Analysis

The main challenges of WEEE collection in Helsinki Capital Region related to the size of permanent collection points. In the smallest reception points, the physical space for collection cages is limited and the amounts of returned devices low. Therefore, mobile collection and retail stores as WEEE bring points have been introduced in 2013. The increase in collected quantities is shown in Table 5 and Figure 22.

[29] Ylä-Mella et al., 2014

Table 5: WEEE collected in Helsinki before and after 2013[30]

	Amount collected 2011	Amount collected 2015	Absolute increase 2011 - 2015
Lamps			
[t/a]	47	63	+26 %
[kg/cap/a]	0.04	0.054	
Capture rate (waste generated / waste collected)	18 %	23 %	
Small WEEE			
[t/a]	2136	2625	+ 23 %
[kg/cap/a]	1.9	2.379	
Capture rate (waste generated / waste collected)	36 %	41 %	
IT			
[t/a]	752	1113	+ 48 %
[kg/cap/a]	0.7	1.009	
Capture rate (waste generated / waste collected)	42 %	61 %	

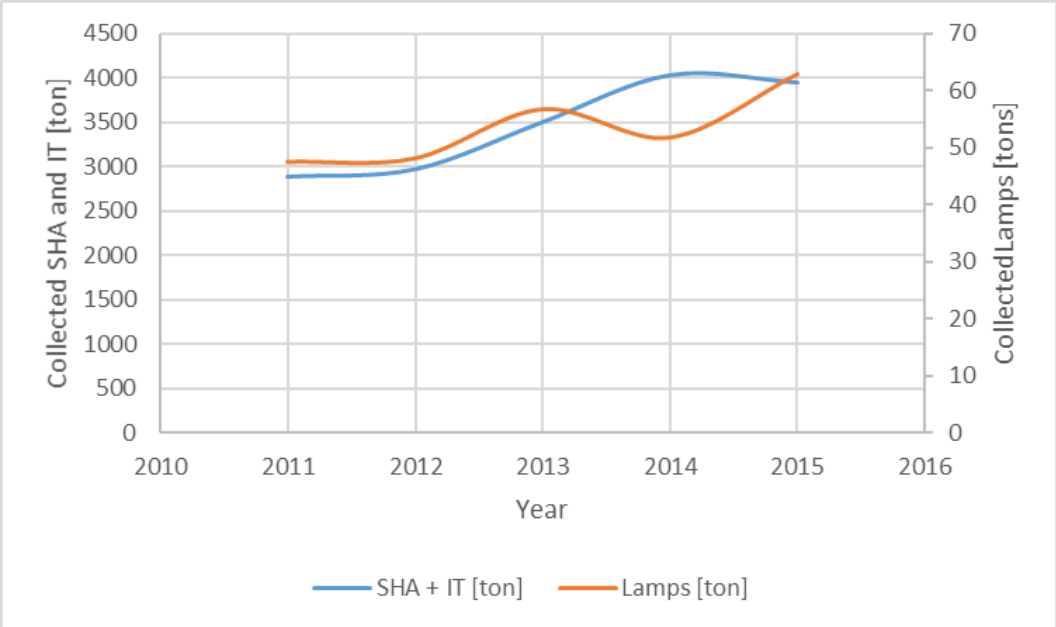

Figure 22: WEEE collection quantities Helsinki

The municipality of Helsinki reported to have collected an estimated 2136 tonnes and 2625 tonnes of small WEEE in 2011 and 2015 respectively, meaning that the capture rate for small WEEE increased from 36% to 41% in this timeframe. An estimated 752 tonnes and 1113 tonnes of IT equipment were collected in these years with a capture rate of 42% and 61% respectively. An estimated 47 tonnes and 63 tonnes of lamps were

[30] Weight of Collected and reported EEE in Finland, http://www.urbanmineplatform.eu/wasteflows/eee/weightpercolcat, accessed on 05.07.2019.

collected in these years with a capture rate of 18% and 23% respectively. Of the WEEE that is not collected by a designated WCS, 71% of WEEE has an unknown fate[31].

The use of retailers' take-back option has been very limited in Finland. However, in accordance with the Directive 2012/19/EU, the retailer take-back option has been extended throughout Finland. Since May 1st, 2013, EOL EEE devices can also be returned to the retailers in association with buying a new, corresponding device, to the store the new device is bought at.

Since May 1, 2013, small WEEE including lighting equipment (all dimensions no more than 25 cm) can be also returned with no purchase obligation to electronics shops with area larger than 200 m^2 or to grocery shops of 1000 m^2 minimum. Additionally, fluorescent lamps and LEDs as well as portable batteries and accumulators can also be returned to the retail shops with no purchasing obligations.

There are no exact guidelines on the implementation of in-store reception, however, shops are required to finance and organise the place, the requisites, and the work contributions needed to receive WEEE[32]. Distributors may forward the received WEEE to the reception points of official collection network by themselves or, alternatively, they may enrol in a distributors register to obtain free unloading services financed by producers' associations.

While at the CAS 4126 t of WEEE (3.5 kg/cap) are collected 8957 t of WEEE (7.6 kg/cap) are collected at the over 2000 retail bring points. Another reason for the increased collection quantities is the improved reporting and reporting accuracy thanks to new treatment operators.

Summary

Helsinki Capital Region is a coastal area with a relatively low population density. There are 5 PROs operating in the area, organizing the transportation of WEEE from reception points and registered stores to the regional treatment plants. At the regional sorting plants, WEEE is separated based on brands, not on product categories or source, for different product cooperatives. This time and resource intensive system, however, does not seem to have a positive impact on the recyclable outputs, as it mainly serves the purpose of providing data on collected quantities for enhanced reporting, but in the end all WEEE ends up mixed in the same recycling facilities. The majority of WEEE is treated in Finland.

WEEE is collected at 450 (in 2011) permanent collection points, mainly at civic amenity sites, accounting for 31 wt. % of all collected WEEE. To account for long distances and low quantities of returned devices a semi-annual mobile collection is organized. When retail stores were introduced as bring points in 2013, the collected quantities of WEEE increased significantly, which is probably due to the fact that it became more convenient for people to bring back their obsolete electronic devices. Today there are over 2000 retail stores all over Finland, where 68 wt. % of WEEE is collected. Counting only the 450 CAS and about 2000 retail bring points, results in one collection point covering 2,245 inhabitants in average.

Both the increased density of collection network as well as the diversification of collection points resulted in an absolute increase in collection of 26 % for lamps, of 23 % for small WEEE and even 48 % of IT between 2011 and 2015. The capture rates have increased from 18% to 23 % for lamps, from 26% to 41 % for small WEEE and from 42% to 61% for IT.

[31] Platform, 2018
[32] Ylä-Mella et al., 2014

3.2.3 The city of Vienna

Flow scheme

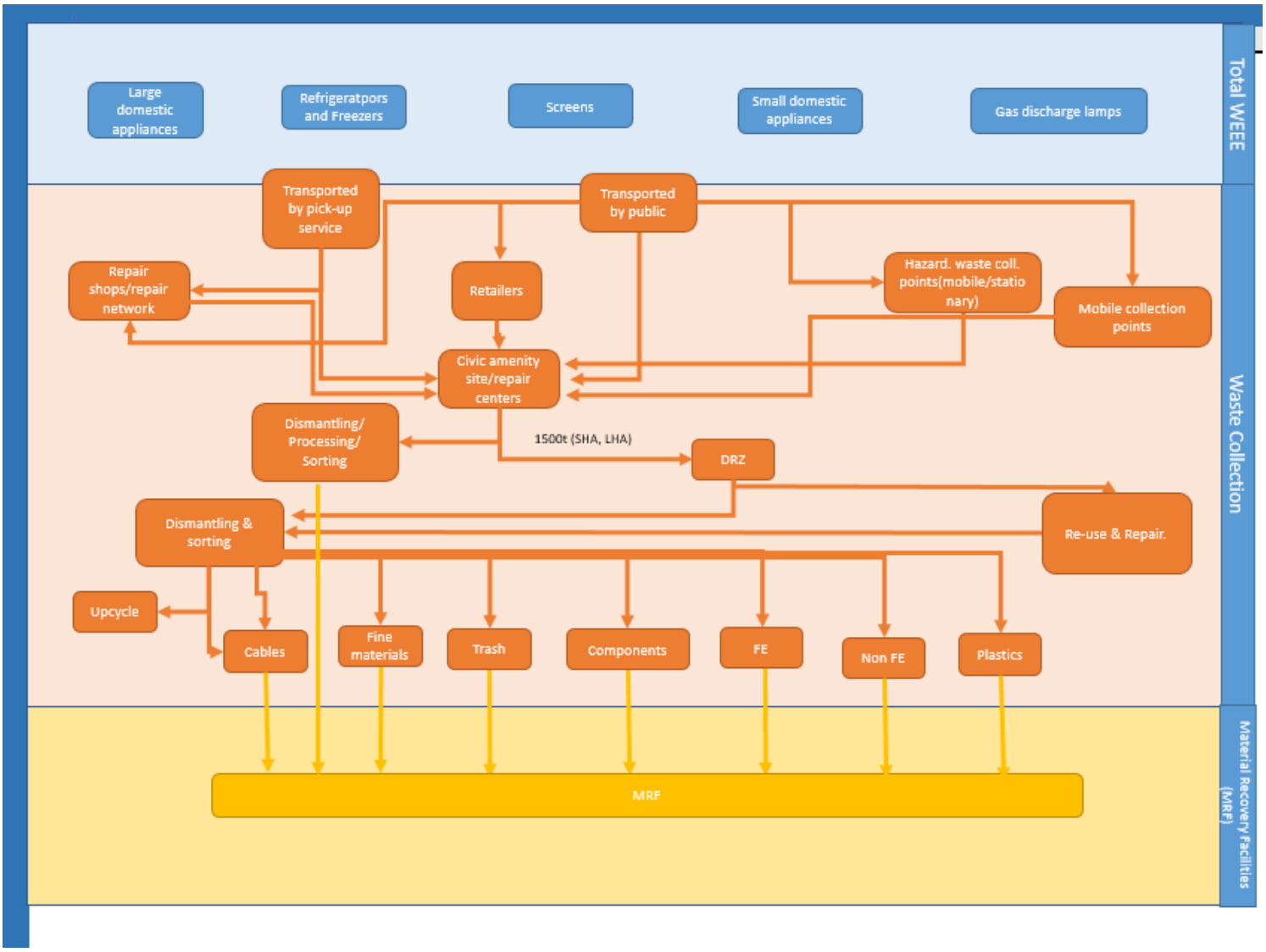

Figure 23: Flow scheme for WEEE collection in Vienna

Highlights (based on Figure 23):

- 16 civic amenity sites (CAS) serve as bring points, with 1 CAS covering 117,000 inhabitants in average;
- In total there are 2100 collection points all over Austria, 1 bring point covers 4,180 inhabitants in average;
- 1500 t of WEEE went to a social recycling centre for preparation for reuse, and 150 t were sold in re-use-shops.

Case Study Background

Vienna, being the capital of Austria, covers 414.87 km^2 and has 1.87 million inhabitants (2017) with an average population density of 4502 inhabitants /km^2 [33]. 40 % of the population lives in multi-family houses, 60 % in (semi)detached houses[34]. The average household size is 2.06 persons. The GDP in 2017 amounted to 47,700 EUR / cap[35].

In Austria, around 80,000 tonnes of WEEE are collected every year; the ARA service group[36] (specifically, the ERA="Elektroaltgeräte- Koordinierungsstelle" compliance service) accounts for 40 % of this amount. Every Austrian resident collects around 9.5 kg of WEEE per year. This collection rate is mainly due to the high collection point density. There are over 2100 collection points spread out over the country where WEEE and used batteries can be deposited free of charge. ERA provides 100 such points. In addition, people can also return WEEE to retailers/distributors when they purchase a new, equivalent device which fulfils the same functions as the old one, provided that the shop's sales area is greater than or equal to 150 m^2. Batteries can always be returned to vendors free of charge without a need of purchase [37].

