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Survey on waste collection systems with evaluations for decentralised applications

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DECISIVE

A DECENTRALISED MANAGEMENT SCHEME FOR INNOVATIVE VALORISATION OF URBAN BIOWASTE

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A Decentralised Management Scheme for Innovative Valorisation of Urban Biowaste

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EXECUTIVE SUMMARY

This "survey on biowaste collection systems with evaluations for decentralised systems" consist of three main parts: the identification of factors important for biowaste collection (section 2), the evaluation of the current biowaste collection in Europe (section 3), and the provision of a framework on biowaste collection chains for decentralised valorisations (section 4). The focus of the study was set on food waste from households and catering, since both waste types are actually underutilised, available in most locations, and suitable as feedstock for the decentralised micro-scale anaerobic digestion facilities, which are the anticipated valorisation unit within DECISIVE.

Waste collection involves many different stakeholders and a multifaceted infrastructure. Hence, many ambient, social and technical factors and their interactions have to be considered as well as the status quo on waste collection for the implementation of decentralised systems. Commonly applied biowaste collection systems have been reviewed for the six DECISIVE countries Belgium, Denmark, France, Germany, Italy and Spain. The Spanish region of Catalonia was exemplarily evaluated in more detail. The review revealed significant differences not only between countries, but also between regions and municipalities. Door-to-door as well as bring systems are applied and the components, which are allowed in- or excluded from biowaste, vary partly strongly. Biowaste collection chains for decentralised systems consist principally of three levels, namely the "biowaste level", the "biowaste generator level", and the "biowaste caretaker level". The "biowaste level" focuses on the origin and the properties of locally available biowaste types such as food waste from households and catering as well as green waste from private and public land. The "biowaste generator level" tackles the first storage and collection at the waste generator site, e.g. in the household or the garden. The second storage, collection and third storage represent parts of the "biowaste caretaker level". The three levels are interdependent. A multitude of options for implementation of collection chains exist and many possible elements for all levels were introduced. For transition to decentralised biowaste management systems each location must be evaluated singularly and individually.

The survey represents an important step towards the development of the DECISIVE decision-support-tool which aims at supporting local stakeholders on the implementation of urban biowaste collection solutions connected with a decentralised micro-scale anaerobic digestion unit.

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LIST OF SHORTCUTS

AD	Anaerobic Digestion
BP	Bring point collection (definition: section 1.4)
CAS	Civic amenity sites (definition: section 1.4)
DD	Door-to-door collection (definition: section 1.4)
DST	Decision support tool
FW	Food waste (definition: section 1.4)
mAD	Micro-scale anaerobic digestion
Mg	Mega gram (SI-unit); 1 Mg = 1 ton
MBT	Mechanical-biological treatment
PAYT	Pay as you throw
SSF	Solid-state fermentation
WW	Woody waste (definition: section 1.4)

Table of content

1 Background, study goals, interfaces, and terminologies

1.1 BIOWASTE VALORISATION AND THE DECISIVE PROJECT

Since fossil raw materials are becoming scarce, biowaste is more and more a resource for valorisation. A system for a complete and efficient utilisation of biowaste and other urban biogenic residues for energetic and substantial valorisation purposes defined Körner (2014) as a "civilization biorefinery". Urban biocycles are also addressed in Morlet et al. 2017. Moreover, the idea of a closed loop is addressed on European level within the circular economy package (European Commission, 2015b). Though, the "civilization biorefinery" is still a vision today, but examples exist which demonstrate their potential and steps into realisation.

DECISIVE provides a new approach in this direction (Figure 1): A network of decentralised micro-scale anaerobic digestion (mAD) plants is supposed to transform local urban biowaste e.g. from households, restaurants and commercial activities into the energy carrier biogas and the digestate, which contains substantial valuables. In combination with a new, small-scale type of Stirling engine, the biogas can provide heat optionally combined with power for local consumption. The engine can be coupled with hydrogen, concentrated solar energy or additional fossil fuels (Alanne et al. 2010; Dorer and Weber 2009), which may support the flexibility of the decentralised system.
To achieve the transition from an end-of-pipe thinking to a circular approach, also the valorisation of digestate is considered. The efficient utilisation of digestate determines the overall success of a circular approach (Körner 2014). DECISIVE proposes to reuse the digestate circularly and locally after post-treatment. Users may be local urban or close peri-urban farms which have a demand on soil improvers and fertilisers. Solid-state-fermentation (SSF) would allow producing additional products from digestates. Options are enzymes or biomolecules such as organic acids, pigments, phenolic compounds, aromas and biosorbents (Yazid et al. 2017, Soccol et al. 2017). First investigation in DECISIVE narrowed the possibilities to biopesticides, which will be investigated in more detail.

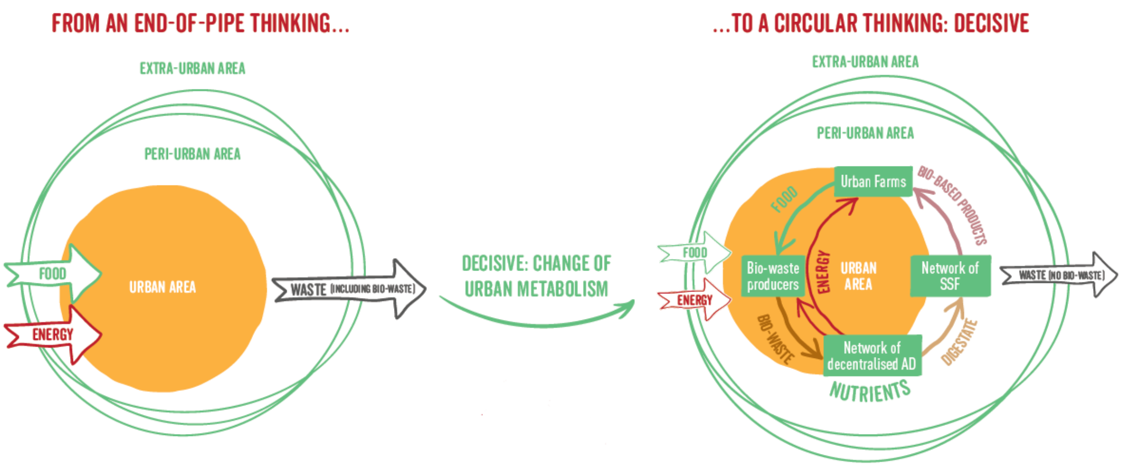


FIGURE 1: DECISIVE vision towards a decentralised biowaste management.

The principal DECISIVE scheme is designed to provide local population and any generators of urban biogenic waste with decentralised solutions for the management of their biowaste aiming to close the organic cycle taking into consideration the intra-, peri- and external urban areas. Finally, DECISIVE will provide a decision-support-tool (DST) to be able to design locally adapted solutions.

1.2 WASTE COLLECTION SURVEY WITHIN DECISIVE

DECISIVE has eight interrelated work packages. Work package WP 3.2 deals with “Waste collection” and consists of three parts. One is the “Survey on waste collection systems with evaluations for decentralised applications” (D3.5). Figure 2 shows the interactions with closely related DECISIVE tasks.

FIGURE 2: Interfaces of this survey (D3.5) to other work packages within the DECISIVE project (D4.1, D3.5 and upcoming deliverable at the DECISIVE webpage: http://www.decisive2020.eu/.

Based on the previous DECISIVE deliverable D4.1, food waste (FW) was evaluated as the most suitable fraction for valorisation in mADs. Thus, the present study focuses on FW, especially on municipal FW from households and catering, since they occur in most locations. However, other food residues such as market wastes or residues from the food-processing industry and distribution are suitable for mADs as well as other anaerobically biodegradable feedstocks such as grass cuttings. The hypothesis of DECISIVE is that decentralisation can improve waste management. This implies that also waste collection is decentralised.
Specifically, the following goals are addressed within this survey:

1. **Critical aspects of waste collection** *(section 2):* In order to develop strategies for transition from current biowaste management systems towards more efficient ones, the evaluation of the state-of-the-art of waste collection systems defines the basis.
2. **Current collection situation** *(section 3):* The currently applied collection procedures were investigated based on a survey for the DECISIVE countries and selected cities within these countries. For Spain, the region of Catalonia was exemplarily considered in detail.
3. **Collection chain classification** *(section 4):* A collection chain classification for decentralised applications was developed as basis for local decisions. The specific units within this classification are explained.

This survey includes information from open source literature and databases, as well as knowledge of the contributing DECISIVE partners. Since the issue on waste collection is complex and location-specific, it is challenging to identify and systematise the most relevant information for further incorporation into the DECISIVE-DST. Collection-related data currently available are heterogeneous, sometimes scarce or entirely inadequate for this scope. Therefore, the issue of missing key data was addressed in order to provide strategies to fill this data gap in the future.

1.3 INTERFACES OF THE WASTE COLLECTION SURVEY TO OTHER DECISIVE WORKS

The results of this study reveal several interfaces to other activities within DECISIVE (Figure 2). Within work package WP 3.2 this survey (D3.5) builds the foundation for the upcoming deliverables on "Models for decentralised collection" (D3.7) and "Household food waste collection" (D3.6). All the previous will be contributing to the collection case study of the eco-innovative city quarter Lübeck-Flintenbreite as well as to the mAD demonstration sites (WPs 6/7). The gathered information will also be used to provide comprehensive data inventories to feed the life cycle assessment and to design the connection to the waste management life cycle inventory (WP 3). Furthermore, this survey on biowaste collection contributes the visualisation of the spatially distribution of biowaste potentials (WP 3.3). It includes information from D4.1 with pre-definitions for mAD units and will support the further development of mAD processes (WP 4.1). Therefore, this waste collection study received from and supplied information to the project partners. Overall, this study will support the design of the DST with the key information to waste collection for decentralised collection schemes.

1.4 WASTE COLLECTION TERMINOLOGIES

Commonly used terminologies for waste and collection related issues vary among partners, stakeholders and countries. In order to improve the mutual understanding, the terminologies used in the survey were defined. Biowaste is defined according to the directive 2008/98/EC (European Commission, 2015a) "*as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants. It does not include forestry or agricultural residues, manure, sewage sludge, or other biodegradable waste such as natural textiles, paper or processed wood. It also excludes those by-products of food production that never become waste."* Following, biowaste is subdivided in more specific components as predefined in deliverable D4.1 (Figure 3). Those take specifications, needed for the development of decentralised collection schemes and linkings to other biowaste types, into consideration. Other specific waste types as well as waste collection types are defined as well.

Categories of biowaste:

- **Food waste** (FW): from private households and from the catering sector (e.g. restaurants, hospitals, school or prison canteens) or from retail sector (e.g. markets, bakeries or food distribution shops); FW generation starts from the retail sector; similar residues from composition, but generated earlier in the food chain (e.g. in food processing industry) are food losses (FAO, 2017); FW may contain packaging materials as impurities in significant amounts. Furthermore, it can be divided in avoidable and not avoidable fractions.
- **Green waste** (GW): anaerobically degradable waste from private gardens and public green structure such as parks, cemeteries, roadsides, railway slopes; it is one possible part of garden or landscaping waste; it is soft and compactable; it contains a high content of "green" fractions (e.g. grass cuttings, leaves, flowers, herbs) and no or a low content of woody fractions (e.g. twigs, branches, stems).
- **Woody waste** (WW): lignocellulosic (wood-rich) substrates (e.g. twigs, branches, stems); commonly not anaerobically biodegradable (at least not without a special pre-treatment); it is one possible part of garden or landscaping waste; it is rigid and bulky; it may contain a certain part of GW fractions (e.g. leaves attached to twigs).

Biowaste			
Food waste		**Garden / landscaping waste**	
Avoidable FW	Unavoidable FW	Green waste	Woody waste

FIGURE 3: Subdivision of biowaste into specific biowaste types

Categories of feedstocks for mAD:

- **Core substrate:** priority feedstocks for mAD; in this investigation FW was chosen (D4.1, Figure 2).
- **Co-substrate:** further locally available and anaerobically digestible substrates (e.g. GW; but not WW).

Categories of mixed wastes with FW shares:

- **Mingled waste:** All types of waste fractions are collected together including FW since no separation system is offered.
- **Residual waste:** All types of waste fractions are collected together including only a part of collected FW since a source-separation system for biowaste is offered. The biowaste guidelines have to point out that FW is allowed within the biowaste.

Categories of collection systems:

- **Door-to-door collection systems** (DD): All systems with collection devices such as buckets, bins, bags or containers, which belong to one single building.
- **Bring points** (BP): All systems where the collection devices such as bins, bags or containers used by inhabitants from several buildings.
- **Civic amenity sites** (CAS): Cover collection sites which are typically enclosed and operated by qualified staff. The citizens bring the waste to those sites.

These definitions may be upgraded in the further progress of DECISIVE and shall be included in the DST to allow mutual understanding.

2 Critical aspects of waste collection

Since each transition from an existing into a new system is a challenge, the critical ambient, social and technical aspects are highlighted in this section. The system of waste collection comprises many different actors and a multifaceted infrastructure. Furthermore, waste collection systems have to be adapted to their local surrounding. Hence, many factors and their interactions are important and have to be considered. Although these factors are described separately, they are interdependent. It should be noted that many of the subsequent aspects described for waste collection are also valid for waste management systems as a whole. The evaluation focuses on biowaste as a major fraction in municipal solid waste.

2.1 AMBIENT ASPECTS

Waste collection is influenced by many ambient factors including environmental, economic and regulatory factors and their resulting interactions (Pires et al. 2011). The ambient factors are specific for each country, region and/or location. For all DECISIVE-countries EU legislations and strategies are valid.

EU roadmaps and legislation:
Roadmaps (e.g. regarding climate protection and FW avoidance; European Commission 2015a/b) may lead to legislations in the future and frame the upcoming trends. DECISIVE-relevant legislation was summarised in the annex 1 of D4.1 (Figure 2) and is regularly updated. The directive 1999/31/EC targeted for the exclusion of biodegradable municipal waste from landfills. In addition, a proposal to amend this directive on waste included the separate collection of biowaste to contribute to an increase in preparing for reuse and recycling rates. Reuse and recycling include composting and anaerobic digestion (AD) as well as the production of environmentally safe materials from biowaste (European Commission 2015a). Synergistically, this directive is in alignment with the EU action plan on a “circular economy”. This plan set priority areas including to halve FW per capita at the retail and consumer level by 2030 and to turn biowaste into a bioresource for substantial and energetic applications (European Commission 2015b). This EU action plan announces a maximum of 10% of landfilling of municipal solid waste (MSW) by 2030 including a recycling goal of 65% of MSW. The communication for ‘waste-to-energy’ (European Commission 2017) promotes AD where the digestate is used as fertiliser considering good practice conditions to support the achievement of the recycling goal. Legislations are actually providing the frame for practical implementations of waste collection systems, whereas roadmaps give an outlook on the future.

