1. DATA MANAGEMENT PROVIDED BY WASTE COLLECTION SYSTEMS

The implementation of technology to convey pay as you throw schemes (PAYT schemes) or fair waste charges generates a lot of information that should be properly managed. It is important to follow a series of guidelines that make it possible to get the most out of the data and to apply the fair waste charge reliably and unequivocally. This chapter will introduce the essential aspects to consider when monitoring the behaviour of taxpayers and personalising waste charges according to the data collected.

1.1. Waste collection models linked with PAYT models (distribution of equipment needed)

The identification of the user of the waste collection service is the first step to develop a PAYT scheme, as it is the subject to whom the waste charge will be assigned. The material needed to identify and measure the participation of users must be distributed in advance of the approval and roll-out of the waste charge. Furthermore, this material should be managed and linked to the database that is used to calculate the waste charge individually for each user.

Depending on the waste collection model, different identification systems are recommended and, consequently, different materials need to be distributed:

- Systems with container identification (door-to-door collection systems).

These are used in individualised collection systems -such as door-to-door- where the bucket, bin or bag are identified by leaving them in front of the entrance of the household or business. Then, a tag or chip can be incorporated into each bucket, bin or bag that can be read by the technology carried by the truck or by the collection operators and it allows the number of deliveries made by each user to be digitally counted. In the case that technology (tags or chips) is not implemented, the most common way to convey a PAYT scheme in an individualised collection system is through a pre-payment system, where a standardized bag or bucket is paid in advance according to the volume and the collection frequency needed.

Pre-payment systems can work by standardized bag or by standardized bin or bucket with predetermined frequency. In these cases, the containers do not have information associated with the user.

In the case of pre-payment systems per standardized bag, the user of the service pays for each bag at the time of purchase. Bag prices vary by fraction and volume.

In the case of pre-payment per bin or bucket systems, the payment depends on the fraction, the volume required by each taxpayer and the pre-established collection frequency. Thus, the payment is independent of the uses. This case is more common in scenarios where applying payment for each delivery involves a high risk of waste tourism - for example, in the case of commercial collection that operates door-to-door in combination with open containers for households in the public space. It is also usually applied to the organic fraction for commercial activities in combination with residual post-payment PAYT schemes to not discourage the separation of this fraction. This pre-payment model per

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bin or bucket is also applied to domestic users in some countries such as the United Kingdom or Germany (Berlin is one example of that). In those cases, there are normally more than one volume per fraction offered.

In the case of Pay-per-bag (also valid for bag models with a tag), it is recommended that two types of bags are distributed per fraction, one domestic size and one commercial size. The recommended volumes for the residual fraction are generally 10-20 litres for households and 50-70 litres for businesses. In the case of packaging fraction, volumes of 30-50 litres and 90-110 litres are recommended, respectively. On the other hand, it is recommended that these bags have a distinctive logo. They should be translucent so that operators can verify that there are no inappropriate items and that the deposited waste corresponds to the fraction represented by the bag.

The organic fraction is not usually charged in the case of households to avoid discouraging its separation.

Diapers should have a special bag so they can stand out from the residual fraction. Diapers should generally be able to be collected more often and should not be charged for like the residual fraction.

The bags should be distributed by the municipality or by collaborating intermediaries such as stores with collaboration agreements. In cases where intermediaries distribute bags, no type of commission should be charged and VAT would not apply. There are also bag dispensing machines (without tags or with tags assigned to the user) with examples in Italy.

The post-payment option generally works with buckets with a chip, tag, or some other identifying element. This identification element of the bucket or bag includes information associated with the corresponding fraction, the volume of the bucket, and identifying information of the taxpayer to whom the bucket corresponds.

Payment can be by weight or by volume. While there are a few pay-per-weight experiences, pay-per-volume is more common for two reasons; 1) because it is easier to register; the weight needs a scale built into the truck to allow continuous weighing of the buckets, and 2) because the volume allows minimising the number of deliveries since taxpayers tend to deliver when it is full.

