D4.5. Guidelines for successful implementation

Executive summary

Guidelines for improving local waste collection systems

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Credits

Disclaimer

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Municipal waste management: guiding principles

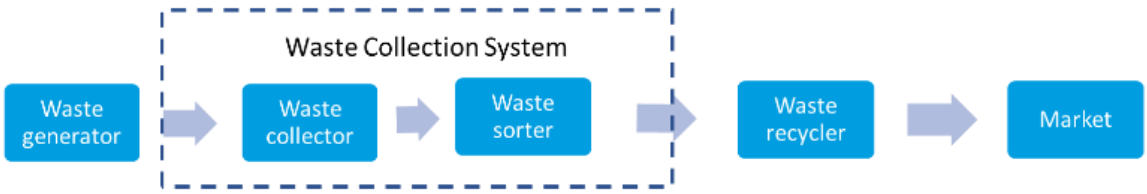
RECOMMENDATION 1: FOLLOW THE WASTE HIERARCHY

The environmental impacts associated with the production and consumption of products are generally significant compared to the ones associated with their end-of-life. While improving waste collection and recycling yields significant benefits, **prevention and re-use** represents the most relevant actions to mitigate the environmental impact linked with material resources.

Therefore, it is of utmost importance to ensure that the waste collection system consider this aspect e.g. by **promoting waste prevention as much as separate collection**, or by **including re-use schemes and organisations within the waste collection system.**

RECOMMENDATION 2: ALIGN WASTE COLLECTION SYSTEMS WITH THE RECYCLING VALUE-CHAIN

Waste collection systems should not be regarded as "insulated systems": one of their purposes is to provide quality materials in-line with recyclers' requirements, so that it can meet the demands of the end-users.



Three factors enable waste collection systems to create more value for the whole recycling value chain:

- **Traceability of the collected waste**: it is important to ensure that recyclers can obtain information on the sorted materials, as well as that there is a proper reporting of collected streams;
- **Supply of collected waste**: the collection system must aim at optimising capture rates to ensure a consistent supply of sorted material;
- **Quality of the sorted waste**: the sorted waste must meet some quality requirements to enhance recycling into marketable secondary materials.

Among these factors, quality seems to be the dominant one for enhancing the performance of the recycling value chain, by unlocking higher quality recycling.

RECOMMENDATION 3: SECURE THE PARTICIPATION OF CITIZENS

The intention to sort waste is mostly conditioned by four factors.

- **Information**: both the practical sorting guidelines and information on what happens to the sorted waste are important. Information should be easily accessible, distributed in a pro-active manner, clear, harmonised, and consistent, and adapted to the different target groups;
- **Environmental concerns**: an increasing number of people consider the environmental concern as an overarching factor. The positive outcome of their individual sorting behaviours on major environmental issues such as climate change should be highlighted;
- **Social norm:** when the waste collection system is properly implemented and most inhabitants participate, waste sorting actually becomes a part of local life and thus becomes a social norm that citizens are expected to follow.
- **Convenience:** waste collection systems must provide a convenient system limiting as much as possible the effort required to properly sort waste by ensuring the accessibility of collection points, taking into consideration the possible lack of space e.g. in vertical housing, and preventing possible nuisances.

It is also recommended to get a better hindsight on the population's perspective on waste management to understand their knowledge and motivations through regular surveys.

RECOMMENDATION 4: IMPROVE WASTE COLLECTION STRATEGIES THROUGH MULTI-CRITERIA DECISION MAKING

The principle of MCDM is to break down complex challenges into more comprehensive components. This allows assessing different dimensions of the problem one at a time, through a collaborative approach.

MCDM processes consist in several successive steps:

Definition of the problem

- The definition of a **general objective** for the decision-making exercise
- **The division in sub-objectives** reflecting different (technical, environmental, etc.) dimensions
- **The definition of criteria** that describe the performance of the different alternatives being compared, reflecting the selected dimensions.

Data collection stage

- Defining the different **alternatives** considered for the decision
- Collecting **data and information** to document these alternatives
- Creating a **matrix** to describe the performances of the alternative for the different dimensions.

Decision-making stage

- Assessing and measuring the **decision-makers' preferences** regarding the criteria weights
- Depending on the selected MCDM method, **further preferences** regarding the values of the criteria performances can be elicited.
- **Ranking** the different alternatives according the selected method.

