ACR+

BENEATH THE SURFACE: INSIGHTS FROM SIX CITIES CHANGING THEIR WASTE COLLECTION

Analysis of underground container systems and sorting areas

EXECUTIVE SUMMARY

March 2025

ACR+ is an international network of cities and regions sharing the aim of promoting a sustainable resource management and accelerating the transition towards a circular economy on their territories and beyond.

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INTRODUCTION

CONTEXT

This report describes how six European cities implemented waste collection systems resorting to underground containers. It analyses their experiences to better understand the impact of these containers on the operational aspects of collection, the sorting performances, costs, and the satisfaction of users. The study focuses on underground containers but also addresses the concept of "sorting areas". These refer to a set of underground containers located in the same area for the collection of different waste fractions. These sorting areas are generally dedicated to specific typologies, such as high-rise buildings, historical centres, or a given neighbourhood, as an alternative to e.g. shared wheeled bins or traditional bring banks. Various aspects of waste collection come across the report: sorting in high-rise and multi-family buildings, the change of collection modes (e.g. from a door-to-door to a bring scheme), and their "underground" aspect that impacts their capacity, visual integration, but also their cost.

The case studies selected reflect highly urbanised contexts and different situations in terms of typology, changes operated, or operational aspects of the underground containers.

UNDERGROUND CONTAINERS

The study analyses the impact of changes in collection methods for municipal waste management in various major European cities, with a particular focus on bring schemes and underground containers, two aspects of these "sorting areas". Underground containers are used for different reasons and impact different aspects of waste collection, such as:

- **Sorting convenience:** implementing underground containers creates a new interface with the users compared to the previous collection method. It might improve the "sorting experience", e.g. by giving more flexibility to users for disposing of their waste.
- **(Pre)collection capacity:** in areas where waste generation is very concentrated and where public and private space to store waste is limited, underground containers bring an adequate solution while limiting the public space taken.
- **Containerisation of waste:** underground containers might be implemented to replace a system collecting waste in bags that are exposed to vermin and might clutter up pavement during collection.
- **Urban integration:** underground containers might limit the visual impact of collection equipment, especially compared to traditional, above ground containers.

Initial research on underground containers, carried out to select the case studies, reveals several difficulties inherent to this system. These include some new constraints for users (possible limits of volume that can be brought or due to differentiated opening on containers), the need to adjust collection routes according to the filling levels, the additional "permanent" consumption of space when it replaces a door-to-door scheme, or the need for maintenance. Another frequently reported issue is illegal dumping, linked to saturation or malfunction of containers, or to other factors.

FEATURED **CASE STUDY**

FROM DOOR-TO-DOOR TO UNDERGROUND CONTAINERS (ANTWERP – BE)

Population 536,000 inhabitants (2023).

Density 2,600 inhabitants/km² (2023).

System studied The «sorteerstraat» consists in sets of containers generally including different fractions. They are in public spaces or at the foot of high-rise buildings.

Fractions collected	Residual	Bio-waste	P/C	PMC	Glass	Other
	✓	✓	✓	✓	✓	–

DESCRIPTION

Containers
- 4 to 6 m³.
- Controlled opening with PAYT.
- Different openings depending on the fractions.

Network
- 180 sorting areas / +700 containers.
- 48,000 users (<10% of the population).

Location
- Eco-districts.
- High-rise buildings / social housing.

Sorteerstraats in Antwerp.

IMPACT OF THE SYSTEM

Operations New collection vehicles, optimisation of collection routes thanks to filling sensors.

Performances Sorting performances comparable with door-to-door scheme, high contamination for bio-waste possibly connected with the PAYT system (illegal use for residual waste).

Cleanliness Illegal dumping next to containers, but it improved cleanliness of pavements compared to collection in waste bags.

Economy Savings achieved on staff costs, balanced by high investments and maintenance costs. Potentially comparable costs with door-to-door if extended to the whole city. Not viable if both collection systems are kept in parallel.