Vienna alone has 16 recycling-centres (Mistplätze), 93 mobile collection points and 4 stationary collection points on markets, plus the retail collection points.[38] Separate WEEE collection is divided among 4 PROs operating in the entire country (ERA, UFH, ERP and ISA). 3 WEEE categories are collected in containers:

- 30 m^3 containers (small WEEE);
- lattice boxes (IT-monitors / display devices);
- 240l bins (gas-discharge lamps; w/ 120l bag, if broken).

In Vienna, specific attention is given to reuse of EEE, before it becomes WEEE. In recent years there has been a significant increase in the reuse and recycling of electrical and electronic appliances in particular. Based on the Directive on waste electrical and electronic equipment (WEEE) 2012/19/EU, the reuse of WEEE is a high priority in legal terms.

To facilitate the reuse practice, Austria has a dedicated reuse network, RepaNet. Together with the City of Vienna (MA48) and the ReparaturNetzwerk Wien, RepaNet works on the establishment of a reliable Vienna wide network, in which reusable devices will be categorized separately, tested and get repaired to be sold as high quality second-hand products. The DRZ (Dismantling and Recycling Centre) is one of Vienna's biggest reuse centres. Annually, the DRZ processes 1,500 tons of electrical equipment (mainly large, small and IT appliances), of which they manage to reuse and sell 150 tons[39]. As can be seen in the figure below, the collection rate of Small WEEE/IT electronics and lighting has been increasing significantly in the last couple of years[40]. Of the WEEE categories considered in this report, small WEEE and IT can be collected for reuse.

[33] Stadt Wien, 2017: Wien in Zahlen 2017, https://www.wien.gv.at/statistik/pdf/wieninzahlen-2017.pdf, accessed 18.07.2018.
[34] Stadt Wien, 2015: Wien im Querschnitt der Zeit - Ergebnisse aus der Registerzählung 2011; Teil 1: Gebäude und Wohnungszählung. In: Statistik Journal 2/2015; https://www.wien.gv.at/statistik/pdf/wien-quer-sj-2-15.pdf, accessed 12.07.2018
[35] Stadt Wien 2017.
[36] https://www.ara.at/en/
[37] https://www.ara.at/en/circular-economy/weee-and-batteries/
[38] Strategische Umweltprüfung zum Wiener Abfallwirtschaftsplan (Wr. AWP) 2019-2024 und zum Wiener Abfallvermeidungsprogramm (Wr. AVP) 2019-2024
[39] Interview with DRZ, July 2019
[40] Taetigkeitsbericht EAK 2017, EAK, Coordinating entity of WEEE in Austria, https://www.eak-austria.at/presse/TB/Taetigkeitsbericht_2017.pdf

Circular Economy Analysis

Measures to improve the cost efficiency ratio include public relation schemes, restrictions to informal collection, reduction of expenses for logistics costs, and improved collection pickup coordination with partners/recyclers.

The municipality of Vienna reported to have collected an estimated 2,397 tonnes and 3,677 tonnes of small WEEE incl. IT in 2011 and 2015 respectively, meaning that the capture rate for small WEEE & IT increased from 20% to 29% in this timeframe. An estimated 89 tonnes and 159 tonnes of lamps were collected in these years with a capture rate of 33% and 55% respectively. Of the WEEE that is not collected by a designated WCS, 66% of WEEE has an unknown fate[41].

Table 6 shows an increase in collected quantities.

Table 6: WEEE collected in Vienna between 2011 and 2015 (own questionnaire)

	Amount collected 2011	Amount collected 2015	Absolute increase 2011 - 2015
Lamps			
[t/a]	94	159	+70 %
[Kg/cap/a]	0.05	0.085	
Capture rate (waste generated / waste collected)	33 %	55 %	
Small WEEE incl. IT			
[t/a]	2397	3677	+54 %
[Kg/cap/a]	1.28	1.97	
Capture rate (waste generated / waste collected)	20 %	29 %	

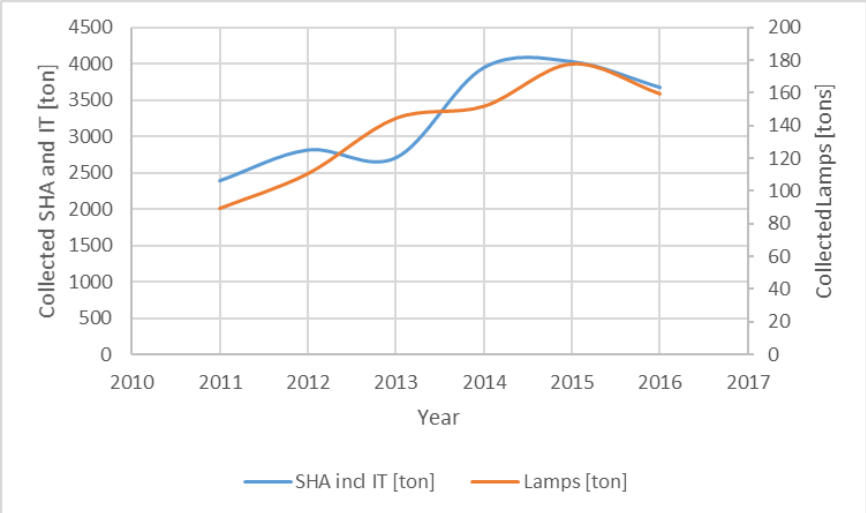

Figure 24: WEEE collection data Vienna

[41] Platform, 2018

Summary

The municipality of Vienna is an urban, non-coastal area with a relatively high population density. Several PROs operate in the city, organizing the transportation of WEEE from reception points and registered stores to the treatment plants.

There are 2100 collection points all over Austria, with 1 bring point covering 4,180 inhabitants in average. In Vienna only there a 16 CAS.

Between 2010 and 2015 the capture rates for lamps increased from 33 % to 55 %, from 20 % to 29 % for small WEEE and 57 % to 60 % for IT. This is due to constant improvements over time, such as public relation schemes, restrictions to informal collection, reduction of expenses for logistics costs, increase revenue in marketing, improved collection pickup coordination with partners/recyclers. 1500 t went to DRZ, a social recycling centre for preparation for reuse, and 337 tonnes of WEEE entered re-use-shops

3.2.4 The Cyclad serviced area, north-east of Charente-Maritime

Flow scheme

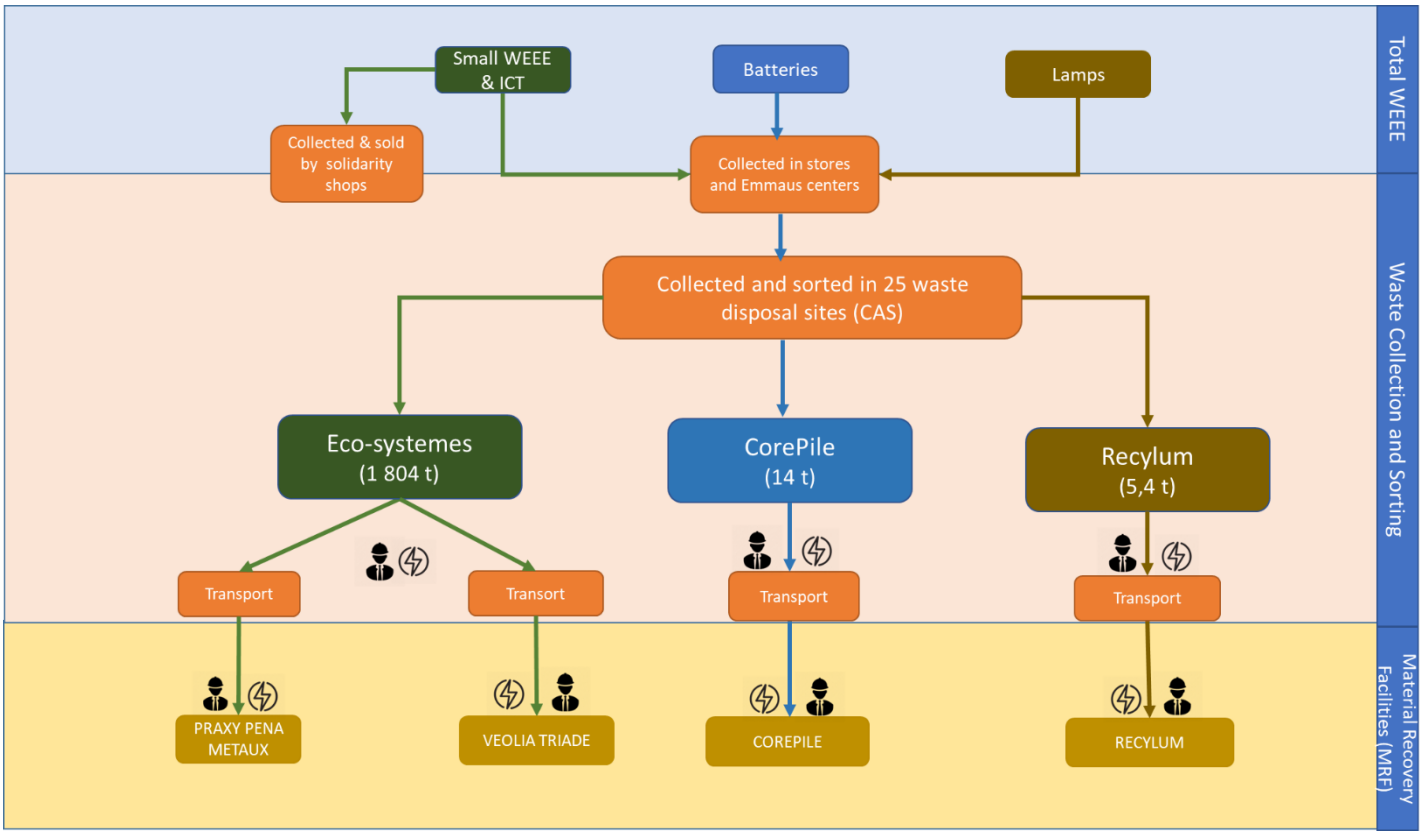

Figure 25: Flow scheme for waste collection in the Cyclad serviced area, until January 2018[42].

Highlights (based on Figure 25):

- 65 wt. % of all WEEE is collected at 25 CAS, with 1 CAS covering 5,900 inhabitants in average;
- 25 wt. % is collected in retail stores and social recycling centres;
- ecosystem is the main PRO in the region.

Case Study Background

The Cyclad Mixed Syndicate ensures the collection, treatment and recovery of waste produced by households in the region of the north-east of Charente-Maritime, in the following referred to as 'Çyclad serviced area'. It also organizes awareness campaigns for sorting and reducing waste, and is labeled "Zero Waste Territory, Zero Waste" by the Ministry of Ecology, Sustainable Development and Energy. The syndicate's formation shows the political will of a rural area to make use of synergies for an efficient waste management in a sparsely populated area. The average GDP in Charente-Maritime was 20,919 EUR / cap in 2005, being below the national average of 27,811 EUR / cap[43]. The average number of persons living in one household is 2.2 (2015)[44].

[42] As described below, in January 2018 Eco-systemes and Recylum have been merged an unified eco-organization provisionally named ESR. In October 2019 ESR has been renamed ecosystem.