It is generally recommended to offer several distinct bucket or bin sizes because this allows users to get a size according to their general need, resulting in more correspondence between waste generation and payment.

The recommended volumes of the domestic buckets or bins in regular door-to-door collection schedules would range between 15 and 25 litres for the organic fraction, between 20 and 25 litres for the residual fraction, and between 40 and 50 litres for the packaging fraction.

Diapers should have a special identifying bag that should be delivered more often without supposing an extra charge for the taxpayer. To obtain these types of bags, the taxpayer should prove the condition that allows their use, such as, for example, the presence of babies in the home or elderly people with specific needs.

> Systems with user identification (collection in e-containers or smart containers).

These systems are installed in areas where shared containers are used. In this collection system, the containers of the monitored fractions can only be opened after the identification of the user (using a

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magnetic card or an equivalent system). The container can have a volumetric chamber that allows a maximum volume of waste to be dumped (pay-per volume) or it can have a weighing system incorporated (pay-per-weight).

Another option is to just count the number of openings of the container as a proxy (pay-per-use), although this can reduce the reliability of the fee charged to each taxpayer. For this reason, in this scenario, user incentives for properly separating waste fractions (participation) are usually proposed in the first instance, especially for the organic fraction.

User identification systems can be integrated into any type of container – including surface, underground, pneumatic and self-compacting containers. Normally, when smart containers are implemented, the management software allows restriction of which container can be opened by each user, so that users can only access one or two containers that have been allocated near to their residence. This makes it easier to control more precisely and identify the user(s) responsible for incidents or misuse.

1.2. Technologies for user or container identification

The diagram in Figure 1 summarises the electronic identification systems of the containers and the users, in the case that such identification technology is necessary to apply the PAYT scheme. Note that for pre-payment systems with standardised bags or buckets with a predetermined frequency, this technology would not be necessary.

There are different identification technologies:

- Radio-frequency identification (RFID) using electromagnetic cards.
- Near-Field-Communication – NFC, with smartphones.
- QR codes inserted on containers to be read by smartphones.

This identification can be compulsory or voluntary by the users, depending in the type of technology and systems implemented:

