WASTE2ROAD

Biofuels from WASTE TO ROAD transport

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Deliverable Report

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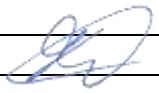
Document approval	Duncan Akporiaye	05.07.2021	

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Description of the deliverable content and purpose

The deliverable D2.6 *Public report on deployability in European context* is described in the GA (part A, p. 18 of 59) as "*a public report based on D2.4 and D2.5*". The descriptions of deliverables 2.4 and 2.5 are provided below:

D2.4 is "*a public report based on operational data from the last 3 years of collection, sorting and treatment of biological waste from the City of Oslo*".

D2.5 is "*a confidential report based on knowledge and cooperation in existing organizations ("Avfall Norge", "Avfall Sverige" and ISWA) including qualified estimates of amounts available and ready for deployment in Europe*."

The three deliverables are linked to Task 2.4 *European perspective and deployment*. The task objectives are interpreted as follows:

- Demonstrate feasibility of waste partnership and collaboration within Europe in relation to supply of feedstocks and choice of optimal source sorting strategies,
- Make an inventory of feedstocks available in Europe in WASTE2ROAD relevant waste categories,
- Evaluate the impact of feedstock deployment for production of advanced biofuels on already established value chains (e.g., incineration, anaerobic digestion).

The main purpose of D2.6 is to describe, for relevant waste categories, the currently employed methods for waste management (collection, sorting, treatment) and to provide qualified estimates of waste amounts potentially available considering the European waste management strategy and the competing waste management operations (e.g., anaerobic digestion of food waste and recycling of wood waste).

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1 Executive summary

The aim of this report is to provide qualified estimates of waste amounts available and ready for biofuel deployment in Europe. The focus has been mainly given to feedstocks from waste categories that are relevant for WASTE2ROAD, that is **food residues** (especially from households) and **contaminated wood**. The waste statistics was gathered mainly from Eurostat and from data presented in published reports and literature. The way the waste is handled today (collection, sorting and treatment) is different across Europe. In North-Western Europe, waste management is generally more developed than in countries in South-Eastern Europe where landfilling of waste is still significant. Examples of how waste is handled in some European countries are provided for both food waste and wood waste. The European perspective on how waste should be handled in the context of circular economy transition to ensure maximum resource efficiency while preserving the environment is given. This provides an insight into future directions in waste management in Europe, with higher focus on re-use, recycling, and energy recovery to replace fossil fuels and thereby contribute to reduction of GHG emissions. Considering the latest (2018, Eurostat) data on amounts of waste generated in Europe, the currently used treatment methods (recycling, landfilling, incineration, energy recovery), and information available in published reports and literature, an attempt is made to estimate theoretical amounts of food waste and wood waste potentially available for biofuels deployment in Europe in the future.

Food waste

To enable valorization and utilization of food waste in different types of treatment applications (composting, anaerobic digestion, and valorization of higher value products including advanced biofuels), a separate collection of food waste based on source-sorting or specially designed sorting plants is necessary. Separate food waste collection is not yet available in all European countries and their regions. Even with separate food waste collection in place, still significant amounts of waste end-up in mixed waste and the potential cannot be utilized. Also, there is a need to measure how much food waste is generated/collected and record how it is treated to be able to quantify the potential based on reliable data. The estimates of food waste available in Europe provided in this report are theoretical, based on assumed generation of food waste per person. Different approaches were used to determine how much food waste is generated. The theoretical energy potential assumed that each person in Europe generates on average 90 kg of food waste per year. Taking to account the current population in EU28, the total theoretical amount of food waste generated was calculated. Assuming that in the near future, food waste will be collected in every country in Europe, a theoretical collection rate of 85 % is considered to determine the amount of food waste that can be collected for treatment. In Norway, where food waste management is well-developed, almost all the food waste that is collected is either treated in composting or anaerobic digestion. It is assumed that in the future, composting, anaerobic digestion as well as production of advance biofuels could be among the employed technologies for treatment of food waste. Using Norway as an example and the current share of food waste sent to composting and anaerobic digestion, it is assumed that about 50 % of the theoretical amount of food waste collected could be available for the production of advanced biofuels. For EU28, this amount corresponds to 19 843 ktonnes. Taking into account the humidity and ash content, the theoretical energy potential has been estimated to about 1.8 Mtoe/year.

Wood waste

The estimates of contaminated wood are purely based on wood waste data available in Eurostat. To fully utilize the potential of wood waste across Europe, it would be useful to unify the way wood waste is classified in Europe and to develop improved methods for wood waste collection, sorting and recording the wood waste amounts collected in the different wood waste categories, such as clean (untreated), treated and impregnated (hazardous) wood waste. Currently, the wood waste data in Eurostat is recorded only on non-hazardous/hazardous basis. The wood waste is today primarily treated in recycling (particleboard, chipboard, panel board and similar) and in energy recovery (bio-energy plants) to partially replace fossil fuels and generate renewable energy. The European strategy is to prioritize recycling to waste incineration for energy recovery. On the other hand, diverting wood waste from energy recovery solutions would require a replacement of wood waste by another renewable feedstock in bio-energy plants. For the estimation of waste amounts, it is thus assumed that the bio-energy produced today from wood waste can be substituted by another source of renewable energy and the wood waste, thus diverted, can be used fully for the production of transport fuels. Based on the latest (2018) wood waste data in Eurostat, the amounts of wood waste available are then estimated as the difference in the total amount of wood waste treated and the amount of wood waste recycled. The potential amount of wood waste available in EU28 is estimated to 24.4 Mtonnes/year, corresponding to a theoretical energy potential of 10.8 Mtoe/year. This wood waste represents the total amount of wood waste from different industrial sectors including households. The highest potential is in countries that treat the highest amounts of wood waste, such as France, Finland, United Kingdom, Sweden and Netherlands.