[43] Produit intérieur brut en 2005 : comparaisons départementales sur http://www.insee.fr/, accessed 05.07.2019

[44] INSEE, 2015, Recensement de la population

For waste collection, treatment and final land disposal Cyclad provides services to 6 intermunicipal associations (see Figure 26), namely to the Aunis Atlantique, Aunis Sud, Vals de Saintonge, and Coeur de Saintonge, Gémozac and Saintonge Viticole, comprising 188 communes with 148,659 habitants covering an area of 2704 km^2 (55 inhabitants / km^2). Further they provide waste treatment services, but no collection, to Ile de Ré and Agglomeration of Saintes.[45]

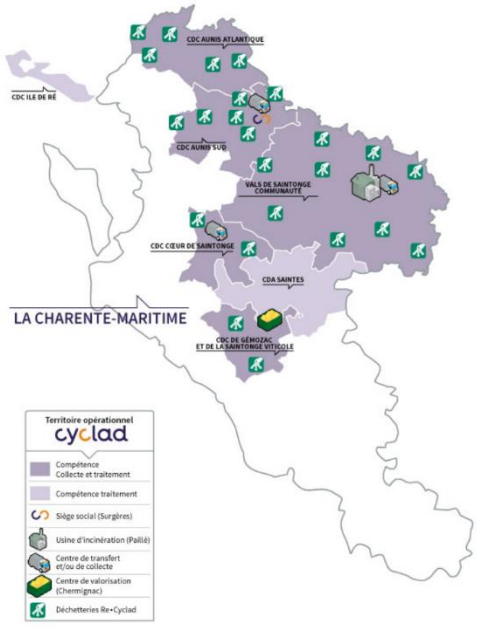

Figure 26: Cyclad serviced area

The recycling of WEEE is financed by the Eco-participation fee paid with each purchase of new equipment. Under the EU WEEE directive vendors have an obligation to recover end-of-life devices. Most communities are offering this line to their population to facilitate sorting and promote recycling. This is the case for Cyclad, offering the collection in partnership with the PRO ecosystem. Together they collect about 90% of the local WEEE and lamps. Batteries are collected separately by CorePile. At the big civic amenity sites (CAS), there are normally two containers (metallic cages or containers) for small WEEE & IT, and separate areas or sea containers for large WEEE, see Figure 27. Once they are full, Cyclad contacts ecosystem to pick it up and transport it to intermediary storage centres and recycling facilities. Since January 2018, Cyclad and Eco-systèmes merged by the name, ESR, with the interest of developing a more circular economy and promoting eco-design initiatives of member producers. Since October 2019, the name of the company is ecosystem.

Figure 27: Containers implemented at civic amenity sites in the Cyclad serviced area

[45] http://www.cyclad.org/page.php?P=11

WEEE collection in the Cyclad serviced area is also undertaken by ecosystem in cooperation with a number of retailers. When the retailers' storage space is full, they contact ecosystem to picking up the WEEE. In addition, supermarkets provide drop off points for lamps, batteries and mobile phones. There are five social economy shops in Cyclad serviced area, where people can drop off WEEE and buy second hand upcycled/recycled WEEE objects, i.e. the Emmaüs and Envie networks.

In France in 2017 Eco-systèmes collected 533,640 t of WEEE amounting to 50 % of the global amount, i.e. 10.2 kg/capita. Out of this number 6.6 kg (65 %) are collected at CAS, 1.7 kg (17 %) at supermarkets and retail stores and 0.3 kg (3%) at social reuse centres, and 1.5 kg (15 %) via other channels. In our target region in 2017 Cyclad collected 1568 t of WEEE (equivalent to 260,104 domestic appliances) in 4 categories, namely small WEEE & IT (546.8 t), screens (218.4 t), cooling devices (258.3 t) and large WEEE (544.9 t).

Circular Economy Analysis

According to representatives from both Cyclad, ecosystem and WEEE Forum, theft of WEEE was one of the biggest challenges to increase WEEE collection. In 2011 France introduced a legal ban on cash transaction for metals, to avoid WEEE leakage at borders and to include scrap dealers in the system and avoid WEEE non-compliant treatment. From 1 September 2015, operators are not allowed to collect and treat Household WEEE without having a contract with a take-back system. From 1 January 2017, operators are not allowed to collect and treat any WEEE without having a contract with a take-back system[46].

In order to protect and avoid theft of WEEE and batteries Cyclad bought containers (20ft) with special locks in cooperation with ecosystem (which is supplying and paying the leasing for 12 months before the purchase by Cyclad). In addition, Cyclad invested in video surveillance at all sites. Marking appliances with bright orange paint to make WEEE collected easier to recognize has been another mandatory effective measure promoted by ecosystem and WEEE French organization to offer an additional number of subsidies provided by the PRO to promote the securing of WEEE. Furthermore, they have a special contract with the police, who regularly checks the collection sites.

Additional measures include awareness raising campaigns to encourage people to bring back the small WEEE that people keep at home in their drawers. For a long time, there was a hoax in France that all collected WEEE was going straight to non-compliant treatment location and also to illegal export, which discouraged people to bring their WEEE to the correct collection points. Several campaigns have been launched by PRO and all the 1000 community of communes to inform the general public on the correct WEEE treatment routes in France.

All the measures together have resulted in a constant increase of collected small WEEE quantities as shown in Table 7.

The area serviced by Cyclad reported (see Table 7 and Figure 28) to have collected an estimated 433 tonnes and 547 tonnes of small WEEE and IT in 2014 and 2017 respectively, meaning that the capture rate for small WEEE increased from 36 % to 40 % in this timeframe. While in 2014 2 tonnes of lamps were collected, 3 tonnes of lamps were collected in 2017, resulting in a capture rate of 11 % and 17 %.

[46] Bill of energy transition for the green growth 2015

Table 7: WEEE collected in the Cyclad serviced area 2014 – 2017 (own data from questionnaire)

	2014	2015	2016	2017	Absolute increase 2014 – 2017
Small WEEE & IT					
[t/a]	433	478	508	547	+26%
[Kg/cap/a]	2.9	3.2	3.4	3.7	
Capture rate (waste generated / waste collected)	36%	43%	49%	40%	
Lamps					
[t/a]	2	1	2	3	+50%
[Kg/cap/a]	0.013	0.007	0.013	0.02	
Capture rate (waste generated / waste collected)	11%	9%	17%	17%	

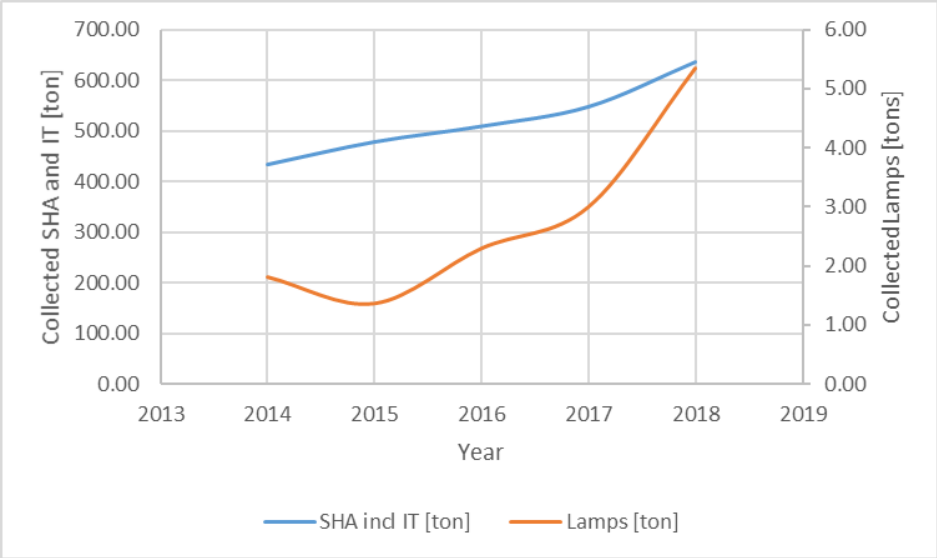

Figure 28: WEEE collection data Cyclad

Summary

The Cyclad Mixed Syndicate, together with ecosystem being the main PRO in the region, ensures the collection, treatment and recovery of WEEE in the region of the north-east of Charente-Maritime, a rural area with low population density. 65 % of all collected WEEE is received at 25 CAS, while 25 % are collected in retail stores and social recycling centres. 15 % of WEEE is collected via other channels. In order to increase WEEE collection quantities and to avoid leakage, three different measures lead to an absolute increase as well as increased capture rates between 2014 and 2017, namely 1) improved security of civic amenity sites to prevent theft (locked containers, camera surveillance and regular police checks), 2) a legal ban on cash transaction for metals and 3) campaigns against misinformation on what happens to WEEE after collection targeting the general public. Cyclad collects the highest percentage of small WEEE and IT that is generated of all the municipalities considered.

3.2.5 The city of Genova

Flow scheme

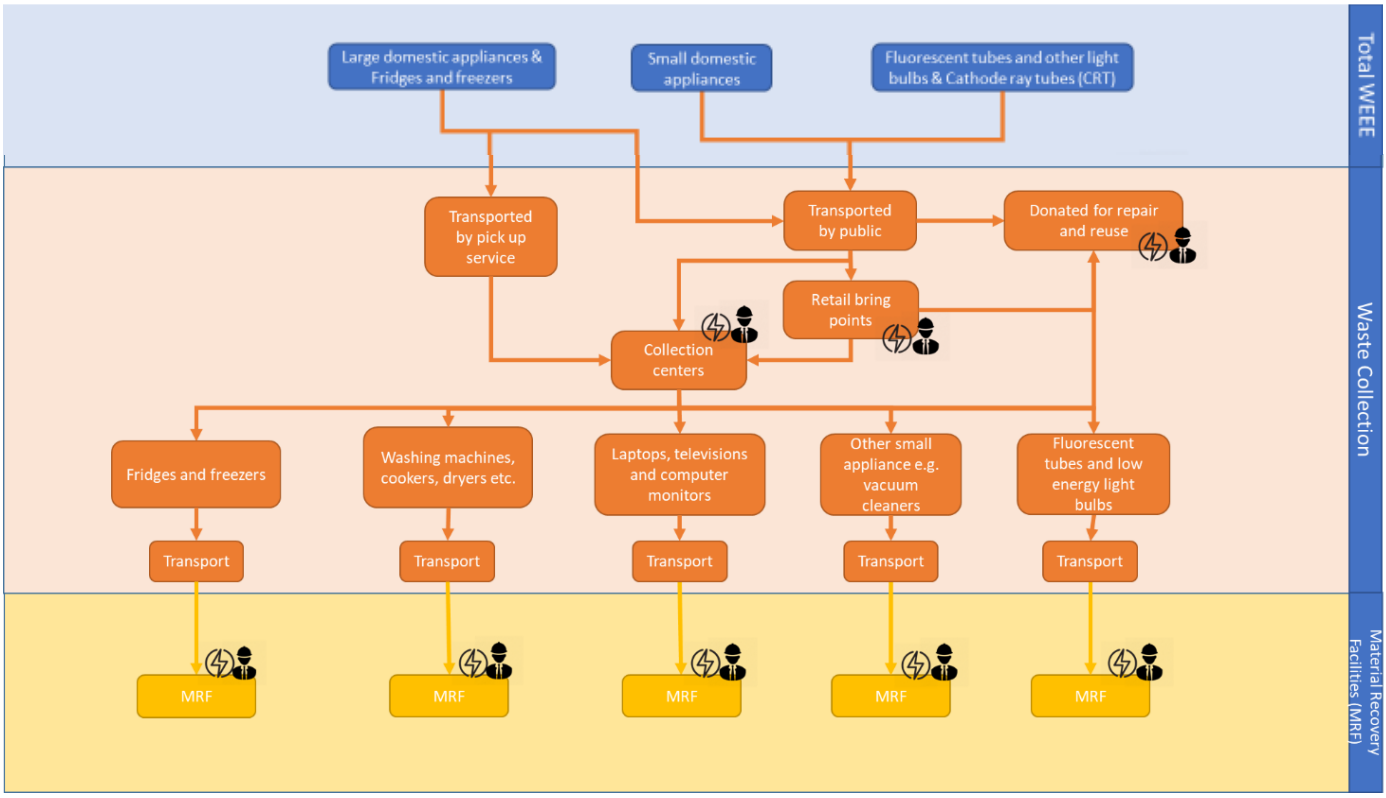

Figure 29: Flow scheme for waste collection in Genova

Highlights (based on Figure 29):

- Retail bring points received 20 % of all collected WEEE
- Permanent collection points, mainly CAS, received 80 % of all collected WEEE
- 47 new mobile collection points were introduced

Case Study Background

Genova is the capital of the Italian region Liguria and the sixth-largest city in Italy. It is located in Northern Italy on the Gulf of Genoa in the Ligurian Sea, covers 240 km^2 and has 580,097 inhabitants (2017) with an average population density of 2417 inhabitants /km^2 [47]. The GDP in 2012 amounted to 20,529 EUR / cap[48].