It is recommended to consider the following clusters of criteria for MCDM applied to waste management:

Capture and recycling rates	How much waste is sorted/recycled compared to the quantities sent to disposal
Degree of separation and quality	Level of contamination and discarded quantities from the different sorting stages
Convenience and coverage of collection	Proximity and visibility of collection points, coverage of door-to-door schemes
Engagement and participation	Existence of feedback-gathering mechanisms, reach of communication actions
Environment, health and safety	Impact on climate change or local pollution
Socio-economic impacts	Costs, job creation

Paper and packaging waste (PPW)

ASSESSING THE SITUATION AND MONITORING

Improving local waste collection systems starts from a proper assessment of the initial situation, regarding the level of performances, but also regarding the current organisation of waste collection. Assessing the situation can be done by comparing the performances with legal targets, or by comparing performances with other "comparable territories".

Comparisons should take into account the following elements:

- **Local data might be calculated in an inconsistent way:** it is important to collect information on the definition of the indicators along with quantitative data;
- **The scope of PPW might be very inconsistent:** whether commercial PPW is included, the share of commercial PPW in municipal PPW, or the existence of parallel collection schemes can make comparisons less relevant.
- **The contexts can also impact the performances:** several contextual parameters are important to consider, such as population density, GDP per inhabitant, the number of overnight stays per resident population, or the share of secondary residences;

Waste fraction	Main contextual parameters for PPW production and capture rates
Glass packaging	Glass generation is significantly higher in territories with very high tourism activity, and high-density areas, and lower Glass generation tends to be lower in low-GDP areas, in low density areas, and in places in places with a parallel deposit-refund system (DRS)
Paper and cardboard	P/C generation tends to be higher in high-GDP areas and lower in low-GDP areas P/C generation tends to be higher in low density areas
Plastic packaging	Plastic packaging generation tends to be significantly higher in territories with very high tourism activity.
Capture rates	Capture rates tend to be lower in high-densely populated areas, and in low GDP areas

Key indicators to assess and compare different waste collection systems can be recommended:

Cluster	PPW Criteria	Comments
Capture and recycling rates	Capture rates of plastic, paper & cardboard, glass and metal	Recycling rates should be preferred to capture rates since they also include information on the quality of sorted fractions. If no data on quality is available, capture rates can be used along with information on quality requirements.
	Shares of PPW in mixed residual waste	This gives an indication on the unsorted quantities and the potential for improvement.
Engagement & participation	Citizen satisfaction	Establishing methods for systematic feedback collection is necessary for understanding the needs of the users, and evaluating their participation and acceptance.
Socio-	Annual waste fee per	Comparing the value of the annual waste fee per capita or

economic impacts	capita or per household, (€/capita or €/household)	per household across different territories might be difficult to do in a consistent way. It can be relevant to also identify how much the waste fees cover the collection costs
	Operational costs (€/tonne): collection and sorting costs for PPW, collection and treatment cost for residual waste	Data on collection and processing costs are generally calculated in heterogeneous ways or might reflect different costs (technical costs if reported by the operator of the collection, or cost charged by the subcontractor if reported by a local authority not operating the collection). However, comparing technical costs of two alternative scenarios is relevant if the costs are assessed and presented in a consistent manner.
	Employment impacts (no. of direct jobs)	Employment can be relevant to local elected representatives. However, data is generally limited and it might have trade-offs with cost-efficiency and productivity.
Convenience & coverage	Proximity (no. of bring points, door-to-door coverage and distance to bring points)	Data such as the number of bring points per inhabitant is generally highly valued by decision-makers and might give a first good indication on the convenience of the collection system.

To conduct comparisons, individual factsheets presenting the waste management organisation and performances of all the documented waste collection systems are accessible on the COLLECTORS webplatform.

SETTING PRIORITIES

The new EU packaging Waste Directive has set ambitious targets, along with a new calculation method excluding contamination from the recycling figures. The COLLECTORS project assessed the corresponding collection targets required to reach them.

Fraction	Recycling target in 2030	New calculation points	Associated collection targets for 2030
Glass	75%	Input of a glass furnace, or the production of filtration media, abrasive materials, glass fibre insulation and construction materials.	94%
Ferrous Metal	80%	Input of a metal smelter or furnace.	-
Aluminium	60%		64%
Paper and cardboard	85%	Input of a pulping operation	86%
Plastics	55%	Plastic separated by polymers entering pelletisation, extrusion, or moulding operations; or plastic flakes input in their use in a final product.	76%

The different PPW fractions yield different benefits regarding quantities, costs, and environmental impact. The potential environmental benefits arising from the improvement of the capture rate or of the quality of the sorted fractions also differ from one PPW fraction to another:

Waste fraction	Associated benefits	Environmental benefits from improving the sorted quantities or its quality
Glass packaging	Large quantities, lower collection and processing costs compared to the other PPW fractions, and possibly to residual waste	Comparable benefits
Paper and cardboard		More benefits from improving capture rates
Plastic packaging	Higher impact on climate change, especially for plastics	More benefits from improving quality
Metal packaging		More benefits from improving capture rates

These considerations have to be regarded as average situations; A case-by-case evaluation of the optimal measures to improve waste collection, sorting, and recycling activities is, therefore, recommended.