National and regional legislation and regional implementation:
Waste-collection-related EU-legislations are implemented differently on national and regional levels and result in different national and regional legal frameworks (see annex 1 of D4.1, Figure 2). An example for the regional level is the Catalan (Spain) waste regulation. It made the biowaste collection mandatory in Catalan municipalities larger than 5000 inhabitants since 1996 and for all municipalities and commercial activities since 2009 (Regions for Recycling 2014). A national example is the German biowaste regulation (BioAbfVO 2013), which obligates separated biowaste collection since 2015 (UBA 2015). Every municipality or regional authority takes the responsibility for the practical implementation of the waste collection system on regional level and will further specify the national legislations. This results in a wide variety of systems and its different technical infrastructures (BiPRO/CRI 2015). Regional legislations may further be translated into a readable form for the inhabitants, e.g. in form of brochures, which give the collection guidelines. The quality of such materials has big influence on the final collection performance. The regional legislation determines also the local financial system for covering the waste collection expenses (e.g. fees, taxes, other contributions).

Economy:
Many systems for financing waste collection exist. “Pay as you throw” (PAYT) systems are considered to be the best choice for transition to new decentralised systems. They can be a successful method to encourage people to reduce and separate waste as well as give basic information for local plannings of waste management. The economic situation of citizens may influence the collection system design as well. Regarding Rosenhauer (2011) the amount of discarded food is above-average in households with a high income and a higher education level. However, this is no general rule. On the other hand, citizens with higher income could afford to eat more at restaurants, thus shifting waste generation away from private homes. The costs of equipment and devices (e.g. buckets, bins) or other devices allocated to households have also to be taken into account. Furthermore, costs occurring also for storage and collection devices as well as transport systems used by local caretakers or waste managers. New systems will compete with the current ones. Economically more affluent inhabitants may be able and willing to pay more, if the service improves.

Regional stakeholders:
A broad range of actors from local government and waste management companies to residents’ boards and caretakers are connected to the waste collection chain at one stage or another. A connection to the key stakeholders e.g. from public authorities and waste management companies is necessary, when implementing new systems. For that reason, within DECISIVE, regional waste experts interviews will be carried out. The results will be published in the upcoming deliverable D 3.7 (Figure 2). Furthermore, the opinion of citizens is considered by interviews. The results will be included in the second upcoming deliverable D3.6 (Figure 2).

Settlement structure:
Issues on the settlement structure are addressed in scientific literature as of high influence on waste generation and collection (e.g. Krogmann 1994, Körner et al. 2009, Adwiraah 2015). Based on Adwiraah (2015) the collected waste from multi-family buildings differed from single-family houses. The availability of a garden had an impact on collected biowaste amounts and composition, since garden waste was placed in the biowaste bin. The FW was mainly present in the residual waste since the biowaste bin was preferably used for garden waste. Geographical factors play an important role for determining biowaste quantities on local level and the frequency of the collection as well. Borosowski et al. (2016) and Hertel et al. (2015) highlight the importance of size of the land as potential area for GW generation. Adwiraah (2015) addresses the importance of the structure of population as generators of FW. Individual consumption patterns are influenced by household size and income. Information about the sizes of land and land use as well as information on the number of inhabitants including population density are major factors which have to be known. Infrastructural elements such as roads or isolated houses have a strong influence in the design of the collection system as well.

Seasonality:
Seasonality is addressed in scientific literature as of high influence on biowaste generation (e.g. Krogmann 1994, Körner et al. 2009, Adwiraah 2015), since environmental and climatic conditions play an important role for vegetation growth. Principally, in Europe four seasons with different temperatures and precipitation values are distinguished. For the DECISIVE-countries, the climatic zones are given in Tables 1 to 6 (section 3.2.1). In general, the growing season lasts from March until November. Therefore, the seasons are closely connected to GW generation (Adwiraah 2015, Scherhaufer et al. 2015). A further fact is that higher surrounding temperatures require a higher collection frequency especially in waste collection systems (Regions for Recycling, 2014). Oppositely, the food retail sector is less affected by seasonal variations (Scherhaufer et al. 2015). In touristic places the population and consequently the biowaste generated increases during the touristic seasons e.g. summer or winter. Contrary, cities with many students may have a lack of population during study free periods and therefore generated waste amounts reduce. All this factors should be considered when planning a decentralised waste collection scheme. For that reason it is suggested to design new collection systems taking seasonal variations into account.

2.2 SOCIAL ASPECTS

The waste collection behaviour of citizens and commercial stakeholders can be a critical aspect for the success of any waste management scheme. The evaluation of social aspects focuses on citizens, since household waste collection is especially challenging and relevant for each local system. Previous studies have indicated a number of factors which are pertinent for source separation and waste handling at household level. The following is based among others on Petersen (2017), which in turn includes a literature study. The issue will be further addressed by citizen interviews within an upcoming DECISIVE deliverable (D3.6, Figure 2).

***Comprehension and competence*:**
Knowledge about what and how to separate is crucial for any kind of waste management system but not always shared by citizens. It is closely linked to the design of the waste collection system and especially to the waste destination (e.g. landfilling, incineration, recycling such as AD). The waste categories for source-separation in households are commonly defined by the professional actors in the waste management system. However, the suggested categories and the common knowledge of everyday life do not always match. For instance, Henriksson et al. (2010) describe difficulties to distinguish between packaging and non-packaging waste, if the waste is composed from the same material (e.g. plastic from food packaging vs. plastic from a toy). Also, citizens do not always know or understand to what extent food-remains must be removed from metal, glass and plastic packagings before they are disposed in the proper bins, or they do not know how to distinguish between solid and soft plastics, as it has been required in the municipality of Copenhagen for a period (Petersen 2017). The knowledge on the purpose of source-separation in terms of recycling of the separated fractions is rarely sufficient too. Furthermore, also if the knowledge exists, it is often not implemented due to practical and convenience reasons. In summary, the waste separation guidelines should be easy comprehensible and goal-oriented and the knowledge about correct source separation needs to be worked into daily routines (Petersen 2017).

***Ethics*:**
Various legislations and rules regarding waste handling exist in different surroundings. But implementing general norms into successful practice are a critical challenge. Some studies indicate that in some countries and regions it is considered a civic duty to separate waste for recycling (Henriksson et al. 2010, Ekkvall and Malmheden 2012, Refsgaard and Magnussen 2009, Petersen 2017). Though, this civic duty is framed in different ways by different people, either as part of a general environmental concern, as part of a general understanding that usable things and materials should never be discarded or as part of an aesthetic and hygienic order requiring clean, nice and tidy living environments. However, they are framed, such civic norms are not universally shared, not even in the same settlements or among people living under the same conditions. Some citizens do not care at all or only care about the waste being removed from their own living quaters. Others try to reduce their waste and separate strictly to or even beyond the provided rules. Therefore, for designing collection schemes, on the one hand the general norms of the majority should be known and on the other hand the possible behaviors considered as well.

***Proximity and accessibility*:**
Many studies (e.g. Barr et al. 2003, Dahlén et al. 2007, González-Torre and Adenso-Diaz, Rousat et al. 2015, Sörbom 2003, Struk 2017) indicate that citizens need easy access to the collection points for recyclable and non-recyclable waste fractions. The collection infrastructure should be close to everyday domestic work. If this is not the case, lower recycling rates and poorer qualities of source-separated wastes may be obtained. Interviews with caretakers and residents' boards (upcoming D3.7, Figure 2) will give indicators on the disposal behaviour of citizens if e.g. bins for various recyclable fractions are not located close to each other. The above mentioned studies are not specific regarding convenient distances for citizens to walk either to the DD or the BP collection site. The same is true for CAS, but those are rather reached by driving. The studies conclude that proximity is preferable. However, it can be added as an example that the municipality of Copenhagen, Denmark established that the distance to a waste collection bin cannot be more than 50 m from the citizen's home (upcoming D3.7, Figure 2).

***Sensory experience*:**
When it comes to source-separation of biowaste many citizens may have some concerns regarding sanitary and sensory implications (Refsgaard and Magnussen 2009), both in their homes and at the collection points. It is assumed that this is even more relevant for DD compared to BP. People may feel disgust for preparing the biowaste for recycling (e.g. scraping aged food remains out of jars) and resent the possibility of foul smells from the buckets in their kitchen, which may occur if FW is stored too long. They may also be disgusted by touching the collection bins or containers especially for biowaste. People may fear that collection points for biowaste, e.g. in their garden, basements, sheds, and at DD points at kerbsides emit foul smells, leaks and/or attract bugs and vermin, and thereby limit the use of their outdoor spaces. Such concerns may lead to resistance against biowaste collection.

***Space within the home*:**
Waste is usually kept within the home for a while (e.g. depending on the size of the vessel, the collection times of the bin, the cooking activities, the caretaking activities) until it is delivered to the next step in the collection chain – whether it is a DD, BP or CAS collection system. The storage time may also depend from the transport distance (e.g. within the perimeter of building or transport to BP or CAS stations). Some studies indicate that space in the home is a critical factor (Barr et al. 2003; Martin et al. 2006) while others indicate that this problem is less significant or easily manageable (Fahy and Davies 2007, Petersen 2017). Space is probably an important issue especially for small apartments and for waste collection rules which include many recyclable fractions and an even more important issue when biowaste is included in the recyclable fractions (upcoming D3.7, Figure 2).

***Space outside the home*:**
It might also be difficult to find enough space outside the home. If DD-collection is used, there is not only space at kerbsides needed for the waste pickup by the waste management company, but rather space outside (e.g. in driveways, car ports, front gardens, gardens) or inside a building (e.g. in waste rooms, sheds, garages etc.) for all the bins or containers needed for recyclable fractions. Furthermore, the space for DD- or BP-collection points may be especially limited in areas with high population density, where buildings are very close along the periphery of the streets. In this case, bins are often placed in the basements of buildings where space for biowaste separation is often difficult to ensure. Especially in basement options complications regarding the transport of the heavy collection containers to the kerbside have to be considered.

***Time*:**
According to some studies, the time available for waste separation is also a determining factor. Thus, Martin et al. (2016) found that citizens with small children tend less to separate their waste due to missing time. It can be argued that also other household types can lack sufficient time, but however, time is closely linked to proximity and accessibility of collection points as well as to knowledge and the integration of this knowledge into everyday routines. Waste separation behaviour is strongly habitual (Henriksson et al. 2010) and if citizens know what, where and how to handle different waste fractions they may just do it routinely and the time spent becomes a smaller problem (Petersen 2017).

Trust:
Trust is also a critical factor in source separation. Some studies indicate that people need the assurance that waste collected for recycling is actually recycled, otherwise they lose trust in the system and may stop recycling (Refsgaard and Magnussen 2009). Other studies show that citizens trust the systems by default and do not need prior proof or assurance that the systems work. They show almost no interest in or do not have knowledge about the procedure with the recycled fractions after they have been collected, but that does not keep them from separating these fractions (Petersen 2017).

Individual specifics:
FW is one of the most important fractions generated in households. Rosenbauer (2011) proposes that the age of citizens and household sizes have a high impact on the amount of generated FW, e.g. younger people as well as persons living in more than 3 person's households may produce by trend more FW. The lifestyle of the citizens influences not only the FW generation and collection behaviour, but is also important in terms of food consumption habits. Similarly, household size and composition,

their norms and knowledge regarding eating may influence food consumption.
Such parameters, including the differences between people's cooking and eating behaviour, are difficult to track (Adwiraah 2015). Especially under consideration of the FW reduction goal of 50% (United Nations Report 2015, European Commission 2015b) a priority topic for transition to decentralised FW collection and valorisation schemes includes the differentiation of FW into avoidable (e.g. spoiling due to long or wrong storage) and non-avoidable fractions (e.g. peels and not edible parts) which is highly depending on individual specifics.

2.3 TECHNICAL ASPECTS

Waste collection is connected with complex technical infrastructures. It is equally important to understand the details of and the differences between various systems when one wants to estimate the quantities and qualities of waste. Reliable waste data are the basics for any technical planning process. The following section outlines principal considerable technical factors for planning of decentralised waste collection schemes independently if it involves state-of-the-art or innovative elements.

Waste types:
A lack of standardisation appears already in the different definitions and categorisations used from statistical offices, in scientific literature and in practice. However, waste types are classified and codified in the European waste catalogue provided by EPA (2002). In the catalogue different types of agricultural, municipal, and industrial wastes and wastes from further sectors are listed comprehensively and defined using a six-digit code. The list is oriented towards the traditional waste management goal "to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use". The EPA-list contains more than 80 waste types that are biogenic or contain biogenic fractions of significant amounts. However, waste type definitions related to the new demands for collection schemes for decentralised AD are necessary (section 1.4).

Waste origins:
Waste collection and management depend on the sector from which wastes originate, whether it is from households, food handling businesses, other types of public and private businesses, or from public areas such as parks and urban spaces. Waste generators from different sectors behave in different ways and the factors that influence qualities and quantities of collectable fractions may vary depending on the origin. Within DECISIVE the focus is laid on FW from households and from the catering sector (section 1.4). Other origins may be relevant as well, depending on the specific local situation of waste generation (e.g. industrial food processing residues, FW from wholesale and retail). Regarding Kranert et al. (2012), German food residue shares related to different origins as follows: households (61%), industry (17%), large consumers (17%), and trade (5%). FW from households waste is expectedly occurring regionally everywhere, whereas the availability from the other sector is highly depending on the specific location. The sectors of origins were adapted to DECISIVE demands in section 4.2.

Waste collection systems:
Waste collection procedures used in Europe are described in many publications (e.g. Rodrigues et al. 2016, Pires et al. 2011, BiPRO/CRI 2015) and are variable not only on national, but also on regional, municipal and even local level (Rodrigues et al. 2016). This includes whether biogenic waste fractions are co-mingled with mixed or residual wastes, valorised at home (e.g. fed to animals, home composting) or collected separately. Various studies point out the advantage of source-separation as a fundamental prerequisite for achieving high collection rates and good waste qualities for further valorisation (BiPRO/CRI 2015, Schüch et al. 2016, Nelles et al. 2016, Pires et al. 2011). The collection system influences the collected amounts and qualities (Adwiraah 2015). DD systems might provide higher recycling rates and waste fractions with better quality compared to BP systems, but appear to be more expensive (BiPRO/CRI 2015; Regions for Recycling, 2014). A monitoring carried out by the Catalan waste agency (1500 samples in 2015) showed that biowaste contained 14 %

impurities if BP collection was applied, but only 6 % with a DD system. However, further municipality-specific factors might be influencial (e.g. types of separated fractions, feedback information, incentives, connection rate of inhabitants to a specific system). For instance a biowaste collection system might be offered to the citizens, but parts of the population are excluded since they are doing home composting, the district produces low qualities, or houses are too far located from the valorisation facility. The differences in the principal collection procedures are described in section 3.2 for the DECISIVE countries, and a classification on the collection chain for decentralised valorisations is provided in section 4.1. The collection chain addresses the questions, how waste is separated, collected, stored and transported by the generator (e.g. citizen or commercial stakeholder) as well as by the municipality or the caretaker in subsequent steps until disposal, treatment or recycling in common schemes or to valorisation by mAD in DECISIVE schemes.