The Italian Ministerial Decree 31 May 2016 no.121, implementing the EU WEEE directive, stipulates that every retailer must accept WEEE free of charge under the condition that the collected device is equivalent and has the same functions as the newly purchased one. In addition, retailers with a sales area above 400

[47] Population; https://www.tuttitalia.it/liguria/45-genova/statistiche/popolazione-andamento-demografico/

[48].Rapporto URBES 2015 - Il benessere equo e sostenibile della città - GENOVA; accessed 05.07.2019https://www.istat.it/storage/urbes2015/genova.pdf, accessed 05.07.2019.

m^2 must collect small WEEE (under 25 cm) independently of purchasing a new item, acting de facto as a bring point. Retailers must, clearly and directly, inform the customer about the free collection service.[49]

Azienda Multiservizi e d'Igiene Urbana (AMIU) organizing the WEEE collection for the city of Genova is totally owned by Genova Municipality. In 2017 total 3533 t of WEEE were collected, i.e. 6.1 kg / cap. The retail bring points receive 706 t of WEEE (1.2 kg/cap), while the civic amenity sites (CAS) received 2825 t (4.9 kg/cap).[50]

Circular Economy Analysis

The WEEENMODELS project[51] was launched to provide new solutions for citizens and sector operators to make the WEEE collection system more efficient. As a result, the WEEEE collection system in Genova was completely revised: AMIU created 47 new mobile collection points for small WEEE (see Figure 30) and 4 ecological islands, i.e. collection and recycling areas, distributed all over the territory, where citizens can bring their WEEE.

Figure 30: Illustration of mobile collection point for WEEE

The mobile collection system operates daily in different parts of the city. In practice the mobile collection system operates through a system of two equipped vans (ECOVAN +, and ECOCAR) which stop at different stations at scheduled times and locations and where citizens can confer their small WEEE, including lamps. Small household equipment can be brought to the ecological islands and to the ECOVAN+. IT equipment can be brought to the ecological islands or to the ECOVAN+.

The WEEENMODELS project involved the testing of a mobile collection system of WEEE in 6 locations (all located to the western side of Genova) for 5 months (September 2015 - February 2016) to understand if citizens would appreciate such collection system. Of the 6 collection stations, 2 have received very positive results, 2 were moderately used by citizens, and other 2 were almost not used. In total 1172 kg of small WEEE were collected, out of which 377 kg could be re-used.

[49] http://www.weeenmodels.eu/allegati/Laymans%20report%20eng.pdf, accessed 15.07.2019
[50] inventory masterfile, own data.
[51] http://www.weeenmodels.eu/allegati/Laymans%20report%20eng.pdf, accessed 15.07.2019

The retailers who joined the WEEENMODELS project have a free platform, a container for collecting small WEEE, which is provided by AMIU, a low-cost collection service and the possibility to take WEEE to the AMIU Collection Centre. More than 1500 retailers and associations promoted the WEEENMODELS project.[52]

The communication campaign, carried out by AMIU, has increased awareness about the separate collection of WEEE. Online courses, workshops and laboratories were organized for students and young participants to increase their knowledge on the concept of circular economy. Moreover, a joint research projects with local universities was carried out, proving that reuse of EEE is to be preferred over recycling and recovery when it comes to environmental impacts.[53]

The measures taken within the WEEENMODELS had a positive impact also in the following years, as shown in Table 8 and Figure 31.

Table 8: WEEE collected in Genova before and after the WEEENMODELS project in 2015 (own data from questionnaire)

	Amount collected 2012	Amount collected 2016	Absolute increase 2012 – 2016
Lamps [t/a] [Kg/cap/a] Capture rate (waste generated / waste collected)	 4.5 0.008 5%	 6.9 0.01 7%	 + 38 %
Small WEEE including IT [t/a] [Kg/cap/a] Capture rate (waste generated / waste collected)	 296 0.5 9%	 493 0.85 17%	 + 67 %

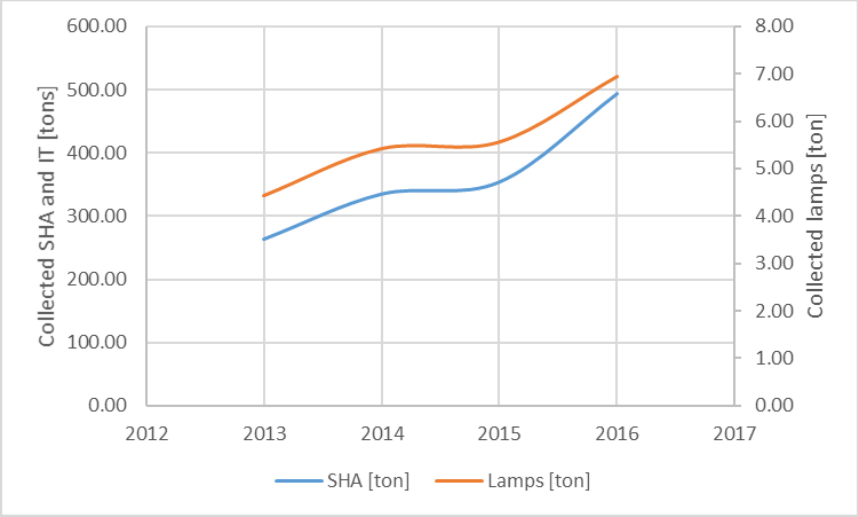

Figure 31: WEEE collection data Genova

[52] http://www.weeenmodels.eu/allegati/Laymans%20report%20eng.pdf, accessed 15.07.2019
[53] https://www.amiu.genova.it, accessed 05.07.2019

Summary

Genova is a coastal city with a high population density. Within the WEEENMODELS project the WEEEE collection system was completely revised. Introducing 47 new mobile collection points for small WEEE and 4 new permanent collection and recycling centres, improving the convenience for citizens. Moreover, campaigns and creating long-term networks between key stakeholders, such as retailers, universities, schools and the general public, improved communication and awareness. The improved coverage and convenience of collection combined with these outreach measures helped increase the amount of collected WEEE significantly.

3.2.6 Specific solutions to improve the quality of collected WEEE

Introduction

As described in section 3.1 and more specifically addressed in sections 3.2.1 to 3.2.5, specific 'good practice actions' observed from producer responsibility organizations (PRO) in the case studies and which resulted in increased WEEE collection quantities between two points in time were identified and analysed. Examples of such practices included transport optimization, increased pickup frequency, increased coverage of collection points, additional and innovative awareness campaigns, etc.

However, those analyses did not allow us to draw any conclusions on the quality of the materials due to the lack of data on the outputs of recycling plants mainly because of confidentiality issues. To complement those analyses and evaluate how and to which extent WEEE collection systems could provide specific solutions to improve the quality of the collected waste in order to enable the sorter and/or the recycler to produce better quality secondary materials, several PROs were contacted, and interviews were conducted. For conducting those interviews, a questionnaire has been developed.

Questionnaire development

In order to obtain complementary insights to the 'good practice' analysis previously performed; it was essential to first identify factors that could influence the quality of collected WEEE. Together with PROs involved in the development of this questionnaire, three factors influencing the quality of collected WEEE were identified:

- Level of scavenging (illegal removal of valuable parts, such as for example hard drives),
- Conditions of waste collection and storage (e.g. broken equipment that hinders proper treatment and depollution), and
- Presence of non-WEEE in the collection stream (considered as unwanted materials/impurities)

Considered as relevant for obtaining those complementary insights, the following questions were thus defined and addressed to PROs for understanding how and to which extent specific solutions implemented in their local context are addressing those factors. Questions establishing this questionnaire are reported in Table 9 below.

Table 9: Questionnaire developed to evaluate how and to which extent WEEE collection systems could provide specific solutions to improve the quality of the collected waste

Section	Number	Question
Background information	Q1	Could you please provide a brief description of the local context (collected tons/year, separately collected WEEE device categories, collection methods e.g. retail bring points, civic amenity sites, organisation of the collection e.g. public authorities in charge of operations…)?
Influence of the collection method	Q2	Have you noticed any quality differences (e.g. less broken lamps, less damaged screens, more reusable devices, less non-WEEE objects, etc…) between WEEE collected through different collection types/methods (e.g. retailer vs civic amenity sites)? Between WEEE collected with the same method but at different points (e.g. between two civic amenity sites)? If any, please describe which factors are affected and, according to you, what might be the causes of those variations.
	Q3	Have you implemented specific containers for those WEEE categories (i) Lamps, (ii) Small equipment and (iii) Small IT and telecommunications equipment? And/or for mobile phones? If yes, please describe the reasons which motivated this measure.
Collection for sorting	Q4	At collection points, are there any separation-at-source measures (such as training, information to users, specific containers, …) implemented for facilitating the sorting (separation-at-source might be implemented for different reasons, e.g. at some collection points devices are separated per brand or size)? Are some parts/components of WEEE removed at collection points (e.g. batteries, cords)? If yes, please describe how the quality of the WEEE improved by those measures.
Monitoring the presence of non-WEEE	Q5	Do you monitor the presence of non-WEEE in the amount of collected WEEE? Do you have quantitative information concerning their presence? Subsequently, have you implemented a system for monitoring and/or quantifying the presence of non-WEEE in the amount of WEEE collected? If yes, how are you using that quantitative information?
Monitoring scavenging	Q6	Do you monitor the scavenging level in the amount of collected WEEE? Do you have quantitative information on the scavenging level (e.g. share of devices without copper coil, share of PCs without hard disk drive)? Subsequently, have you implemented a system for monitoring, preventing and/or quantifying the scavenging level in the collected WEEE? If yes, how are you using that quantitative information?
Role of standards	Q7	Are you applying specific standards at collection points (e.g. EN 50625-4 on Collection and Logistics)? If yes, what are the drivers for doing so? If not, why?
Others	Q8	Are there any other specific solutions that you have implemented/would like to implement to improve the quality of the collected WEEE that you would like to share?

Answers overview

In addition to PROs operating in the areas of the selected case studies (Pembrokeshire, Helsinki, Vienna, Cyclad serviced area, Genova), several additional PROs operating in Europe were contacted for conducting those interviews. Interest in collaboration and answers to the questionnaire were received from Remedia (Italy), Ecodom (Italy), Ecotic (Romania), ElektroEko (Poland), Appliances Recycling SA (Greece), Electrão (Portugal), WEEE Malta (Malta), ecosystem (France). As the objective was to obtain complementary insights and not to define additional case studies, as well as for confidentiality reasons, a qualitative and generic (not respondent-specific) analysis of received answers is provided below, per defined question:

Q1 - Could you please provide a brief description of the local context (collected tons/year, separately collected WEEE device categories, collection methods e.g. retail bring points, civic amenity sites, organisation of the collection e.g. public authorities in charge of operations…)?

Those interviewees are operating in six different countries and specific local contexts. The organization of the collection and especially the role of private organisations (especially with regards to public authorities) is specific to each context. For some respondents collected quantities are mainly coming from retail bring points while for some others those quantities are mainly coming from public collection points. WEEE collected quantities per year are mostly situating in between 25,000 tons to 145,000 tons according to the respondents. One respondent collected significantly higher quantities with almost 600,000 tons of household WEEE collected in 2019.

In general, respondents are representing PROs which are hired by EEE producers for managing WEEE collection, treatment and disposal of WEEE. Usually such services are externalized, so PROs set up agreements and contracts with collection points, logistics companies and WEEE recycling facilities. Information on the performance of PROs activities (e.g. tons collected, rates of WEEE recycling and recovery, collection network etc.) is regularly sent to waste competent authorities.

Q2 - Have you noticed any quality differences (e.g. less broken lamps, less damaged screens, more reusable devices, less non-WEEE objects, etc…) between WEEE collected through different collection types/methods (e.g. retailer vs civic amenity sites)? Between WEEE collected with the same method but at different points (e.g. between two civic amenity sites)? If any, please describe which factors are affected and, according to you, what might be the causes of those variations.

