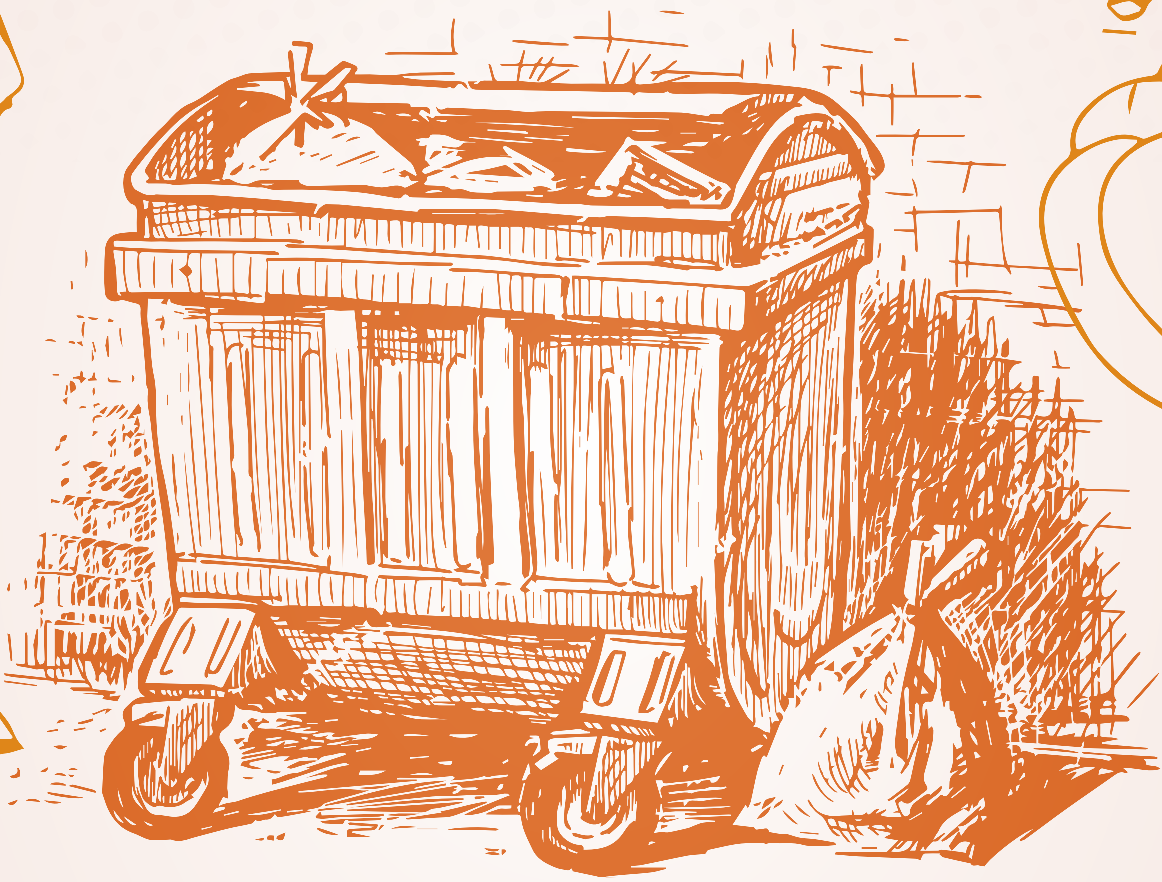

EFFICIENT TREATMENT OF FOOD WASTE

#REDUCEFOODWASTE

Guideline for Waste Management Sector

2019

Interreg CENTRAL EUROPE

European Union European Regional Development Fund

STREFOWA

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TAKING **COOPERATION** FORWARD

ABOUT THE PROJECT

Strategies to Reduce and Manage Food Waste in Central Europe is a three-year project in Central Europe to find and design new ideas dealing with food waste. Our aim is to reduce food waste or to treat it in a better, more useful way, along the whole supply chain.

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FOREWORD

According to the Food and Agriculture Organization of the United Nations (FAO), about one-third of all food produced worldwide is lost or wasted; the production of this amount of food generates about 8 % of global greenhouse gas emissions [1].

Food waste is a very important theme for the European Union's policies as it affects many different sectors from an environmental, ethical and economic point of view. In this regard, Vytenis Andriukaitis, European Commissioner for Health & Food Safety, in the message[2] sent to the final FUSIONS European Platform Meeting “No more food to waste”, said:

“For me food waste is the most repulsive side of the consumerism, consumerism that is strongly rooted in our society and this is why fighting food waste requires a thorough rethink on how we produce, market and consume food at each step as a food supply chain. It requires concrete actions on the ground by all players” (© European Union, 2018).

Food waste is food that is lost or wasted along the entire food chain, and therefore involves farmers, the transport sector, food manufacturers and processors, operators in the hospitality sector, retailers and consumers.

Each sector interacts in many ways with other sectors that is why some food that cannot be used in one sector could be used in another one.

In addition to the prevention of food waste, another very important aspect is the quality of this kind of waste in terms of the degree of contamination by, e.g. packaging materials.

“Organic waste management is a very important theme: poor quality collection leads to high management costs as well as higher environmental impacts. Composting plants only accept organic waste with a low percentage of impurities. A significant presence of the latter implies, therefore, the disposal of organic waste in other types of plants, such as waste-to-energy plants and landfills, and, consequently, a quantity of CO^2 emissions up to 10 times greater. The Emilia-Romagna region is promoting the correct waste sorting, including organic waste, not only through training and awareness raising, but also through the introduction of punctual pricing, which in fact encourages citizens to a better and more careful waste sorting. It is important for citizens to understand that with a very simple gesture, such as sorting organic waste well, they can help to reduce emissions of greenhouse gases and thus help to tackle climate change.” – Patrizia Bianconi, Emilia Romagna Region (Italy).

1 http://europa.eu/rapid/press-release_MEMO-16-3989_en.htm

2 http://ec.europa.eu/avservices/play.cfm?sitelang=en&ref=I120617&starttime=0&endtime=0&autoStart=false&videolang=EN

CONTENT

ABOUT THIS GUIDELINE

The lifecycle of food ideally follows a continuous circle. Food gets produced, harvested, processed, marketed, distributed, purchased, consumed and managed as waste. This entire lifecycle is also called the food supply chain, with each step in the chain represented by a separate sector: primary production, food processing & marketing, retail, food service, consumers and waste management.

Figure 1: Food Supply Chain

Along the entire food supply chain – in each step and each sector – food is wasted, e.g. on the field during harvest, broken or spilled in the processing, left over in retail and food service and not consumed by final consumers. Food waste is therefore not a problem of one single sector; it is rather the cumulative effect of interlinked conditions. As the sectors often work hand in hand and interact in many ways there is a high potential to tackle the problem of food waste. Solutions encompassing several sectors or even across the entire food supply chain should be considered. Food, which might not be able to be used in one sector, could be an interesting resource for another one. This cross-sectoral cooperation is a core aspect of this guideline.

THIS GUIDELINE AIMS

to provide a compilation of information and a comprehensive tool with regard to collection and treatment of food waste. Furthermore, this guideline aims to highlight problems and explain reasons why food waste is generated along all sectors of the food supply chain, as well as to describe possible treatment options.

This publication dedicated to personnel in the Waste Management Sector aims to provide a compilation of information and a comprehensive tool with regard to collection and treatment of food waste. Furthermore, this guideline aims to highlight problems and explain reasons why food waste is generated along all sectors of the food supply chain, as well as to describe possible treatment options.

All of the actors of the food supply chain are included in the target group. Food waste is generated, e.g. by farmers, food manufacturers and processors, operators in the hospitality sector, retailers and consumers.

Actors involved in managing food waste consist of environmental managers in the retail and food service sectors, the concerned public but also policy makers. To these should also be added those directly occupied with food waste treatment, like waste management authorities and companies (public authorities, waste management companies, waste consultants, collectors, biogas plants, composting plants, municipalities, associations, etc.).

BENEFITS

- Climate protection
- Extending the lifetime of landfills
- Renewable energy production
- Nutrient-rich soil created in the compost process
- Resource optimisation for material and energy production
- Convenient and cost efficient collection and treatment of food waste?
- Fulfilment of legal requirements

ABOUT FOOD WASTE

WHAT IS FOOD WASTE?

Food is defined as any substance – whether processed, semi-processed, or raw – that is intended for human consumption including any substances that have been used in the manufacture, preparation, or treatment of food, excluding drinks.

Inedible parts = unavoidable food waste: refers to components associated with a food that in a particular food supply chain are not intended to be consumed by humans. This is food thrown away that has not been edible under normal circumstances for most of the inhabitants. Examples could include bones, rinds, or pits/stones. On the contrary, avoidable food waste comes from originally edible parts.

Food waste (including food loss) refers to food, as well as associated inedible parts, removed from the food supply chain. That means they are not used for normal human consumption.

Inedible parts (Bones, skins…)	**Non-avoidable**
Preparation residues (skins, …)	**Non-avoidable**
Consumption residues	**Avoidable**
Partially consumed food	**Avoidable**
Entirely uneaten food (as purchased, whole, unopened)	**Avoidable**

WHERE DOES THE FOOD WASTE OCCUR?

Food waste occurs along the entire supply chain; wherever food is produced, processed, traded or used.

WHAT AMOUNTS ARE WE SPEAKING ABOUT?

Exact amounts of food waste are not known, as reliable data is scarce, due to data collection difficulties. Estimates range from 20–30 % loss of our total food production. Some countries waste up to about 50 % of the food production. Despite the inconsistent data situation, food waste is present in all areas of the food supply chain, with visible impacts.