MAIN CONCLUSIONS

- Nuanced impact of underground containers/sorting areas, leading to the identification of typologies where their implementation is relevant: eco-district, high-rise buildings, enough users within a reasonable perimeter.
- Generally positive feedback from household users.
- Interesting economic analysis showing comparable overall costs with door-to-door for an optimised network of containers ensuring sufficient proximity with users.
- Some sorting areas were removed for various reasons (operational issues, illegal dumping, etc.) but the implementation of underground containers is still underway.

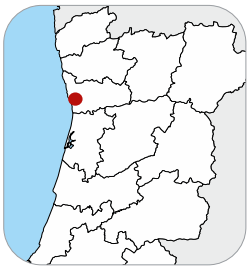
FEATURED **CASE STUDY**

UNDERGROUND CONTAINERS TO OPTIMISE STORAGE (PORTO – PT)

Population 231,800 inhabitants (2021).

Density 5,600 inhabitants/km².

System studied The installation of underground containers in part of the historic centre of Porto, in addition and replacement of overhead and above ground containers.



Fractions collected	Residual	Bio-waste	P/C	PMC	Glass	Other
	✓	✓	✓	✓	✓	–

DESCRIPTION

Containers
- 3 to 5 m³, grouped in "ecopoints".
- Open access.
- Same opening for all containers.

Network
- 17 ecopoints for the sorted fractions and 59 containers for residual waste grouped with ecopoints or isolated.
- 7,000 inhabitants using the system.

Containers in Porto.

Location
- Historical centre of the city, but such containers are also implemented in other parts of the city.

IMPACT OF THE SYSTEM

Operations Reduction of the number of collection points, but increase of their total capacity. The same collection vehicles are in use than for the "traditional" above ground ecopoints.

Performances Better collection performances according to the municipal company, but limited impact on the overall city performances and no quantitative data available waste).

Cleanliness Reduction of the saturation of collection points, but illegal dumping is still present.

Economy Reduction of household collection costs linked to the shift to underground containers, but the implementation of a parallel door-to-door system for assimilated waste led to additional costs.

MAIN CONCLUSIONS

- No significant change in the collection mode: the reduction of the number of collection points allowed to optimise collection without impacting too much the proximity to users. The larger capacity and improved visual aspect increased user-friendliness.
- Specific door-to-door service for commercial waste to reduce the saturation of containers.
- Improvement of collection performances and optimisation of collection routes leading to an expansion of the underground container system in other parts of the city.

FEATURED **CASE STUDY**

A CITY COLLECTED USING PREDOMINANTLY UNDERGROUND CONTAINERS (ROTTERDAM – NL)

Population 664,300 inhabitants (2023)
(metropolitan area: 2.6 million inhabitants).

Density 3,000 inhabitants/km².

System studied Network of underground containers installed in a large part of the city.

Fractions collected	Residual	Bio-waste	P/C	PMC	Glass	Other
	✓	✓	✓	–	✓	Textile

DESCRIPTION

Containers
- 5 m³.
- Controlled access only for bio-waste (voluntary participation upon registration).
- Different openings depending on fractions.

Network
- 6,650 underground containers out of 7,550 containers, among which 5,250 for residual waste. 1 residual waste container for 100 households.

Containers in Rotterdam (Donald Trung Quoc Don - Wikimedia Commons)

Location
- Covering almost the entire city, except the areas with single housing that have a door-to-door collection.
- Not necessarily organised in sorting areas.

IMPACT OF THE SYSTEM

Operations Implementation in the 90s to replace a collection with waste bags. Many changes and innovations to optimise the system over the years.

Performances Average collection performances, with slow improvement. The areas using door-to-door collection apparently present better performances, that might also be linked with the type of housing using the door-to-door system.

Cleanliness Illegal dumping around containers, with very variable intensity depending on the areas, and few collection points concentrating the majority of fly-tipping. Significant work on understanding the causes behind illegal dumping, that tend to greatly differ depending on the locations and identifying adequate solutions.

Economy Important maintenance costs. The city considers that the savings on staff costs and the greater lifespan of underground containers compared to traditional ones manage to make the system viable.

MAIN CONCLUSIONS

- A network in constant evolution and revision.
- The underground character is very relevant in a dense, urban area.
- A significant work on illegal dumping and on finding solutions adapted to the identified causes (better management, information, controls and fines, etc.).