The amount of wood waste generated in only the household sector represents on average about 10 % of the total wood waste generated in Europe. In 2018, 5520 ktonnes wood waste were generated in EU28. This corresponds to a theoretical energy potential of 2.4 Mtoe/year. Country-wise, the highest theoretical potential is obviously in countries which generate most wood waste in the household sector, such as France, Italy, United Kingdom, Poland, and Romania.

2 Project background

WASTE2ROAD aims to develop advanced biofuels from selected low-cost, widely available and diverse biogenic wastes. The project has an ambitious scope covering the whole value chain from waste management and pre-treatment strategies in local regions, to bio-conversion (liquefaction) and co-refining, through to validation of the biofuels' end-use compatibility in engines and transport vehicles (Figure 1).

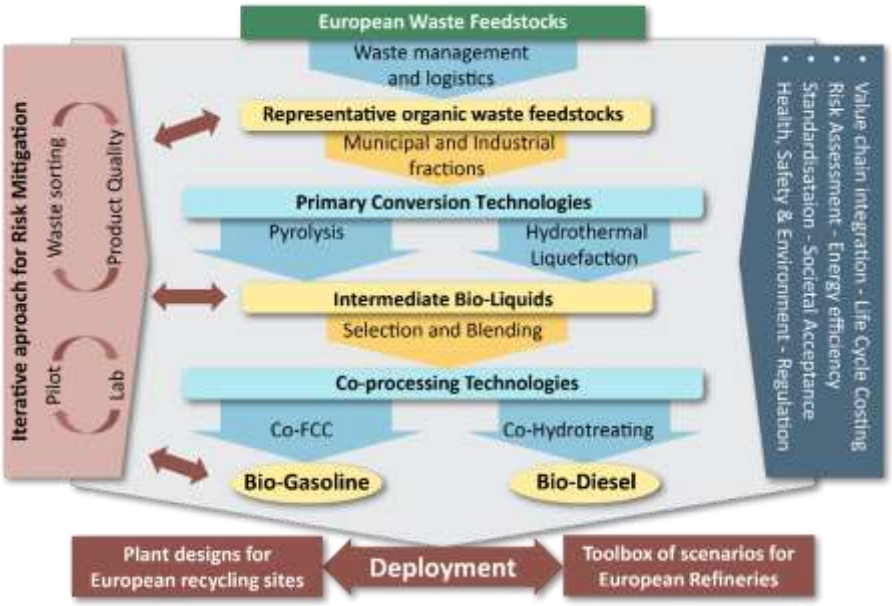


Figure 1: WASTE2ROAD concept.

The project targets waste fractions from three basic categories: food residues, contaminated wood, and black liquor. The food residues in the context of the WASTE2ROAD project include food and kitchen waste from households, restaurants and waste from food-processing plants (e.g., sunflower seed husks). The contaminated wood tested in the project is defined as 'class B'. This is wood waste that has received some level of chemical treatment and may contain residues of paint, varnish, glue, coating but no organic halogenated compounds or heavy metals (non-hazardous). Black liquor is a lignin-rich by-product formed during the pulping of wood to make paper. It contains about half the energy of the wood input to a kraft pulp and it is used in the pulp as a source of energy [1].

This report focuses mainly on analysis of the first two feedstocks, food residues from households and contaminated wood. It attempts to provide qualified estimates of these feedstocks available in Europe. The analysis of waste amounts available is largely based on data available in Eurostat but also on information gathered from published reports and literature.

3 Food waste

Bio-waste (defined as food waste and garden waste) represents the largest fraction of municipal waste in the EU with 34 %. About 60 % of bio-waste is food waste (including food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food-processing plants), which implies that the share of food waste in municipal waste is about 20 % [2]. According to Eurostat ('env_wasmun' [3]), the amount of municipal waste[1] generated in EU28 in 2018 was about 252 million tonnes, of which about 20 % was food waste, amounting theoretically to about 50 million tonnes (or about 98 kg per person). Most of this waste comes from households as household waste represents a major share in municipal waste (about 86 % when comparing the values of household and municipal waste for EU28 in 2018).

It is estimated that about one third of all the food produced in the world is wasted along the whole food supply chain from production to handling and storage, processing, distribution and market, and consumption [4]. In Europe, about 50 % of food is wasted in the consumption stage (Figure 2). Excessive generation of food waste and poor food waste management lead to significant GHG emissions and other environmental challenges. Thus, prevention of food waste and utilization of food waste as a resource in circular economy concepts has become the major focus in Europe and worldwide.