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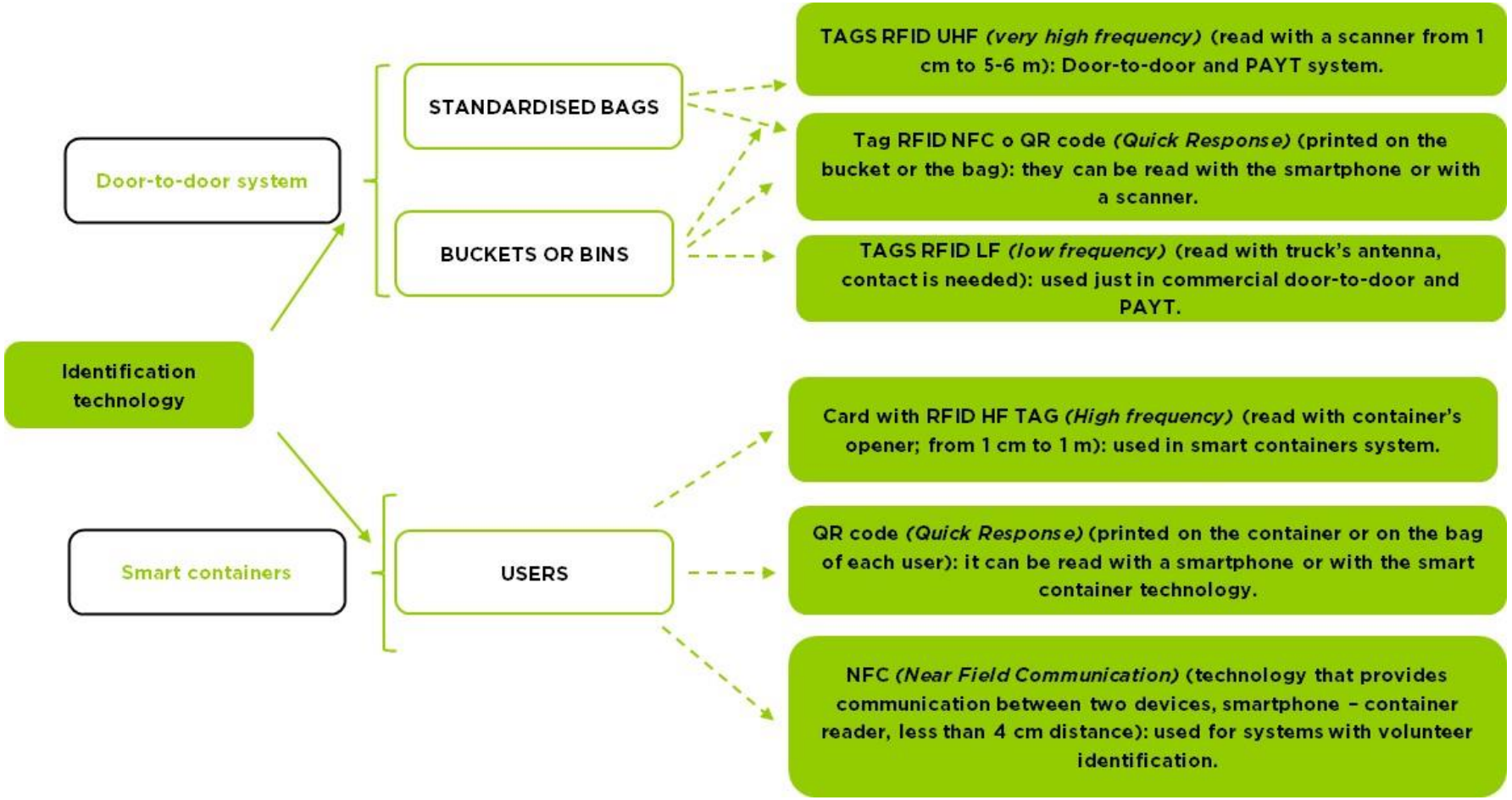
Figure 1. Diagram of the electronic identification systems used in door-to-door collection systems and smart containers



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1.3. Service management software (front and back office)

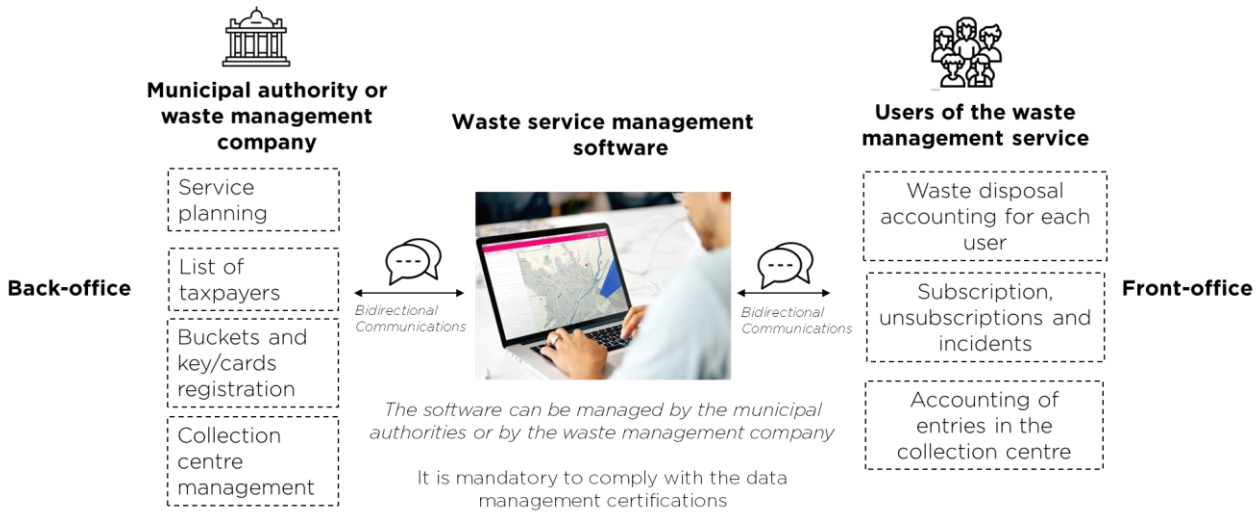
Generally, the information needed to calculate waste charges is managed using a software that handles the information reported by different Apps or web services. The local authority or the company in charge of the waste collection introduces the information necessary for the operation and planning of the service into the software, such as collection routes and schedules, containers or containers for door-to-door collection, closed areas, waste collected in rubbish dumps, operators, incidents that can be reported by operators, etc. Once all of this information is entered and managed through the service management software, the list of taxpayers must also be linked so that each user can be associated with their use of the service.