All respondents reported they have noticed significant quality differences between WEEE collected through different collection methods. They all emphasized a higher quality of WEEE collected from retailers rather than WEEE collected through municipal collection points. Factors affecting this quality difference are mostly the scavenging level and the conditions of waste collection and storage: meaning that WEEE collected from municipal collection points are more damaged/broken and vandalised than those collected through retailers.

For one respondent, for which its collection network includes B2B, retailers, municipalities and scrap dealers, higher rates of non-WEEE materials are also observed in loads of scrap dealers and municipalities. Additionally, less broken lamps are found in B2B loads, in contrast with municipalities and retailers which have the highest rates of broken lamps.

Causes of those variations described by the respondents are also converging. Management of waste carried out by professionals and the surveillance are the two main mentioned causes. Several respondents precisely described that at retailers/B2B partners, the staff is trained and has a better awareness of handling waste as well as is using appropriate equipment. Those same respondents especially target the loading operations that are more accurately performed. A more limited access to the facilities and subsequently an increased surveillance (reducing thefts) at retail bring points compared to municipal collection points is the second cause provided by respondents for explaining the difference in scavenging level.

One respondent provides an additional element combining those two causes, explaining that the staff at retail bring points can be directly considered responsible in case of scavenging and in that case, the efficiency reward[54] could be not granted to the collection points due to the poor quality of collected material.

Answers from respondents are slightly more contrasted with regards to quality differences with the same method but at different points. Some indicated that they are not noticing significant differences. For some

[54] The efficiency reward refers to an economic compensation paid by PROs to those collection points that meet certain conditions (Source: https://www.cdcraee.it/DownloadPubFile.pub_do?id=2ca980a56a249010016a256637d64587)

others they have noticed the positive impact of awareness campaigns when collecting door to door, or again noticed quality differences between civic amenity sites for which the level of surveillance is disparate.

Q3 - Have you implemented specific containers for those WEEE categories (i) Lamps, (ii) Small equipment and (iii) Small IT and telecommunications equipment? And/or for mobile phones? If yes, please describe the reasons which motivated this measure.

Most respondents indicated they have implemented specific containers for (i) Lamps as well as for (ii) Small equipment including (iii) small IT and telecommunications equipment. Small equipment and small IT and telecommunications equipment are thus collected together. Containers for lamps are often made of a metallic cage and a cardboard inside. Plexiglass and/or cardboard are mostly used to collect small equipment. The reasons for implementing those specific containers are for reducing breakage but also facilitating the transport. Two respondents indicated they have implemented two specific containers for separately collecting fluorescent lamps from other lamps. Some other respondents mentioned the implementation of specific containers for toners and ink cartridges as well as for batteries already separated by citizens.

Q4 - At collection points, are there any separation-at-source measures (such as training, information to users, specific containers, …) implemented for facilitating the sorting (separation-at-source might be implemented for different reasons, e.g. at some collection points devices are separated per brand or size)? Are some parts/components of WEEE removed at collection points (e.g. batteries, cords)? If yes, please describe how the quality of the WEEE improved by those measures.

Mostly all respondents converge to say that besides specific containers implemented for separately collecting the different WEEE categories, there are no additional separation-at-source measures at collection points. One respondent for instance explains that information to citizens are visible on containers, providing images and name of waste as well as contact details of the PRO. Similarly, one respondent mentioned the implementation of posters indicating the list of concerned equipment and differentiating collection areas for each WEEE category. Some respondents indicated that the only additional measures are referring to the separation of lamps containing hazardous elements, as this is a requirement for transportation.

They explain that at municipal collection points it is not allowed to separate parts or components provided by citizens: this must be performed in an authorised treatment facility. Building on the results of a consultation activity performed within the project PolyCE[55] (the consultation aimed to investigate the possibility to organize the collection activities in clusters, namely products or component families defined taking into account material composition), a respondent details the reasons why sorting activities are extremely difficult to implement at municipal collection points level:

- *"Additional space would be required to allocate different bins (in this regard, it should be taken into account that often highly frequented collection points have a small space available and different bins will have different filling rate)*
- *Trained personnel should be dedicated for the product identification; this is related to additional costs;*
- *Municipal collection points can place a certain number of containers in an authorized space; therefore, the position of new bins would require additional authorization;*

[55] https://www.polyce-project.eu/

- *Citizens should be properly informed regarding the correct disposal of different products;*
- *Currently, it often occurs that municipal collection points (due to citizens and collection points operators' error) are not able to deliver to WEEE treatment plants material properly segregated (e.g. monitors may arrive to the WEEE treatment plant in the same container as the small domestic appliances)*"

One respondent still indicated that trainings with regards to sorting activities have been implemented for the personnel at collection points. Supervisors and regional managers indeed must provide a sorting guide to the collection's personnel as well as explain them the importance of the separation-at-source for preventing pollution effects and reducing social costs of WEEE collection. The same PRO mentions they are managing 5,000 visits of collection points per year, for training people and defining action plans to increase collection performance, frequency and implement actions to avoid theft.

Q5 - Do you monitor the presence of non-WEEE in the amount of collected WEEE? Do you have quantitative information concerning their presence? Subsequently, have you implemented a system for monitoring and/or quantifying the presence of non-WEEE in the amount of WEEE collected? If yes, how are you using that quantitative information?

Some respondents indicated they do not have implemented such monitoring system. One reason provided is that non-WEEE is not registered in their PRO system. Another respondent explained that sampling was made in WEEE collected from civic amenity sites and from specific containers for small appliances used in shopping centres. According to this sampling campaign, the amount of non-WEEE was around 5% of the total of waste collected. The same PRO explains that non-WEEE quantities are not monitored but that this 5% value is assumed.

Several respondents indicated they are qualitatively monitoring (while not so frequently for some) the presence of non-WEEE. Non-WEEE are classified (e.g. gas bottles, explosive materials, ordinary wastes, ...) and registered by incoming trucks for specific collection points. During the on-site visits, mentioned by one of the respondents for answering the previous question (see Q4 above), supervisors representing the PRO verify the sorting conformity for each WEEE category and thus monitor the presence of non-WEEE. Sorting errors are registered for providing a gentle reminder to the site's WEEE collection manager as well as for checking the improvement of sorting quality in the later follow-up visits. None of the respondents register the weight of non-WEEE in the amount of collected WEEE. By monitoring this presence of non-WEEE, respondents are mentioning some implemented preventing measures such as returning the materials to the suppliers or not granting an efficiency reward to a specific collection point if unproper separation is detected.

Recycling plants may sort non-WEEE materials from the WEEE containers received at their facilities. Recyclers report to PROs the amounts of WEEE received at the facilities as these are accountable for reaching collection targets. The management of non-WEEE materials is usually a cost for recycling facilities and may affect treatment tariffs agreed with PROs if the shares of non-WEEE received with the WEEE are relevant.

Q6 - Do you monitor the scavenging level in the amount of collected WEEE? Do you have quantitative information on the scavenging level (e.g. share of devices without copper coil, share of PCs without hard disk drive)? Subsequently, have you implemented a system for monitoring, preventing and/or quantifying the scavenging level in the collected WEEE? If yes, how are you using that quantitative information?

None of the respondents indicated having a monitoring system quantifying the scavenging level of collected WEEE, included within the scope of our analysis. One respondent indeed mentioned a monitoring procedure concerning incoming cargos from all collection points regarding the following:

- Washing machines, fridges and air conditioners with no motors/compressors.
- Broken/scavenged CRT & FPD displays

Based on the obtained data and their analysis, measures (e.g. financial) were taken for the prevention of scavenging. It is indeed mentioned by another respondent that most stolen components are "refrigerator compressors", "TV deflection yokes" and "washing machine motors and cables". Based on the on-site visits (see Q4 and Q5) organised by one respondent, one PRO has also implemented a quantitative system for monitoring the scavenging level of large household refrigeration appliances, screens, and computer central units. Data collected during visits, i.e. the supervisor checks whether the compressor is still attached to the equipment or has been removed, and/or whether the copper circuit on the equipment remains or has been cut, are used for developing and calculating indicators enabling comparisons of scavenging level in different areas, logistic zones or again waste treatment plants. Similarly, quantitative information is used to reinforce measures in specific areas/collection points for improving the quality of collected WEEE.

For some respondents, specific forms for anomalies within their internal management system can be used to report scavenging cases. Punctual information (e.g. yearly for one respondent) concerning the scavenging level, is coming from or is requested to treatment facilities. That information are aggregated data not targeting specific collection points. While not having implemented a monitoring system as such, one respondent explains that they are aware most of the equipment collected from civic amenity sites and other public collection points does not have cords, copper and other valuable parts. However, they do not have any percentage. To prevent scavenging, the same respondent mentions they are increasing the number of agreements set with collection points in retail, B2B and other private places with more surveillance.

One respondent mentioned that until 2 years ago, they were legally required that a small share (about 3%) of the collection services for C&F and LHA was carefully evaluated in terms of scavenging level (i.e. reporting the number of missing compressors, doors, etc…).

Q7 - Are you applying specific standards at collection points (e.g. EN 50625-4 on Collection and Logistics)? If yes, what are the drivers for doing so? If not, why?

One respondent specified they are currently applying EN 50625-4 on Collection and Logistics. While not using EN 50625-4 on Collection and Logistics, some respondents indicated they were using similar internal standards. One respondent mentioned that specific standards are implemented during transportation of WEEE as equipment containing hazardous elements must be separated from the remaining one. Another respondent explained that they urge their collection partners to follow environmentally sound practices, developed within the project Infocycle[56] and based on specific standards.

Some other respondents indicated that no specific standards are applied at collection points, only legal requirements such as those referring to impermeable surfaces, storage by types, coverage for hazardous WEEE. One respondent indicated that the introduction of standards at the collection level can be beneficial only if the staff employed at collection points is properly trained.

[56] http://en.infocycle.gr/

Q8 - Are there any other specific solutions that you have implemented/would like to implement to improve the quality of the collected WEEE that you would like to share?

Additional specific implemented solutions shared by respondents are targeting several parameters of the waste collection systems.

One respondent explained that for limiting theft, as public collection points are manned during the day, having a fence is essential. In their local context video surveillance and again roofed-containers are used.

Several respondents explained that having implemented a door-to-door system has demonstrated benefits as it allows checking the quality, completeness of WEEE and making decision on the way of transportation. For one respondent, trainings to collection and logistics operators is a measure that led to an improvement of the quality of collected WEEE. For this same respondent, the placement of more containers at collection point is also considered as a beneficial measure in that purpose.

Answers from mostly all respondents also reflected the potential of information and awareness campaigns. One respondent particularly explained that in addition to such campaign, competitions with specific prizes for specific categories such as lamps were organised. Still according to this respondent, those measures led to an improvement not only concerning the quantity but also the quality of collected WEEE.

One respondent, Ecodom, also shared some insights from related and relevant research initiatives: the CRM Close Loop Recovery[57] project and the InnoWEEE project[58]. Those insights are transcribed in the two boxes below.

CRM Close Loop Recovery project: the Italian Trial

Today citizens have the possibility to dispose their WEEE in the municipal collection centres and through the bins located in the retailers (according to the one for one system and one for zero system mentioned above). The Italian collection trial implemented by Ecodom within the CRM Closed Loop Recovery project brought the collection activity closer to the citizens. Aiming to meet citizens' need, the WEEE collection bins were positioned in places that are part of the daily life of everyone, as grocery shops. Therefore, it has been realized a small container allowing citizens to manage by themselves the disposal of small WEEE and giving the possibility to store the container inside the shops to alleviate security concern. For the continuous collection in grocery shops, the design of the container has been developed specifically for the collection of small WEEE. The small bins have been designed avoiding the possibility to remove the WEEE once they have been put inside and it is equipped with a plastic removable bin (240 l) that facilitate the unloading operations.