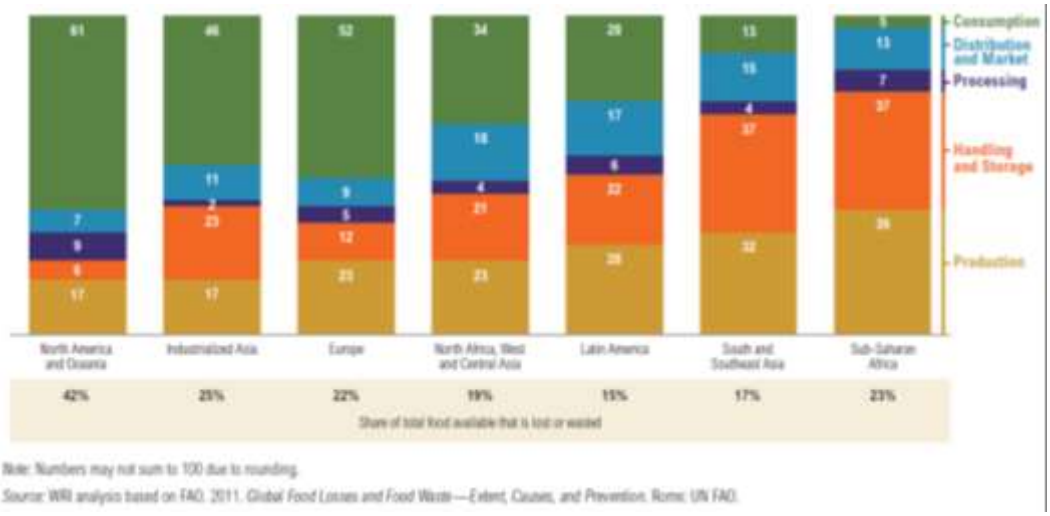


Figure 2: Share of total food waste lost in different stages of food supply chain worldwide (Source [4]).

3.1 Food waste management in Europe

To enable valorization and utilization of food waste in different types of treatment applications (composting, anaerobic digestion, and valorization of higher value products including advanced biofuels), a separate collection of food waste based on source-sorting or specially designed sorting plants is necessary. This makes the recovery of nutrients and energy more efficient and gives flexibility in the choice of the waste treatment method. The currently employed recycling methods (composting and anaerobic digestion) as well as the alternative technologies that are under research and development (biofuels and bio-chemicals) require that the level of contaminants in waste is kept as low as possible, avoiding remains of plastics from plastic bags which are commonly used in food waste

[1] Municipal waste is defined in Eurostat as waste mainly produced by households including similar wastes from sources such as commerce, offices and public institutions (according to metadata in env_wasmun in [3]).

collecting bins and inorganic impurities due to poor sorting by consumers. This can be best achieved through source segregated food waste collection and educational programs that encourage and teach consumers to sort their waste.

In Europe, large differences exist in how bio-waste (food and garden waste) is collected and treated both among and within the countries. Some countries have a well-established system for separate collection of bio-waste from households, which covers most of the country's population while in other countries, separate bio-waste collection is only possible in some regions or large cities. Some countries collect separately food waste and garden waste while other countries collect garden waste together with food waste in one container. In some of the countries, especially in the southern and eastern part of Europe, introduction of separate bio-waste collection system is only at its early phase and bio-waste in these countries is mostly collected with mixed waste [4, 5]. In some countries, it is common that consumers treat their bio-waste in home composters, and this reduces the amount of bio-waste in the waste management system. There is currently no data available on how much bio-waste is treated by home-composting in Europe.

Although, the share of municipal waste treated in composting or anaerobic digestion gradually increases (from 11 % in 2004 to 17 % in 2018), a high proportion of European bio-waste ends up in landfills or incineration [2]. Decomposition of biodegradable waste in landfills produces methane which contributes to greenhouse gas emissions and therefore, the EU introduced a Landfill Directive (1999/31/EC) which requires that the member states reduce their amount of biodegradable waste to landfills to 35 % of the 1995 levels by 2016 (for some EU countries by 2020). According to the Waste Framework Directive (amendment 2018/851 to 2008/98/EC), the EU member states are obliged to measure and report food waste generation annually (starting from 2020), collect bio-waste separately from the end of 2023 and develop food waste prevention strategies [2].

The following sections provide examples of how food waste is collected and treated in three selected European countries (Norway, Portugal and France). More examples of different food collection systems in cities worldwide are reviewed in [4].

3.1.1 Norway

In Norway, the primary treatment of municipal solid waste (MSW) is incineration (about 50 %) and material recycling (about 40 %) (Figure 3a). Since 2009, Norway has imposed a landfill ban on biodegradable waste. MSW containing more than 20 % of organic matter has to be treated to reduce the organic fraction prior to landfilling [6]. The amount of 'food and wet organic waste'[2], separately collected by municipalities, accounted for about 8 % of total household waste generated in 2020 [7]. The two primary treatment methods are biogas production and composting. Figure 3b shows that biogas production has increased and composting has decreased in the last four years, while the amount of separately collected 'food and wet organic waste' remained approximately the same.

The amount of 'food and wet organic waste' incinerated in Figure 3 seems low but this data only represents waste removed during the processing of organic waste in treatment applications (e.g., pre-

[2] 'Food and wet organic waste' is an SSB's waste code consisting of organic waste that easily decomposes, like discarded food and processing waste from the manufacturing of food products, etc.

treatment rejects from the biological treatment before anaerobic digestion). In reality, the amount of organic waste incinerated together with mixed waste is significantly higher due to poor sorting of food waste by the consumers at home. In a recent report [8], it has been estimated that the amount of food waste that ends up in mixed waste is on average about 56 % while 44 % is separately collected which is in line with the degree of food waste sorting estimated in the City of Oslo [4] and the data presented for EU28 in [2].