IMPROVING CAPTURE RATES AND QUALITY

Waste collection systems should be adapted to the specific contexts where they are implemented, meaning that different collection modes should be defined depending on the typologies of the different areas of one given territory. The main recommendations to improve capture rates and quality are the following:

SEPARATION SYSTEM

- Source separation is highly recommended for glass packaging, and paper and cardboard;
- No notable difference could be identified between systems separating glass by colours and systems collecting all different colours of glass together when it comes to capture rates and quality;
- For plastic, metal, and drinking cartons, no evidence could be found on the advantage of source-separation over co-mingled collection;
- Collecting all types of plastic packaging together, possibly with metal and drinking cartons, seems relevant if the sorting processes are adapted accordingly.

COLLECTION MODES

- Every collection mode has advantages and drawbacks. Door-to-door systems are usually perceived as more convenient and associated with higher participation rates, but might also be more expensive and space-consuming for households. Bring bank systems can be seen as more flexible for inhabitants and less expensive, but might lead to less participation and higher contamination;
- For glass packaging, bring bank systems slightly lower capture rates than door-to-door systems, however the quality is higher in average;
- For plastic packaging, both the capture rates and quality obtained with door-to-

door systems seem higher than with bring bank systems;

- Reducing collection frequency of residual waste can have a positive impact on the capture rate of door-to-door systems;
- To be effective, bring systems needs to ensure a good proximity and visibility of bring points, along with strategic location (next to shops, public buildings, schools, or on the way to transport hubs);
- In very dense area where there is limited available space, combining a door-to-door system with punctual or permanent bring points can contribute to improve the sorted quantities.

Figure 1: one of the eco-station in Parma (source: G. Folli, 2016)

INCENTIVES

- Strong incentivising instruments such as pay-as-you-throw (PAYT) schemes or sorting obligations are highly recommended to improve sorting performances;
- PAYT systems can be implemented in various manners, depending on the context and typology of housing. Such implementation requires significant efforts on communication, and a close monitoring of contamination and illegal behaviours. These side effects tend to decrease over time;
- Alternatively, “know-as-you-throw” systems where individual sorting behaviours are monitored to provide individual feedback can be implemented.

IMPLEMENTING CHANGES

- **Assess the impact of changes on the following elements**: available space in households and buildings, additional time and efforts for inhabitant to comply, and accessibility of collection points, if any;
- Focus communication on the **practical modifications and implications on inhabitants, and on the reasons behind the changes**. Direct communication activities (e.g. door-to-door campaign) can be recommended to ensure that the information reaches the inhabitants;
- Monitor the participation and reception of the changes, through a **feedback-gathering mechanism** (e.g. webpage or phone number to address complaints).

TOWARD A CIRCULAR ECONOMY APPROACH

As for the alignment of PPW collection systems with the rest of the value-chain, the following recommendations can be formulated:

- Easily sortable fractions, such as PMC, can be collected together without hindering the quality of the separated fractions; however, glass and paper/cardboard should be source-separated to secure the quality.
- The number of collected materials for each stream should be limited ("do's and don'ts) to allow more homogeneous fractions.
- Ensure the alignment of the various steps: collection, sorting, and recycling, by:
  - Making clear agreement on the scope of each fraction;
  - Securing the transfer of information between the consecutive steps;
  - Ensuring clarity on the specifications for the outputs of collection, sorting, and recycling;
- Control the quality of the collected fractions, by using transparent equipment, asking collection operators to visually check the quality of the content of the sorted fractions before collection, and organising punctual controls of the content of the bins with corrective actions (information on sorting guidelines, or fines).

ECONOMIC BALANCE OF WASTE COLLECTION SYSTEMS

The analyses conducted by COLLECTORS and the review of previous studies highlighted the following elements:

- Collection and processing of PMC is generally the most expensive fraction per unit of mass, while costs per tonne for glass and paper cardboard are comparably less expensive, and cheaper than the cost per tonne for residual waste collection and treatment;
- For most case studies, the waste fee paid by the inhabitants is the main source of incomes for the waste management of paper and packaging waste;
- For all five case studies increasing the separate collection of PPW lead to higher collection costs, that were compensated by increasing revenues and savings on treatment costs for residual waste. Therefore, the waste fees remained stable, or decreased;
- Based on available data from France and the Netherlands, it appears that bring bank systems seem to be cheaper options for glass and PMC.