The activities performed within the CRM Close Loop Project framework showed that the collection of small WEEE increases significantly if citizens can bring easily (e.g. reducing time constrains and shorting the distance to travel for the disposal) their unwanted devices.

Evaluating the performance of the implemented collection activities, it is evident that being closer to the citizens has a significant positive impact on the collection performance, both in quantitative that in qualitative terms. The amount of collected WEEE increased in comparison with the current situation.

[57] http://www.criticalrawmaterialrecovery.eu/
[58] http://www.innoweee.eu/en/home

Taking advantages of the collection events, people disposed WEEE that they usually keep in their houses. Moreover, people disposed WEEE with high CRM content that are not present in the usual waste flow. This is one of the most relevant results: WEEE disposed through those activities were the WEEE that usually are not found in municipal collection point: ICT equipment, mobile phones are not present at all in traditional collection points because they are kept at home. For this reason, the lesson learnt is that by facilitating the disposal of WEEE to the citizens, it is possible to increase the quantity and the quality of the WEEE collected. The communication effort has been extremely important to reach the achieved result.

InnoWEEE – traceability and collection system and geointeroperability of WEEE data

The InnoWEEE project aims to identify innovative systems for the traceability and the increase of the small WEEE collection in urban areas and to develop methods for extending the products life, based on the principles of the Circular Economy and thanks to the use of big data. The project is divided into three different pilot actions: two in Italy - in the schools and the squares of Trento and in the shopping centres and the streets of Cava dei Tirreni - and one in England - in the Bathnes area.

The pilot implemented in Cava de' Tirreni is based on the idea of the utilization of smart bins. They represent an integrated and innovative system for the WEEE collection that directly interacts with citizens. The smart bins are dedicated to the SHA WEEE collection and to the collateral collection of exhausted batteries and light bulbs. The smart bins have been strategic positioned on the territory of the city; the selected locations are a shopping mall, the city hall, the offices of the municipal waste management company and two schools.

They bins are equipped with a software that allows:

- to perform remote control,
- the information exchange with all the equipment belonging to the system (stations + PC authorized to connect),
- to aggregate data from the various equipment (i.e. type of product disposed) into a single database,
- to archive the documents,
- to generate graphs showing the progress of the WEEE collection at the various location points,
- to calculate any score accrued by each user according to pre-established criteria (i.e. each disposal activity is associated with a score, for example environmental benefit of the disposal activity),

The features of the smart bins are considered potentially beneficial to encourage citizens to dispose small WEEE, to proper manage the collection services, to avoid scavenging issues (the smart bins are closed and can be opened only through the personal national health card). The final project results of this collection activity are not available yet.

Additionally, desk research allowed us to identify other practices for improving the quality of WEEE:

- Establish economic compensations to be paid by PROs to collection points. These compensations are based on the level of WEEE separation, so collection points separating WEEE into two streams will

receive a lower compensation than those collection points separating WEEE into five streams. Economic compensations are usually agreed between the PRO and the collection point bilaterally, or via collective agreements between PROs and regions, or the clearing house and regions...

- In many member states PROs are required to finance communication campaigns.
- In some countries, PROs collaborate with collection points for tackling scavenging practices, some examples are the “efficiency reward’’ in Italy, or helping collection points install closed containers and camera surveillance measures in France. These measures are usually paid or co-financed by PROs via de Clearing House, and are paid provided certain criteria are met by the collection points.

3.3 Conclusion

For the analysis of the WEEE case studies from a circular economy perspective, we performed a delta analysis meaning that the performance of the WEEE collection system is compared for two points in time[59]. Specific 'good practice actions' which were performed by the producer responsibility organization (PRO) in the case study and which resulted in increased WEEE collection quantity (or increased WEEE supply to recyclers) and quality were identified and analysed, such as transport optimization, increased pickup frequency, increased coverage of collection points, additional awareness campaigns, etc. , leading to more waste supply, of a better quality, to recyclers.

In all five case studies the absolute numbers of WEEE collected as well as the capture rate, being a ratio between waste generation and collection in one specific year, have increased over the last decade. Vienna has by far the highest capture rate for lamps, i.e. 55 % (2015), followed by Helsinki, Cyclad serviced area and the county of Pembrokeshire (all about 30 %) and Genova (7%).

The county of Pembrokeshire and the Cyclad serviced area, territories with relatively low population density, both collect a similar percentage of small WEEE and IT equipment in a combined fraction capturing about 40 %, although they follow different collection strategies. In Helsinki, where these fractions are separately collected, 41 % of small WEEE and 61 % for IT are captured. In Vienna a capture rate of 29 % for small WEEE incl. IT is achieved. In Vienna this is due to constant improvements over time, such as public relation schemes, restrictions to informal collection, reduction of expenses for logistics costs and improved collection pickup coordination with partners/recyclers.

In Helsinki WEEE is collected at 450 permanent collection points, mainly at civic amenity sites, accounting for 31 wt. % of all collected WEEE. To account for long distances and low quantities of returned devices a semi-annual mobile collection is organized. When retail stores were introduced as bring points in 2013, the collected quantities of WEEE increased significantly, which is probably due to the fact that it became more convenient for people to bring back their obsolete electronic devices. Today there are over 2000 retail stores all over Finland, where 68 wt. % of WEEE is collected. Counting only the 450 CAS and about 2,000 retail bring points, results in one collection point covering 2,245 inhabitants in average. Both the increased density of collection network as well as the diversification of collection points resulted in an absolute increase in collection in Helsinki.

For Pembrokeshire, REPIC is the only contracted PRO for the region. Other than the 6 CAS - with one CAS covering 20,833 inhabitants in average. Retail stores can serve as bring points, but have the possibility to opt out and have therefore no major role in the system. Some CAS offer repair or second-hand shops where certain products can be fixed and resold, or donated to a charitable organization.
The Cyclad Mixed Syndicate, together with Eco-systèmes being the main PRO in the region, ensures the collection of WEEE in the Cyclad serviced area. 65% of all collected WEEE is received at 25 CAS, whilst 25% are collected in retail stores and social recycling centres. 15% of WEEE is collected via other channels. In order to increase WEEE collection quantities and to avoid leakage policies were successfully introduced in France to decrease exportation and theft. Increased capture rates of WEEE in the Cyclad

[59] This approach differs from the CE analysis approach as described in D2.2 and focuses more on the identification of implemented measures leading to more WEEE collection; the corresponding analysis has been performed in a more pragmatic way.

serviced area is likely the result of a legal ban on cash transaction for metals which helps prevent WEEE leakage via complementary flows or other fates; this has been paired with improved security at the CAS, i.e. locked containers and camera surveillance and regular police checks.

The densely populated urban areas, Vienna and Genova, capture 29 % and 17 % of small WEEE incl. IT respectively. For small WEEE and IT, the biggest progress over the last decade has been made by Genova increasing the absolute collected quantities by 67 %. Introducing 47 new mobile collection points for small WEEE and 4 new permanent collection and recycling centres, improving the convenience for citizens. Moreover, campaigns and creating long-term networks between key stakeholders, such as retailers, universities, schools and the general public, improved communication and awareness and supposedly helped to increase the collected WEEE quantities.

Similarly, in Pembrokeshire, the increase in collected quantities and higher capture rates is mainly due to the building of new reuse centres, school education programs and research and development funding as well as extensive campaigns in cooperation with charity organizations to create public awareness and to promote waste diversion strategies, such as preparation for reuse.

Although we are aware that five case studies do not allow to make any statistically meaningful statement, some general observation can be made:

1. In scarcely populated areas successful measures to increase collection quantities include a) introducing retailers as bring points and / or b) introducing a mobile collection, i.e. making collection more convenient (Helsinki).
2. In remote areas with low GDP increasing the security of collection infrastructure might be a good idea to prevent theft (Cyclad serviced area).
3. In both high GDP cities (Vienna) and low GDP areas (Pembrokeshire) re-use centres seem to be successful, as it is both the young urban ‘hipster’ population as well as people who cannot afford to buy new stuff who are interested in inexpensive second-hand items.
4. Communication always helps to enhance WEEE collection. However, it is advisable to first survey people’s level of knowledge and their opinion on the topic to better target certain issues, e.g. counteracting misinformation on fate of waste (Cyclad serviced area), or just a general awareness raising campaign on the relevance of WEEE recycling (Pembrokeshire, Vienna), or informing the general public on newly introduced collection sites (Genova).

As discussed in section 3.2.6, the analyses of those five case studies did not allow us to draw any conclusions on the quality of the materials due to the lack of data on the outputs of recycling plants, mainly because of confidentiality issues. While European waste management targets relate to the weight of waste, it is their quality that determines their value as secondary raw materials in the circular economy and may determine proper treatment. Therefore, it has been judged essential to contact and conduct interviews with PROs for obtaining complementary insights and evaluate how and to which extent WEEE collection systems could provide specific solutions to improve the quality of the collected waste in order to enable the sorter and/or the recycler to produce more qualitative secondary materials. The following observation can be made:

1. Clear and significant quality differences between WEEE collected through retail bring points and through municipal collection points are noticed. Having waste managed by trained professionals and concomitantly increasing the surveillance can reduce the number of broken appliances as well as the

scavenging level. Increasing and homogenising the surveillance methods between municipal collection points can also reduce the scavenging level.

2. Besides implementing specific containers for separately collecting the different WEEE categories there are almost no other measures implemented at collection points for facilitating the sorting (taking into consideration that the scope of the study is limited to three WEEE categories). It seems that the role of the waste collection system for facilitating the sorting is extremely limited (see insights obtained from the consultation activity performed within the project PolyCE and described above) and rather than focusing on “collection for sorting” is rather focusing on “collection for transport”.
3. Qualitatively monitoring the presence of non-WEEE by identifying and classifying unwanted materials can be an incentive for improving the quality of collected WEEE. Partners in charge of the collection can be rewarded or penalized according to the quality of materials provided.
4. No monitoring systems as such are being implemented to quantify the scavenging level at collection points. Increasing the surveillance in municipal collection points is nevertheless considered as essential for reducing the scavenging level and improving the quality of collected WEEE from public sources.
5. There is no harmonization in the use (or not) of specific standards at collection points.
6. It is considered essential to have trained professionals carrying out collection and logistics operations.
7. Information and awareness campaigns, eventually combined with rewarding competitions can lead to an improvement in the quality of collected WEEE.
8. According to an assessment performed in an additional shared research project, some implemented collection activities, being closer and increasing the convenience to the citizens, had a significant positive impact on the collection performance, both in quantitative and in qualitative terms.
9. Economic compensations paid by PROs to collection points for improving the infrastructure of collection points against thefts or encouraging collection point for collecting WEEE in good condition, and compensations to increase the degree of WEEE separation were also identified.

4. Construction and Demolition Waste

4.1Structure of the analysis of the case studies

In contrast to PPW and WEEE, the collection of CDW is mainly in hands of private companies, being the building companies and contractors. The relevance of publicly organised waste collection systems is very different for CDW compared to PPW and WEEE, and mostly limited to providing a service to citizens for the collection of specific fractions of CDW that citizens want to get rid of.

The goal of the circularity analysis is to assess the role of the waste collection system within the waste recycling value chain, helping to turn waste into a resource, and to identify the aspects within the specific case studies that can be considered as a good practice of a waste collection system contributing to a circular economy from the perspective of the recycler, and to explain why.

The analysis of the case studies has the following structure for each case:

- Case study background;
- Flow Scheme;
- Recycling value chain.

Case study background

For each of the selected cases, we first provide a short description of the case including the regional characteristics and of the organisation of the waste collection.

Flow scheme

In a next step an overview of the waste collection and subsequent treatment steps is given in the format of a flow scheme.

The scope of the flow scheme is one or more selective collected CDW fraction. The flow scheme not only represents the waste generation and collection, but also the subsequent treatment steps as sorting and recycling, and any logistical steps (as transport, storage and reloading at transfer station).

Based on this flow scheme some specific highlights for the case are described, and the organisation of the collection is described (such as the involved organisations and their relation).