Waste collection equipment:
Various simple (e.g. buckets, bins and/or bags) and more specific equipment (e.g. containers, collection vehicles and trucks) might be applied. Moreover advanced systems are described in literature or are applied to a small extend (e.g. kitchen waste shredder for homes; underfloor collection containers for place saving collections; Richter et al. 2017). Technical factors to evaluate state-of-the-art collection equipment and equipment usable for the decentralised collection schemes include e.g. material and fuel types (bio-based or fossil-based) and the need of additional means (e.g. cleaning water, place demands). Furthermore, investment and operating costs need to be evaluated. A classification on equipment option is provided in sections 4.1 with more specific explanations in section 4.2, 4.3, and 4.4.

Pathways of collected waste:
The pathways of the collected waste end either at a disposal site, a treatment facility or a valorisation facility. The destination influences the type of collection strongly, e.g. regarding the demanded purity levels. For valorisation by AD, the biowaste separation degree, the content on impurities (e.g. glass, stones, and plastics), and on hazardous substances (e.g. heavy metals) are important factors. Mixed and residual wastes, however, could have incineration or mechanical-biological treatment (MBT) as preparation for landfilling as a destination. Conventional waste destinations need to be known as benchmark to evaluate DECISIVE collection schemes. They will be described in DECISIVE work package WP 3.1 (Figure 2). If the destination of the biowaste is a mAD facility, the collection scheme has to consider the demands of a mAD unit, which were described in D4.1 (Figure 2). The purity demand of feedstocks for mAD is higher compared to conventional AD due to limitations regarding the integration of sorting units.

Biowaste amount:
Eurostat data base provides a statistical overview of waste data across Europe, including the following biowaste categories: Animal- and mixed FW (W091, item 31) which includes “non-hazardous animal and mixed FW of food preparation and products” as well as vegetal waste (W092, item 32) which includes “non-hazardous vegetal waste from food preparation and products, including sludge’s from washing and cleaning” (Eurostat 2010). Eurostat receives information from each member state, but each country sets own predefinitions regarding the statistical approach. Furthermore, not the same categorisations are used, which impede the comparability of data. Although Eurostat data consist of high heterogeneity, it forms the most reliable waste amount information system on European level. However, data are not usable for design of decentralised collection schemes, also because metadata do not include information about the exact investigation methods used. National and regional environmental agencies or statistical offices may provide biowaste data too. If no country-comprehensive national statistical data exist for biowaste, commonly municipalities have knowledge on the collected biowaste amounts. For instance the Catalonia Waste Agency recovers all municipal data in monthly bases and publishes it each year (ARC, 2017). However, if it comes to the design of new collection schemes it has to be differentiated between potentially available and collected amounts. A clear definition of the term “biowaste amount” is crucial to avoid planning errors due to false assumptions (Brosowski et al. 2016). Scientific reviews (e.g. Brosowski et al. 2015, 2016; Kranert et al. 2012) demonstrate that biowaste quantities actually available do not only cover a wide range, but also often appear without exact differentiation of the biowaste types included and the respective origins.

Types of food residues:

The food chain starts in agricultural production and food consumption is the core of the chain. Regarding the terminology, food wastes, food losses and by-products of food processing industry are often not differently addressed. However, clear definitions for potentials and collected FW amounts, clear boundaries between the sectors as well as strategies to come to reliable local data are crucial to plan resilient and efficient decentralised systems. The residues which occur until food arrives at the consumer level are referred to as “food losses” and at the consumer level as “FW” (Körner 2014; section 1.4). Food losses occur in agricultural production and harvest, during post-harvest handling and storage, and during industrial processing. Basic data on national food supplies and food losses are available at FAO’s “food balance sheets”. However, many data were gained only in sections of the chain, with different methods and under various circumstances and intentions. Calculations often also contain vague estimations (Körner 2014). Neither in the FAO database, nor in other statistical databases “FW” data is available. The boundary between food losses and FW should be the consumer level, starting with the retail sector (section 1.4).

Food waste amounts:

Only a few studies addressed the issue of FW generation in households. Data on the commercial sector are even scarcer. Available FW data have to be considered as estimates and suffer from the lack of unique and agreed upon definition. They include indifferent fractions of resources which makes them difficult to compare and to monitor trends (Fusion, 2016). For EU-28, a range between 83 and 101 kg per capita and year was given for FW generated in households, whereas food losses and FW covering the sectors of primary production, industrial processing, wholesale, retail and households were given with 173±27 kg per capita and year (Stenmarck et al. 2016). In Catalonia, according to statistics, the municipal FW was 147 kg per capita and year including commercial activities; and 73 kg per capita and year without commercial activities. 50 kg per capita and year has been selectively collected in average (including commercial activities), which accounts for one third of the total biowaste produced. 35 kg per capita and year were considered as avoidable (Generalitat de Catalunya 2011). DEPA (2014) gave a FW value of 83 kg per capita and year for Denmark. A scientific study of Kranert et al. (2012) provided differentiated FW data for Germany: 82 kg per capita and year generated within the households and thereof 62 kg per capita and year collected (43 kg via residual waste bins and 19 kg via biowaste bins). Furthermore, 65% of the FW was considered as avoidable or partly avoidable and 35% as not avoidable. A local evaluation (households from 2 streets within the district Bergedorf, Hamburg, Germany) based on waste sorting’s carried out by Adwiraah (2015) resulted in collected FW amounts between 44 and 59 kg per capita and year, whereas following fractions were differentiated: food processing residues, food leftovers, complete food packages, opened food packages, not packed food. Further FW shares might be in the fraction, which was smaller than 10 mm, but could not explicitly be assigned.

3 Current biowaste collection

To get an overview of the wide range of options on the currently applied biowaste collection options, a survey was conducted, focusing on waste collection systems from selected cities in the DECISIVE-countries. Additionally, a more comprehensive survey was carried out for the region of Catalonia, Spain. The knowledge on the state-of-the-art forms the basis for transition of current systems to more efficient collection systems, which are connected with a subsequent on-site valorisation technology.

3.1 METHOD: DESKTOP SURVEY ON COMMONLY USED WASTE COLLECTION SYSTEMS

A survey on commonly used waste collection systems was performed with focus on cities from the six DECISIVE countries. By this selection the diversity of the applied systems is expected to be well covered for European situations. The survey focuses on the collection of biowaste from households but also addresses waste collection systems in general. General information has been taken from national reports which included information on waste collection systems, available on websites and ministries. More specific information on municipal waste management has been taken from public waste collection guidelines describing the local systems for the citizens. In the evaluation a differentiation was made from country to country, and among the cities in one country. Considering the complexity of European waste collection systems, an evaluation of every single city in a country would neither be feasible due to time constraint nor deliver value-added information regarding the scope. The cities were chosen by the following criteria:

- **Degree of urbanisation:** Most people live and the largest amount of household waste is produced in cities. At the same time cities are the most detached from circular resource flows. Hence, the biggest achievement in recycling of biowaste from household waste can be achieved in cities.
- **Study focus:** Municipalities with populations between 20,000 and 3,500,000 inhabitants were considered. Despite some exceptions, commonly the largest cities from the country were chosen. In result, the range for sizes of most cities lays between 100,000 and 600,000.
- **Case variety:** By choosing different cities from the six DECISIVE countries (Belgium, Denmark, France, Germany, Italy and Spain) across Europe the study covered a broad variety of collection schemes, which includes also a comprehensive variety of aspects relevant for biowaste collection.

The selected cities of the six DECISIVE countries were assigned to one of the following groups regarding the collection of biowaste:

- No comprehensive biowaste separation carried out
- Comprehensive biowaste separation carried out

The resulted grouping was implemented in the graphical information system (GIS) software Quantum GIS (QGIS) 1.7.4 based on geographical data from OpenStreetMap (http://www.openstreetmap.org). The results are provided in Figure 4.

Considering the selected cities, more detailed country-based sorted factsheets on biowaste collection were prepared to present the available information in a standardised way (Tables 1-6). The general section of the fact sheet includes information on the population and the basic collection type (DD, BP, CAS; section 1.4). The latter includes information on collection frequency, occurrence of biowaste separation and biowaste types, which are in- or excluded from the separate biowaste collection.
As an example for a whole region, in Catalonia, Spain a more detailed investigation was performed.

Catalonia was chosen since it applies biowaste collection already since a long time. Furthermore, within DECISIVE, in Catalonia a decentralised collection with subsequent mAD shall be implemented as demonstration case, and a suitable location for that has to be chosen. For Lyon, the location of the DECISIVE-mAD demonstration facility is already set; therefore, Lyon was considered in the common evaluation only.

3.2 RESULTS: OVERVIEW ON WASTE COLLECTION PROCEDURES

3.2.1 Biowaste collection in the DECISIVE countries

The state-of-the-art of biowaste collection across the six DECISIVE countries is shown in Figure 4. Cities were marked with a green symbol if the public available guideline of the municipality provided biowaste separation regulations which included FW as one fraction of the biowaste.
Based on this it was assumed that a comprehensive biowaste collection is in practice and that biowaste collection covers FW at least partially.

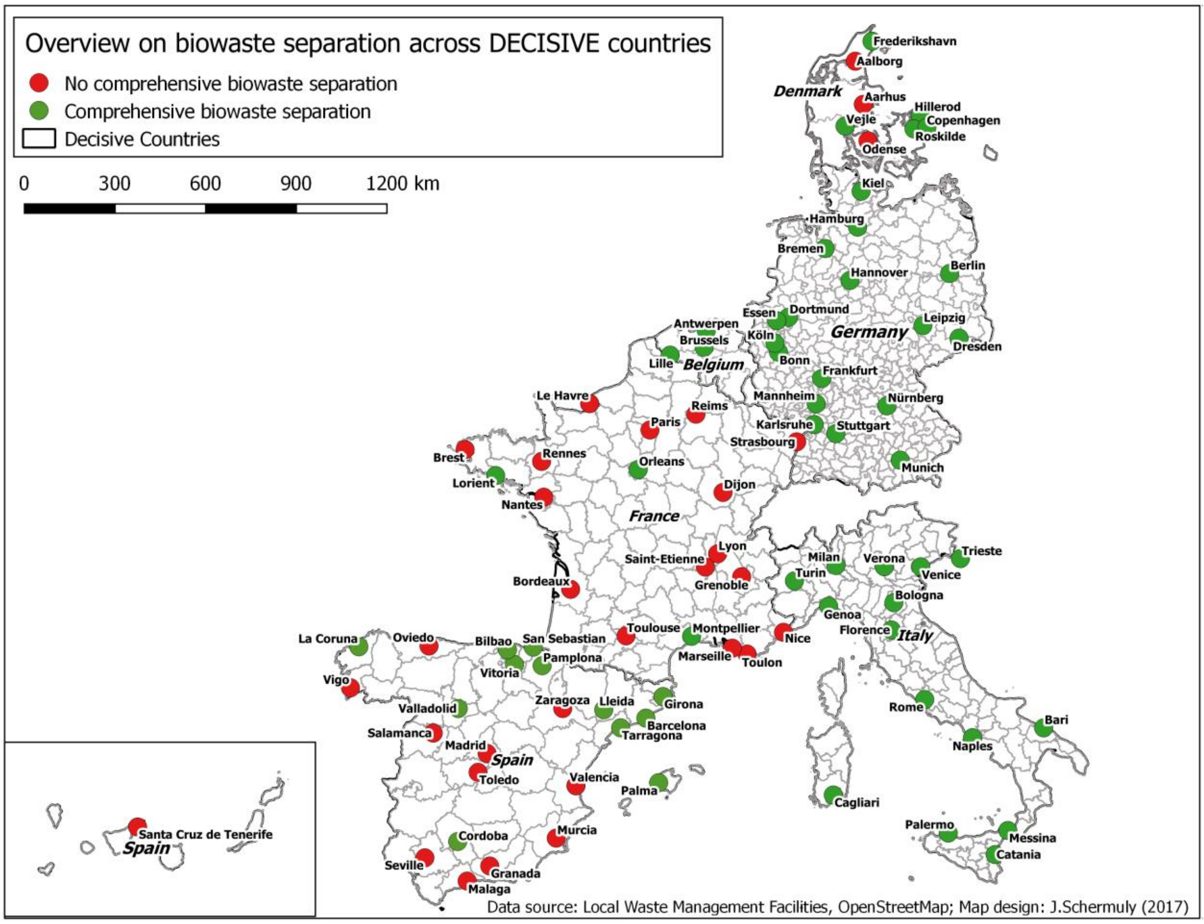


FIGURE 4: Overview on biowaste separation of exemplarily selected (not all) cities of the six DECISIVE countries Belgium, Denmark, France, Germany, Italy and Spain.

Green: biowaste separation is conducted for many households and the biowaste contains FW

Red: biowaste separation is not or seldom conducted or biowaste does not include FW

DECISIVE-case study regions: CATALONIA and LYON

Some Danish cities received a red symbol although biowaste separation is offered, but only for garden waste. Paris received a red symbol since the majority of inhabitants are not connected to a biowaste system, and biowaste collection is applied in only 2 districts since 2017. Rennes received a red symbol even though parts of the inhabitants separate biowaste for home or community composting. Both cities do not offer a comprehensive municipal collection service for separate biowaste collection.

The situations discovered in the selected cities were quite diverse. As Figure 4 displays, a nationwide separate collection of biowaste is available in Belgium, Germany, and Italy. While the collection system in Germany evolved independently step by step in the municipalities since the first biowaste collection was introduced in 1985 (UBA 2015), Italy installed this system over the last decade. In all other countries the situation is regionally divers. The country-based sorted factsheets (Tables 1-6) provide an insight into biowaste management procedures for the selected urban areas. Following a short summary of the Tables 1-6 is provided.

- **Collection types:** DD systems dominate in all countries except Spain, where BP systems dominate; partly as BP systems on demand. Frequently, CAS systems are offered for exceling amounts. Some of the DD and the BP systems work with an electronic chip system.
- **Collection frequencies:** They ranged between daily up monthly. Mostly the collection rhythms were constant for the whole year, but partly they did vary monthly. This was the case e.g. for the garden wastes (GW+WW) in Denmark due to seasonality of plant growth, but also for FW in Copenhagen. In Lille, France, collection frequency varies with the population density within the city. In Cagliari, Italy, the biowaste is collected 6 times a week in summer time and only 3 times a week in winter time due to changing climatic conditions. In hot climates the biowaste degrades faster and therefore rather leads to bothering. In Palma de Mallorca and Catalonia the collection frequency is differed in high and low season, since it is a touristic area with varying numbers of people present.
- **Included fractions in biowaste:** Following fractions were mentioned explicitly to be allowed in biowaste, whereas the listings can differ from city to city - wood, leaves, grass, FW, biodegradable bags, food leftovers, expired food, peels, coffee grounds, tissues, paper towels, compostable bags, animal waste, not cooked FW, FW prepared and raw without packaging materials. For FW sometimes rather specific description are given. E.g. for Hamburg, Germany they are summarised in Table 4 under FW, but in the public guidelines following fractions are explicitly mentioned: fruit residues, vegetable residues, cooked food left overs, coffee filters, tea bags, milk products without packaging, bread, egg shells (SRHH 2017). For animal waste in some municipal guidelines it is mentioned, that only small amounts are allowed.
- **Excluded fractions in biowaste:** Following fractions were mentioned explicitly to be allowed in biowaste, whereas the listings can differ from city to city (cooked FW, shells and bones are for example allowed in Catalonia): cooked FW, napkins, ashes, egg/nut/oyster/mussels shells, animal waste, bones and fish bones, fruit stones wood, biodegradable bags, egg and other shells, wood. In some French and all Italian cities wood, leaves and grass are excluded, in all Spanish WW and in the Danish FW.