WHAT ARE THE CONSEQUENCES OF FOOD WASTE?

Food waste accounts for 3.3 gigatons of CO^2 emissions (cf. FAO, 2011). Huge quantities of water in production and processing are wasted on unconsumed food; moreover, food production uses large areas of agricultural land. Consequently, this causes negative impacts on biodiversity, soil, ground water and much more. From an economic point of view, both the direct and indirect costs of discarded food must be considered, e.g. caused by superfluous transport, infrastructure etc.

WHAT IS BEING DONE ABOUT IT?

Every nation has individual legal acts which directly or indirectly interfere with the food waste issue, such as hygiene guidelines or packaging standards. In addition, public and private food waste prevention and management activities aim for reducing food waste via practical implementations or education, covering different areas, target groups or food types.

Despite these efforts, the food waste problem still exists, and further steps need to be taken – in all sectors. In a first step, the problem needs to be considered in detail and ideas and approaches have to be developed.

Individuals as well as groups can become active in their working environment and their communities. This guideline does not represent a general viewpoint but addresses parts of the supply chain to highlight practical approaches.

ORIGIN AND COLLECTION IN DIFFERENT SECTORS

PRIMARY PRODUCTION

Origin of food waste and problems

Quantifying the exact amount of discarded food originating from primary production is not possible based on currently available data. Recent assumptions range from 25 % to 30 % of the total food production (FAO, 2013) or from 10 % to 50 % of the production of one specific food item (Mutter Erde, 2017). A significant part of this so called "waste" is of good quality and appropriate for human consumption.

According to interviews with farmers and current literature (Pladerer et al. 2016; Leibetseder 2012), there are several reasons why vegetables and fruits are being discarded and thus labelled as waste:

- Mechanical losses: food losses during harvest and processing due to inadequate and/or lacking harvesting technologies
- Handling losses: damages occurring during washing and packaging
- Logistic losses: damaging due to inadequate transportation and storage of large amounts of non-storable crops
- Selection losses:
  - Regulated quality criteria for marketing and hygienic standards are not met by the product, e.g. size, shape, other quality standards, infected by disease or pest, mechanical damage, etc.
  - Non-regulated appearance of crop is not met, which is defined by individual marketing channels, e.g. colour, shape, etc.
- Losses due to market situations:
  - Surplus crops due to unpredictability
  - no marketing possibilities due to market saturation
  - deliberate overproduction, to compensate losses and to guarantee a certain quantity for delivery
  - not harvested or infrequently harvested because of economic unprofitability
  - overproduction due to favourable weather conditions

The discarded crops have different levels of quality, including class I and class II crops, crops not meeting marketing standards because of size, shape or colour, and crops affected by pests or diseases. On farm level, the amounts of discarded crops vary considerably and can range from "hardly any" to almost 100 % of the crop. Predominant cause for this variability is the unpredictability of the surplus crops, influenced by variables only partially controllable, such as adverse or favourable weather conditions, outbreaks of pests and diseases, market constraints, etc.

Together with the discarded food, a number of resources, like energy, fertilizers, labour and land, are either not used efficiently or are completely wasted. Besides large quantities of discarded crops left on the fields can have negative effects on crop production in the following year (Fig. 2). This can be caused, for example, by adverse and hard to predict fertilizing effects, or by pests and diseases originating from the leftover crops.

Figure 2: Figure 2: Mounds of discarded vegetables from primary production © TT (reader)

Collection and Transport Systems

No specific regulations or standardized systems exist for the transport of discarded vegetables and fruits from their point of origin to the treatment facilities. Containers can have any kind of shape or size and can be made from wood, plastic, metal, etc., whichever is most efficient for the collector in order to transport the food wastes to the site of further processing (e.g. compost or biogas plant).

RETAIL

Origin of food waste and related problems

Despite the fact that actual data might be described as contradictory, food waste is present in all areas of the food supply chain, with visible impacts. According to FUSIONS (2016) approx. 88 million tonnes of food are wasted annually. The resulting financial losses are estimated to amount to almost 143 billion euros. The retail sector is responsible for approx. 5 % of the total amount of food waste in the EU (Fig 3). However, the responsibility of the retail sector for the generation of food waste is more substantial than its own food waste rate shows, since it also indirectly affects the increase or decrease of food waste amounts in other sectors.

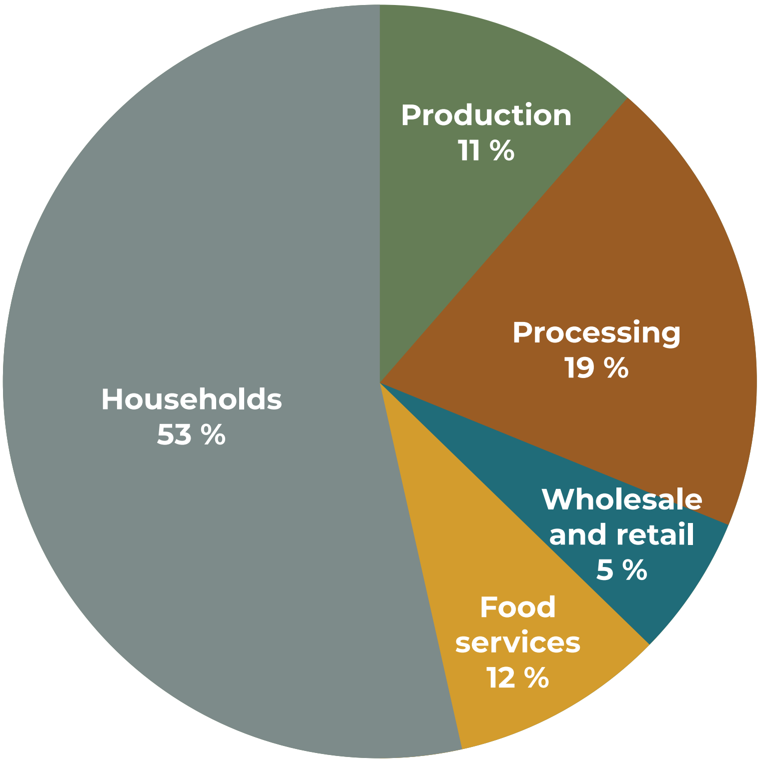


Figure 3: Shares of EU-28 food waste in 2012 by sector; includes food and inedible parts associated with food (FAO, 2011)

TESCO HUNGARY (Fig.4) presented the composition of food waste generated in their stores in 2016/2017, showing the shares of food wastes that remained after the donated part (concerning donation for humans and animals) had been excluded. [3] [3]

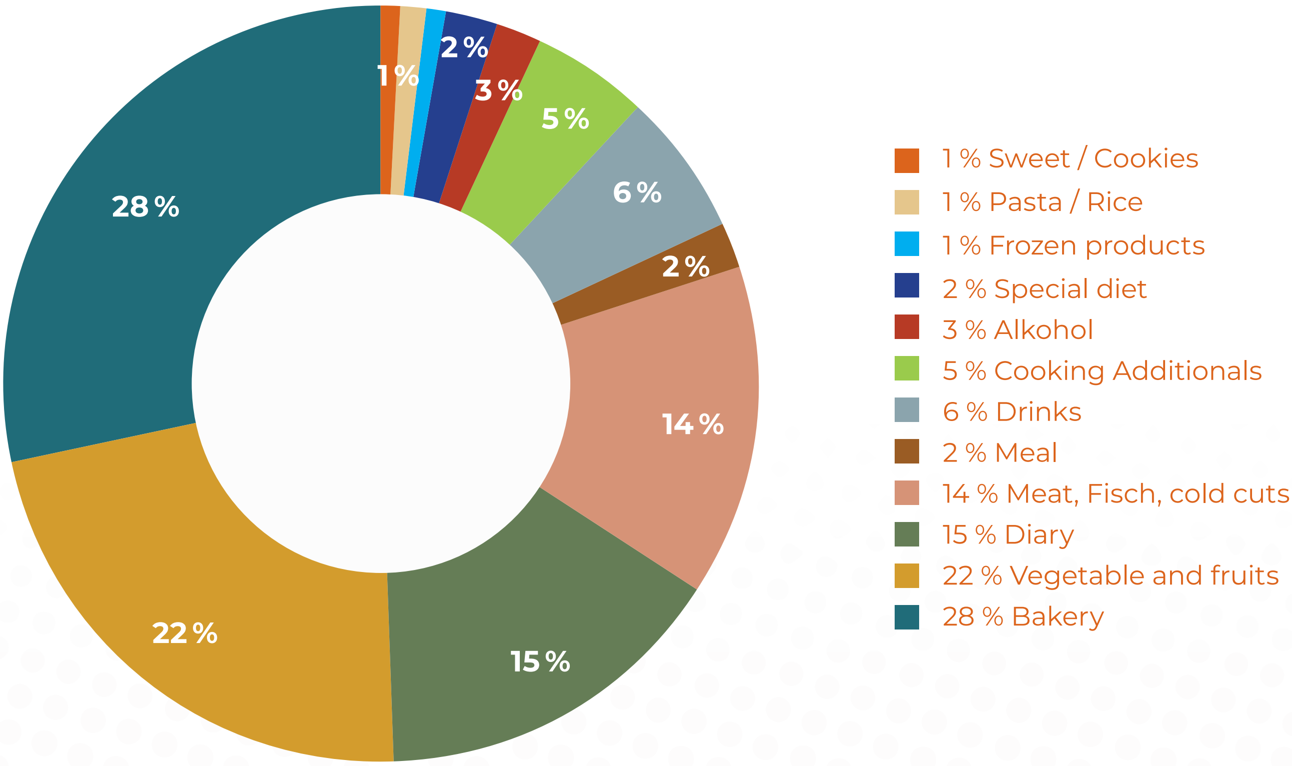


Figure 4: The shares of food wastes generated in the stores of TESCO HUNGARY in 2016/2017

The largest shares of the food wastes consisted of bakery products (25 %), fruits & vegetables (20 %), dairy products (13 %) and meat-fish-cold cuts (12 %).