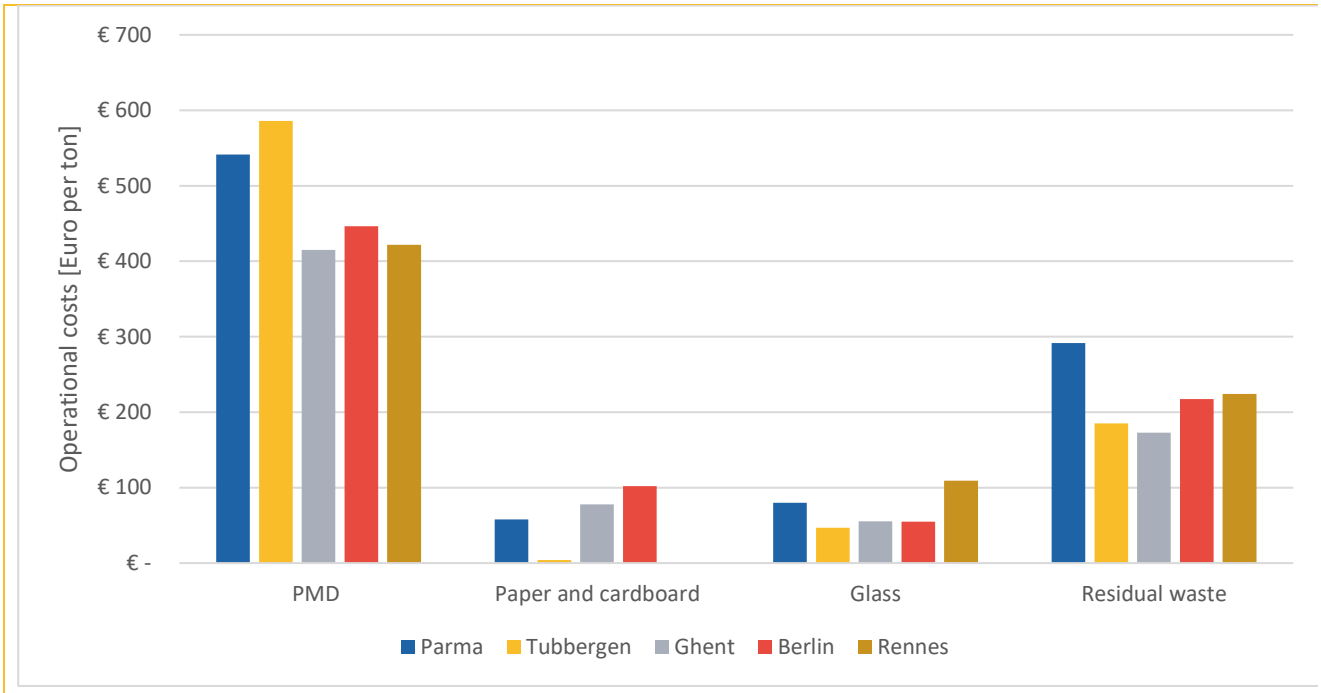


Figure 2: Operational costs per tonnes for each PPW stream, for the documented case studies

Waste Electrical and Electronic Equipment

ASSESSING THE SITUATION AND MONITORING

Improving local waste collection systems starts from a proper assessment of the initial situation, regarding the level of performances, but also regarding the current organisation of waste collection. Assessing the situation can be done by comparing the performances with legal targets, or by comparing performances with other "comparable territories".

Comparisons should take into account the following elements:

- **Local data might not be reported in a consistent way:** the exact scope of data might be very heterogeneous among local territories. The share of non-household WEEE, the collection points included or not, or the codification used for reporting might be inconsistent;
- **Significant data gaps** linked with illegal practices or mislabelling of WEEE streams can also lead to discrepancies;
- **The contexts can also impact the performances:** local consumption patterns can lead to more or less WEEE generation, or the presence of big retailers as collection points can lead to the collection of WEEE from outside of the administrative border of the considered territory. Besides, high-densely populated areas and low-GDP cities generally present lower collection rates compared to other territories.