In the tables 1-6 population size of the municipalities, chosen for the evaluation, was given. However, waste collection is often organised in the scale of a region. Therefore, the information sometimes also applies for larger areas. In some cases, the information listed in the table may not be the most actual or might be misinterpreted from the cited guidelines. For instance, if pilot plants are installed in a city, the impression of comprehensive collection might be indicated by the brochure. If asking experts with local contacts, the impression might differ. This is for example the case for some of the listed Spanish cities, where representatives from Spanish regions confirmed at the organic matter workshop in the Spanish Ministry (12.07.2017) that biowaste collection is not comprehensive, but applied in demonstration scale.

TABLE 1: Factsheet on biowaste management across selected Belgian cities (Climate: Oceanic).

General Information			Biowaste				Literature
City/Region (Abbreviation)	Population (2016)	Collection Type	Frequency[1]	Biowaste separation	Biowaste allowed	Biowaste excluded	
Antwerp (A)	459,805	DD /underground container/CAS	1/w	yes	WW, leaves, grass, not cooked FW, biodegradable bags	animal waste, cooked FW	1,2,3
Brussels (B)	1,019,022	DD	-	yes	food leftovers, expired food, peels, coffee grounds, tissues and paper towels, compostable bags	napkins, ashes, egg/nut/oyster/mussels shells, animal litter, bones and fish bones, fruit stones	4,5,6
Charleroi (C)	200,132	DD; CAS	1/w	yes	WW, leaves, grass, cooked and not cooked FW, animal waste and biodegradable bags	-	7,8
Gent (G)	231,493	DD*	1/w	yes	leaves, grass, not cooked FW	WW, animal waste, cooked FW, biodegradable bags, egg and other shells	9,10,11
Liege (L)	182,597	DD	-	yes	WW, leaves, grass, cooked and not cooked FW, animal waste and biodegradable bags	-	12
Namur (N)	106,284	DD	2/m	yes	WW, leaves, grass, cooked and not cooked FW, animal waste and biodegradable bags	-	13,14,15

*- lack of data; * application of an electronic chip system; [1] frequency: x/w = x-times per week; x/m= x-times per month*

TABLE 2: Factsheet on biowaste management across selected Danish cities (Climate: Temperate, no dry season).

General Information			Biowaste				
City/region (Abbreviation)	Population[P]/ households[H] (2017)	Collection type	Frequency[1]	Biowaste separation	Fractions allowed in biowaste	Fractions not allowed in biowaste	Literature
Copenhagen (CPH)	606,057[P] 296,367[H]	DD	GW+WW: 1/m, Mar-Nov FW (from 2017): 1/2w, Sep-Apr; 1/w, May-Aug	yes	Until 2017 only GW+WW collection (grass, leaves, plants, wood). From fall 2017 also FW including biodegradable bags	FW until fall 2017	16,17
Capital region (CapR)	1,811,809[P] 838,586[H]	-	-	-	-	-	16,17
Odense (OD)	200,695[P] 97,265 [H]	DD, CAS	1/m	yes	GW+WW	FW	18,19
Aalborg (AAL)	211,876[P] 104,461[H]	-	GW+WW: 1/m, Mar-Nov	yes	Only GW+WW: leaves, grass, plants, WW	FW	20
Aarhus (AH)	336,370[P] 158,185[H]	-	GW+WW: 1/m, Mar-Nov	yes	GW+WW: leaves, grass, plants, WW	FW	21
Hillerod	31,505[P]	-	GW+WW	yes	GW+WW: leaves, grass, plants, WW	-	22
Roskilde	50,046[P]	DD, CAS	2/m (home composting)	yes	GW+WW, FW (prepared and raw without packaging materials)	-	23
Vejle	111,138[P]	-	GW+WW: 1/m	yes	GW+WW, FW	-	24
Frederikshavn	23,501[P]	-	-	yes	GW+WW	FW	25

*- lack of data; * application of an electronic chip system; [1] frequency: x/w = x-times per week; x/m= x-times per month*

GW+WW: In Denmark often termed as "green waste" in the meaning of garden waste, in contrast to the green waste (GW) definition in section 1.4

TABLE 3: Factsheet on biowaste management across selected French cities (Climate: Oceanic)

General Information			Biowaste				Literature
City/Region (Abbreviation)^{x}	Population (2014-16)	Collection Type	Frequency[1]	Biowaste separation	Biowaste allowed	Biowaste excluded	
Ajaccio (A)	68,587	-	-	no	-	-	26
Bordeaux (B)[28]	231,844	-	-	no	-	-	27
Brest (Br)[8]	139,384	-	-	no	-	-	28
Dijon (D)[24]	153,668	-	-	no	-	-	29
Lyon (L)[59]	472,317	-	-	no	-	-	30
Le Havre (LH)[17]	172,807	-	-	no	-	-	31
Lille (LL)[85]	228,328	DD	1/w and 2/w in densely populated areas	yes	FW, animal waste, WW, leaves, grass	-	32
Lorient (LO)[25]	57,662	DD	1/w	yes	FW, animal waste, biodegradable bags	WW, leaves and grass	33
Marseille (M)*	794,811	-	-	no	-	-	34
Montpellier (MO)[31]	248,252	DD, BP	3/w	yes	FW, animal waste, biodegradable bags	WW, leaves and grass	35
Nice (N)	338,620	-	-	no	-	-	36
Nantes (NAN)[24]	277,269	-	-	no	-	-	37
Orleans (O)[22]	114,977	BP except for people with reduced mobility	2/m (only for people with reduced mobility)	yes	WW, leaves, grass	-	38
Paris (P)	2,138,551		Started in two districts	partly	-	-	39
Rennes (R)[43]	213,454	-	-	no	-	-	40
Reims (RE)[143]	183,042	-	-	no	-	-	41
Strasbourg (S)[28]	274,845	-	-	no	-	-	42
Saint Etienne (SE)[43]	170,761	-	-	no	-	-	43
Toulon (T)	165,584	-	-	no	-	-	44
Toulouse (TO)[37]	433,055	-	-	no	-	-	45

*- lack of data; * application of an electronic chip system; [1] frequency: x/w = x-times per week; x/m= x-times per month; (Abbreviation)^{X}: X = used by X (number) municipalities in the region*

TABLE 4: Factsheet on bio waste management across selected German cities (Climate: temperate)

General Information			Biowaste				Literature
City/Region (Abbreviation)	Population (2016)	Collection type	Frequency[1]	Biowaste separation	Biowaste allowed	Biowaste excluded	
Berlin (B)	3,460,725	DD	1/w	yes	WW, leaves, grass, FW, animal waste	biodegradable bags	46-50
Bonn (BO)	318,809	DD	2/m	yes	leaves, grass, FW	WW, cooked FW, animal waste, biodegradable bags	51
Bremen (BR)	547,340	DD	2/m	yes	WW, leaves, grass, FW, animal waste	biodegradable bags	52,53
Dortmund (DO)	580,444	DD	2/m	yes	WW, leaves, grass, FW, animal waste	biodegradable bags	51,52
Dresden (DR)	523,058	DD	1/w	yes	grass, leaves, FW	WW, animal waste, biodegradable bags	56,58
Essen (E)	574,635	DD	2/m	yes	WW, leaves, grass, FW, animal waste	biodegradable bags	59,60
Frankfurt/Main (F)	679,664	DD	2/m	yes	WW, leaves, grass, FW, animal waste	biodegradable bags	61
Hamburg (HH)	1,786,448	DD	2/m	yes	leaves, grass, FW, animal waste	WW, biodegradable bags	62
Hannover (H)	522,686	DD	2/m	yes	WW, grass, leaves, not cooked FW	cooked FW, animal waste, biodegradable bags	63,64
Kiel (KI)	246,306	DD	2/m	yes	WW, leaves, grass, FW	animal waste, biodegradable bags	65
Köln (K)	1,007,119	DD	2/m	yes	leaves, grass, FW, animal waste	WW, biodegradable bags	66,67,68
Leipzig (L)	522,883	DD	2/m	yes	WW, leaves, grass, FW	animal waste, biodegradable bags	69,70,71
Mannheim (MA)	305,780	DD	2/m	yes	grass, leaves, FW	WW, animal waste, biodegradable bags	72,73,74
München (M)	1,353,186	DD	2/m	yes	leaves, grass, not cooked FW, animal waste	WW, cooked FW, biodegradable bags	75,76,77
Nürnberg (N)	505,664	DD	1/w	yes	WW, leaves, grass, FW	animal waste, biodegradable bags	78,79
Stuttgart (S)	606,588	DD	1/w/2/w	yes	leaves, grass, FW, cooked, animal waste	WW, biodegradable bags, animal waste/litter	80,81

*- lack of data; * application of an electronic chip system; [1] frequency: x/w = x-times per week; x/m= x-times per month*

TABLE 5: Factsheet on biowaste management across selected Italian cities (Climate: Mediterranean).

General Information			Biowaste				Literature
City/Region	Population (2016)	Collection Type[1a]	Frequency[1b]	Biowaste separation	Biowaste allowed	Biowaste excluded	
Bari (B)	326,344	DD	2/w	yes			82
Bologna (BO)	386,633	DD	2/w	yes			83,84
Catania (C)	314,555	DD	3/w	yes			85
Cagliari (CAG)	154,460	DD	summer 6/w, winter 3/w	yes			86
Florence (F)	382,808	DD	3/w	yes			87
Genoa (GE)	586,655	DD	3/w	yes			88
Milan (M)	1,345,851	DD	2/w	yes	FW, animal waste, biodegradable bags	WW, leaves, grass	89
Messina (ME)	238,439	DD	3/w	yes			90
Naples (N)	974,074	DD	3/w	yes			91
Palermo (P)	674,435	DD	3/w	yes			92
Rome (R)	2,864,671	DD	3/w	yes			93
Turin (T)	890,529	DD	2/w	yes			94
Trieste (TR)	204,420	DD	3/w	yes			95,96
Venice (V)	263,352	DD	daily	yes			97
Verona (VE)	258,675	DD	2/w	yes			98

*- lack of data; * application of an electronic chip system; [1] frequency: x/w = x-times per week; x/m= x-times per month*

TABLE 6: Factsheet on biowaste management across selected Spanish cities (Climate: Mediterranean).

General Information			Biowaste				Literature
City/Region	Population (2016)	Collection Type	Frequency[1]	Biowaste separation	Biowaste allowed	Biowaste excluded	
Barcelona (B)**	1,608,746	BP	daily	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	99,100
Bilbao/Biskaia (BI)	345,122	BP*	6/w	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	101
Cordoba	326,609	BP	daily	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	102
Girona	98,255	BP	daily -1/2w	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	103
Granada (G)	234,578	-	-	no	-	-	104
La Coruña (LC)	243,978	BP	daily	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	105
Lleida	138,144	BP	daily	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	106
Madrid (M)	3,165,541	-	-	no	-	-	107
Malaga (MA)	569,009	-	-	no	-	-	108
Murcia (MU)	441,003	-	-	no	-	-	109
Oviedo (O)	220,567	-	-	no	-	-	110
Pamplona/Navarra (P)	195,650	BP	3/w	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	111
Palma de Mallorca (PM)	407,648	BP	d high season, 3/w low season	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	112
Seville (S)	690,566	-	-	no	-	-	113
Salamanca (SA)	144,949	-	-	no	-	-	114
San Sebastian (SS)	186,064	BP	3/w	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	115
Tarragona	131,094	BP	daily - 1/w	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	116
Toledo (T)	83,459	-	-	-	-	-	117
Valencia (V)	797,028	-	-	no	-	-	118,119
Valladolid (VA)	301,876	BP	6/w	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	120
Vitoria (VT)	244,634	BP*	daily	yes	leaves, grass, FW, animal waste, biodegradable bags	WW	121
Zaragoza (Z)	661,108	-	-	no	-	-	122
Santa Cruz de Tenerife (TE)	203,585	-	-	no	-	-	123

*- lack of data; * application of an electronic chip system; [1] frequency: x/w = x-times per week; x/m= x-times per month; ranges depend on population density in the city (Girona, Tarragona)*

*** Barcelona is the representative for Catalonia; all Catalan cities apply separate biowaste collection; the issue is addressed in detail in section 3.2.3*

3.2.2 National waste collection specifics

Biowaste collection is closely connected with the collection of other waste fraction. Therefore, national specifications regarding waste and biowaste collection for the six DECISIVE-countries are summarised in the following. This might also include the situation in smaller municipalities and regional levels.

Belgium:
The collected main fractions are similar in the three Belgian regions Wallonia, Flanders, and Brussels. Glass waste is collected at BPs (Belgian term: bring banks), separated into white and coloured glass. Some of the glass bottles are part of a deposit system and have to be brought to shops. Paper waste and cardboard waste are collected together either in DD collection or at BPs. Plastic and metal packagings are collected together with multi-layered beverage cartons either in DD collection or at BPs. Biowaste separate collection includes FW but is not comprehensively available in Belgium. Larger cities installed a DD collection (Table 1). Home composting is recommended by several municipalities. Commercial biowaste and biowaste from public institutions, which is similar to household biowaste, is commonly managed together with the household biowaste within the municipal waste management systems. In Wallonia, by the end of 2014, about 140 communes out of 262 had implemented biowaste collection. A consortium of seven municipalities organises municipal waste management. Most of them perform the selective biowaste collection at least on a part of their territory. In two municipalities FW is excluded from the biowaste collection. Among these two, one allows the citizens to bring their FW to CAS. Likewise, in Flanders region, the municipalities partly have implemented the biowaste collection. Consistently, animal by-products are excluded from the sorting guidelines (Ovam 2016). In Brussels, shells and bones are excluded from the biowaste collection. The system is applied in all the 19 communes since 01/01/2017. However, the collection of separated FW is on volunteer basis and the waste generators have to purchase special bags (Table 1). Complementary, GW is only collected from April until the end of November in the Brussels Capital Region. Additionally, CAS' are common. In Antwerp (Flanders) for biowaste a mixture of DD and underground containers as local BP are applied. Underground containers are used in dense urban centre. CAS are supplementary applied.