FEATURED **CASE STUDY**

UNDERGROUND CONTAINERS IN A HISTORIC CITY CENTRE (FLORENCE – IT)

Population 367,150 inhabitants (2022).

Density 3,600 inhabitants/km².

System studied Underground containers installed in the UNESCO city centre zone.

Fractions collected	Residual	Bio-waste	P/C	PMC	Glass	Other
	✓	✓	✓	✓	✓	–

DESCRIPTION

Containers

- 5 m³, few areas with 20 m³ containers.
- Controlled access except for glass, smart app for non-residents. Door-to-door collection for paper/cardboard waste.
- No different opening for each waste fraction.

Network

- 62 sorting areas with 340 containers in 2023. 94 containers are expected at the end of the implementation.
- In the UNESCO area, with 44,000 inhabitants and many commercial waste producers.

Location

- In 2023, 70% of the UNESCO area was covered.
- For both household and commercial waste.

Underground containers in Florence.

IMPACT OF THE SYSTEM

Operations New collection vehicles, but the new system allowed to optimise collection routes.

Performances Improvement of the collection rate, good quality except for PMC, collection performances close to the ones in the other, less dense parts of the city using a door-to-door or a above ground containers system.

Cleanliness Illegal dumping occurring around collection points.

Economy Significant investments but important savings on operational costs (36% less expensive than door-to-door collection), and significant savings on disposal costs.

MAIN CONCLUSIONS

- Significant improvements compared to the previous system mixing large, wheeled bins for residual waste and above ground bring points for recyclable.
- Paper and cardboard still collected door-to-door due to size and volume.
- High collection performances considering the challenging, urban context.

FEATURED **CASE STUDY**

CONTAINERS TO COMPLEMENT OR REPLACE DOOR-TO-DOOR DELIVERY (HAMBURG – DE)

Population 1,964,000 inhabitants (2023).

Density 2,600 inhabitants/km².

System studied Drop-off containers deployed in Hamburg alongside or in place of wheeled bins or bags, including "depotcontainers", traditional containers for paper, cardboard and small WEEE, and underground containers installed at the initiative of developers or landlords in high-rise residences.

Fractions collected	Residual	Bio-waste	P/C	PMC	Glass	Other
	✓	✓	✓	✓	✓	–

DESCRIPTION

Containers

- 5 m³ for underground containers, 1 m³ for depotcontainers.
- Controlled access for underground containers, not for depotcontainers.
- No differentiated opening for underground containers.

Underground containers in Hamburg (photo: SRH)

Network

- 960 sorting areas in high-rise buildings.
- 5,100 depotcontainers, mostly for glass and paper and cardboard.

Paper/cardboard depot container in Hamburg (photo: SRH)

Location

- Underground containers: in high-rise building at the request of landlords.
- Depotcontainers on the public space depending on needs and possibilities.

IMPACT OF THE SYSTEM

Operations Increase of the number of vehicles, initial difficulties with the collection routes of depotcontainers.

Performances No noticeable improvement connected with the implementation of containers, lack of specific data.

Cleanliness Problem of illegal disposal next to depotcontainers, especially for paper and cardboard due to saturation of containers. No problem reported for underground containers.

Economy Little quantitative data, possible increase of overall waste management costs.

MAIN CONCLUSIONS

- Two different systems of containers studied, with different applications, either replacing or complementing door-to-door schemes.
- Problems of remoteness and sometimes of saturation of depotcontainers due to their use during weekends and public holidays.
- Underground containers preferred over wheeled bins in high-rise buildings for cleanliness, capacity, and convenience, but no visible impact on performances.

FEATURED **CASE STUDY**

SWITCHING TO DOOR-TO-DOOR SERVICE IN A CONTEXT OF HYPER-DENSITY (BARCELONA – ES)

Population 1,703,000 inhabitants (2024).

Density 16,800 inhabitants/km².

System studied Two neighbourhoods (Sarria and Sant Andreu) that have switched from a drop-off system to a door-to-door collection for households.