Key indicators to assess and compare different waste collection system can be recommended:

Cluster	WEEE Criteria	Comments
Capture and recycling rates	WEEE capture rate WEEE collection rate	Capture rate is regarded as one of the most relevant indicators, yet it is generally uncertain as what is put on the market on local level is an estimation. Monitoring the share of large WEEE received non-intact can also help to identify scavenging. Besides, WEEE ending up in scrap dealers can be considered as another relevant criterion.
	Share of WEEE in mixed residual waste (%)	WEEE in mixed residual waste can give a hindsight on the potential for improvement.
Engagement & participation	Existence of feedback gathering system	Identifying efforts to establish a communication with the inhabitants can give good indications of a waste collection system performing well in terms of social acceptance and general communication.
Environment, Health & safety	Climate impact	Climate impact is a relevant criterion for early phase prioritisation of improvement actions regarding WEEE collection on a case region with developing collection system.

	Getting the hazardous substances out of the loop and critical materials recycled	It is regarded as relevant for early phase prioritisation of improvement actions regarding WEEE collection on a case region with mature collection system
Socio-economic impacts	Increase in local employment	This criterion is especially relevant for re-use and disassembly activities that are job-intensive and can play a relevant role for the social economy.
	Total costs of WEEE collection (€/tonne)	The cost of collection is an important parameter, especially when considering the waste collection system in a low-GDP area.
Degree of separation & quality	Number of WEEE categories collected in CAS	This parameter can give an interesting hindsight on the quality of the separation system.
	Share of WEEE collected in CAS in relation to total WEEE collected	The quality of WEEE received through retail bring-points is in general of better quality when compared to other sources.
Convenience & coverage	Number of inhabitants / 1 retailer bring point and non-retail bring points	In parallel with the number of bring points per inhabitants, information on their proximity be also considered
	Easy access to collection (for consumers)	Other indicators for assessing the proximity (such as the average distance to bring points), opening hours, visibility, availability of different collection modes, etc. can give an overview of the convenience of collection.

To conduct comparisons, individual factsheets presenting the waste management organisation and performances of all the documented waste collection systems are accessible on the COLLECTORS webplatform.

SETTING PRIORITIES

The fate of a large share of WEEE is unknown, as shown on the following figure mapping the stream of small WEEE and lamps in Helsinki:

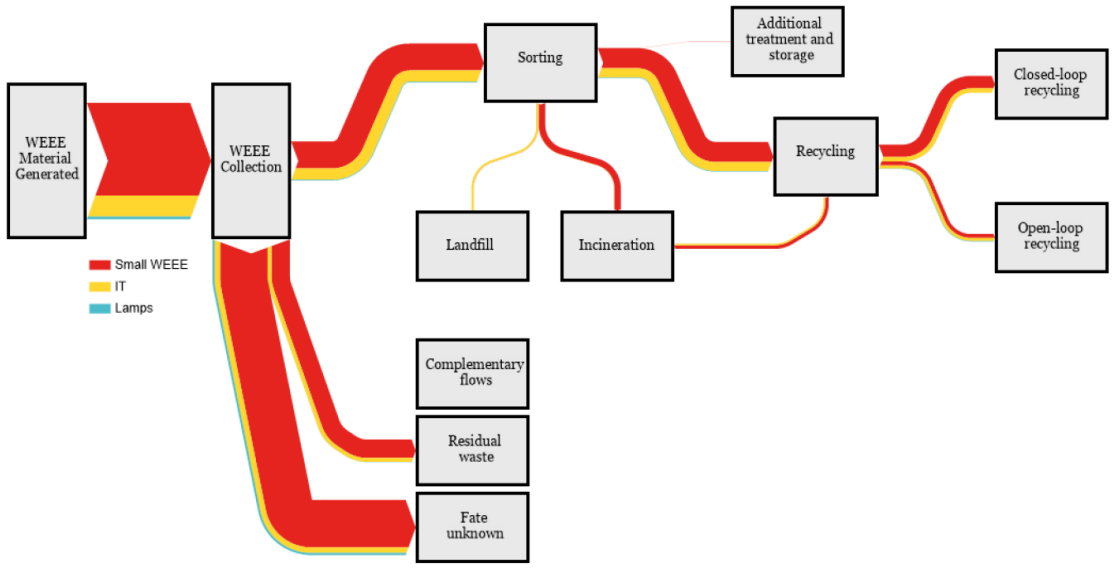


Figure 3: streams of small WEEE, IT equipment, and lamps, in Helsinki, Finland

WEEE might be hoarded or passed on, illegally managed (scavenged or treated as scrap metal), or illegally exported. It is therefore relevant to better monitor these unreported quantities, and improving local management of WEEE must focus as much on improving collection than on tackling illegal practices.

From an environmental point of view, recycling of specific WEEE fractions such as IT equipment has a limited environmental benefit due to technical limitations. For such fractions, re-use yields a significant potential to improve the environmental impact linked with EEE products. On the other hand, the environmental balance of re-use might be more nuanced with equipment with different range of energy efficiency. It might be more environmental beneficial to replace an old appliance with a low energy efficiency, by a new one with a better energy efficiency, especially if the "consumption phase" of the product has a significant contribution.