Denmark:
In Denmark, recyclables and residual waste are collected by DD collection. In the larger cities, FW has been collected within the residual waste fraction. CAS collection for garden waste (GW+WW) has been established in almost all Danish municipalities. A DD collection for garden waste on demand is also possible, but only with extra payments. Commonly FW has been collected with residual waste and incinerated with production of electricity and heat. Several cities have established biowaste collection schemes, among others Roskilde, Copenhagen and Odense. Testing various separate waste collection systems and also quality monitoring of the resulting biowaste has been performed and documented in public available surveys (COWI 2017, DEPA 2003, 2014b, 2015, 2016a,b, NIRAS 2013). Biowaste separation and collection from households in e.g. Roskilde and Copenhagen will start in the autumn of 2017. In Copenhagen, a voluntary collection scheme from single family houses has already been established since 2015. In Odense from October 2016 to October 2017 various new collection schemes including biowaste separation are tested. The test on biowaste separation includes 2000 households (corresponding to 2% of all households in Odense). Since 2003, Biovækst located in Holbæk have received separate collected household biowaste from ten municipalities (Kalundborg, Holbæk, Odherred, Frederikssund, Egedal, Gribskov, Halsnæs, Hillerød, Rødovre, Ringsted) (Biovaekst 2017). Separate collection of household biowaste is increasing in Denmark over the last years. For example, Roskilde municipality have separate collection of garden and FW from 1st of September 2017, while Værløse municipality is an example of a city where household waste is sorted in eight fractions since June 2016 (Furesoe Kommune 2016).

France:
In France, the public waste management service is in charge for household waste and assimilated waste from companies. The waste management competency lies by the municipalities or by inter-municipal organisations (e.g. EPCI), syndicates, or at “département” level (Local County). Choices for operational management of waste differ from one organisation to the others, e.g. regarding the collection type (DD or BP) and frequency. In terms of separate collection of recyclable waste, three main collection types are relevant: two-flows - glass / paper and packagings (60%); tri-flows - glass / paper / packagings (17 %); tri-

flows - glass / paper and cardboard / plastic and metal (5%). The other 18% of the recyclable waste masses are collected using specific local systems. The distribution of the collection types varies with the housing type. For example in urban municipalities with dense housing, only the two first types are applied. Only 9% of the population collect biowaste separately of which 6% were garden waste. At the moment the biowaste separation is not mandatory (unless for big producers with more than 10 Mg FW/a) but most of the municipalities have promoted home and proximity composting to reduce the quantity of FW in residual municipal waste.

Germany:

In Germany it is mandatory to separate biowaste since January 2015 (KrWG, § 11 para. 1). Although the DD collection is of a high coverage (Table 4), it does not cover the entire population. According to the German Environmental Protection Agency, in 2012, 52% of the households used a biowaste bin or container (80 l to 1100 l) (UBA 2015). In 2016, 80% of the households from the 387 administrative districts were able to use the biowaste collection system (Richter et al. 2017). However, households can be freed from biowaste collection, if they apply home composting or don't have place for biowaste collection bins. Among others, the container and bin sizes as well as the fee system determine the amount of collected biowaste (UBA 2015). Although biowaste separation is commonly applied, about 70 % of the FW is disposed in the residual waste (Kranert et al. 2012). UBA (2015) shows, that even in best cases of biowaste collection, at least about 20 kg biogenic matter per capita and year remains in the residual waste and follows most likely incineration pathways (Thrän et al. 2016). The separate collected biowaste was a long time mainly treated primarily by composting, but now increasingly also in combination with AD. The developments were mainly driven by regulations. Since August 2017 also for commercial waste it is mandatory to improve waste separation (GewAbfV, 2017). Therefore, it may be expected, that biowaste amounts collected from commercial sectors will increase in the near future. In Germany, many waste fractions are separated such as wastepaper and cardboard, packaging materials and waste glass. DD, BP and CAS options are available.

Italy:

In Italy, commonly biowaste collection is applied (Table 5), but different collection vessels may be used. If separate collection is not available, co-mingled collection is common with various fraction combinations. Since DD collection is applied in large cities (Table 5), BPs at kerbsides (bins and dumpsters) are also often established for all recyclable wastes (FW, garden waste, glass cans, paper and plastic), and for non-recyclable household waste. Home composting is promoted by incentives such as discounts on the waste collection tax. CAS exists for bulky waste such as furniture, electrical appliances, demolition wastes, and more. Sometimes a free public service (up to a certain weight) is offered to transport the bulky waste from the kerbside to the CAS. Additionally a free public DD service is offered for large pieces of garden waste (WW such as branches). It has to be noted, that quite different specific methods of waste collection are applied at municipality level, even in the same region.

Spain:

The predominating collection system in Spain is the BP system. Partly, this includes also separately collected biowaste (Table 6). However, most Spanish regions actually do not apply biowaste separation. Catalonia is the only Spanish region where biowaste separate collection is comprehensively implemented for a long time (section 3.3). The Spanish Framework Waste Management Plan (Ministerio de Agricultura, Alimentación y Medio Ambiente, 2016) established the obligation to include biowaste separate collection in the regional waste management plan. Consequently, all Spanish regions must include this collection system in their plans. Some regions have recently started the biowaste separate collection, and Guipuzcoa is the one where the system is more widely implemented yet. In some regions such as Navarra, Valencia, Asturias, experiences have been made with some pilots. Moreover, waste collection procedures of the regions are quite often unique and individual. For instance San Sebastian and Pamplona use a chip-opening container system on voluntary basis respectively and a key-opening system for biowaste. In parts of Guipuzcoa (e.g. Tolosaldea community) a card opening system is applied for both, biowaste and residual waste. In Spain commercial waste from small businesses such as retailers, hotels, and restaurants is often handled together with the waste from households. Therefore, biowaste from commercial activities is included in the general municipal biowaste management system. Large commercial generators may have the choice to either choose the municipal waste management service or contract a private service. Further detailed explanations are provided for Catalonia within the following section 3.3.

In summary, biowaste collection systems are widely applied in Germany, Italy, Belgium, Denmark, and Catalonia (Spain) or rarely e.g. in France, and in most parts of Spain. Sometimes, biowaste is collected without FW shares as it is the case in many Danish municipalities. Biowaste without FW shares can also be brought to BP or CAS stations on demand, e.g. in Italy or Germany, respectively. Additionally, in Belgium GW bags might be bought and collected via DD systems. Often, biowaste collection includes FW shares, sometimes also exclusively as it is the case in large Italian cities. For such biowaste, often DD collections are used, e.g. widespread in Germany, in Italian large cities, and in 130 municipalities in Catalonia. In Catalonia and Italy also BP systems are applied. The survey also showed that specific biowaste fractions can be collected separately. The example of Italy showed that FW can also be collected solely without GW fractions. If no separate biowaste collection is applied, FW is collected together with the mingled waste, which is commonly done in parts of Spain, most of France, parts of Demark and Belgium. When source separated biowaste collection exists, the residual waste still consists of significant amounts of biowaste, particularly FW. Furthermore, additional FW fractions can be recycled at home, e.g. in home composting, which is frequently the case e.g. in France.

3.2.3 Details for Catalonia

Catalonia is a region in north-eastern Spain with approximately 7.5 Mio. inhabitants. It is organised in the four provinces Barcelona, Girona, Lleida and Tarragona (Figure 5). The majority of the population (5.5 Mio. inhabitants) lives in the province of Barcelona. The Catalonia region consists of 946 urban, semi-urban and rural municipalities.

The separate collection of biowaste started in 1996 in two municipalities, Torrelles de Llobregat and Molins de Rei, covering a population of about 20,000 inhabitants. The experience gained in this project helped to design and optimise the composting process and the separate collection scheme, and also gave valuable information on the impact of impurities on the composting process and the quality of the compost as product (Regions for Recycling, 2014). Today, generally large Catalan cities (>50,000 inhabitants) use BP collection, while municipalities with populations lower than 50,000 and larger than 5,000 (semi-urban) use either BP or DD collection. However, there are no significant differences in the fee to pay for the citizens. PAYT system is applied in three municipalities of Catalonia with Argentona (12,000 inhabitants) as the largest.
The region of Catalonia introduced a landfill tax in 2004 through the Catalan Law 16/2003 on financing waste treatment infrastructure and waste management taxes. The initial rate of the tax was 10.00 €/Mg of municipal waste. In 2008, the Catalan Law 8/2008 (modified in 2011) on financing infrastructure and waste management taxes, kept the landfill tax of 10.00 €/Mg and established an incineration tax of 5.00 €/Mg. However, since 2010 municipalities that had not initiated biowaste collection, are charged with raised taxes of 20.00 €/Mg for landfilling and 15.00 €/Mg for incineration. On 31 March 2017, the tax was adjusted to 30.00 € /Mg for landfilling and 14.50 € / Mg for incineration. The disposal tax is established by the Waste Management Fund (Fons de Gestió de Residus). At least 50% of the revenue generated by the disposal tax has to be destined to biological treatment of biowaste and the mechanical-biological treatment (MBT) of residual waste, aiming at reducing the biogenic content of the residual waste finally going to landfill or incineration. The remaining revenue is refunded to the local authorities according to their performance regarding separate collection of biowaste, which is incentivised by refunds that vary depending on the quantity and the quality of the biowaste delivered to the biological treatment plants. The biowaste quality in terms of purity and contamination rate, respectively, is assessed by periodical composition analyses. There are other refund criteria, which are subject to annual revision by the Municipal Waste Governing Board, and thus can act as steering instruments to promote separate collection of particular waste streams, alternative methods of material recovery as, for instance, home composting (Regions for Recycling, 2014).

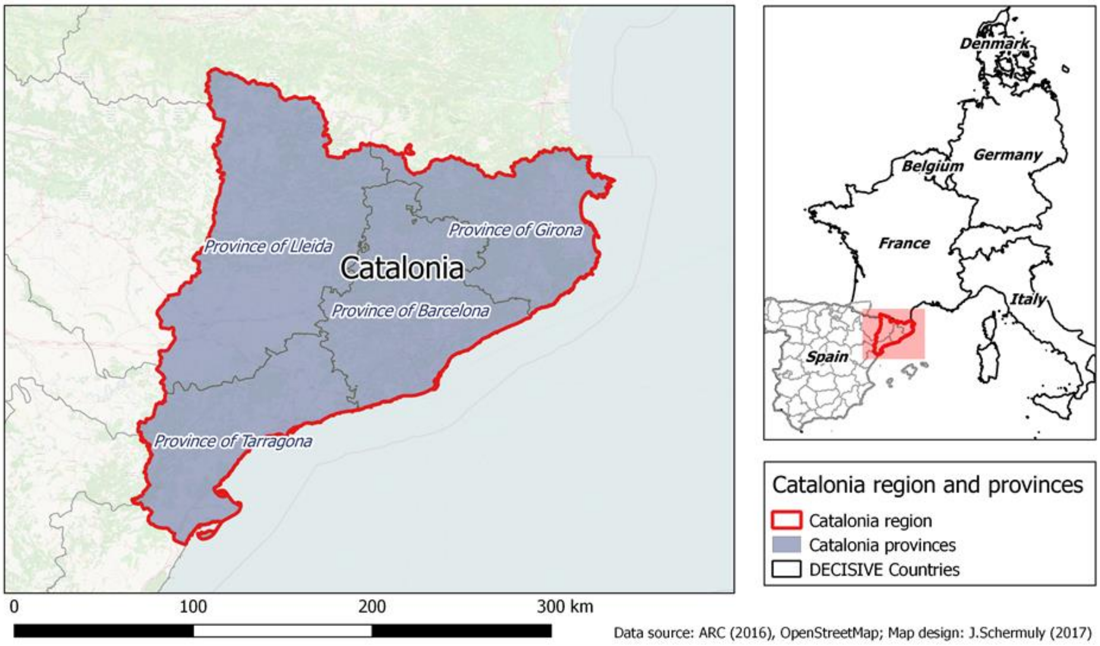


FIGURE 5: Map of the Catalonia region with the four provinces and positioning in Spain.

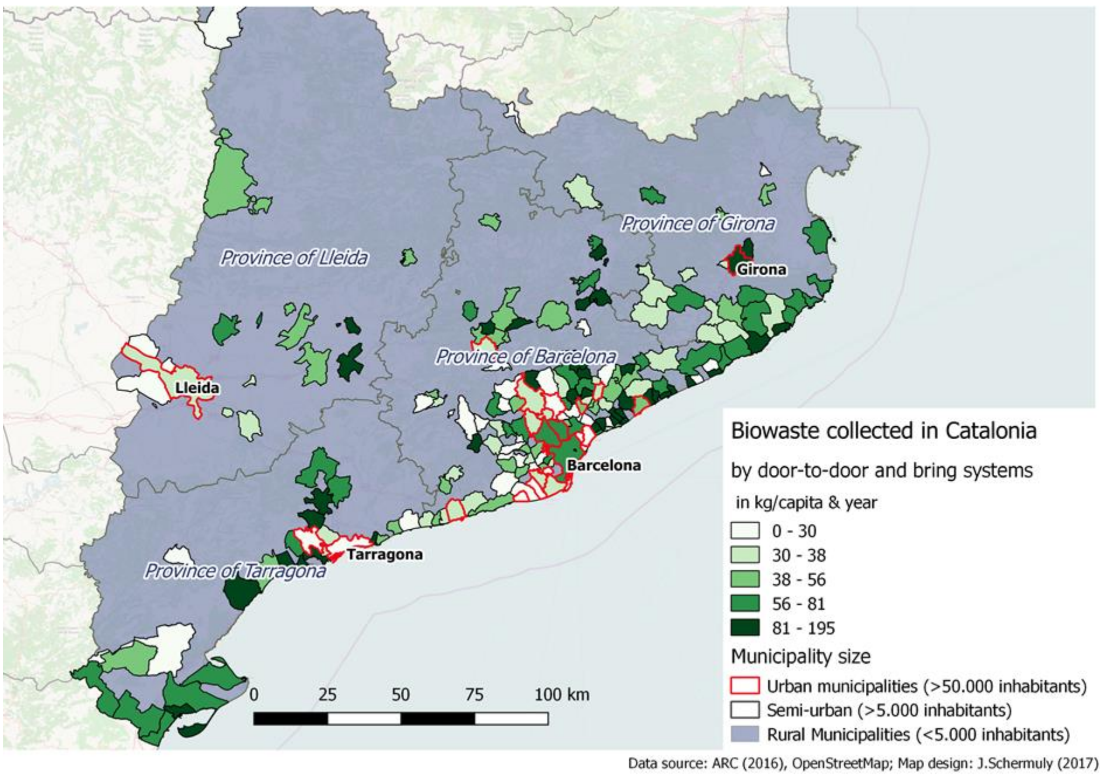
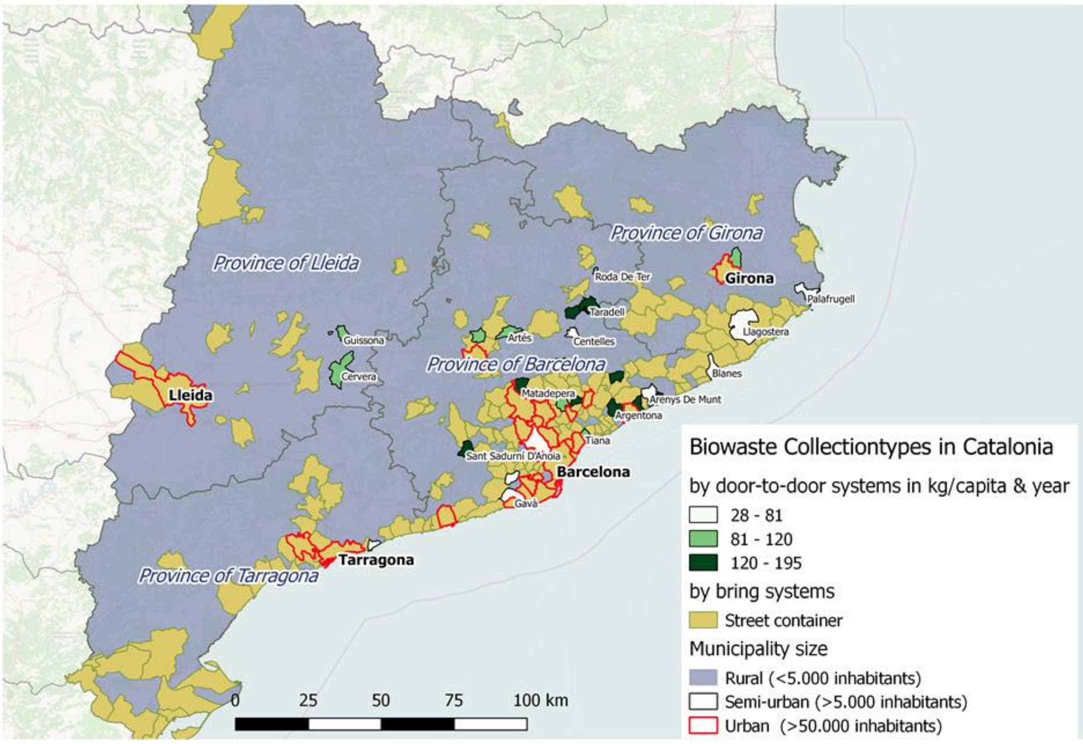