Fractions collected	Residual	Bio-waste	P/C	PMC	Glass	Other
	✓	✓	✓	✓	✓	Sanitary textiles

DESCRIPTION

Containers

- Door-to-door with (transparent) bags.
- Bottle banks kept for glass packaging waste.
- Smart containers introduced for food waste (in one of the two districts) and sanitary textiles.

Network

- Containers for food waste on the public space or next to large, high-rise buildings (Sant Andreu).
- 15 containers for sanitary textiles.

Location

- About 40,000 inh. in both Sarria and Sant Andreu.

Containers with controlled opening for bio-waste in small buildings (left) in large buildings (lower right) and door-to-door collection starter kit (source: https://www.barcelona.cat)

IMPACT OF THE SYSTEM

Operations New vehicles, more collection routes.

Performances Significant increase of sorted quantities after the switch to door-to-door or after smart containers for food waste.

Cleanliness Little data, but many non-compliant presentations of waste bags (outside of collection hours, etc.).

Economy Increase of collection costs, but no detailed economic balance for both districts.

MAIN CONCLUSIONS

- Significant increase of sorted quantities, especially bio-waste.
- Strong opposition of the population against the new system (transparent bags, limited hours to dispose of their waste, collection rounds during the night, etc.).
- Containers with controlled access as an intermediary solution for bio-waste.

CROSS ANALYSIS

COLLECTION METHOD

For some of the cities, the shift to underground containers meant a change in the collection method. Assessing how such a change influences collection performances is challenging: the shift from bring banks to a door-to-door scheme considerably improved collection performances in Barcelona, whereas in Antwerp, shifting from door-to-door to underground containers had no noticeable effect. Two aspects of the collection method appear to influence sorting behaviour and user satisfaction:

- The convenience and user-friendliness of collection, largely determined by the space available for storage and the proximity of collection points, and the "anonymity" of collection
- The individualisation: anonymous systems (i.e. where individual contributions cannot be identified) generally lead to a reduced sense of individual responsibility and to worse performances.

DIFFERENT SYSTEMS

The case studies present quite different approaches when it comes to the design of underground containers and sorting areas, reflecting different objectives and local constraints.

The documented cities tend to use underground containers for the same types of waste fraction (residual waste, bio-waste, paper and packaging), with some cities also using them for more specific fractions such as textiles. Bio-waste appears to cause problem in Antwerp due to misuse of the bio-waste containers by some residents to dispose of their residual waste for free. Paper/cardboard is still collected door-to-door in Florence due to its size and difficulty to compact.

Grouping all the different fractions in common sorting areas seems to lead to better sorting performances. However, residual waste and bio-waste might require additional collection points to ensure sufficient proximity for users, since they tend to be the most frequently used containers. Closed containers also tend to give better results in terms of quality than open ones.

In the different case studies, the networks are designed to include between 350 and 500 users per collection points, and a proximity ranging from 50 to 250 m depending on the fractions.

When it comes to the design of a network of collection points, a balance must be found between ensuring a good proximity to users and reaching a sufficient number of users per sorting area to limit costs.

Local authorities tend to play a central role in the design and implementation of sorting areas. Several cities mention the importance of involving different municipal departments and setting clearly defined protocols to speed up the implementation of new points. In many cases, private players also financially contribute to the investment.

Finally, the different case studies highlight several key challenges: narrow, one-way streets where underground container collection can lead to traffic problems, non-compliant use of containers for "free fractions" when residual waste is subject to a fee, and saturation problems, as inhabitants tend to use the containers during weekends and public holidays when collection is not running.

IMPACTS OF SORTING AREAS

The shift to underground containers results in various **operational** impacts that mostly depends on the system being replaced. Moving from a door-to-door system leads to more changes than from a container-based system, such as new collection vehicles, new collection routes, smaller collection crews, and more maintenance. Besides, collecting illegal deposits might require different vehicles than the ones used to empty containers. Many case studies highlight the relevancy of optimising collection routes based on the filling dynamics, possibly with the use of sensors. Finally, all analysed cities mentioned significant cleaning and maintenance costs, some resorting to specific contractors for it.

Overall, it seems that the shift to underground containers does not guarantee higher performances.