Recycling value chain

On top of that, per collected waste fraction a schematic presentation is given of the role of the waste collection system in the recycling value chain to tune the waste into a secondary material, based on the collection method, collection, sorting and recycling outputs, similarly as for the PPW case studies (see 2.1).

Based on this recycling value chain, we described some highlights as what can be considered as a good practice or what can be interesting to disseminate to other stakeholders.

4.2Results of the analysis of the cases

4.2.1 Odense (DK)/ focus on bricks and insulation

Case description

Odense is the third-largest city in Denmark. It has a population of 178,210 as of January 2016, and is the main city of the island of Funen. In the present day, Odense remains the commercial hub of Funen, and has a notable shopping district with a diversity of stores. Several major industries are located in the city including the Albani Brewery and GASA, Denmark's major dealer in vegetables, fruits and flowers.

Odense has 8 recycling stations (CAS), with over 40 containers for collecting different waste fractions. The vast majority of containers will be found at all the recycling stations in Odense. However, the smallest ones do not have space for all 40 containers. The CDW fractions that are collected separately at the recycling stations include:

- Window glass with frames
- Window glass without frames
- Double glazing with PCB
- Asbestos and Ethernite
- Roofing board
- Gypsum
- Concrete and Bricks
- Mineral wool
- White toilets and washbasins
- Building waste with PCB
- Bricks only

Figure 32 illustrates the setup of the recycling stations in Odense.

Figure 32: Overview and picture of a recycling station in Odense

Flow scheme

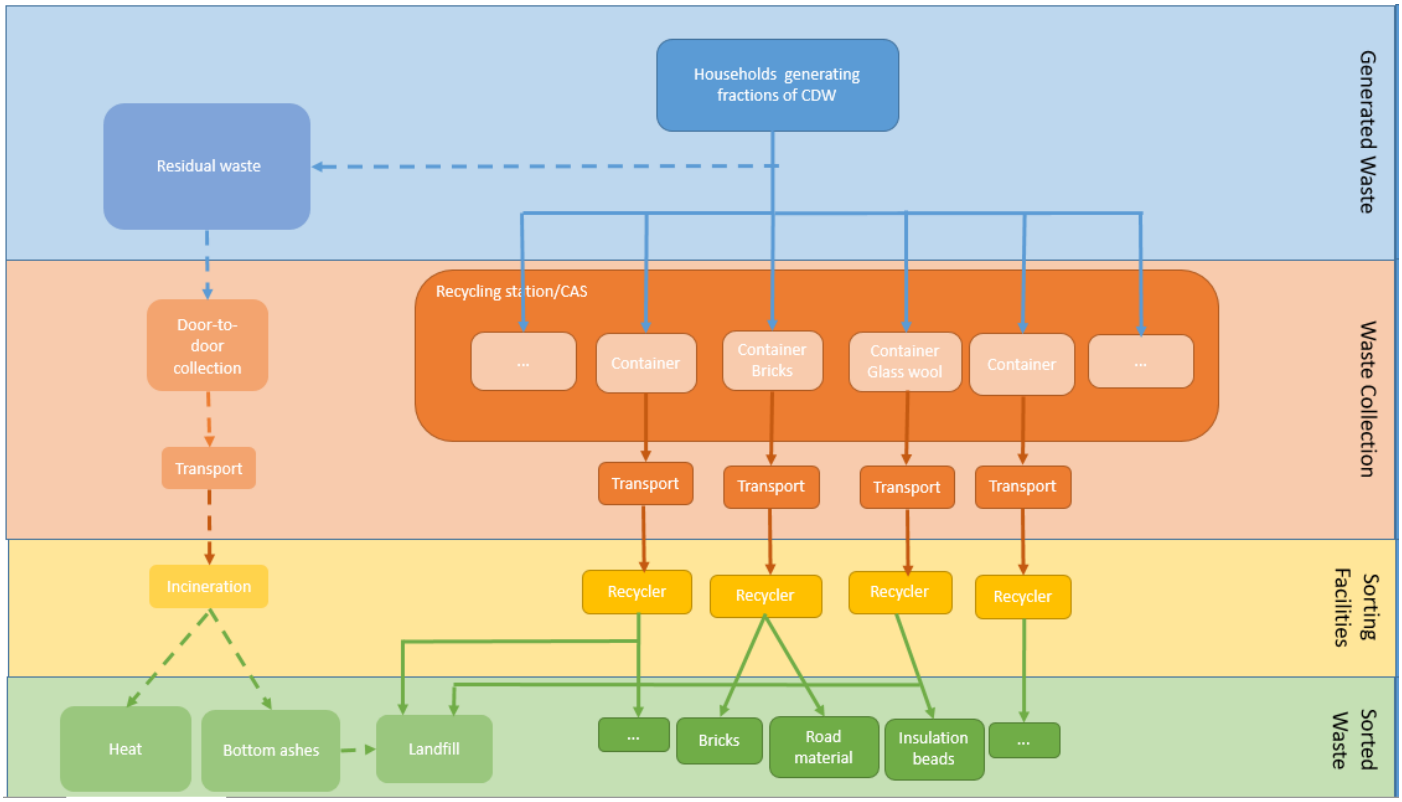

Figure 33: Flow scheme of CDW collection at CAS and corresponding recycling in Odense

The CDW fractions are directly transported from the CAS to the recyclers as soon as the container is about full, so respectively to Gamle Mursten (bricks), Noreco (insulation) and KI Hansen (sanitary).

Highlights

- Waste fractions directly transported to sorter-recycler-reseller;
- Separate collection of specific fractions in function of potential valorisation;

Recycling value chain

Bricks				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Bricks	• **CAS (recycling station)** **Transported when container is full**	• **Mixed Bricks + mortar**	• **Bricks, sorted by colour**	• **Bricks, sorted by colour** • Road material • Landfill
Insulation				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Glass wool	• **CAS (recycling station)** **Transported when container is full**	• **Mixed glass wool fraction**	• **Sorted glass wool**	• **Insulation beads** • Landfill

Highlights

- The scope of the collection is discussed and agreed with the sorter and recycler;
- The setup of the sorting step is adapted to the mixed composition of the collected output;
- Focus on high-value recycling/reuse (closed loop) for bricks;
- Market for end application was the starting point for setting up the recycling value chain;

4.2.2 Reimerswaal (NL)/ focus on gypsum

Case description

Reimerswaal is a municipality in the province of Zeeland in the southwestern Netherlands on Zuid-Beveland, named after the lost city. The municipality had a population of 22,432 in 2017, and has a surface area of 242.42 km² (93.60 sq. mi) of which 140.43 km² (54.22 sq. mi) is water. The municipality of Reimerswaal was established in 1970, from the aggregation of the municipalities Krabbendijke, Kruiningen, Rilland-Bath, Waarde, and Yerseke.

The municipality is responsible for the collection and management of household waste and has this outsourced to private scheme The Zeeuwse Reinigingsdienst (ZRD). ZRD does the collection of all household waste (residual, organic, plastics and beverage cartons) as well as the management of all the CAS in Zeeland, where all CDW fractions are collected.

Flow scheme

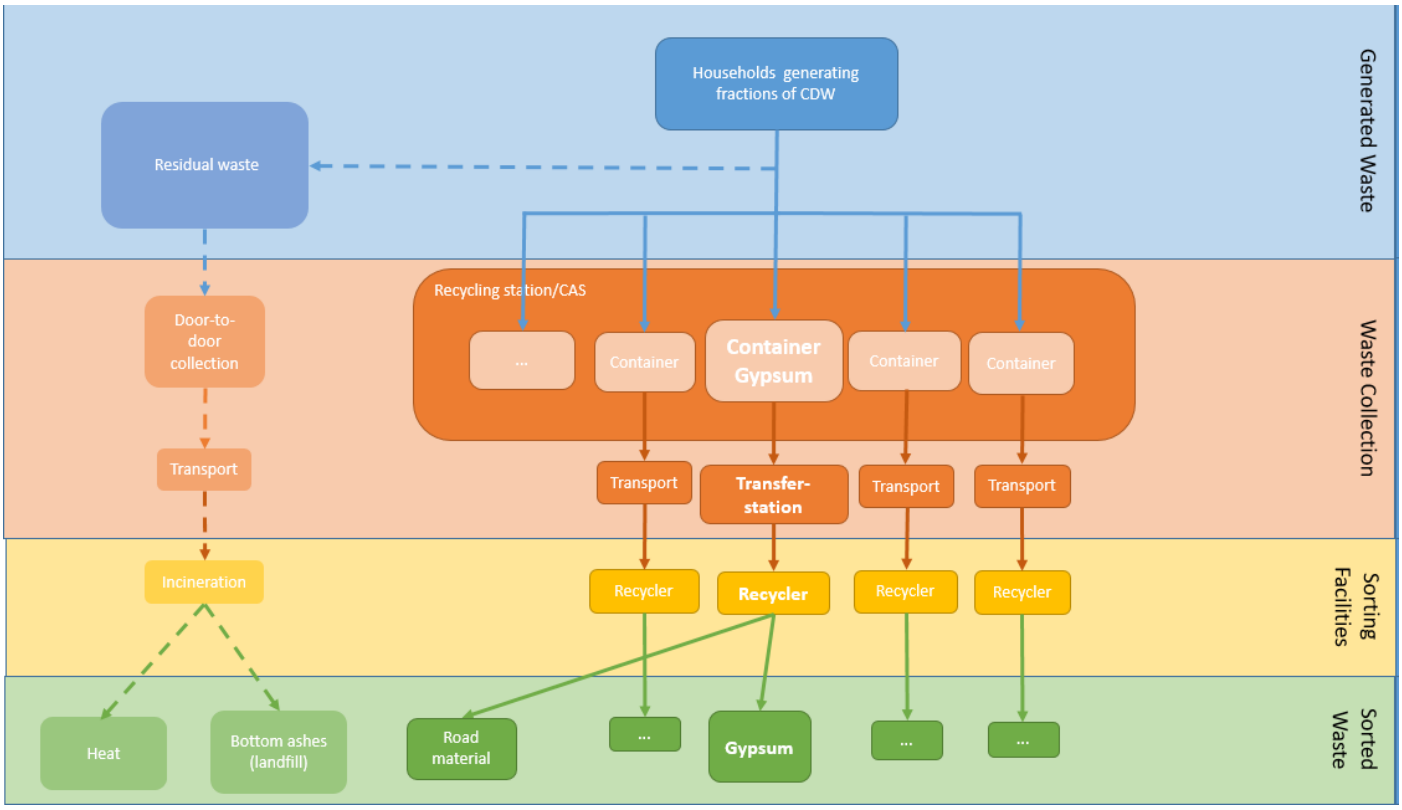

Figure 34: CDW collection at CAS and corresponding recycling in Reimerswaal

After collection in a separate container, the gypsum waste is transported to a transfer station from where it, together with gypsum waste from neighbouring municipalities serviced by ZDR, is transported to New West Gypsum Recycling in Kallo near Antwerp.

Recycling of gypsum products involves the collection and processing of the gypsum waste, and the delivery of the obtained recycled gypsum to the manufacturer of gypsum products. It is therefore essential that the recycled gypsum achieves a pre-determined quality suitable for the manufacturing of new gypsum products. Presently there is no standard pre-determining the recycled gypsum's quality and the criteria vary from plant

to plant. By choosing closed loop recycling the need for manufacturers to acquire virgin gypsum is reduced. The most advanced plants have substituted up to 30 per cent of virgin gypsum raw materials with recycled gypsum

Highlights

- Separate collection of specific fractions in function of potential valorisation;

Recycling value chain

Gypsum				
Scope	**Collection method**	**Collection output**	**Sorting output**	**Recycling output**
Gypsum (boards, powder)	• **CAS (recycling station)** **Transported when container is full**	• **Mixed gypsum**	• **Gypsum powder**	• **Gypsum board** • Road material • Landfill

Highlights

- The scope of the collection is discussed and agreed with the sorter and recycler;
- Focus on high-value recycling/reuse (closed loop);
- Market for end application was the starting point for setting up the recycling value chain;

4.3 Conclusion

The circular economy analysis for the two case studies on CDW fractions shows that setting up a dedicated recycling value chain can be interesting for specific CDW fractions. The starting point for the collection of the CDW fractions in both case studies was the presence of a clear market for the end application, and the corresponding business case (see CBA in D3.2).