FIGURE 6: Map of quantities of collected biowaste per capita (kg/capita*2015) in urban and semi-urban municipalities (framed) of Catalonia.

Bins for other waste fractions are provided as well (residual waste, waste paper, packaging waste and/or waste glass). If a fraction is not included in the DD system of a municipality it is collected in BP containers. Generally, the larger municipalities (based on population) have BP systems for all the waste fractions (including biowaste), while smaller municipalities have DD-systems for all the waste fractions, except for waste glass and garden waste which are collected with BPs.

Generally, in Catalonia “soft” GW is collected with FW, and WW is collected with a different system, either as DD on demand or BP system. The largest municipalities have BP systems for all the waste fractions (including biowaste), while the smallest ones have DD for all the waste fractions except for glass and garden waste which are collected with BPs. The most important exception in Catalonia is the Osona County. The municipality provides a system with both DD and BP in different parts of the area. Though, only 4 fractions are collected because waste paper and packaging waste are collected together.



Data source: ARC (2016), OpenStreetMap; Map design: J.Schermuly (2017)

FIGURE 7: Map of collected biowaste amounts (kg/capita*year) according to collection type (DD and BP) of the different urban and semi-urban municipalities of Catalonia.

Source separated biowaste is either brought directly to biological treatment or to MBT (Figure 8). Most facilities apply composting (e.g. Mancomunit at la Plana), but in few of them biowaste is anaerobically digested (e.g. Consortium for Waste Management of Vallès Oriental (2017a, 2017b, 2017c)). For residual waste, the predominant pathway in Catalan municipalities including the Barcelona province is landfilling or incineration.

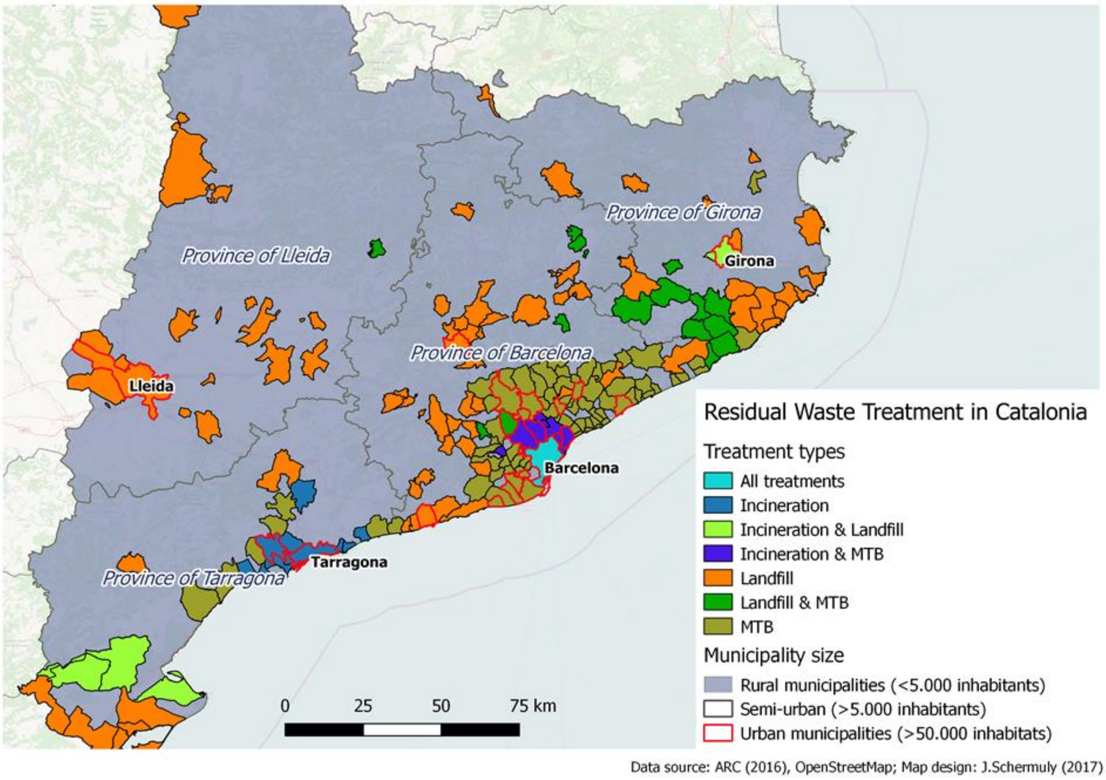


FIGURE 8: Map of Disposal and treatment pathways of residual waste in the different urban and semi-urban regions of Catalonia.

In Catalonia there are several supra-municipal public institutions that are the responsible of the waste management of multiple municipalities, among others Mancomunitat la Plana and Consorci per a la gestió dels Residus del Vallès Oriental. They operate source separated biowaste collection, CAS and BP as well as a material-recovery-facility for paper and packaging waste. The Consortium for Waste Management of Vallès Oriental (2017c) operates an AD plant with post-composting for source-separated biowaste and one material-recovery-facility residual and packaging waste. From the approx. 400,000 inhabitants in the county Vallès Oriental, they collected 20,530 Mg biowaste annually (equal to 51 kg per capita and year) (Consortium for Waste Management of Vallès Oriental, 2017c). The biowaste is mainly composed from FW and contains small items of GW such as grass cuttings. In Catalonia there are 25 biotreatment facilities, of which 21 include composting and 4 include AD plus post-composting facilities. The capacity reaches from 300 Mg/a (Boadella composting plant in a decentralised scheme) up to 90.000 Mg/a (Barcelona AD plant in a centralised scheme). Furthermore, there are 43 facilities which treat residual waste.

4 Collection chains for decentralised applications

DECISIVE aims to provide a decision support tool (DST) to compare options for a more effective utilisation of FW from households and catering and other anaerobically degradable biowaste fractions. This involves multiple possibilities for the biowaste collection. In this chapter, the generation of local biowaste and its possible collection pathways until mAD is analysed in order to enable evaluations for local collection options. Though, the valorisation itself remains beyond the scope of this survey.

4.1 OVERVIEW CHAIN CLASSIFICATIONS

Figure 9 describes schematically the potential collection chain option from the different local biowaste sources to mAD or, in broader context, to another on-site valorisation unit. A variation of any chain element involves a direct causal link to other elements from the chain. The biowaste collection chain was subdivided into three principal levels (Figure 9): 1 - Biowaste level (section 4.2), 2 - Biowaste generator level (section 4.3), and 3 - Biowaste caretaker level (section 4.4). Level 4 (section 4.5) is the interface to mAD and SSF, and only roughly introduced. The scheme in Figure 9 does not include all options and could be completed within the progress of the DECISIVE project, if new ones emerge. For instance pneumatic underground systems for waste collection may be an additional option (exist already in some places, e.g. Barcelona’s Olympic neighbourhood, but biowaste quality is the lowest in Catalonia). Thus, the “bag” or “bucket” could be connected with the “pipeline” button, if the former collection system is implemented and therefore reduce the process steps to the valorisation unit. In this scheme also options for “reverse logistic”, for instance delivering food and taking back waste, are not considered yet. This point becomes especially important when the interface to mAD is taken into account; the digestate has to be used (after being treated) which leads to the necessity of transport processes. A similar scheme considering this interface to digestates should be topic of a later stage in DECISIVE. Furthermore, the scheme points out that connections to external valorisation sites eventually have to be considered, which can also be elaborated in more detail in future works.

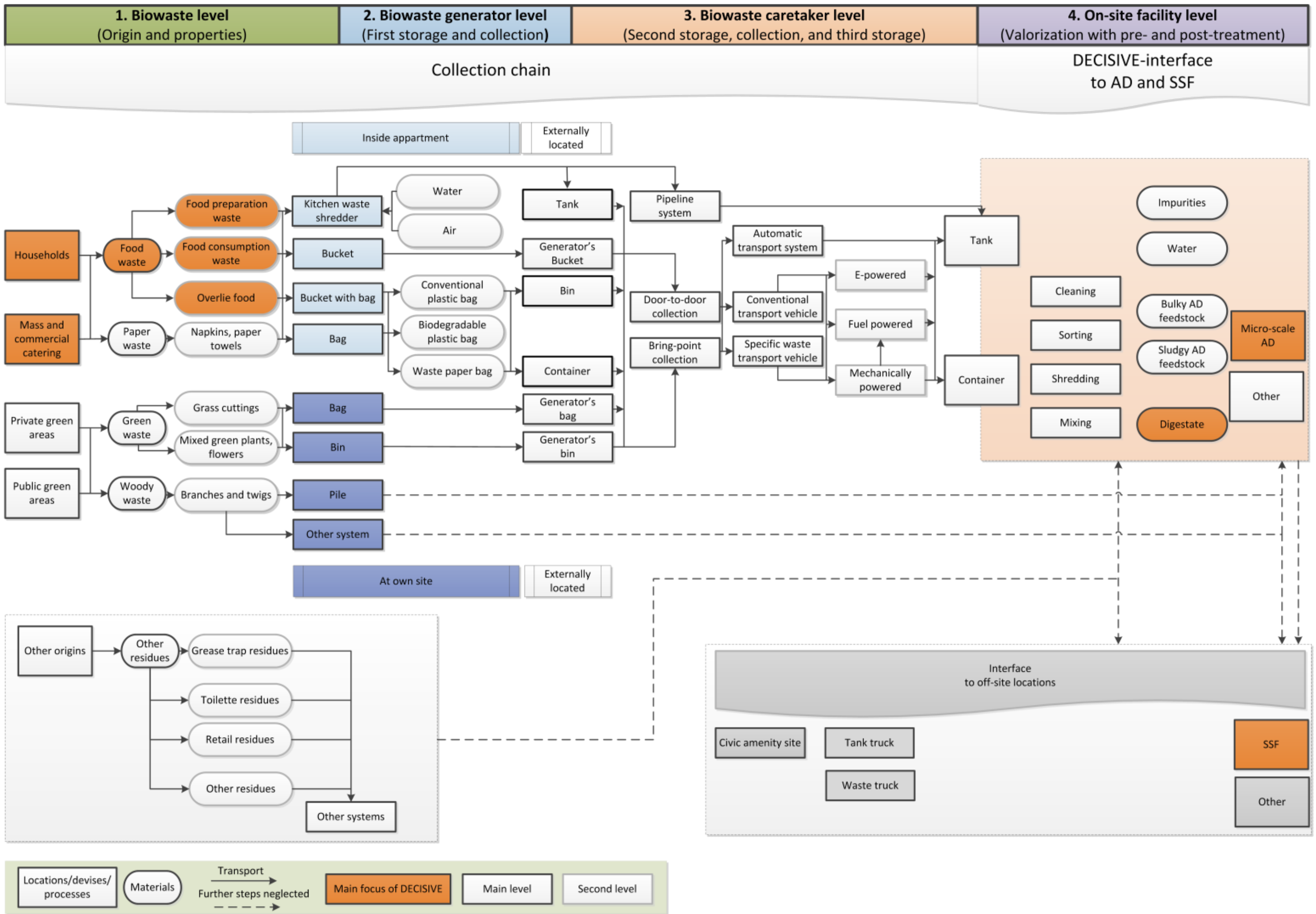


FIGURE 9: Classification of collection chain options for pathways form local biowaste to decentralised on-site valorisation with connections to external biowaste handling systems.

4.2 BIOWASTE LEVEL: BIORESOURCE ORIGIN AND PROPERTIES

The "collection chain inputs" were distinguished regarding their origin, which is closely linked to the property of assigned biowaste type. FWs from households and from catering units were marked in Figure 9, as chosen "core substrates". All other locally available biogenic substrates which are anaerobically degradable can be important for local collection and valorisation systems as well. In the following list, examples for input origins are introduced. Private households, mass and commercial catering as well as private and public green areas were identified as the four major sources of locally available biowaste. However, other origins may be of supplementary importance for each different case (Figure 9).

- **Private households** produce FW as major biowaste type in kitchens. Household FW includes food preparation waste (e.g. peels, green plant parts, pits), food consumption waste (e.g. raw and processed food leftovers and overlie (e.g. old bread, expired food). Especially in the last group a large avoidance potential has to be considered. Generally, the "buying step", taking place before the "collection chain" starts, is important for avoidance.
- The **mass and catering sector** covers e.g. canteens from hospitals, schools or universities. Furthermore, restaurants and coffee shops are included. Here, FW is the main biowaste, with the same subdivisions regarding avoidance as in the first group. "Food preparation" can be considered as the most important avoidance step.
- **Private green areas** are commonly gardens which generate garden waste. If a mAD facility is the destination, it is important to subdivide it into the hardly digestible and stiff "WWs" and into the well digestible and soft "GWs" (section 1.4). Since commonly different vegetation types are the source it appears to be possible to separate well and easy into WW and GW fractions during gardening activities.
- **Public green areas** produce landscaping waste e.g. in municipal parks and gardens. Furthermore, landscaping waste may be generated at roadsides, at dikes, at cemeteries or other locations with vegetation growth. For the landscape management the same subdivision into GW and WW waste as in the group before is necessary and seems to be easily to realise during caretaking activities.
- **Location-specific further substrates** may be available. Examples are food residues from the food processing sector, and FW from the retail sector (e.g. bakeries, shops, markets). Larger kitchens (e.g. from restaurants and canteens) may use grease traps to remove cooking oil and fats from wastewater streams. Grease trap residues have high energetic values and are ideal as co-substrates for AD (Hertel et al. 2015). Furthermore, toilette residues (e.g. concentrated blackwater from vacuum toilettes) can be considered, but would lead to additional sanitary and contamination issues to consider. However, this will require local- specific evaluations.