3 http://www.dontwasteit.hu/2017/09/22/kozzetette-elso-elelmiszer-hulladek-jelenteset-a-tesco

Collection systems

Selective collection is one of the most important measures when there is no possibility to use the surplus for human consumption.

The Revised EU Waste Legislation from May 2018, appeals to the member countries to adopt measures to monitor food wastes and reduce their generation at all stages of the food supply chain. A measure can consist of, e.g. the fee for food waste disposal, which is rising year by year, motivating the actors of the retail sector to avoid the disposal of such wastes. The proper separation of food wastes (not mixed with packaging waste such as plastics, wood) has to start at the stores in order to promote a well-established selective collection system. It is necessary to instruct the staff accordingly, implement constant measuring schemes of the different waste fractions and update the database regularly with the amounts and types of food waste, also including the destinations (animal farm, biogas facility, compost plant, landfill or other) for these amounts and types of food wastes.

In retail the most commonly used collection systems are bins in different size (120, 240 or 1,100 litres) or new approaches tested currently in Austria so called tank-connected collection systems. This system consists of a unit, in which organic waste is crushed and mixed with added water, and a storage tank, where the produced biomass slurry is stored.

FOOD SERVICE

Origin of food wastes and related problems

According to the European Environment Agency and National waste management directory, the restaurant- and catering sector is responsible for 14 % of the total amount of food wastes.

Wastes in the food service sector mainly result from the surplus of servings or prepared food, food purchased in excess and the inability to consume it before the expiration date, the difficulty of correctly interpreting the indications provided on the labels, and faulty preservation of food.

To these causes must also be added:

- the difficult planning of food purchases, which is even more complicated in buffet services (which usually involves preparing more food than needed);
- the low prevalence of practices that allow customers to take home the "leftovers" of their meals (Barilla CFN, 2012).

Many studies in this field have been carried out in the UK by the Waste and Resources Action Programme (WRAP), an organisation set up to promote sustainable waste management. Almost 18 % of food purchased in the hospitality and food service sector in the UK is thrown away. Of all this food, 75 % could have been eaten (Fig. 5)

Figure 5: Foggod purchased in the food service sector (WRAP, 2013)

On average, 21 % of catering and restaurant food waste arises from spoilage (food that has to be thrown away due to the use by date being exceeded or it being damaged); 45 % from food preparation (inefficient practices or cooking mistakes) and 34 % from consumer plates (too much food or some other issues with the food) (Fig.6). These ratios are general estimates from hospitality and food service research in the UK. They can vary according to different kitchen operations and how much food is brought in pre-production. WRAP estimates that each meal (in the service sector, including preparation and consumption phases) generates, on average, about 220 grams of organic waste (WRAP, 2013).

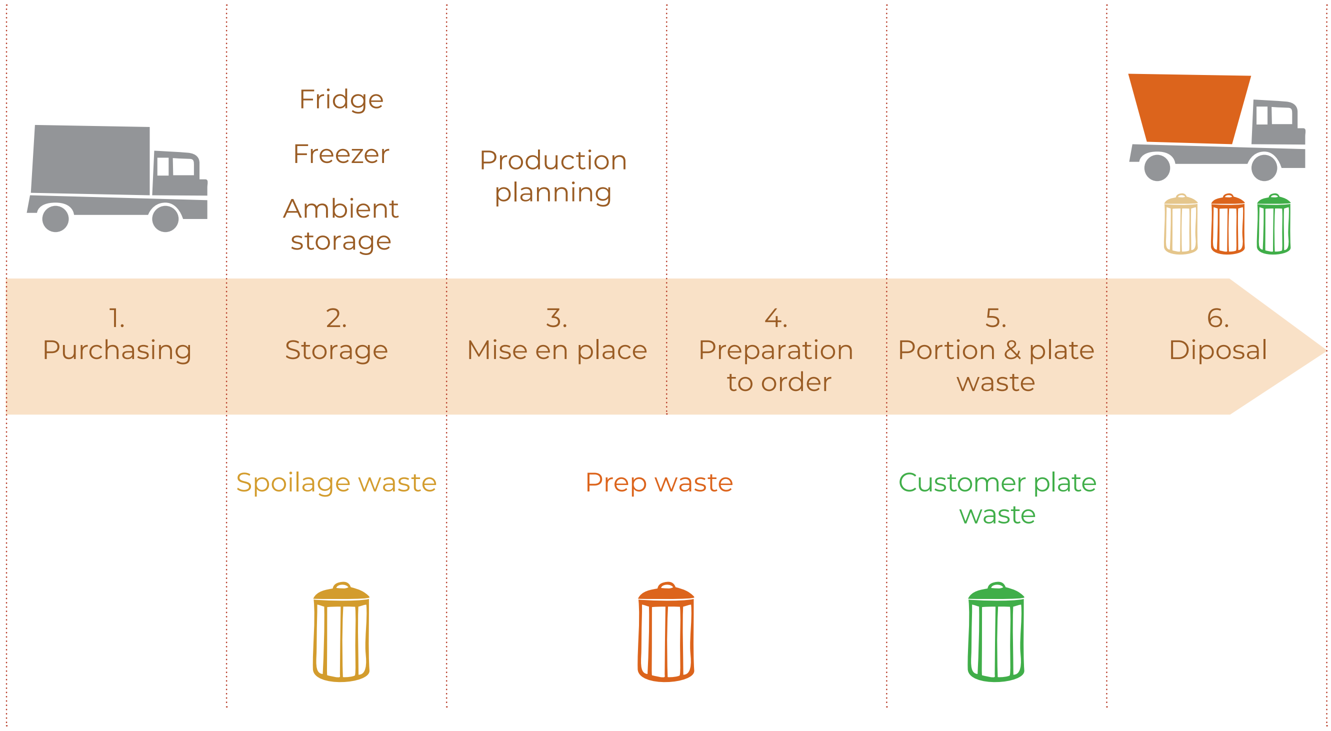


Figure 6: Origins of food waste in the food service sector (WRAP, 2013)

Collection systems

Hotels and businesses usually receive specific containers for paper/cardboard, glass, organic and for the collection of undifferentiated waste, according to the needs and type of waste produced in that kind of business. These bins usually are conceded to commercial activities free of charge by the authorities or companies responsible for waste collection and disposal, depending on country laws and/or programme agreements with local and regional authorities.

Food waste collection systems in hotels and restaurants generally consist of one or two bins in the kitchens, in compliance with health and hygiene standards. One of these bins is placed near the chef's workstation in order to collect waste from the preparation stage. The second collection point is located in the area where the dishes are washed and is used by kitchen staff to dispose of waste left on the dishes by customers. The contents of these bins are poured into a larger container stored on the hotel or business property, and are easily accessible for the waste collection trucks (usually at the back of the restaurant). Generally, the cleaning of containers is a responsibility of hoteliers and dealers, while their maintenance is a responsibility of the waste collection and disposal company.

The bins are emptied according to a predetermined timetable set by the municipality and, in particular, organic waste is generally collected between 3 and 7 times a week depending on localization and season. The frequencies are scheduled in order to avoid problems related to high temperatures that, by speeding up the decomposition of waste, cause bad odours.

Origin of food waste and related problems

Bio-waste is the largest fraction of municipal waste in terms of generation. However, in most countries the collection level is relatively low, lower than the level for dry recyclables. In a number of countries, food waste is most often collected mixed with residual or mixed waste. In other countries however, municipalities and their inhabitants are obliged to separately collect bio-waste, including food waste. Fig.7 shows the development of bio-waste collection in European countries over a decade.