IMPROVING CAPTURE RATES AND QUALITY

COLLECTION MODES

Waste collection systems must be adapted to the specific contexts where they are implemented. Many different collection modes are available, ranging from on-demand collection to permanent collection points. The key to success lies in the proper combination of complimentary modes, and their adequation with inhabitants' constraints

Several guiding principles can be listed when it comes to the design and implementation of collection systems:

- **Proximity and accessibility**: proximity is especially important in densely-populated areas. It includes different criteria, such as opening hours fitting the constraints of inhabitants, or specific services to people that might experience difficulties in carrying their waste;
- **Visibility:** collection points should be visible, e.g. following a proper, possibly consistent visual identity, designed with clear instructions. Visibility is also a matter of information on the location of collection points;

Figure 4: one of the Eco-van collecting small WEEE in Genoa, Italy

- **Security:** collection points should also be located in secured locations to preserve the value of the collected WEEE and avoid scavenging;
- **Simplicity:** using the collection schemes should be as simple as possible: conditions to use them should be easily available information. Having trained employees able to help the users with WEEE sorting greatly contributes to their user-friendliness;
- **Motivation:** a better understanding of their perspectives and motivations, as well as their possible misconception on WEEE management, will contribute to more adapted messages to promote sorting behaviours;
- **Cleanliness:** dirty collection points will deter inhabitants from using them. Collection points should be associated with “resources” more than with “waste”.

There is no “perfect”, one-size-fits-all collection system, and each of them has advantages and drawbacks. It is recommended to avoid collection options with which WEEE are handled with other items, get damaged or that can lead to scavenging. For instance, collecting WEEE with regular kerbside collection of mixed bulky waste might not enable qualitative recycling.

COMMUNICATION

As with other waste fractions, communication is a key element for a successful local waste collection system. Communication activities focus on several aspects:

- Provide **practical information** on WEEE collection to waste producers, and ensuring a consistent communication covering the different collection options, regardless of the operator (city, retailers, charity organisation);
- **Promote proper sorting behaviours**, by lifting mistrust and doubts on WEEE management, and raising awareness on the negative outcomes of illegal practices;

- **Collect feedback from inhabitants** on their behaviour, perspective, and motivations.

PRESERVING THE QUALITY

Ensuring a good quality for the sorted WEEE is very important to guarantee its proper re-, use, recycling, and recovery of materials. Quality is impacted by **scavenging**, i.e. the removal of valuable parts from EEE products, **improper collection and storage conditions**, and **contamination by non-WEEE** in the collected streams. Preserving quality can be done through:

- **Adapted collection equipment and proper segregation**, such as specific containers for lamps, small WEEE, and small IT equipment, and collected separately from bigger appliances;
- **Training of staff at municipal collection points,** in identifying the different products, informing the users, and properly storing and handling the different fractions;
- **Better communication** on collection points, with clear indications on the different banks and containers;
- **Securing collection points;**
- **Better monitoring of contamination** in the different fractions, e.g. on specific key types of WEEE;
- **Standards for collection.**

Quality of collected WEEE is generally higher in retail collection points, where the staff is trained and security is higher than in civic amenity sites.

PROMOTING RE-USE

One third of WEEE, furniture, and leisure goods disposed at civic amenity sites could be prepared for re-use. Integrating re-use into WEEE collection systems is necessary to increase the quantities made available for re-use organisations.

When it comes to collection, preserving the integrity of collected items must be the main focus. Several recommendations can be listed:

- In civic amenity sites, train the staff on re-use, better inform the users on the re-use options, and improve the handling and storage of WEEE (in closed, secured areas);
- Define other collection schemes for re-usable products: on-demand collection, mini recycling stations located in urban centres, punctual collection events on the public space, or collection in stores.

Figure 5: punctual WEEE collection point in Paris (source: ecosystem)

TACKLE ILLEGAL PRACTICES

Illegal practices such as scavenging and theft have a significant impact on both the capture rate and the quality of sorted fractions, which seriously hinder the further possibilities for re-use or recycling.