FW from households can be estimated by number of local citizens, GWs from private and public areas by the size of the land. For all substrates from the group "other origins" unit-specific inventories have to be carried out. Therefore, for estimations of mAD feedstock amounts capita-, area- and unit-related inventory strategies have to be applied. The specific properties of the collected biowaste depend on the origin but in connection with the specific situation. Especially impurities may be problematic for mAD:

- **Household FW:** In minor share e.g. flowers, animal litter, tissues, napkins, and kitchen towels may be contained. They are anaerobically digestible. If causing problems it usually depends on the applied mAD unit. Some type of FW, such as bones or stones from fruits, might also be important to exclude. Impurities to avoid are glass, plastic, metal fractions.
- **Catering FW:** Often paper waste is contained (e.g. tissue papers such as napkins, paper towels). It was therefore included as a separate biowaste fraction (Figure 9).
- **GW:** GWs can contain minor WW fractions (e.g. leaves attached to twigs), which are to consider as impurity and ideally should not enter mAD respectively the collection chain. This accounts also for non-biogenic impurities such as plastic bags, glass and stones.

4.3 BIOWASTE GENERATOR LEVEL: FIRST STORAGE AND COLLECTION

The interface to the “biowaste generator level” is the collection device (Figure 9, blue markings). In the following options for household FW are described exemplarily.

- **With short-term storage (first storage):**
  - Bags are convenient to dispose, but cause expenses in purchasing. Options are e.g.:
    - various colours (e.g. for different fractions)
    - different materials (e.g. from paper, biobased or conventional plastics)
    - different size (e.g. 5 , 10, 15 L)
    - different biodegradability (not, aerobically, anaerobically biodegradable)
    - different provision (mixed own bags, bought specific bags, provided bags)
    - placed in a bucket or not placed in a bucket
  - Refillable buckets without bags need frequent washing, but expenses for bags would be saved. The differentiation is mostly in size, but also shape (e.g. with or without lit). Also “aerated bags” are possible (successful examples known from Italy and Catalonia).
- **Without storage (the FW is fed directly to the next level):**
  - A kitchen waste shredder placed in the sink prepares the FW for transport to a pipeline system (e.g. vacuum or water driven). Vacuum systems for decentralised waste transports are already available in practice (e.g. in residential settlements, offices, airports, big commercial kitchens; Jacoby 2017). In Odense, Denmark, some households have installed kitchen waste shredders and households can apply for installation.

The collection devices are usually located inside the building, commonly in the kitchen and require space. They might need some supplements (e.g. water for cleaning buckets or operating the FW shredder). Optimally, storage times should be short considering hygiene and valorisation intends. The biowaste generator level ends, if the citizen delivers the FW or GW to the further pickup by a caretaker or directly to the mAD unit.

4.4 BIOWASTE CARETAKER LEVEL: SECOND STORAGE, COLLECTION AND THIRD STORAGE

4.4.1 Second storage

The second storage will commonly be located in or beside the housing complex or within the city quarter (Figure 9, “externally located”). It is possible that FW and GW are mixed at this stage, if the mAD can handle both types. Three principle storage options were identified for household FW:

- **In the “generators” device (small):** The citizen brings the bag or bucket outside for direct pickup by the caretaker (DD collection); chips, badges or barcodes are possible devices for identification of the generator in order to apply a PAYT system,
- **In an additional “caretaker” device (large):** The citizen disposes the bag or empties the bucket into a bin or container (differentiated by size, supplied with PAYT devices for identification), which is used by several citizens. It may be placed outside the building (DD-collection) or at “quarter-centralised” BP, in reasonable distance to the household
- **No second storage:** The citizen brings the bag or the bucket directly to the mAD area. Alternatively, the FW is transported automatically, e.g. if kitchen waste shredder is applied.

DD- or BP-containers can be placed underground with storage volume optimisation by implemented waste presses. The principle is rarely applied for collection of street waste, e.g. in Hamburg. Furthermore, innovative systems using transport pipelines could completely replace the necessity of containers, however, maybe quite cost-intensive. Such systems may be easier to apply in newly built areas compared to existing urban infrastructures. In some places, like Barcelona Olympic neighbourhood, pneumatic underground systems are running. FW and GW from institutions, commerce and public areas might either be included in the second storage system or directly linked to the on-site-facility level.

4.4.2 Collection

For the design of the bring system to the on-site facility (Figure 9) several factors have to be considered.

- The distance between the collection points and the final destination as well as the amount of FW and GW determines the vehicle type. Transfer stations have to be considered as well.
- The decision on collection type and frequency has an impact on decisions regarding transport infrastructure. At very small locations the transportation infrastructure can be economised by human-powered transport devices (e.g. trolleys, bikes or tricycles) or horse-powered devices (not in Figure 9) as practiced in some places in Greece. At larger locations conventional vehicles could be used (e.g. e- or fuel powered). In case of large locations or if several locations are serviced together, specific waste trucks are needed.
- The collection frequency must be aligned to the demands of removal from the collection points (e.g. daily, weekly, seasonal variations in amounts; surrounding temperatures, sensory experiences such as foul smell, and infestations of vermin) and to the take-in at the mAD site (e.g. available storage capacities; desired feeding frequency).
- Collection can be concentrated for multiple decentralised systems or decentralised for every single decentralised system.

4.4.3 Third storage

The caretaker level ends when the waste arrives at the on-site facility (interface to level 4, Figure 9). Depending on the system, the storage unit may be a tank for sludgy wastes or a container for bulky wastes (e.g. “beaches” applied in Catalan biotreatment facilities: recommended max. height 3 m; max. storage time 24 h). Optimally, storage at the site should be avoided thanks to well-organised collection system and continuous mAD operation. However, the provision of a constant feedstock quantity of a desired quality incorporates the need of storage possibilities. Temporary unavailability of the mAD may be balanced by alternative management at off-site locations. The locally available biowaste quantities and qualities influence the required storage capacities.

4.5 ON-SITE FACILITY LEVEL: BIOWASTE VALORISATION WITH PRE- AND POST-TREATMENT

The interface between level 3 and 4 are the containers or tanks where the locally generated and collected waste is disposed for further valorisation (Figure 9). The collected biowaste mixture determines the physico-chemical properties of the mAD feedstock (dry matter, organic dry matter, C/N, biomethane potential, impurity contents, bulk density; Fisgativa et al. 2016). The physico-chemical properties affect the design of the mAD with regard to the fermentation type (dry, wet), retention time and feeding frequency. The properties of the mixture can be estimated, if the properties and the amounts from the single biowaste types listed in level 1 are known. A database will be provided (D 3.7, Figure 2).

Depending on the chosen mAD process a biowaste pre-treatment may be needed. This includes the elimination of inert impurities (e.g. plastic bags, glass, woody fractions) by sorting devices or manually. Although plastic bags are not suggested for DECISIVE-systems, they may occur. Further simple pre-treatments for size reductions and homogenisation may be needed for an effective mAD. Devices to destroy collection bags, reduce particle size and provide basic homogenisation are e.g. industrial kitchen waste shredders or grinders. In most cases pre-treatment is supported by the addition of water, which might also occur during the collection (i.e. washing of refillable buckets, kitchen shredder vacuum system). The valorisation unit in DECISIVE is a mAD system. According to deliverable D4.1 (Figure 2) the input amount is set between 50 Mg/a (minimum scenario) and 200 Mg/a (maximum scenario). The capacity of the mAD defines the biowaste amounts to collect. The mAD feeding frequency (from discontinuous weekly batches to daily and/or continuously feedings) defines the frequency of collection or storage necessities. Limitations of space e.g. for sorting and storing capabilities increase the demand on the collection system. Post-treatment might be needed for mAD digestates.

5 Conclusions and outlook

The amenities of the transition to waste management schemes with decentralised elements are manifold and reach from a more efficient biowaste valorisation, traffic savings in urban areas until a closer connection of citizens to urban cycles and more. However, waste collection is an important element. It is influenced by a multitude of ambient, social and technical factors (section 2). Moreover, the state-of-the-art in the DECISIVE countries showed a huge diversity in actually applied waste collection systems (section 3). If new collection systems are intended, the complexity even improves, since a multitude of technical options exist (section 4). In conclusion for transition to decentralised systems, it cannot be expected to find the one, optimal collection solution. It would rather be specific in each case for the respective location.

For the design of decentralised systems it is crucial to understand and document the different elements of a collection chain. A collection chain for decentralised solution consists of 3 levels: biowaste level, biowaste generator level, and biowaste caretaker level, whereas a multitude of specific pathways are possible (section 4). The comprehensive structuration of the collection chain forms the basis for the decision making in order to find location-specific best practice options. In this context, the collection chain will be included in the DST, which will be developed within DECISIVE. A pre-condition is the definition of the term “decentralisation”. So far, no common definition exists. In the DECISIVE-context, the size of the mAD unit was set as frame with 50 to 200 Mg input per year (D4.1, Figure 2).

Different national legal frameworks, people’s individual lifestyles and other factors result in wide regional differences in waste collection systems. Biowaste collection systems across Europe also vary between countries, regions and municipalities. Also the types of locally present biowaste are manifold and range from households, catering FW to GW from gardening and landscaping and many others. Also, if only FW from household would be considered, the ranges are wide due to varying amounts, compositions and local distributions. The literature review revealed a lack of common definitions and terminologies. The term “biowaste” covers a wide range of wastes types from biogenic origin. Some types are more important for transition to decentralised mAD systems than others, and some such as WW are not usable at all. Therefore, clear definitions to biowaste fractions, but also to the elements of the collection chain are needed and be included in the DST. In any way, adapted collection guidelines have to be prepared to guide the citizens.

The focus of DECISIVE was laid at FWs from household and catering. The literature review revealed a lack of data regarding the generated FW amounts. Only a few studies are available for the DECISIVE countries. However, a large amount of avoidable FW occurs and has to be considered in planning’s, especially taking into account the visionary EU avoidance goal of 50% of FW (section 2). Therefore, a reliable inventory regarding the potentials of FW from households (capita-related), but also of GW from private and public green areas (area-related) and other sources (unit-related) is a prerequisite to design decentralised biowaste collection systems. The development of a unified inventory strategy is a challenging task. Besides clear definitions, local spatial biowaste quantification is required. This task will be approached in DECISIVEs GIS-related work package.

To extract the most critical national, regional and local factors from the presented aspects (section 2), concerning the transition from the current system towards biowaste management with decentralised sites, local stakeholders have to be involved. Therefore, expert interviews with practice stakeholders from selected regions of the DECISIVE countries are ongoing, and will be presented in the upcoming deliverable D3.7. Moreover citizens will be involved also by interviews with results expected in the upcoming deliverable D3.6.

6 Appendix

6.1 SOURCES FOR INFORMATION OF TABLES 1-6

	City	Source	No.	Link
Belgium	Antwerp	Antwerpen.be (2017)	1	https://www.antwerpen.be/nl/overzicht/correct-sorteren/papier-en-karton
			2	https://www.antwerpen.be/nl/overzicht/correct-sorteren/glas
			3	https://www.antwerpen.be/nl/overzicht/correct-sorteren/pmd
	Brussels	Brussels propreté (2017)	4	https://www.brussels.be/artdet.cfm/4023#a_3
			5	https://www.brussels.be/artdet.cfm/4023#a_3
			6	https://www.arp-gan.be/images/upload/files/memo_tri_2017.pdf
	Charleroi	ICDI-2017 Intercommunale de collecte et de valorisation des déchets ménagers de la Région de Charleroi (2017)	7	http://icdi.be/citoyens/collectes-porte-a-porte/types-de-collectes/conteneur-a-puce-vert.htm
			8	http://icdi.be/citoyens/collectes-porte-a-porte/calendrier-des-collectes.htm
	Gent		9	https://stad.gent/international-students/living/accommodation/housekeeping/waste-management/how-manage-your-waste
			10	https://www.ivago.be/thuisafval/gftikdoemee
			11	https://www.ivago.be/thuisafval/afvalgids/gft
	Liege		12	http://www.liege.be/proprete/guide-du-tri
	Namur		13	http://www.bep-environnement.be/trier-ses-dechets/
			14	http://www.bep-environnement.be/collectes/andenne
			15	http://www.geopostcodes.com/Namur_Arrondissement
Denmark	Copen-hagen	NEM Affaldservice (2017)	16	http://international.kk.dk/artikel/how-handle-your-household-waste
			17	http://www.nemaffaldsservice.kk.dk/
	Odense	Odense Renovation (Waste Management Company, 2017)	18	http://www.odenserenovation.dk/Genbrugsstation/affaldssortering.aspx
			19	http://www.regions4recycling.eu/upload/public/Good-Practices/GP_Odense_paper-collection.pdf
	Aalborg	Aalborg waste management company (2017)	20	http://www.aalborgforsyning.dk/renovation/affaldstyper.aspx
	Aarhus	Affaldvarme Aarhus (2017)	21	http://www.aarhus.dk/sitecore/content/Subsites/CityOfAarhus/Home/activityareas/Climate-and-the-environment/Waste-and-heating.aspx
				http://sorter-mer.nu/media/1121/sorting-guide.pdf
	Hillerod	Hillerod Forsyning	22	http://hillerodforsyning.dk/affald