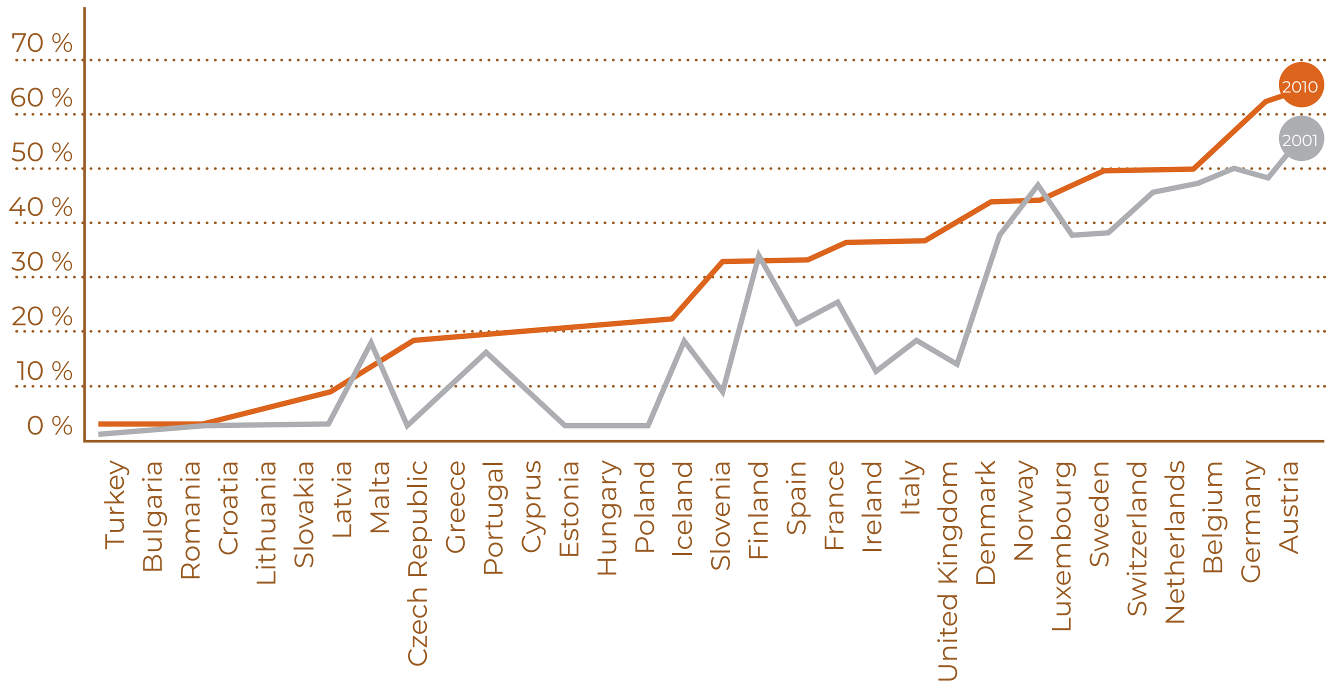


Fig.7: Bio-waste recycling as a percentage of municipal waste generation in 32 European countries (adapted from EEA 2013)

Article 22(a) of the Waste Framework Directive only requires measures to encourage the separate collection of bio-waste, with a view to composting and digestion, by the Member States (contrary to the separate collection of dry recyclables, which is mandatory). Bio-waste (in all cases including food and kitchen waste) is collected separately door-to-door in 14 Member States (AT, BE, CZ, DE, FI, EE, IT, HU, LU, NL, SI, SE, IE, UK) in 2015 (BiPRO/CRI 2015). Fig.7 shows that those countries with a nationwide separate bio-waste collection scheme have the highest bio-waste recycling rates. Furthermore, twelve member states so far do not collect bio-waste separately. Most of these countries are Central European (BG, CY, ES, FR, EL, HR, LT, LV, PL, PT, SK and SI). They have so far only implemented pilot studies on separate bio-waste collection or/and collect bio-waste (i.e. garden waste) in civic amenity sites.

In BiPRO/CRI (2015), the separate collection schemes in European capitals are assessed. The main results for bio-waste in Central Europe are summarised in Table 1.

In most cases, the national reuse and recycling rate surpasses the separate collection rate of the country's capital. In large cities, due to the higher share of high rise buildings, the collection rate is generally lower than in the country-side and in smaller towns. In Ljubljana however, the results in the capital are better than the overall country values. Ljubljana also shows that it is even possible to capture over 70 % of the bio-wastes generated at households. Also Rome and Vienna show that in large cities, over one third of the bio-waste can be collected separately. However, in other cities the bio-waste collection system is not optimised yet.

City	MSW generation kg/cap.	% of separate collection (all systems)	Bio-waste capture rate	Bio-waste collection kg/cap	NATIONAL MSW reuse and recycling rate in %
Berlin	394,7	27,4 %	15,7 %	21,7	64,5 %
Bratislava	338,3	14,2 %	3,4 %	4,3	13,0 %
Bucharest	391,3	2,9 %	0 %	0,0	2,6 %
Budapest	424,2	7,6 %	10,7 %	12,4	25,4 %
Ljubljana	318,2	55,4 %	72,5 %	76,5	39,5 %
Prague	322,5	14,4 %	12,9 %	3,6	23,1 %
Rome	612,9	16,3 %	32,0 %	49,0	38,2 %
Sofia	348,3	4,0 %	8,8 %	10,5	25,2 %
Vienna	556,7	29,2 %	34,1 %	60,6	59,2 %
Warsaw	370,3	4,5 %	7,5 %	8,9	19,4 %
Zagreb	449,1	1,0 %	0,2 %	0,3	14,6 %
Average EU28	446,7	19,0 %	15,6 %	19,6	32,0 %

Overall, as estimated within the Fusions project (...), over 90 kg of food wastes per inhabitant was generated in European households in 2012. In Fig.8, the different types of waste destinations are shown.

The main way of discarding food waste is the municipal collection system for solid waste, either by

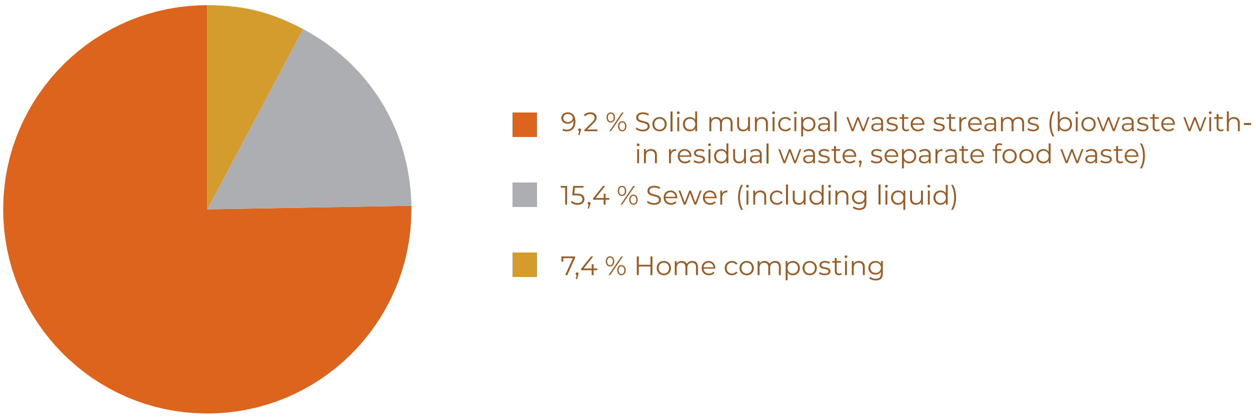


Figure 8: Principal destinations of food wastes generated by EU households in 2012 (kg/inh.yr) (adapted from Stenmarck et al. 2016)

specific food waste collection schemes, bio-waste collection or remaining within the residual waste. The sewer and home composting together make up for about a quarter of the food waste generated.

The main reasons for wastage of food in households are (Monier et al., 2010):

- Having bought too much
- Bad storage
- Confusion over labels (e.g. best before date)
- Discarding parts of food that are thought to be inedible (bread crusts, apple peels)

4 Based on national waste composition

- Preparation of too big portions
- Discarding of leftovers

According to consumer tests performed in Poland, the main reason for food wastage is forgetting about the expiration date, although this cause is continuously decreasing from over 50 % in 2012 to 29 % in 2018. The second most important reason is buying too much (20 % in 2018), followed by bad quality goods and too large portions (both 15 %) as well as bad storage (13 %) and lack of ideas to use ingredients for other dishes (5 %).

Collection systems

In the planning of a waste management system, the choice of a certain set of treatment facilities determines the design of the temporary storage system. The design of the temporary storage system on the other hand influences the performance of the separate collection of selected waste streams, and with these, the design capacities and input qualities of the treatment facilities.

A well designed collection system should be:

- easy to use, both for the inhabitants and the collection workers. The effort to start and continue separating bio-waste should be kept at a minimum. The available volume for disposal and the collection frequency should be fitted to the expected amounts generated. Apart from temporary storage outside, from which the bio-waste is collected, inside small kitchen bins, eventually in combination with (biodegradable) plastic or paper bags can be provided. Walking distance should be limited, ideally not exceeding the one for residual waste.
- reliable and flexible. Non-compliance with the schedule has a negative influence on the participation and recognition rate. The opportunity for the inhabitants to use the collection system should be guaranteed at all times. At the same time, the system should be flexible to changes in circumstances. Amounts to be collected may rise, resulting in increases of collection frequency or bin volume. Also the system should be open to inhabitant demands, e.g. increasing frequencies in hot periods or additional bin washing services to combat odour problems.
- ommunicative. The communication should inform and motivate. Information should be provided about the system infrastructure, sorting rules, collection times but as well about the results of the system and treatment options. Apart from knowledge transfer the inhabitants should be motivated to participate in the system and properly segregate waste. Also feedback from the inhabitants to the municipality should be enabled.

Solutions in food waste collection

Bio-waste or food waste

The most common collection systems are those where food or kitchen wastes are collected together with garden or green wastes. In practice, in high-rise areas the kitchen waste amounts usually are predominant, whereas in one family housing areas, the share of garden wastes will be higher. The collected waste generally is treated in an anaerobic digester producing biogas. In most cases however, there is a joint scheme of food waste collection from gastronomy and households in city centres.

For composting, the addition of garden waste to kitchen waste adds more structure to the substrate, enabling better aeration. In anaerobic digestion, garden waste components can be processed as well, however, the woody parts are not suitable for digestion and should be taken out.

Door-to-door vs. bring system

In general, door-to-door systems lead to higher collection rates than bring systems (BiPRO/CRI 2015). This is also true for bio-waste collection. Bring systems (public containers) cause the citizens to have to transport their bio-wastes to the containers, which, due to the physical properties of these wastes, is far less practical than in case of dry recyclables, e.g. paper or glass.