The **economic impacts** are closely related to the operational aspects mentioned above. Overall, it is difficult to clearly assess the financial impact of underground containers due to a lack of comparable data. Available data suggest that overall collection costs are comparable to door-to-door systems in a dense context, though with a markedly different cost structure. Underground containers require significant investments and maintenance costs, offset by reduced staffing and collection costs thanks to optimised collection routes. To ensure the economic viability, it is however important to ensure that each collection point serves enough users.

The impact of underground containers on **sorting performances is also nuanced**. Overall, it seems that the shift to underground containers does not guarantee higher performances. These are more likely influenced by a combination of instruments: quality of service, convenience, communication, and incentivising mechanisms. In several case studies, users not complying with the sorting instructions might lead to high contamination (of bio-waste or PMC), and it is more challenging to set an individualised quality control with containers. The use of containers operated by card access seems to lead to less impurities compared to open ones.

When it comes to cleanliness, the lack of comparable data makes the assessment challenging. All case studies reported illegal dumping and littering as a major issue, yet it is unsure if they are caused by containers or if sorting areas tend to "concentrate" illegal dumping. Some of these issues might be due to container management problems (malfunctions, saturations) that can be addressed by corrective measures. However, other factors, such as miscommunication or individual behaviours, might also play a significant role. Illegal dumping does not seem to be systematic in all sorting areas and might be caused by various factors depending on the locations, requiring tailored solutions. It is also worth mentioning that underground containers generally contribute to improved cleanliness compared to collection in waste bags, that tend to clutter the pavements and lead to waste being scattered.

Finally, underground containers yield diverse results when it comes to the handling of commercial waste by municipal services. In Antwerp, the shift to underground containers has led many commercial waste producers to opt for private collectors operating door-to-door, and commercial food waste might be too liquid to be well handled in underground containers. In contrast, commercial users seem to be satisfied with the underground containers set in Florence. Rotterdam mentions specific controls on the fraudulent use of sorting areas by commercial activities (abnormal filling levels, over presence of non-household types of waste, etc.). Commercial users can have a significant impact on the use of containers, possibly leading to saturation or malfunction, so their inclusion must be carefully planned and might require increased collection frequencies.

CONCLUSION

Although the study only documented six cities, their cross analysis allows to draw general conclusions.

First, underground containers and sorting areas present several **benefits in specific contexts.** They offer a more flexible and **convenient solution for residents with limited storage capacity,** compared to a door-to-door system, **as long as the containers are at an acceptable distance.** They also allow to "absorb" large quantities of waste in **areas where waste generation is intense,** limiting the saturation of collection points, while minimizing the (public) space taken. This larger capacity means that, if containers are equipped with sensors, it allows to greatly optimise collection routes.

However, implementing underground containers in urban area can be challenging due to difficulties in identifying optimal locations, significant investment and maintenance costs, the risk of fly-tipping, and issues to collect larger waste such as large cardboard. Besides, combining underground containers with door-to-door collection in the same areas does not appear to be a viable solution financially-speaking.

The case studies show that **the impact and effectiveness of sorting areas depends on many factors:** the context, the system that they are replacing, the details in their implementation (type of opening, locations, etc.), but also **the other instruments combined to promote waste separations.** Understanding how such system can improve the sorting experience of users (proximity, reliability, cleanliness) is crucial. Results for bio-waste sorting, especially in terms of quality, are mixed. While illegal dumping is a recurring issue, it is unclear whether underground containers increase the problems or rather concentrate them. Underground containers seem to have a limited impact on sorting performances as such, and **performances might depend more on the combination with other (communicative, economic...) instruments implemented in parallel.** Finally, underground containers seem to be viable only if each container serves a critical number of users within a perimeter of 150-200 m, and if routes are optimised using sensors.

Other considerations worth listing include the need to consider the implementation of a network of underground containers in a strategic way and as a long-term process, that will require improvement and revision. The benefit of using underground containers might be more limited in less dense, residential areas. More importantly, **the introduction of underground containers only covers one aspect of waste collection and should be considered in a larger strategy including communication efforts and incentivising instruments.**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