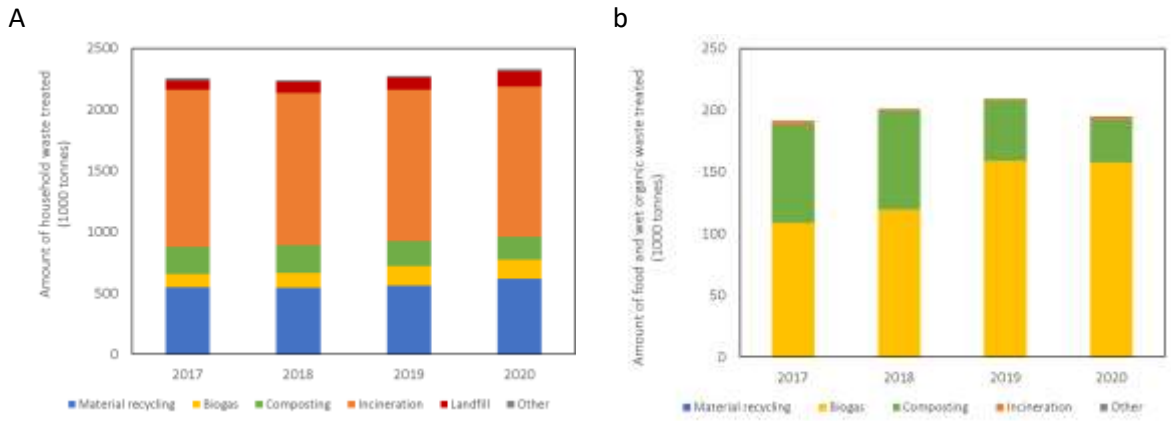


Figure 3: Treatment of household (a) and 'food and wet organic waste (b) in Norway (Source: Table 13136 in SSN [6]).

Norway is a relatively large country with the population of about 5.4 million non-evenly distributed over the land area, making the waste collection in the less populated areas challenging. Separate collection of food waste by households is established mainly in the densely populated regions. There are large differences between the regions in how much food waste is separately collected and how much ends up in mixed waste (Figure 4).

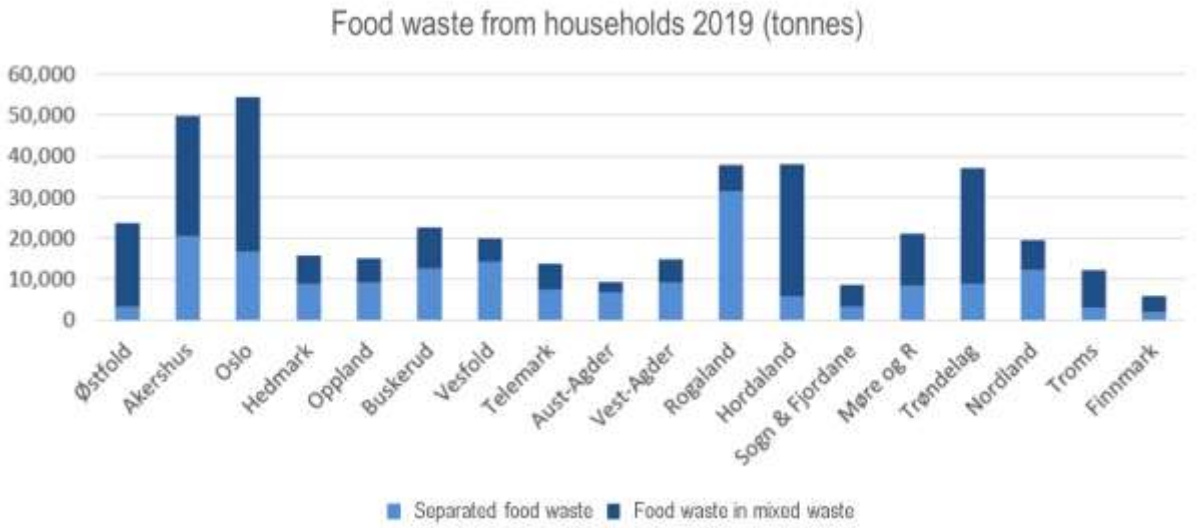


Figure 4: Total amount of generated food waste from Norwegian households 2019, per region, separated and present in mixed waste (adopted from [8]).

Food waste collection in Norwegian municipalities is organized by local private companies or companies owned by either one or more municipalities. Different ways of food collection are used. An example of how food waste is collected and treated in the City of Oslo is described in more detail in

WASTE2ROAD deliverable D2.4 *Inventory on optimal waste fraction availability*. The food waste is collected in green plastic bags (Figure 5a) which are optically separated from other waste and sent to biological treatment in the Romerike biogas plant.

The system of differently coloured plastic bags and optical sorting of waste is also used in Grenland which is a region in the Vestfold and Telemark County in the South-Eastern Norway. In Vestfold, another method is used with special bins which are split in two sections, one for collection of mixed waste and one for collection of food waste. The bins are emptied in a garbage truck with separate compartments for separate collection of mixed waste and food waste (Figure 5b).

a b

Figure 5: Green bags used for food waste collection in the City of Oslo and Grenland (a) and garbage tracks for collection of mixed and food waste in Vestfold (b).

The food waste separately collected in the Grenland and Vestfold regions covers more than 340 000 inhabitants while the City of Oslo collects waste from more than 680 000 inhabitants, corresponding together to roughly 20 % of the Norwegian population. Unlike in the Romerike biogas plant (in the Oslo region), the waste in the GreVe biogas plant is treated together with animal manure collected from local farmers. The process scheme illustrating how the waste is treated in the Romerike and GreVe biogas plants is presented in Figure 6 and Figure 7, respectively.