The setup of the recycling value chain is both cases quite straightforward: starting from the market for the end application, the scope of the collected waste at the CAS is determined and a matching sorting process is selected.

5. Annexes

Generic overview of collection method, collected fractions, sorting outputs and recycling outputs, and corresponding output requirements

Stage	Fraction	Container glass waste
COLLECTION	Collection out of scope	Borosilicate glass (light bulbs & tubes) Bottles of chemicals Vitroceramic glass (e.g. cooktop glass, stove glass, ...) Lead crystal glass Flat glass, mirrors Heat-resistant glass (e.g. pyrex, oven trays, ...) Lab glass Medical glass Bottle & jar lids Domestic glassware
	Collection scope	Clear waste glass bottles and jars Coloured waste container glass
	Collection method	Door-to-door Bring point CAS Door-to-door + bring points Bring points + CAS Door-to-door + bring points + CAS Bring points + CAS + other
	Collection output	Mixed container glass co-mingled with other wastes Mixed container glass Clear container glass Coloured container glass
	Collection target fraction	**Soda-lime-silicate container glass with:** Bulk density < 500 kg/m³ Ferrous metals < 0,3% Coloured glass < 5% (for clear glass only) Ceramics, stones and porcelain < 0,4% Plastic bottles < 2,5% Non-ferrous metals < 0,2% Organic materials < 0,5% Flat glass < 1%
SORTING	Sorting output	Brown container glass cullet Green container glass cullet Clear container glass cullet Mixed container glass cullet
	Sorting output criteria	**BSI/WRAP PAS 101 Untreated cullet** A: Whole or broken containers, colour separated. B: Whole or broken containers, colour separated but to a lesser standard. C: Whole or broken containers, mixed. D: Compacted glass. Contamination limits per grade for ferrous metals, non-ferrous metals and organic material Inorganic contamination (ceramics, porcelain and stones) subject to negotiation between suppliers and reprocessor **CEN/TC 261/SC 4/WG 3 Material recovery** All contaminants < 5% Ceramics, porcelain and stones <10mm < 0,01% Total ceramics, porcelain and stones < 0,25% **US Institute of Scrap Recycling Industries (ISRI) container glass cullet specification (GC-208)**
RECYCLING	Recycling output	Container glass (flint, brown, green) Insulation mineral wool (short glass fibre) Ceramic sanitary ware Fluxing agent in brick manufacture Sports turf and related applications Water filtration media Abrasive Aggregate in construction materials Reflective highway paint
	Recycling output criteria	**BSI PAS 102 Specifications for processed glass for selected secondary end markets** Total contaminant (organic, inorganic, ferrous/nonferrous metals) Particle size distribution Colour requirements Other requirements
USE	Recycled content	Container glass: about 40%; theoretically from 60 (clear glass) to 95% (green glass) Glass wool insulation: up to 80%

Stage	Fraction	Paper & cardboard waste
COLLECTION	Collection out of scope	Wallpaper Cement bags Beverage cartons Ring binders Aluminium foil Cellophane, carbon and parrafin paper Sanitary paper Photographs Cardboard cups
	Collection scope	Corrugated cardboard packaging waste Waste case materials Kraft cardboard packaging waste Waste paper packaging and bags Non-packaging waste paper and cardboard
	Collection method	Door-to-door Bring point CAS Door-to-door + bring points Door-to door + CAS Bring points + CAS Door-to-door + bring points + CAS Bring points + CAS + other
	Collection output	Newspapers & magazines Cardboard Mixed paper & cardboard Paper & cardboard co-mingled with other wastes
	Collection target fraction	**Natural fibre based paper and board suitable for recycling:** Paper and board in any shape Products made predominately from paper and board, which may include coatings and laminates, spiral bindings, etc.
SORTING	Sorting output	mixed paper & cardboard corrugated and kraft newspapers & magazines other and special grades
	Sorting output criteria	**CEPI Classes I to IV** Mixed grades Corrugated and kraft Newspapers & magazines Other grades **EN 643 - European List of Standard Grades of Paper and Board for Recycling** Group 1: ordinary grades, such as mixed paper and board; Group 2: medium grades, such as sorted office paper; Group 3: high grades, such as white newsprint; Group 4: kraft grades, such as unused corrugated kraft; Group 5: special grades, such as used beverage cartons.
RECYCLING	Recycling output	Newsprint Other graphic papers Case materials Carton board Wrappings and other packaging Sanitary and household Other paper and board Construction materials (insulation, bricks and furniture) Animal beddings or compost Fibre applications in construction and manufacturing (in concrete, asphalt, brake linings)
	Recycling output criteria	
USE	Recycled content	Average for paper and board production 52% From 35% in carton board to 93% in newsprint

Stage	Fraction	Plastic packaging waste
COLLECTION	Collection out of scope	Non-packaging plastics waste Chemicals and hazardous substances plastic packaging waste
	Collection scope	Plastic packaging waste
	Collection method	Door-to-door Bring point CAS Other Door-to-door + bring points Door-to door + CAS Bring points + CAS
	Collection output	Plastic packaging co-mingled with other packaging waste Plastic packaging only, co-mingling all polymers Single type of packaging (e.g. only bottles) and/or a single polymer (e.g. PET) Mix of two or more target polymers (e.g. PET, HDPE, LDPE, PE, PP) and/or packaging types (e.g. bottles and foils)
	Collection target fraction	**Plastic bottles and flasks that contained:** water and soft drinks milk washing-up and maintenance products washing powder water softeners bath and shower products destilled water bleaches
SORTING	Sorting output	Mono-colour or mixed colour bales or bags containing a single polymer (PP, PET, LDPE, HDPE, PS, EPS)
	Sorting output criteria	**US Institute of Scrap Recycling Industries (ISRI) baled recycled plastic commercial guidelines (P-2018)** **Plastics Recyclers Europe Bales Characterization Guidelines** HDPE Bales PET Coloured Bales PP Film Bales PET Clear-blue Bales PET Light blue Bales PE Film Bales PET Clear Bales **Specifications Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe (DKR)** PET (DKR 328-1) PE (DKR 329) PP (DKR 324) Film (DKR 310) EPS (DKR 340) Mixed plastics (DKR 350)
RECYCLING	Recycling output	Mono-colour rPET Mono-colour rLDPE / rLLDPE Mono-colour rHDPE Mono-colour rPP Mixed plastic pellets
	Recycling output criteria	**EN 15342 - Characterization of polystyrene (PS) recyclates** **EN 15345 - Characterisation of Polypropylene (PP) recyclates** **EN 15346 - Characterisation of poly(vinyl chloride) (PVC) recyclates** **EN 15347 - Characterisation of plastics wastes** **EN 15348 - Characterization of polyethylene terephthalate (PET) recyclates** **EN 15344 - Characterisation of Polyethylene (PE) recyclates**
USE	Recycled content	PET bottles and trays: 25 to 30%; theoretically at least 50% of rPET in bottles

Stage	Fraction	Steel & aluminium packaging waste
COLLECTION	Collection out of scope	Non-packaging metal scrap Chemicals and hazardous substances metal packaging waste
	Collection scope	Steel & aluminium packaging waste
	Collection method	Door-to-door Bring point CAS Other Door-to-door + bring points Door-to door + CAS Bring points + CAS
	Collection output	Aluminium and steel packaging co-mingled with other packaging waste, often including drinking cartons Aluminium beverage cans only Mixed metal packaging Metal packaging co-mingled with other, non-organic waste
	Collection target fraction	Beverage cans Food cans Bottle caps Lids Aerosol cans of food and cosmetics Aluminum trays
SORTING	Sorting output	Baled or briquetted aluminium cans and/or aluminium meal trays, rigid containers, aerosol cans, screw closures and cappings Baled steel drums and cans Baled drinking cartons
	Sorting output criteria	**EN 13920-10:2003 for baled aluminium beverage cans** Maximum moisture and volatile substance levels Limited concentrations of silicon and a series of metallic impurities Metal yield > 88% Free from burnt or oxidized cans and aluminium foil **EN 139205-14:2003 and EN 139205-15:2003 for used aluminium packaging** < 5 % of steel packaging Free from plastic, paper and blister packs < 60 % of volatile components **Council Regulation (EU) No 333/2011 End-of-Waste aluminium scrap** Maximum levels of combustible non-metallic materials Free from polyvinyl chloride (PVC) in form of coatings, paints, plastics **End-of-Waste iron and steel scrap: Technical proposal on tin-coated packaging scrap** Excessive moisture, metallic copper, tin devices (and alloys) and lead (and alloys) Minimum concentrations of free iron or alloy, or of metallic packaging **European Steel Scrap Specifications** **Standard classifications of national industry associations** **US Institute of Scrap Recycling Industries (ISRI) non-ferrous scrap guidelines (NF-2018)** **US Institute of Scrap Recycling Industries (ISRI) ferrous scrap guidelines (FS-2018)** **ASTM E 1134 : 1986 Specification for source separated steel cans**
RECYCLING	Recycling output	3000-series wrought aluminium alloys Aluminium foam Low carbon steel Fibres
	Recycling output criteria	**American National Standard Alloy and Temper Designation Systems for Aluminum 2017 ANSI H35 standards** **Aluminium 3004 Specifications** ASTM B209 ASTM B221 ASTM B313 ASTM B547 ASTM B548 SAE J454 UNS A93004
USE	Recycled content	Steel cans: 25% Aluminium cans: 70%

Stage	Fraction	WEEE
COLLECTION	Collection out of scope	WEEE not subject to Directive 2012/19/EU
	Collection scope	WEEE subject to Directive 2012/19/EU
	Collection method	CAS Retailer bring point Non-retailer bring point Pick-up on request Mobile bring point Other
	Collection output	Temperature exchange equipment Screens & monitors Lamps Large appliances Small household appliances Small IT
	Collection target fraction	Cooling and freezing equipment. Large household appliances (excluding cooling and freezing equipment) Small household appliances IT equipment Screens Lamps
SORTING	Sorting output	Depolluted appliances Parts from dismantling (cables, compressors, casings, coils & motors, circuit boards, drives, batteries,…)
	Sorting output criteria	**EN 50574 on WEEE containing volatile fluorocarbons or volatile hydrocarbonsCollection** **TS 50574-2: for WEEE containing volatile fluorocarbons or volatile hydrocarbons - Part 2: specification for de-pollution** **EN 50625-1: WEEE General treatment requirements** **TS 50625-3-2: WEEE Specification for de-pollution – Lamps** **EN 50625-2-2: Treatment requirements for WEEE containing CRTs and flat panel displays** **TS 50625-3-3: Specification for de-pollution- WEEE containing CRTs and flat panel displays** **EN 50625-2-3: Treatment requirements for temperature exchange equipment** **TS 50625-3-4: Specification for de-pollution- temperature exchange equipment** **EN 50625-2-4: Treatment requirements for photovoltaic panels** **TS 50625-3-5: Specification for de-pollution- photovoltaic panels** **TS 50625-4: Specification for the collection and logistics associated with WEEE** **TS 50625-5: Specification for the end-processing of WEEE fractions- copper and precious metals**
RECYCLING	Recycling output	Aluminium scrap, ferrous scrap, copper scrap, circuit boards PP, PE, PS, ABS and mixes thereof Glass and mineral fractions
	Recycling output criteria	**US Institute of Scrap Recycling Industries (ISRI) electronics scrap guidelines (ES-2018)** EM1—Eddy-Current (EC) Aluminum EM2—Eddy-Current (EC) Scrap EM3—Circuitboards and Shredded Circuitboards From the Processing of End-of-Life Electronics Electronics Scrap Glass and CRT Cullet Specifications Electronics Scrap Plastics Baled Specs Electronics Scrap Plastics Shredded Specs
USE	Recycled content	