The frequency of a door-to-door (or kerbside) system should be well chosen. Based on the expected amounts and in order to limit nuisance caused by the biological activity of the bio-wastes (odours, flies), the frequency should generally not be below once per fortnight. In BiPRO/CRI (2015) frequencies varying from once per two weeks in Northern European countries to three times per week or even daily in Southern Europe. In order to not increase the perceived odour problems, it is advisable to introduce a collection frequency that is not lower than the frequency for residual waste.

A door-to-door system implies that, at the waste generator's premises, an additional container has to be located. If the space for additional containers is limited, a dual container system could be considered (Fig.9). Such containers are divided in two parts and can contain two fractions of waste, the most typical combination being residual waste and bio-waste. Along with the containers, adapted collection vehicles are necessary.

Figure 9: Dual waste containers (horizontal system) and collection vehicles

(vertical system) (nvrd.nl, WRAP 2008)

Biodegradable bags

To enhance the participation in the bio-waste collection scheme, the citizens can be provided with kitchen bins (approx. 10 l) or biodegradable bags. Biodegradable bags help to keep the kitchen bins clean and prevent leaching, increasing the appeal to participate in the scheme. However, biodegradable bags are costly, causing either lasting costs for the municipality in case they will be provided to the citizens on a permanent basis. Otherwise the costs will be left to citizens, which might lead to sinking participation rates. Also, the citizens might resort to common non-biodegradable plastic bags, due to the apparent similarity of the material, polluting the collected biogenic wastes by bags. In long existing systems as for instance in The Netherlands, it is common practice to put an old newspaper into the kitchen bin. This practical solution is working well, but may be more difficult to communicate in newly introduced separate bio-waste collection schemes.

Although these bags comply with the European norms, in some composting plants with short composting periods, the bags do not decompose properly. On the one hand, this can result in mechanical issues, like clogging of screens and wrapping around revolving parts. On the other hand, not degraded fragments compromise the compost quality. Therefore, the introduction of biodegradable bags should be consulted with the intended treatment facility.

Home composting

All wastes not entering the municipal system leads to avoidance of costs for collection and treatment. Financially, home composting (or backyard composting) is interesting for municipalities. If home composting is stimulated, citizens should be provided with information on how to do proper home composting. Due to the small, non-controlled scale, home composting, when not done properly, may result in higher emissions and lower compost quality. District composting, which also has an important social function, is not permitted everywhere.

It can be argued that home composting is a form of waste prevention, as the wastes do not enter the formal system. However, home composting is hard to quantify. In order to meet their recycling targets, it may be essential for municipalities to include the amounts of home composted bio-wastes in their yearly balances. Therefore, prior to home composting promotion, it is advisable to implement a monitoring system for the home-composted amounts.

Communication

Communication is a key factor in the introduction of a new bio-waste collection scheme. Information should be provided about the system infrastructure, sorting rules, collection times but also about the results of the system and treatment options. Apart from knowledge transfer, the inhabitants should be motivated to participate in the system and properly segregate waste. Also feedback from the inhabitants to the municipality should be enabled. Participation of inhabitants in shaping and planning of the new scheme will enhance its acceptance.

In communication it is important to consider the following themes:

- Goal: what do we want to achieve by the communication?
- Target: who is the target of the communication? General public, children, garden owners etc.
- Medium: how will the message be transferred to the receiver? Letters, flyers, newspaper articles, TV, Radio, Social media, Websites, Apps etc.
- Message: what would we like to communicate? Depends on the targeted population and the chosen media.

A good means of communication is a starter kit, existing of a kitchen bin, a set of biodegradable bags and an information flyer, containing a waste collection calendar. Children are future waste segregators and have a large impact on the behaviour of their parents, so they are also important targets for communication.

Planning

Proper planning is the key for a successful implementation of any bio-waste collection system. Apart from the timely acquisition of the needed bins and vehicles (or the tendering thereof), the distribution of bins and bags should be planned, requiring an inventory of all of the target addresses, which can prove to be difficult in certain regions. Moreover, an essential part of the planning is the prediction of the amounts that will be collected in the future. A very helpful tool is the conduction of waste composition analyses, which provide the necessary data on which the calculations of the expected waste amounts can be based on. Conducted properly and in regular intervals (once per month, once per season) in the year prior to the planned introduction, the amounts and types of generated wastes can be determined with a reasonable degree of accuracy (Langner et al., 1998). Considering the achieved results in Central European capitals, a maximum capture rate of about one third of the generated amounts should be considered for Central European cities (BiPRO/CRI 2015).

To gain experience it is advisable to start with a pilot project.

How to improve the collection results of an existing scheme

A continuous communication focussing on the achieved results and further motivation of participants is essential to keep up and increase the achieved collection levels. Prizes for good separation behaviour and an aspect of competition (between districts, flats, and streets) may curb encourage the enthusiasm of participants. During the year, a continuous communication could focus on monthly themes regarding waste segregation and recycling.

Benchmarking

A good way for improvement is to learn from the best. By benchmarking, separate collection results of various municipalities as well as influencing factors can be compared. Thus, good practices can be properly identified. Costs and effects of various options (collection frequency, bin sizes, collection systems, waste taxation system, communication intensity etc.) can be compared, and the optimal system for the considered municipality identified. According to regular benchmarking in The Netherlands, the results for bio-waste collection are by a factor 4 higher for rural municipalities (up to 20 % high-rises) than for municipalities with high shares (over 50 %) of high-rise areas (Rijkswaterstaat, 2016).

Pay-as-you-throw

Applying Pay-as-you-throw (PAYT) in a waste management system means that households are charged according to the amount of waste they generate. In practice, this is facilitated through an interplay of the three principal components (BiPRO/CRI 2015, Reichenbach 2008):

a) Identification of the waste generator

b) 'Measurement' of the generated waste

c) 'Unit pricing' as the means to convert the individual contribution into a corresponding charge

„Such forms of direct unit pricing realised for the different types of generated waste work as a financial incentive to minimise overall waste production and divert an increased portion of recyclable materials away from the conventional routes for waste disposal. PAYT (…) implies that this strategy is first of all meant to increase the economic pressure especially on the part of those households whose waste generation and disposal behaviour generate the largest impact to society and the environment. The first and foremost observed effect following the adoption of PAYT is an increase of recycling activity, ideally coupled with efforts to achieve a reduction in overall waste generation." (Reichenbach 2008, p.2809)

Pay-as-you-throw schemes often include a combination of flat rate fees or taxes (e.g. certain annual amount) and a variable element, which may be linked to container sizes (volume-based schemes), number of sacks (sack-based scheme), frequency of collection (frequency-based scheme) or the weight collected (weight-based scheme) or a combination of these. The balance between the fixed and variable part is important, as it decides about the success of the system in terms of increased waste segregation (and prevention), but also on the abuse of the system (e.g. so-called 'waste tourism', wild dumping, pollution of segregated fractions). The variable fee is paid for residual waste. In general, the collection of recyclables is free. In some cases, however, a fee for bio-waste collection is applied, generally lower than for residual waste collection.

Well introduced and managed PAYT schemes can have significant results in terms of increased separate collection and an overall decrease in waste management costs for the municipality (and con-

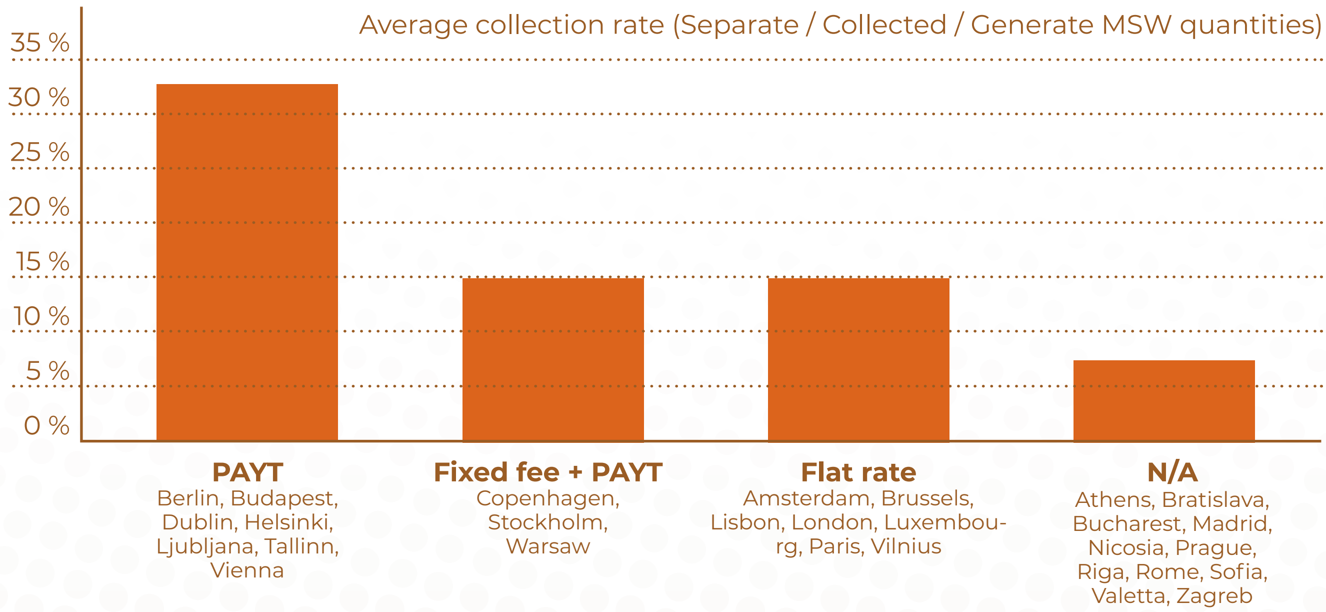


Figure 10: Effects of Pay-as-you-throw schemes on the collection results in European capitals (adapted from BiPRO/CRI 2015)

sequently, for the inhabitants) (Rijkswaterstaat 2016).