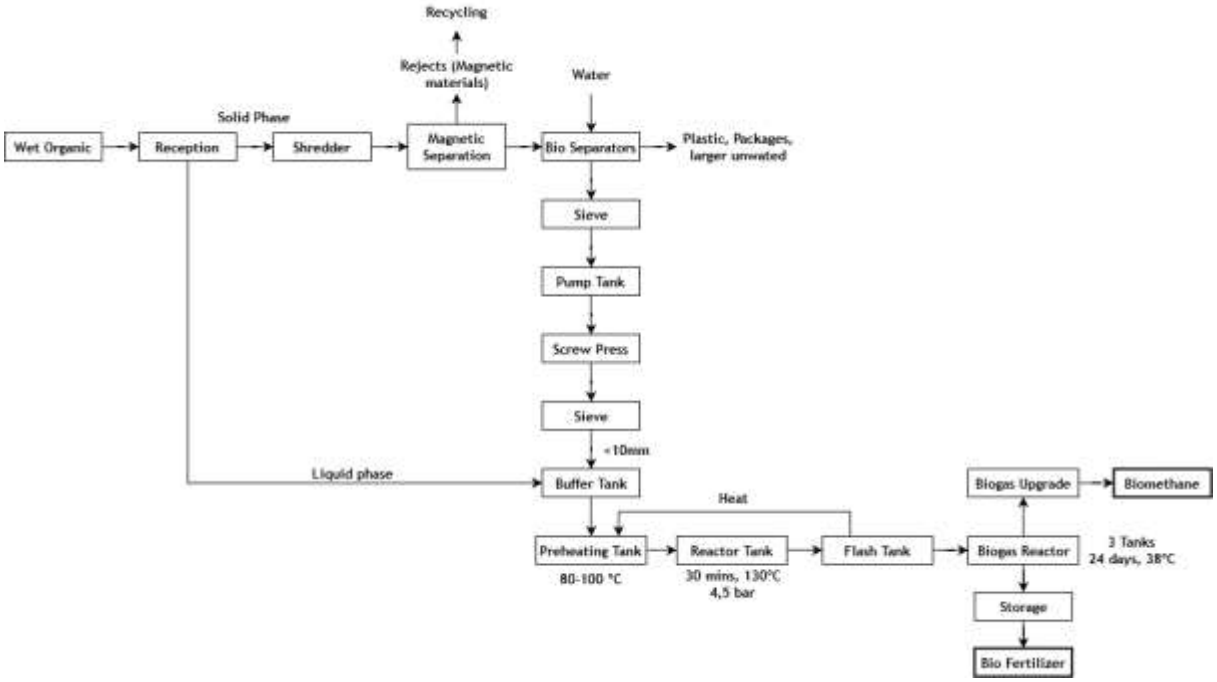


Figure 6: Proces scheme of the food waste biological treatment in the Romerike biogas plant in Norway (Source: [9]).