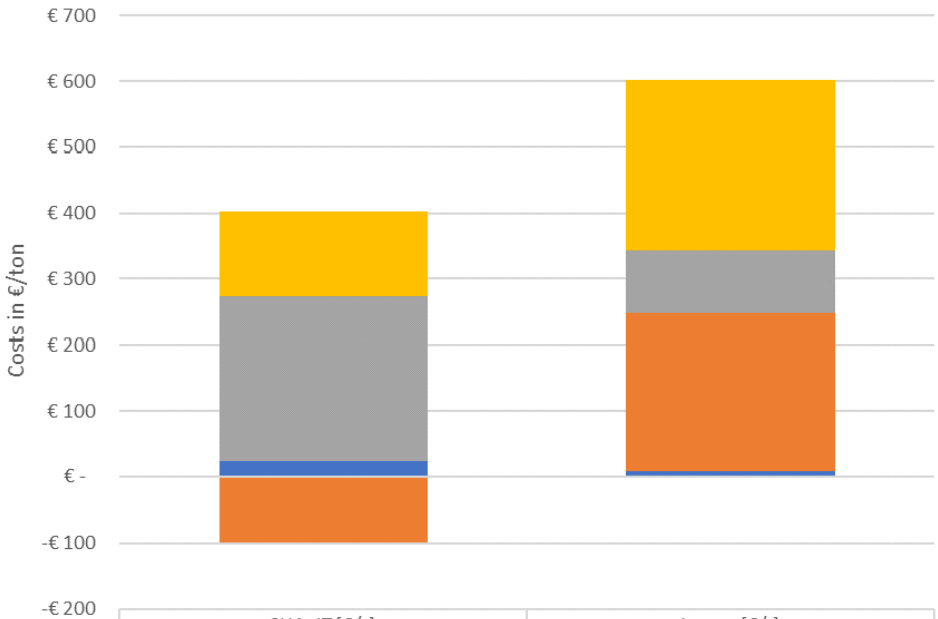
- **Improve surveillance and training of collection staff** in municipal collection points to reduce the level of scavenging, aligning with the practices in retail points;
- **Marking of WEEE** received on the CAS to allow traceability;
- **Cooperation with local police,** that can perform regular checks to monitor the presence of illegal activities;
- **Better monitor the level of scavenging** by identifying missing parts in key fractions and monitoring the individual performances of collection points;

Figure 6: marking of WEEE on CYCLAD's civic amenity site, France (source: Cyclad)

Additionally, other flows of unreported WEEE are associated to WEEE that is collected together with scrap. Specific measures have been set in place in some MS, like for example the ban on cash transactions in France or the requirement to scrap facilities for reporting the WEEE received separately. Enforcement is key for ensuring these measures are implemented.

ECONOMIC BALANCE OF WASTE COLLECTION SYSTEMS

The average cost-benefit balance for the management of small WEEE and lamps are very different, as shown on the following graph:



	SHA+IT [€/t]	Lamps [€/t]
Transport and collection	€ 129	€ 259
Shredding, sorting, dismantling and pretreatment	€ 249	€ 95
Recycling and recovery	-€ 98	€ 240
Incineration and landfill	€ 24	€ 8

Figure 7: average European technical costs for WEEE management, 2008

For small WEEE, treatment costs outweigh collection and transport costs, while the revenues from sorted materials only cover a small part of these total costs. For lamps, collection costs are much more significant, and the fact that they contain hazardous content makes their treatment more expensive, while producing no revenues.

The analysis of five case studies has shown that implementing good practices (such as new collection options, or communication campaigns) lead to positive economic outcomes, due to savings on the cost of WEEEE lost due to improper collection and scavenging (€1,480 per tonne).

Construction and demolition waste (CDW)

MUNICIPAL MANAGEMENT OF CONSTRUCTION AND DEMOLITION WASTE

There are significant differences when it comes to the handling of construction and demolition waste by local authorities. Among the diversity of organisations, several trends can be highlighted:

- Many local authorities only collect CDW through their civic amenity sites;
- Most of them limit the CDW handled by the municipal service: only household waste is accepted, with limited quantities, and only certain fractions (e.g. rubble or asbestos);
- Some do accept non-household waste, but with limits on volumes or weight, or as a paying service. In some cases, quantities beyond a certain limit are charged;
- In many cases, larger quantities (even generated by households) have to be collected by an authorised private company.

Comparing different CDW collection systems can contribute to the identification of good practices, yet the significant differences when it comes to the operational role of local authorities makes it challenging. Besides, several contextual parameters are relevant to be considered as well: the type of housing, population density, and local GDP.

Individual factsheets presenting the waste management organisation and performances of the documented waste collection systems are accessible on the COLLECTORS webplatform.

GYPSUM RECYCLING IN REIMERSWAAL (NETHERLANDS)

Reimerswaal is a municipality in the province of Zeeland in the south-western Netherlands on Zuid-Beveland. 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 is responsible for the collection and management of household waste and outsourced the operation to private scheme the Zeeuwse Reinigingsdienst (ZRD).