As an impression of the effects of PAYT schemes, a comparison of European capitals is presented in Fig. 10.

Reversed collection

Reversed collection ("omgekeerd inzamelen") is a strategy in waste collection introduced in the Netherlands that aims to increase the amounts of separated waste fractions and to decrease residual waste. This is achieved by reversing the conventional collection system. Before the change, parts of the fractions for recycling were collected in a bring system, whereas residual waste was collected door-to-door. The collection frequency for residual waste was the highest. In reversed collection, residual waste is collected in public containers, in a bring system, whereas all recyclable fractions are collected door-to-door. The frequency of the collection of recyclable fractions is increased as well. Therefore, it becomes easier for the inhabitants to dispose of recyclable materials than to dispose of residual waste.

Especially in combination with a Pay-as-you-throw scheme, the reversed collection system leads to significant increases in waste segregation and decreases of residual waste generation. The results of a study show that such a combination led to a significant reduction of the amounts of residual wastes in the tested areas, from 27 % to 31 %, respectively (ROVA, 2013).

TREATMENT OPTIONS

COMPOSTING

Description of the process

Composting is an aerobic process in which organic matter is decomposed by microorganisms. Organic carbon is a predominant element of all organic substances contained in bio-waste and is used by microorganisms as an energy source in the respiration process.

Organic substance + O_2 + biogenic substance =

biomass + undegraded organic substance + CO_2 + H_2O + NH_3 + SO_4^{2-}

+ heat energy

The general equation of the composting process can be summarized as follows:

The biogenic substances are nitrogen, phosphorous, potassium and additional substances necessary for bacterial growth. Undegraded organic substances consist of humic matter (i.e. organic substances which are in a relatively stable, amorphous state, and organic matter which is slowly biodegradable) as well as intermediate products of the decomposition process, including various volatile organic compounds responsible for odour emissions during the process.

The main factors influencing the kinetics and efficiency of the composting process are:

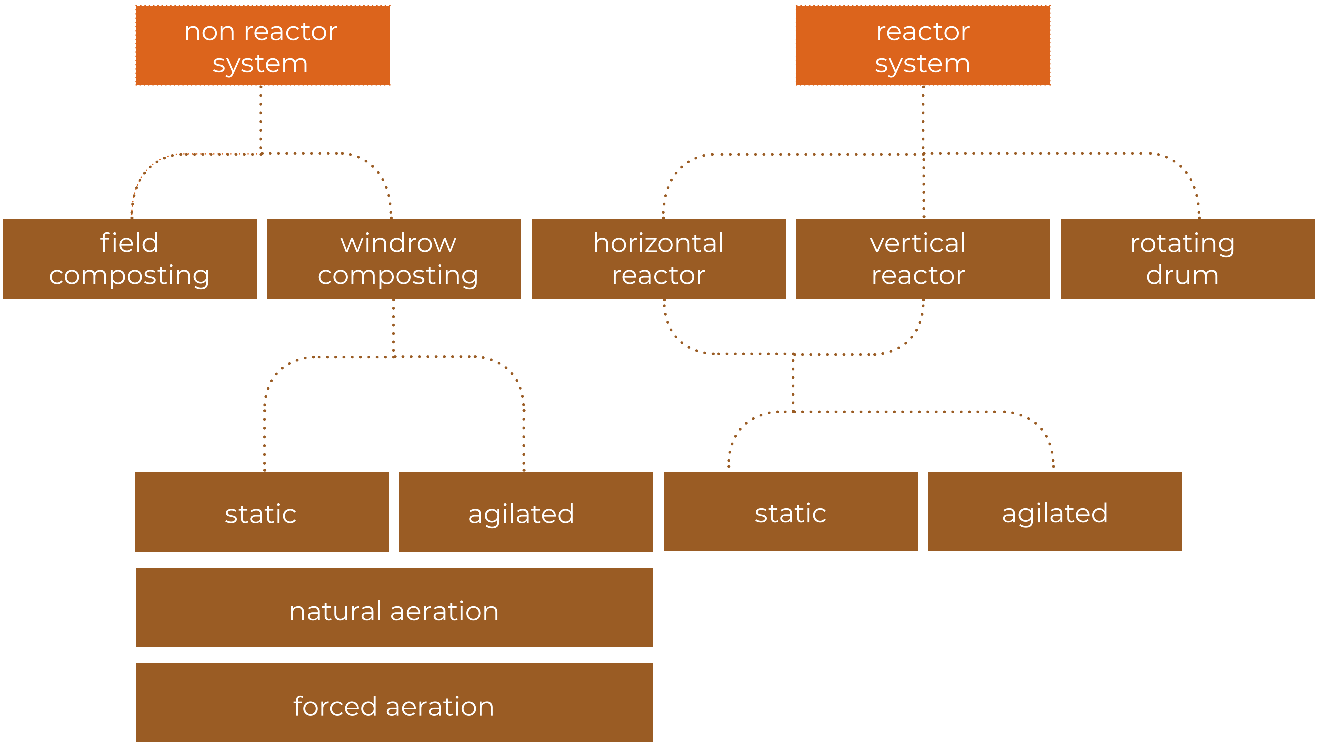
- Composition of the composting mass:
  - biodegradable matter content (the higher the better),
  - moisture content (40–70 %, optimum 50–60 %),
  - availability of biogenic substances: C/N ratio (optimum 20–30), C/P ratio (optimum 100),
  - absence of hazardous substances in input materials (inhibitors)
  - pH (from 4,5 to 9,5 ; optimum 6,5),
- Presence of microorganisms (bacteria and fungi)
- Proper granulometry of waste (particle size 20–40 mm),
- Proper structure of composting mass:
  - free air porosity (> 30 % of porosity) and
  - bulk density (less than 500–600 kg/m^3),
- Effective mixing and aeration,
- Temperature (usually self-induced by microbial activity during composting):
  - optimum 55° C to maximize biodegradation rate and
  - 65° C to maximize hygienization – sanitization, pathogen destruction.

To assure proper composting of food or kitchen wastes, garden wastes or similar material is added to provide structure and assure free air porosity and proper aeration.

Examples from practise

Food waste generated by households can be either collected by the municipal collection system or treated at source in a home composting scheme. A share, especially liquids, will end up in the sewer.

Home composting is sometimes regarded as the environmentally most beneficial way of handling of domestic biodegradable waste as it saves on transport emissions and costs, assures careful input control and increases the environmental awareness of the users. On the other hand, home composting is lacking emission abatement systems, thus generating more emissions of harmful substances per amount of produced compost than controlled composting systems.



In Fig.11, an overview of available industrial composting systems is provided.

The industrial composting process can be subdivided into initial mechanical treatment stages consisting of preparing and conditioning the raw material, followed by the actual composting. To produce a marketable product, it is necessary to convert the compost to an end-product, which involves additional mechanical treatment – conditioning of the composting product.

Mechanical pre-treatment and conditioning

The aim of raw material preparation is to optimize conditions for the subsequent composting process, to remove contaminants in order to protect the technical equipment and to meet quality requirements for the finished compost. The basic steps of raw material preparation are

- shredding (e.g. bulky wood scraps, trees, brush, long grass)
- dewatering of water-rich, structureless wastes (e.g. sludge, restaurant waste)
- addition of water if the wastes are too dry for the composting process,
- mixing of components (e.g. wet and dry wastes, N-rich and C-rich wastes, wastes
- with rough and fine structure)
- manual or automatic separation of impurities (glass, metals, plastics, large stones, etc.).

The actual composting

The actual composting is performed using one of the technologies described in the previous section. The current trend for municipal biodegradable waste composting is the two step technology – intensive composting in an enclosed reactor or in open reactors, but inside a building, and the maturation phase in windrows outdoors on a paved surface, usually covered with a roof.

Mechanical post-treatment and conditioning

The main product of the composting process is compost. Compost may require additional treatment before transport, storage, sale, and application. When post-preparation is needed, the basic steps can be according to (Schuchardt 2005):

- sieving the compost to obtain different fractions for marketing or to remove impurities
- manual or automatic removal of contaminants
- drying wet compost to achieve a granulated, free-flowing and not lumpy product, and drainage of water during storage
- disintegrating lumps in the compost by crushing or grinding to prevent problems that may occur during bagging.
- mixing the compost with additives (soil, mineral fertilizer) to produce potting mixes or gardening soils.

Generated product a nd optimum use

Composts can be used as fertilizers and/or soil conditioners for

- Agriculture – food and non-food crops,
- Landscaping – properties and grounds maintenance
- Nurseries – potted plants, forest seedling crops
- Public agencies – highway landscaping, recreational areas, other public property
- Residences – home landscaping and gardening
- Other – land reclamation and landfill cover

Compost quality requirements depend on its application, but in general the following aspects need to be addressed:

- optimal stability and maturity,
- favorable content of nutrients and organic matter,
- favorable C/N ratio,
- neutral or alkaline pH,
- low content of heavy metals and organic contaminants,
- no components that interfere with plant growth,
- low level of impurities,
- mostly free from germinable seeds and living plant parts,
- low content of stones,
- typical smell of forest soil, and
- dark brown to black color

ANAEROBIC DIGESTION

Description of the process

Anaerobic digestion is a process where microorganisms break down biodegradable (organic) material in an oxygen-free environment. The process occurs naturally in all wet and oxygen-poor environments such as landfills, livestock manure management systems, and rice paddies, but can be contained, controlled, and optimized in anaerobic digesters.