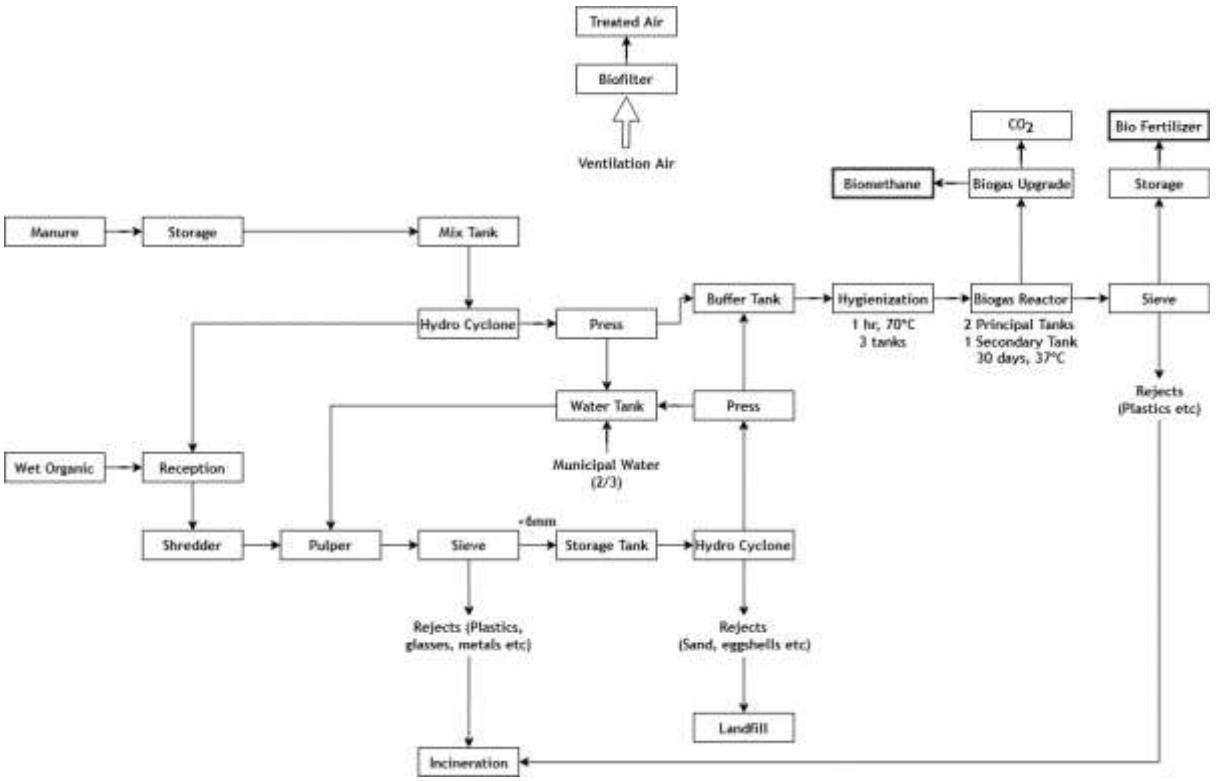


Figure 7: Process scheme of the food waste biological treatment in the GreVe biogas plant in Norway (Source: [9]).

The number of biogas plants has been steadily increasing in Norway. Currently, there are altogether more than 30 biogas plants, of which 8 are primarily used for treating food waste separately collected from households. The number and distribution of biogas and composting stations is Norway is shown in (Figure 8).

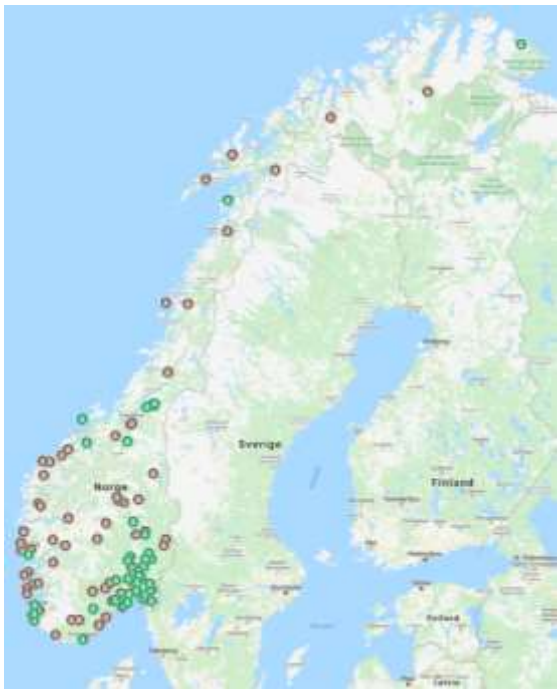


Figure 8: Map showing the biogas plants (green) and composting stations (brown) in Norway (Source: Avfall Norge [10]).

3.1.2 Portugal

Unlike Norway, significant amount of municipal waste is being sent to landfills in Portugal, about 45 % in the years 2014-2017 (Figure 9). Incineration is the second largest method of waste treatment, followed by material recycling and composting and digestion.

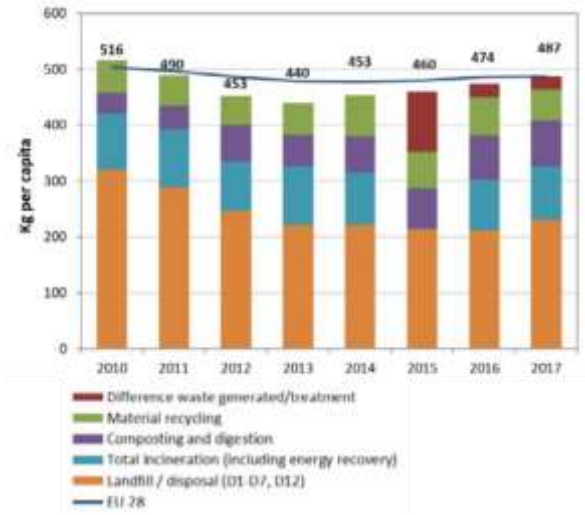


Figure 9: Municipal waste treatment in Portugal in 2010 to 2017 (Source: [11]).

Separate collection of bio-waste has not yet been implemented apart from recently starting pilot projects [5]. The country is mainly relying on Mechanical Biological Treatment (MBT) of undifferentiated waste [12, 13] although selective collection of organic waste for larger businesses, hotels, restaurants and canteens has been introduced in some areas. Domestic sorting of organic waste is being tested in some areas for larger apartment buildings with the goal of expanding the service in the future [9].

In line with the EU Landfill Directive, Portugal aims to reduce the amount biodegradable waste in landfills (reduction of biodegradable waste in landfills to 35 % of values from 1995). Figure 10 shows the amount of biodegradable waste being landfilled in Portugal in the years 2008-2018. The percentage of biodegradable waste in landfills compared to the value in 1995 has declined over the years and in 2018, Portugal was still somewhat behind the target of 35 % (Figure 10).

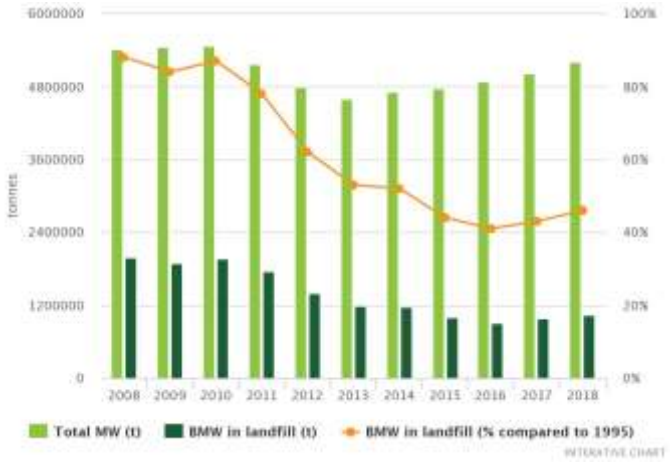


Figure 10: Landfill of biodegradable municipal waste in Portugal, source Agência Portuguesa do Ambiente (APA) 2019 (Source: [14]).