ZRD collects about 25 separate waste streams at the civic amenity site, amongst which are gypsum, wood, bricks and concrete, glass, plate glass, hard plastics, metals. ZRD focusses on collecting clean gypsum waste, free from contamination, such as tiles and wood, and instructs the citizens and other users of the CAS to separate gypsum accordingly. After collection in a separate container, all gypsum waste from ZRD is transported to New West Gypsum Recycling in Kallo, near Antwerp. It is essential that the recycled gypsum achieves a pre-determined quality suitable for the manufacturing of new gypsum products. The collection of gypsum is considered as very good, reaching almost 6 kg/cap in 2017.

The initial reason for source-separation of gypsum was the introduction of a ban on landfilling for waste fraction with a potential for recovery, which is the case for gypsum.

Overall, the low investment costs and transport costs, but mostly the high costs for landfilling, makes the practice economically viable.

RECOVERY OF BRICKS, INSULATION AND SANITARY WASTE IN ODENSE (DENMARK)

Odense is the 3rd largest city in Denmark with a population of 204,200 inhabitants. Municipal waste is managed by a public waste company, Odense Renovation A/S. Odense has 8 recycling stations (CAS), with over 40 containers for collecting different waste materials.

Figure 8: container for toilets and washbasins in one of the civic amenity site in Odense, Denmark (source: Odense Renovation)

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. Discarded bricks have their own dedicated containers at the recycling centres, and is then sent to a factory in Svendborg on Funen, where they are cleaned and sorted before being stacked on pallets ready for reuse in new constructions.

Odense also collects both waste mineral wool insulation and waste ceramic sanitary ware separately in order to repurpose this material. In 2016 Odense started working with two companies for the recycling of both these materials streams.

Odense has reached one of the country's highest recycling rate for bulky waste, with about 87% of bulky waste/CDW being recycled. Then environmental analysis shows that

the avoided impacts linked with the re-use of bricks (and thus the avoided primary production of new bricks), and of insulation materials are extremely significant. For both fractions, the impact of additional transport is negligible. The impact of the recycling process of insulation material is noticeable, but small compared to the avoided impact thanks to the displacement of primary production. The environmental benefit from the use of sanitary ceramics in concrete, on the other hand, is rather limited.

The cost-benefit analysis shows the importance of transport and landfill costs for the economic balance of CDW recycling. The presence of close-by recycling units and competitive gate fees for recycling allow reaching a positive economic balance.

RECOMMENDATIONS FOR CDW MANAGEMENT

The starting point for the separate collection of specific CDW is the availability of a clear market for the final end-application and a clear business-case, in combination with landfill taxes or bans. Defining the waste collection systems according to these end-applications and their associated requirements is strongly recommended.

The approach developed by Odense, were separated fractions are determined according to the new potential routes for valorisation and end-application, seems extremely relevant when it comes to the design of the CDW collection service.

Measures to maintain waste collection and separation in COVID-19 pandemic

KEY RECOMMENDATIONS

The results of the COLLECTORS survey, the review of measures implemented at national, regional, and local level, and other studies and guidelines identified allow to list the following key recommendations for handling waste collection in time of pandemics:

- **Flexibility** is key to ensure the continuation of priority collection services, and the territories that could maintain good collection were the ones that could re-allocate resources among the different collection schemes (e.g., from commercial waste to household waste collection). It might be relevant to multi-skilling the operational staff to help them to fulfil different operational roles to improve the resilience of the service.
- **Keeping civic amenity sites open** with adequate measure can be recommended. Online booking systems received very positive feedback from users, but also from staff.
- **Define priority levels** for collection services, focusing on collection modes limiting the interactions with inhabitants, or on specific waste fractions (e.g., residual waste, food waste, etc.). Keeping collection frequencies for sorted fractions greatly contribute to keep sorting performances steady.
- **Give priority to online communication** to reach inhabitants, provide clear information and simple, coordinated messages, and explaining the reasons behind changes. Taking advantage of the local media can also be recommended. It is also recommended to take the opportunity for giving the priority to messages on waste prevention.
- **Establish a consistent and continuous reporting** of the evolution of quantities.
- **Tackle illegal practices** such as fly-tipping by setting a closer monitoring, the enforcement of the regulation, an adequate communication, and ensuring that alternatives collection systems are still available (such as civic amenity sites).
- **Take advantage of guidance**, support systems and networks, to identify good practices and recommendations.
- **Follow UNEP recommendations** regarding the management of waste from COVID-positive households.

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WASTE COLLECTION SYSTEMS ASSESSED AND GOOD PRACTICES IDENTIFIED

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