The anaerobic digestion process follows several steps involving different microorganisms, resulting in methane, carbon dioxide, trace amounts of other gases, and stabilized residues, called digestate. Anaerobic digestion processes can be conducted either in continuous or batch systems. While both wet (dry matter content < 12–15 %) and "dry" materials (DM content > 20–30 %) can be used in continuous systems, batch systems require a dry matter content of > 30–40 % of the material.

Some organic wastes are more difficult to break down in anaerobic conditions than others. Food wastes, fats, oils and greases are the organic wastes easiest to break down, while livestock wastes tends to be more difficult, depending on the kind of animals. Mixing multiple wastes in the same digester, referred to as co-digestion, can help increase biogas yields and also lead to a more complete degradation of the materials. Although, in some special cases, thermophilic processes (50 °C – 55 °C) are used, the temperature of most commercial anaerobic digesters is kept in the mesophilic range, typically around 37 °C, which is the optimal temperature for the involved microorganisms to break down the biogenic compounds.

Food Waste as Feedstock for Anaerobic Digestion:

Around 30 percent of the global food supply is lost or wasted each year. In 2012 alone, the EU produced roughly 88 million tons of food waste, primarily from the residential and commercial food sectors. The energy potential is significant. For example, with 100 tons of food waste per day, anaerobic digestion can generate enough energy to power 800 to 1,400 homes each year.

Examples from practise

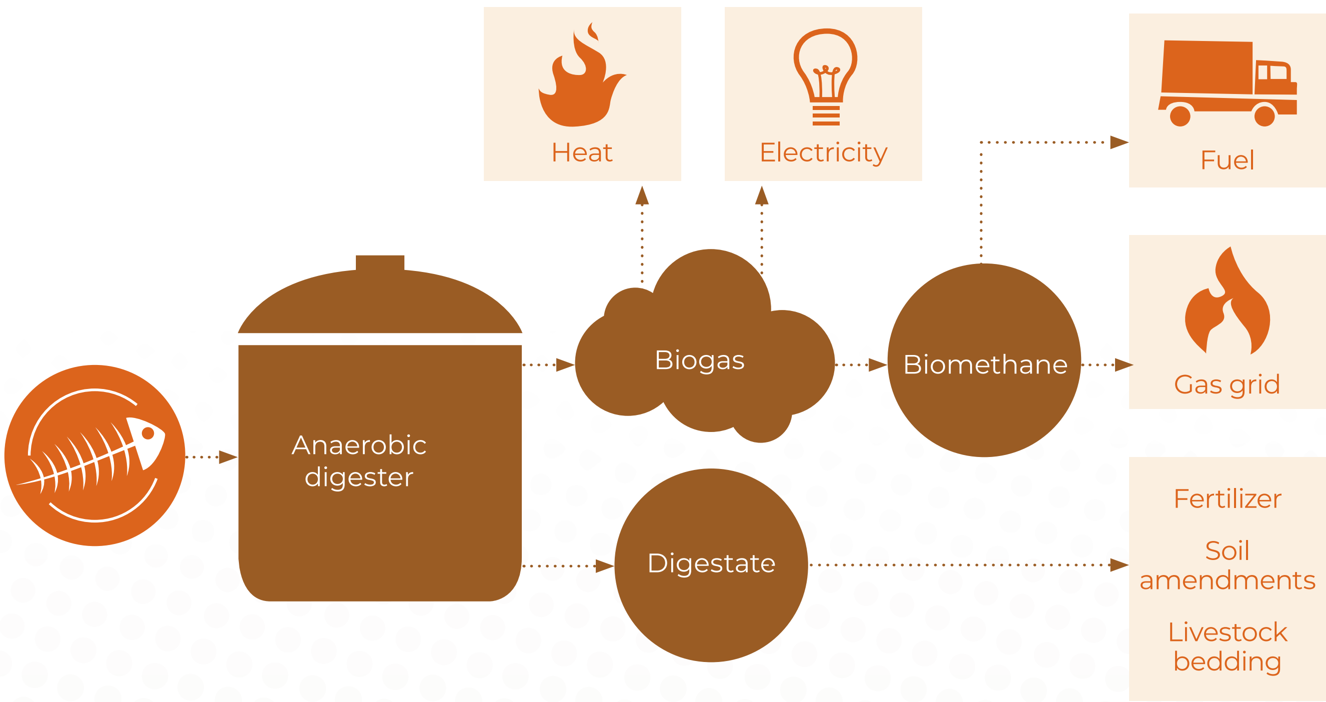


Figure 12: From source to energy – description of the biogas process (adapted from Tanigawa S., 2017)

According to the European Biogas Association, 17,358 biogas plants were operating all over Europe in 2015. Germany is the leading country with almost 11,000 installed biogas plants. The amounts of food wastes as substrates in biogas plants or the share of biogas plants that digest food wastes is low compared to plants using other substrates like energy crops or animal manure. For instance, in Austria, 250,000 tons of food (organic) waste per year is used for biogas production. Experts from the Austrian compost and biogas association estimate the unused potential to be 5 times higher (Arge, 2013).

Biogas plant Deisslingen (Germany)

The plant in Deisslingen treats organic wastes from the Schwarzwald-Baar-Heuberg region and is operating since 2005. The yearly amount of processed organic wastes is 25,000 tons from which Biogas is produced to supply electricity to 2,000 households, as well as heat. The heat is mainly used to dry sewage sludge (from the waste water treatment plant in the neighbourhood). Before the food (organic) wastes are digested, they are treated thermally for hygienization. The solid digestates are used as fertilizers / compost in agriculture.

Waste water treatment plant Fritzens (Austria, Tyrol)

While organic materials can be anaerobically digested in biogas plants with different designs, configurations and process modes (batch vs. continuous), more and more food wastes are processed in the anaerobic digesters of waste water treatment plants (WWTPs) as a co-substrate. The main reason for this is to exploit the idle capacities in the frequently generously dimensioned anaerobic digesters to produce process energy to cover the demand of the whole plant. These digesters have more or less the same requirements as biogas plants. In Tyrol (Austria), 17 WWTP already use approximately 25,000 tons/year of organic/food wastes as co-substrates. One of them is the WWTP in Fritzens which, besides sewage sludge, processes organic wastes from households and gastronomy for biogas production in the plant's digester. The WWTP is treating approx. 3,000 tons a year. According to regulations, the digestate is banned from being used as fertilizer in agriculture, and therefore is dried and incinerated.

Demonstration project in STREFOWA

A new approach developed in Tyrol/Austria, also with participation of PP3 (Waste Management Association Mid-Tyrol and its sorting plant for residual waste in Innsbruck) aims to exploit the potential of organics/food wastes, which are still contained in residual wastes in proportions of up to 20 %. At present, all of the region's residual wastes are treated in a mechanical waste treatment facility, where they are separated into several fractions and transferred to incineration plants. The objective of the new approach is to separate the organic fraction from the residual wastes and use this material as input/co-substrate in digesters at WWTPs.

Generated products and optimum use

Biogas: With little to no processing, biogas can be burned on-site to heat buildings and power boilers or even the digester itself. Biogas can be used for combined heat and power (CHP) operations, or biogas can simply be turned into electricity using a combustion engine, fuel cell, or gas turbine, with the resulting electricity being used on-site or sold onto the electric grid.

Biomethane: Renewable natural gas (RNG), or biomethane, is biogas that has been refined to remove carbon dioxide, water vapour, and other trace gases so that it meets natural gas industry standards. RNG can be injected into the existing natural gas grid (including pipelines) and used interchangeably with conventional natural gas.

Biomethane can be used as a vehicle fuel after it is converted to compressed natural gas (CNG) or liquefied natural gas (LNG). The fuel economy of CNG-powered vehicles is comparable to that of conventional gasoline vehicles and can be used in light- to heavy-duty vehicles.

Digestate: Digestate is the nutrient-rich solid or liquid material remaining after the digestion process; it contains all the recycled nutrients that were present in the original organic material but in a form more readily available for plants and soil building. The composition and nutrient content of the digestate will depend on the feedstock added to the digester. Liquid digestate from mono-digesters (those that exclusively use biogenic residues, without sewage sludge) can be spray-applied to fields as fertilizer, reducing the need to purchase synthetic fertilizers. Solid dried digestate can be used as livestock bedding or composted with minimal processing.

LINKS & REFERENCES

#REDUCEFOODWASTE - TOOL

Use the #reducefoodwaste-Tool to find out what is going on and help reduce food waste along the food supply chain in your area! This tool will introduce you to a lot of important stakeholders in Europe and besides that you can find tips & tricks to prevent food waste, educational materials or information on start-ups, initiatives and other ideas.

https://tool.reducefoodwaste.eu/

References

Arge Kompost & Biogas (2013): Biogas aus organischem Abfall – rundum ein Gewinn http://www.kompost-biogas.info/der-verband/downloads/

Barilla CFN. (2012): Food waste: causes, impacts and proposals. Codice Edizioni

BiPro/CRI (2015): Assessment of separate collection schemes in the 28 capitals of the EU. www.ec.europa.eu/environment/waste/studies/pdf/Separate %20collection_Final %20Report.pdf

FAO (2013): Food wastage footprint: Impacts on natural resources: Summary Report

FAO (2011): Instalment 2 of "Creating a Sustainable Food Future" Reducing Food Loss and Waste 2011. Washington.