Each taxpayer must have bins with a chip associated with their personal information in the door-to-door case, or a card/key to open closed containers, to access emergency areas, or to register entries to the waste collection point. All information stored on the card/key or in the bins with a chip must be associated with a taxpayer (Back-office).

It is important to enable a communication channel for citizens to report incidents related to the service (Front-office), such as the breaking or any malfunction of the smart containers or the user identification system. When an incident communication channel is activated, users benefit from a quick response when an incident happens, and at the same time, it gives continuous improvement of the waste management service.

Figure 2 shows a diagram of how all this information is transferred to the service management software.

Figure 2. Structure of the information management in a waste management service software



1.4. Service monitoring and communication to citizens

The compilation of data by the technology makes it possible to generate indicators of the operation of the service with very diverse statistics such as, for example, percent of users participating in separate collection systems, number of average weekly deliveries per fraction, estimated level of filling of the containers, state of the batteries, openings per day or per week, percentage of waste selective collection, frequencies of access to closed areas, openings per time of the day, delivery frequencies per fraction, etc.

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All this information reported to the local entity responsible for waste management allows services to be adjusted optimally and aimed at achieving the objectives set by the legislation.

Figure 3. Examples of indicators delivered by a waste management software

In addition, the software generates personalised information for each taxpayer, such as the waste charge and how this charge has been calculated based on their use of the collection service. This space can serve as a way for citizens to communicate their concerns and improve the waste collection service, as well as to be better informed and incentivised to reduce waste generation and improve fraction separation.

1.5. Calculation and application of the waste charge

Once the information registration system has been structured as presented in the previous sections, it is important to understand well how this information will be managed and how it will be used in the calculation of each taxpayer's waste charge. The first thing to consider is that the information must be updated constantly. It is important to manually enter the subscriptions and unsubscriptions of taxpayers, as well as the registration of material (buckets, bins, bags, cards, and/or key rings).

All the variables that have been defined (charged fractions, bonuses, minimum deliveries required to access bonuses, etc.) to determine the waste charge of each taxpayer must be structured in a calculation formula and input to the software with an algorithm. Since the software will be linked to the database of service uses (with the established periodicity), the waste charge will be calculated automatically according to the participation reported by the calculation tool/software (which can be daily, monthly, quarterly, half-yearly, yearly, etc.). This information could be shown (or not) in the citizen app. Furthermore, invoicing periods must be defined, so that the waste charge is calculated for the specific periods that have been defined in the local waste ordinance.

Finally, the result of the waste charge calculated by the software should generate an output (an excel sheet with few columns: user code, the value of each variable determining the waste charge, and the final amount of the fee for the invoicing period) that can be linked with the database from the department of the municipality responsible for invoicing (or the entity in charge of invoicing in the case that it is externalized).

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