The MSW in Portugal is managed by more than 20 companies, each adopting its own waste collection and treatment methods [12]. Some examples of waste management companies are given in Figure 11.

Figure 11: Waste management companies – Suldouro (orange), Tratolixo (red) and Valorsul (blue) covering together about 36 % of Portuguese population (adopted from [9]).

Valorsul receives selective green waste and collects organic waste from commercial activities (restaurants, hotels, markets, etc.). Tratolixo treats undifferentiated waste (UW) in the MBT center to recover the organic fraction and receives selectively collected green and organic waste from larger producers. Suldouro receives separately collected green waste and as Tratolixo, treats undifferentiated waste in the MBT center to recover the organic matter. In all three cases, the recovered organic waste is treated in anaerobic digestion. The digestate is typically processed into compost and the produced biogas is used for energy production [9].

According to analysis by Pandrão and Dias [12], the systems for waste treatment in Portugal, based primarily on MBT of undifferentiated waste, are inadequate for valorization of organic waste due to insufficient capacity and inefficient recovery of the organic fraction, resulting in low-quality compost

due to high-level of contamination (heavy metals) and therefore limited applications for soil amendment. The study shows that with domestic sorting significantly higher amounts of organic waste can be theoretically recovered, resulting in less waste being sent to landfills or incineration while achieving more efficient treatment of organic waste and producing higher amounts of compost with a quality complying with compost standards.

The process schemes illustrating the treatment of waste in Valorsul, Tratolixo and Suldouro are shown in Figure 12, Figure 13 and Figure 14, respectively.

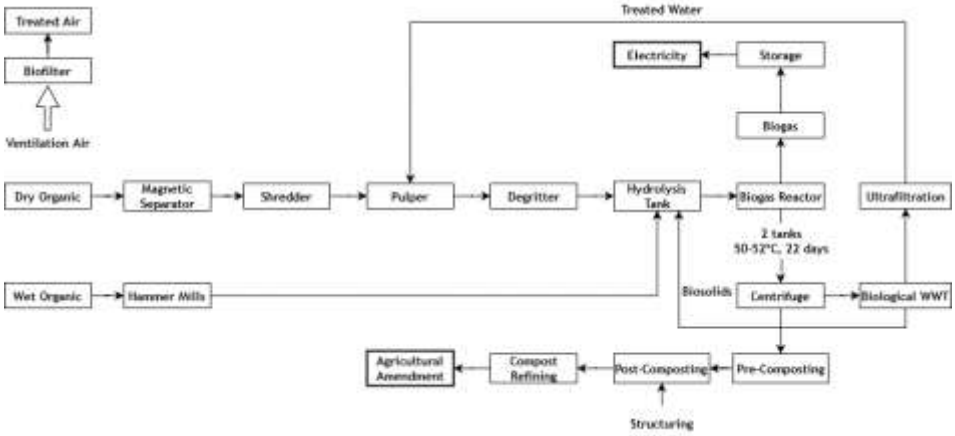


Figure 12: Process scheme of organic waste treatment in Valorsul (Source: [9]).

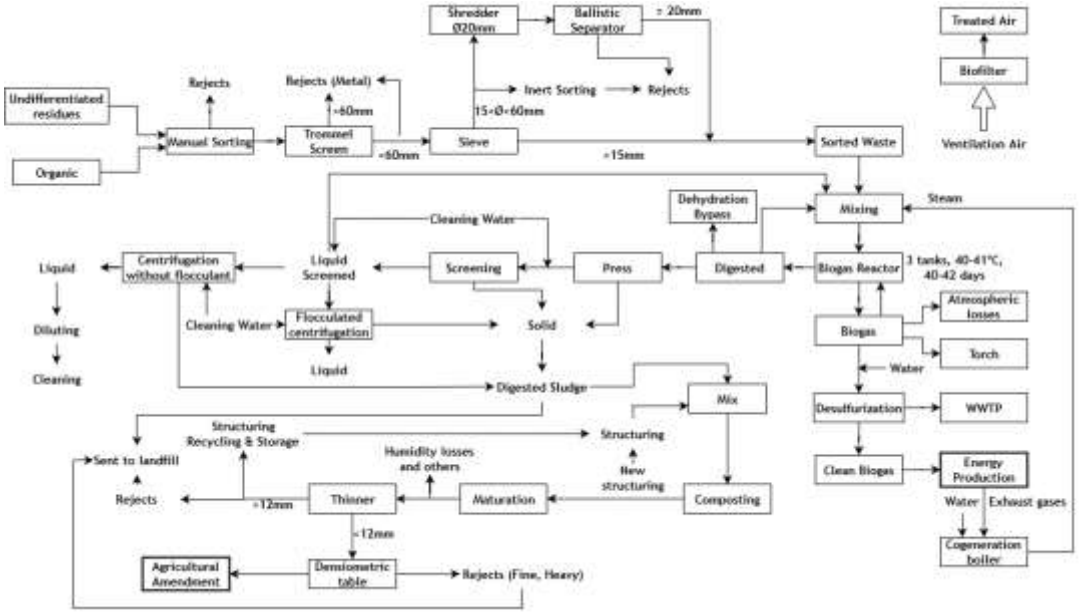


Figure 13: Process scheme of undifferentiated and selectively collected organic waste treatment in Tratolixo (Source: [9]).