	Roskilde	Roskilde Kommune	23	http://roskilde.dk/borger/affald-og-miljoe/ny-affaldsordning-i-2017
	Vejle	AffaldGenburg, Vejle Kommune	24	https://www.vejle.dk/borger/mit-liv/affald-og-genbrug/dagrenovation/
	Frederiks-havn	Frederikshavn Kommune	25	http://frederikshavn.dk/Sider/Affald-og-genbrug.aspx?topemne=724167da-661e-44a2-90a5-ae85f5f229e5&emne=0e9b4879-d045-48db-bdf0-d6c09faa8fdc
France	Ajaccio	City of Ajaccio (2016)	26	http://www.ajaccio.fr/La-collecte-en-sacs-passe-a-l-heure-d-hiver-a-partir-du-7-novembre-emballages-dechets-menagers-et-encombrants_a5054.html
	Bordeaux	Bordeaux Metropole (2016)	27	http://www.bordeaux.fr/images/ebx/fr/groupePiecesJointes/9321/3/pieceJointeSpec/135124/file/aide_memoire_tri_2016.pdf
	Brest	Brest Metropole (2015)	28	https://www.brest.fr/fileadmin/Documents/Au_quotidien/agir_pour_l-environnement/Dechets/Guide_du_tri_2015.pdf
	Dijon	Dijon Metropole (2017)	29	http://www.grand-dijon.fr/decouvrir/environnement/dechets/trier-50264.jsp
	Lyon	Metropole Grand Lyon 2015	30	https://www.grandlyon.com/fileadmin/user_upload/media/pdf/proprete/20150925_gl_gp_tri.pdf
	Le Havre	Communauté d'agglomération Havraise (2017)	31	http://www.clg-lurcat-sarcelles.ac-versailles.fr/IMG/pdf/Guide_du_tri_1_.pdf
	Lille	Metropole Europeenne de Lille (2016)	32	http://www.lillemetropole.fr/mel/services/dechets-menagers/tri-selectif-mode-demploi.html
	Lorient	Lorient Agglomeration (2017)	33	https://www.lorient-agglo.fr/fileadmin/user_upload/Portail_cap/dechets/pdf_Tri/BAT_Nouveau_Guide_de_tri_des_dechets_BD.pdf
	Marseille	Métropole Aix-Marseille Provence (2017)	34	http://www.marseille-provence.fr/index.php/documents/tri-selectif/1466-guide-du-tri/file
	Montpellier	Montpellier Metropole (2016)	35	https://www.montpellier3m.fr/sites/default/files/Guide_TRI-2016_0.pdf
	Nice	Metropole Nice-Cote de Azur (2012)	36	http://tousecocitoyens.org/document/infos_prat_grand_guide_tri.pdf
	Nantes	Nantes Metropole (2016)	37	http://www.nantesmetropole.fr/medias/fichier/consignes-de-tri_1492589162192.pdf?INLINE=FALSE
	Orleans	Communauté de Agglomeration Orleans Val de Loire (2016)	38	http://www.orleans-metropole.fr/1376/collecte-des-dechets.htm
	Paris	Mairie de Paris (2017)	39	https://api-site.paris.fr/images/85060
	Rennes	Metropole de Rennes (2012)	40	http://www.uve-rennesmetropole.fr/images/pdf/GUIDE-DECHETS-2012-WebBD.pdf
	Reims	Metropole de Reims (2016)	41	http://www.reimsmetropole.fr/fileadmin/reimsmetropole/MEDIA/Les_missions/Cadre_de_vie___Environnement/Gestion_des_dechets/Les_consignes_de_tri/A4_DECHET_GRAND_FORMAT_AccessibleV2.pdf.
	Strasbourg	Eurometropole de Strasbourg (2016)	42	http://www.strasbourg.eu/environnement-qualite-de-vie/gestion-dechets/collecter#menagers

	Saint Etienne	Saint-Etienne Metropole (2015)	43	http://www.agglo-st-etienne.fr/fileadmin/user_upload/03_pres_de_vous/votre_environnement/gestion_dechets/tri/GuideDechets2015.pdf
	Toulon	Sittomat (SyndiCat mixte interCommunal de tranSport et de traitement deS ordureS ménaGèreS de l'aire toulonnaise) (2016)	44	https://www.agglo-sudsaintebaume.fr/wp-content/uploads/2016/11/guide-du-tri-apport-volontaire.pdf
	Toulouse	Toulouse Metropole (2016)	45	http://www.toulouse.fr/documents/106871/106948/Guide_tri_Toulouse_encart_dechets_verts_2016/87eb9775-b02a-40e5-85cc-162ecd1db6ad
Germany	Berlin	Berlin Stadtreinigungsbetriebe 2017	46	http://www.berlin-recycling.de/leistungen/haus-und-garten
			47	https://www.bsr.de/wertstoffe-20075.php
			48	http://www.berlin.de/special/immobilien-und-wohnen/energie-und-tarife/3719305-932375-biotonne-wird-2015-zur-pflicht-was-darf-.html
			49	https://www.bsr.de/bioabfall-20009.php
			50	https://www.bsr.de/das-tarifmodell-der-bsr-22979.php
	Bonn	Bonn Orange	51	https://www.bonnorange.de/abfallwirtschaft/private-haushalte/infos-von-a-z/b/biotonnegruene-tonne.html
	Bremen	Entsorgung kommunal Freie Hansestadt Bremen	52	https://www.bremen.de/suche?search_query=waste+disposal
			53	http://www.entsorgung-kommunal.de/entsorgung/abfallarten-2710
	Dortmund	Entsorgung Dortmund GmbH	54	https://www.edg.de/de/entsorgungsdienstleistungen/rein-damit/bioabfall.htm
			55	https://www.edg.de/de/entsorgungsdienstleistungen/dahin-damit/recyclinghoefe.htm
	Dresden	Stadtreinigung Dresden 2015	56	http://www.srdresden.de/dienstleistungen/a-bis-z/
			57	https://www.dresden.de/media/pdf/abfallwirtschaft/Biotonne_Nov2015.pdf
		Stadtreinigung Dresden 2017	58	https://www.dresden.de/media/pdf/abfallwirtschaft/Abfallratgeber2017_web.pdf
	Essen	Entsorgungsbetriebe Essen GmbH	59	http://www.ebe-essen.de/privatkunden/depotcontainer/
			60	http://www.ebe-essen.de/privatkunden/abfallabfuhr/braune-tonne/
	Frankfurt	FES Frankfurter Entsorgungs- und Service GmbH 2017	61	https://www.fes-frankfurt.de/buerger/entsorgung/abfall-abc
	Hamburg	Stadtreinigung Hamburg 2017	62	https://www.stadtreinigung.hamburg/privatkunden/wertstoffe/bioabfall/
	Hannover	AHA Zweckverband Abfallwirtschaft Region Hannover 2017	63	https://www.aha-region.de/bioabfall.html
			64	https://www.aha-region.de/fileadmin/Download/Geb%C3%BChren/Geb%C3%BChren%C3%BCbersicht_2017_14tgl.pdf

	Kiel	ABK Kiel	65	http://www.abki.de/abfallentsorgung/Behaelter-Biotonne.php
	Köln	AWB Abfallwirtschaftsbetrieb Köln	66	http://www.awbkoeln.de/private-haushalte/abfall-trennen-entsorgen/bioabfaelle-braune-biotonne/
			67	http://www.awbkoeln.de/private-haushalte/abfall-trennen-entsorgen/wertstofftonne-ehem-gelbe-tonne/
			68	https://www.awbkoeln.de/tonnen/biotonne/
	Leipzig	Stadtreinigung Leipzig	69	http://www.stadtreinigung-leipzig.de/assets/files/PDF/Flyer/Abfallwirtschaft.pdf
			70	http://www.stadtreinigung-leipzig.de/assets/files/PDF/service_tipps/GS%20Sackverteiler.pdf
			71	http://www.stadtreinigung-leipzig.de/leistungen/abfallentsorgung/abfallbeh%C3%A4lter/
	Mannheim	Abfallwirtschaft Mannheim 2016A	72	https://www.mannheim.de/buerger-sein/haeufig-gestellte-fragen-zur-abfallentsorgung-mannheim
			73	https://www.mannheim.de/sites/default/files/webform/5732/infoflyer_biotonne.pdf
			74	https://mannheim.de/buerger-sein/faq-wertstofftonne
	München	AWA Abfallwirtschaftsbetrieb München	75	https://www.awm-muenchen.de/index/abfalllexikon/liste/eintrag/biotonne.html?no_cache=1
			76	http://www.awm-muenchen.de/privathaushalte/restmuell-papier-und-bio/das-3-tonnen-system.html
			77	https://www.awm-muenchen.de/fileadmin/PDF-Dokumente/privatkunde/Trennliste_deutsch.pdf
	Nürnberg	Abfallwirtschaftsbtrieb Stadt Nürnberg	78	https://www.nuernberg.de/imperia/md/asn/dokumente/asn/biom__llinfo_deutsch.pdf
			79	https://www.nuernberg.de/imperia/md/asn/dokumente/ratgeber_abfall_web.pdf
	Stuttgart	Abfallwirtschaft Stuttgart	80	https://www.stuttgart.de/abfall
			81	https://www.stuttgart.de/bioabfall
Italy	Bari	Amiu Puglia 2016	82	http://www.amiupuglia.it/bari/raccolta-differenziata/
	Bologna	Comune di Bologna	83	http://comune.bologna.it/cantieri/progetti/raccolta_differenziata/dettaglio/vetro-lattine-e-organico
			84	http://comune.bologna.it/cantieri/progetti/raccolta_differenziata/dettaglio/organico
	Catania	Comune di Catania 2016	85	http://www.comune.catania.it/il-comune/uffici/ambiente/catania-rinasce/imghome/istruzioni-raccolta-catania.jpg
	Cagliari	Caggliari Castedu 2016	86	http://www.castedduonline.it/cagliari/centro-storico/33477/rifiuti-a-cagliari-parte-il-conto-alla-rovescia-per-il-porta-a-porta.html
	Florence	ALIA	87	http://www.quadrifoglio.org/lay50.php?IDCategoria=128
	Genoa	AMIU Genoa (2016)	88	http://www.amiu.genova.it/cms/php_docs/docs/multilingua_ita.pdf
	Milan	AMSA (Milano waste company) (2017)	89	http://www.amsa.it/gruppo/cms/amsa/multilingua/en/separate_waste/milano.html
	Messina	Comune di Messina (2016)	90	http://www.comune.messina.it/il-comune/polizia-municipale/aggiornamenti-professionali/ordinanza-261-016-rfiuti-differenziati-ed-indifferenziati.pdf
	Naples	ASIA (Napoli waste company) 2015	91	http://www.asianapoli.it/raccolta-differenziata
	Palermo	Palermo differenzia	92	http://www.palermoambientespa.it/wp-content/uploads/PaDifferenziaLOW.pdf
	Rome	AMA (Roma waste company) 2015	93	http://www.amaroma.it/public/files/pap/calendari/trastevere_calendario_ud_B_inglese.pdf
	Turin	AMIAT	94	http://www.amiat.it/cms/

	Trieste	WWF Trieste 2014 and Gruppo Hera	95	http://www.gruppohera.it/binary/hr_clienti/mappa_RD_Trieste_esecutivo.pdf
			96	http://wwftrieste.altervista.org/umido.shtml
	Venice	Comune di Venezia (2017)	97	http://www.comune.venezia.it/content/la-raccolta-differenziata
	Verona	AMIA Verona (2017)	98	http://www.amiavr.it/Raccoltadifferenziata/Ognicosaalsuoposto.aspx#umido
Spain	Barcelona	Collection managed by the city treatment of barcelona metropolis	99	https://w9.bcn.cat/tramits/Medi_Ambient/preus/Preuspublicsrecollidaresidus2017.pdf
			100	https://www.residuonvas.cat/#
	Bilbao	Bilbao Council (2016)	101	http://www.bilbao.eus/cs/Satellite?c=BIO_Servicio_FA&cid=3007556277&language=es&pageid=3000094370&pagename=Bilbaonet%2FBIO_Servicio_FA%2FBIO_Servicio&anclaServ=aB8&rutaCatServ=3003445085
	Cordoba	Sadeco	102	http://www.sadeco.es/es/recogida-residuos-solidos-urbanos/recogida-selectiva
	Girona	Girona + neta (2017)	103	http://www2.girona.cat/ca/gironaneta_recollida
	Granada	Ayuntamiento de Granad (2017)a	104	http://www.granada.org/inet/wambiente.nsf/ed3681c6eeb6c78cc125788c002d33f7/8584ac45488e3072c1257665003dcd2e!OpenDocument
	La Coruna	Concello da Coruna (2017)	105	http://www.coruna.gal/medioambiente/es/sectores-ambientales/residuos/separacion-en-origen
	Lleida		106	http://urbanisme.paeria.cat/sostenibilitat/residus-i-neteja-viaria/que-pots-fer-amb/informes-recollida-de-residus-de-lleida
	Madrid	Collection managed by the city treatment of Madrid metropolis (2017)	107	https://sede.madrid.es/portal/site/tramites/menuitem.1f3361415fda829be152e15284f1a5a0/?vgnextoid=b2519374bcaed010VgnVCM1000000b205a0aRCRD&vgnextchannel=3476fbff20758310VgnVCM2000000c205a0aRCRD
	Malaga	Limasa (2016)	108	http://www.limasa3.es/recogida/recogida-selectiva-de-envases
	Murcia	Murcia (2017)	109	https://www.murcia.es/medio-ambiente/medio-ambiente/recursos/reciclaje.asp
	Oviedo	Oviedo (2017)	110	http://www.oviedo.es/documents/12103/03a58d8b-17ea-4dc1-8728-8ca1699f7bde
	Pamplona	Pamplona Council (2016)	111	http://www.noticiasdenavarra.com/2016/07/08/vecinos/sakana-leizaldea/acuerdo-para-el-5-contenedor-en-altsasu
	Palma de Mallorca	Waste Management from Palma de Mallorca Council (2017)	112	http://www.conselldemallorca.net/?&id_parent=11311&id_class=13170&id_section=12870&id_son=12873
	Seville	Lipasam (2016)	113	http://www.lipasam.es/index.php?id=93
	Salamanca	Salamanca (2017)	114	http://www.medioambiente.aytosalamanca.es/es/consejosdereciclaje/
	San Sebastian	San Sebastian Council (2016)	115	http://jokogarbia.donostia.eus/contenedor-marron.htm
	Tarragona		116	https://www.tarragona.cat/neteja/gestio-de-residus-i-deixalleries/residus-municipals
	Toledo	Toledo (2017)	117	http://www.cosmatoledo.es/servicios/recogida-selectiva-de-residuos
	Valencia	Entidad metropolitana para el tratamiento de residuos - EMTRE (Collection managed by the city treatment of Barcelona metropolis)(2016)	118	Mediante Decreto 81/2013. Plan Integral de Residuos de la Comunitat Valenciana: Medida 9.2 and 9.5 // http://www.sag.es/documentos/2013_6658-1.pdf
			119	http://www.agroambient.gva.es/documents/20550103/91057977/MANUAL_BBPP/f6b32ce9-bb64-4c59-ad14-e9092b5f3239

	Valladolid	Municipal service of waste collection by the city of Valladolid (2017)	120	http://www.valladolid.es/es/ayuntamiento/cartas-servicios/servicio-limpieza
	Vitoria	Vitoria-Gasteiz Council (2016)	121	http://www.vitoria-gasteiz.org/we001/was/we001Action.do?idioma=es&aplicacion=wb021&tabla=contenido&uid=u_21c818d6_136be8ca538__7fd2
	Zaragoza	Zaragoza (2016)	122	http://www.zaragoza.es/ciudad/limpia/recogida/papel.htm
	Santa Cruz de Tenerife	Ecatar Canarias, S.L. (2017)	123	http://www.ecatar.es/

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