Fusion (2016): Estimates of European food waste levels. Stockholm

Langner, G. et al. (1998): 'Richtlinie Abfallanalytik'. Dresden: Sächsisches Landesamt für Umwelt und Geologie, p. 154.

Leibetseder M. (2012): Lebensmittelabfälle in der landwirtschaftlichen Produktion - Abschätzung des Verlusts von Obst und Gemüse in der Landwirtschaft und während des Transportes zum Händler. ABF-BOKU, pp 102.

Monier et al. (2010): Preparatory study on food waste across EU27. http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf

MUTTER ERDE (2017): https://www.muttererde.at/fakten/, 2.5.2018

PLADERER et al. (2016): Lebensmittelabfälle in Österreich: Fakten statt Mythen, 13. DepoTech-Konferenz, Leoben 10.11.2016

ROVA (2013): Omgekeerd Inzamelen Rapportage 2012. Available at: https://www.vang-hha.nl/publish/pages/106160/rapportage_omgekeerd_inzamelen_2012_rova_2013.pdf.

Schuchardt, F. (2005): Composting of Organic Waste. In: Environmental Biotechnology: Concepts and Applications, pp. 333-354.

Stenmarck A. et al. (2016): Estimates of European food waste levels. FUSIONS http://www.eu-fusions.org/phocadownload/Publications/Estimates of European food waste levels.pdf

Tanigawa, S. (2017): Biogas: Converting Waste to Energy; www.eesi.org/papers, 06.2018

WRAP (2013): Where food waste arises within the UK hospitality and food service sector: spoilage, preparation and plate waste.

EFFICIENT OPERATION WITH FOOD WASTE

#REDUCEFOODWASTE

FOR

WASTE MANAGEMENT

ORIGIN

FOOD WASTE OCCURS IN THE WHOLE FOOD SUPPLY CHAIN

- IN THE PRIMARY SECTOR WHEN HARVESTED FRUITS AND VEGETABLES ARE SORTED OUT AT THE FARM OR RETURNED FROM TRADING PARTNERS
- IN THE FOOD PROCESSING SECTOR IN THE COURSE OF PREPARATION OF PRODUCTS
- IN RETAIL WHEN FOOD CAN´T BE SOLD OR GETS DAMAGED
- IN KITCHENS OF GASTRONOMY (FOOD SERVICE SECTOR)
- IN HOUSEHOLDDS DUE TO ALL THE VARIETY OF REASONS WHY FOOD IS BEING WASTED

FOOD SUPPLY CHAIN

cooperation arrow

Primary Production	Food Processing	Retail	Food Service	Consumers	Waste Management
Factsheet #1		Factsheet #2	Factsheet #3	Factsheet #4	Factsheet #5

COLLECTION SYSTEMS

A PROPER COLLECTION FOSTERS OPTIMUM TREATMENT PERFORMANCE!

#5 Waste Management

BIODEGRADABLE BAG	BIN	CONTAINER AND BIN	TANK
consumer	consumer	at your farm or in cooperation with	Processing, Retail, food service

TREATMENT

USE THE STATE-OF-THE-ART TECHNOLOGY TO GAIN BEST OUTPUT!

COMPOST PLANT	BIOGAS PLANT	WASTEWATER TREATMENT PLANT
Products: compost (→fertilizer)	Products: biogas (→heat, electricity, fuel), biogas slurry (→fertilizer)	Products: biogas (→heat, electricity, fuel), sewage sludge (→P-fertilizer)

BENEFITS

CLOSING LOOPS!

CREATE VALUABLE PRODUCTS AND REGIONAL VALUE!

SAVE RESOURCES AND ENERGY!

AVOID ENVIRONMENTAL PROBLEMS!

RAISE AWARENESS!

Interreg CENTRAL EUROPE
European Union European Regional Development Fund
STREFOWA
CZECH REPUBLIC DEVELOPMENT COOPERATION

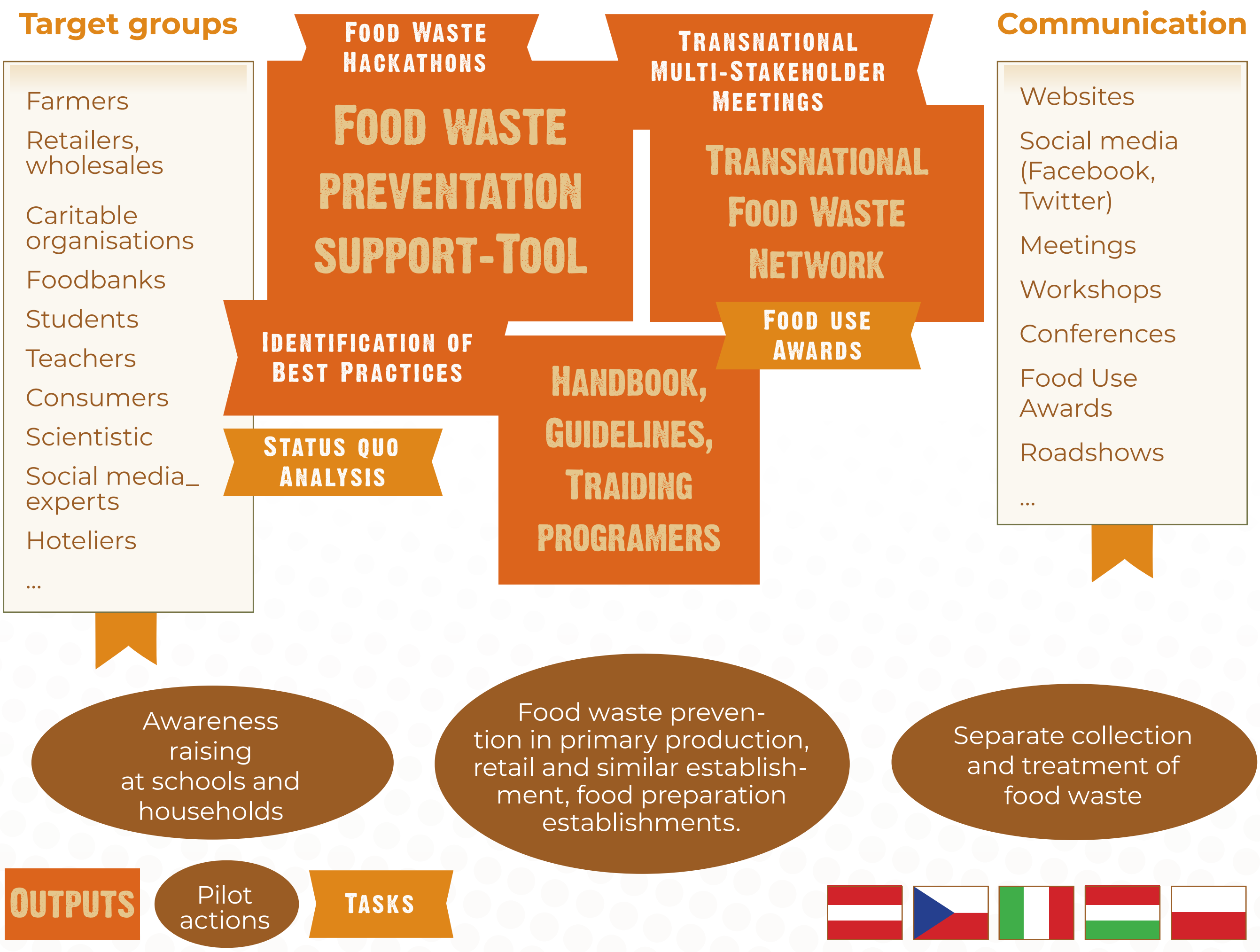
ABOUT STREFOWA

>>> www.interreg-central.eu/STREFOWA >>> www.reducefoodwaste.eu

Strefowa (**St**rategies to **Re**duce and Manage **Fo**od **Wa**ste in Central Europa) is a three-year project implemented in the Central Europe region funded by the Interreg CENTRAL EUROPE Programme that encourages cooperation shared challenges in central Europe. Therefore nine partners in five different Central Europe Countries (Austria, Hungary, Poland, Czech Republic, Italy) are working together. The aim is to reduce food waste or to treat it in a better, more useful way as well as to connect relevant actors in order to achieve a reduction of environmental impacts (e.g. GHG emissions) along the whole supply chain.

The most relevant outputs of this project are:

- **Food waste prevention support – Tool** (https://tool.reducefoodwaste.eu/#/)
  Based on best practice examples and project outcomes, a tailor-made web based software tool provides specific information for different stakeholder groups to prevent and treat food waste.
- **Implementation of Pilot and Demonstration Action**
  Food waste prevention measures as well as the feasibility of food waste separation and separate collection have been tested and evaluated within 16 pilot actions taking place in different partner countries. Newly acquired knowledge will now be accessible for others.
- **Establishment of an appropriate Transnational Stakeholder Platform**
  Stakeholders that are willing to work together are identified and connected through a Transnational Stakeholder Platform.
- **Best Practice Guidelines and Training Programmes**
  Guidelines and training programmes in regard to prevention, reduction and treatment of food waste have been developed and tested for relevant stakeholder groups along the food supply chain. They are based on current scientific findings and best practice examples.



https://www.interreg-central.eu/STREFOWA