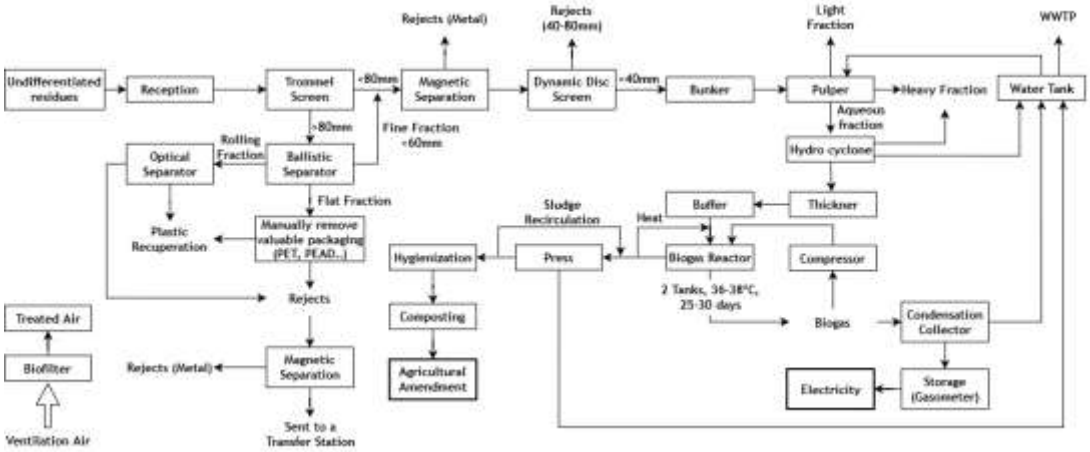


Figure 14: Process scheme of undifferentiated and selectively collected organic waste treatment in Suldouro (Source [9]).

3.1.3 France

France follows the EU's strategy and aims to reduce overall waste generation, implement separate collection for different types of waste, divert recyclable materials from incineration and landfills to material recovery [11]. The amount of municipal waste has somewhat declined from 2010-2017 but the average amount of waste generated per capita per year is still higher than the EU28 average (Figure 15). The amount of waste landfilled has declined from about 28 to 21 %, with a corresponding increase in digestion, composting and material recycling while incineration has remained roughly the same.

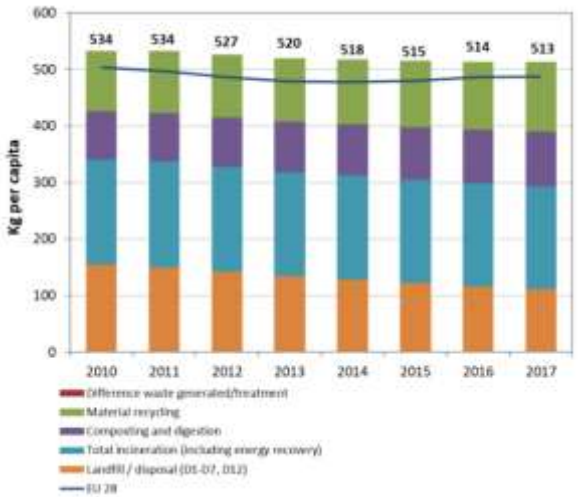


Figure 15: Municipal waste treatment in France in 2010 to 2017 (Source [11]).

While most municipalities collect garden waste separately, domestic sorting of food waste is not yet common in France, with the exception of some municipalities which cover less than 10 % of the French population [5]. Separate collection of bio-waste is still today only mandatory for large food waste producers, generating more than 10 tonnes/year which includes mostly hotels, restaurants, and some canteens. A minor percentage of the population is connected to Mechanical Biological Treatment (MBT) systems (less than 5 % in 2006 [15]).

An example of the use of MBT technology coupled with anaerobic digestion is Amétyst, the largest methane production unit after MBT in France operated by SUEZ, treating municipal and similar waste

from 430 000 residents in Montpellier. The plant treats yearly about 140 000 tonnes of municipal solid waste, including a small amount of separately collected household bio-waste (about 6 000 tonnes) The overall process of waste treatment is illustrated in Figure 16.

The first important step is pre-fermentation of up to 3 days in slow rotating cylinders during which the organic fraction undergoes first microbial growth combined with a strong mechanical sheer stress, resulting in a significant particle size reduction, enabling a more effective separation of the organic fraction from the residual waste. Separation of the organic fraction is done in screen trommels equipped with a mesh of 80 and 20 mm. The finer fraction, 0-20 mm is then further screened on specially designed avalanche screens (patented by SUEZ) producing two fractions of 0-5 mm and 5-20 mm which then undergo anaerobic digestion, composting (the 0-5 mm fraction results in a compost that complies with standards) or further stabilization (5-20 mm fraction). The biogas produced is turned to heat and electricity.

Despite the improvements of the MBT units and a better degree of organic waste sorting and purification allowing the production of a high-quality compost, France aims at extending separate collection of all organic waste by 2025 as stated in the Energy Transition for Green Growth Act adopted by France in 2015 [12]. The act proposes a transition from MBT of undifferentiated waste to dedicated plants for separately collected biodegradable waste. However, the organic content of the household waste will certainly remain consistent.

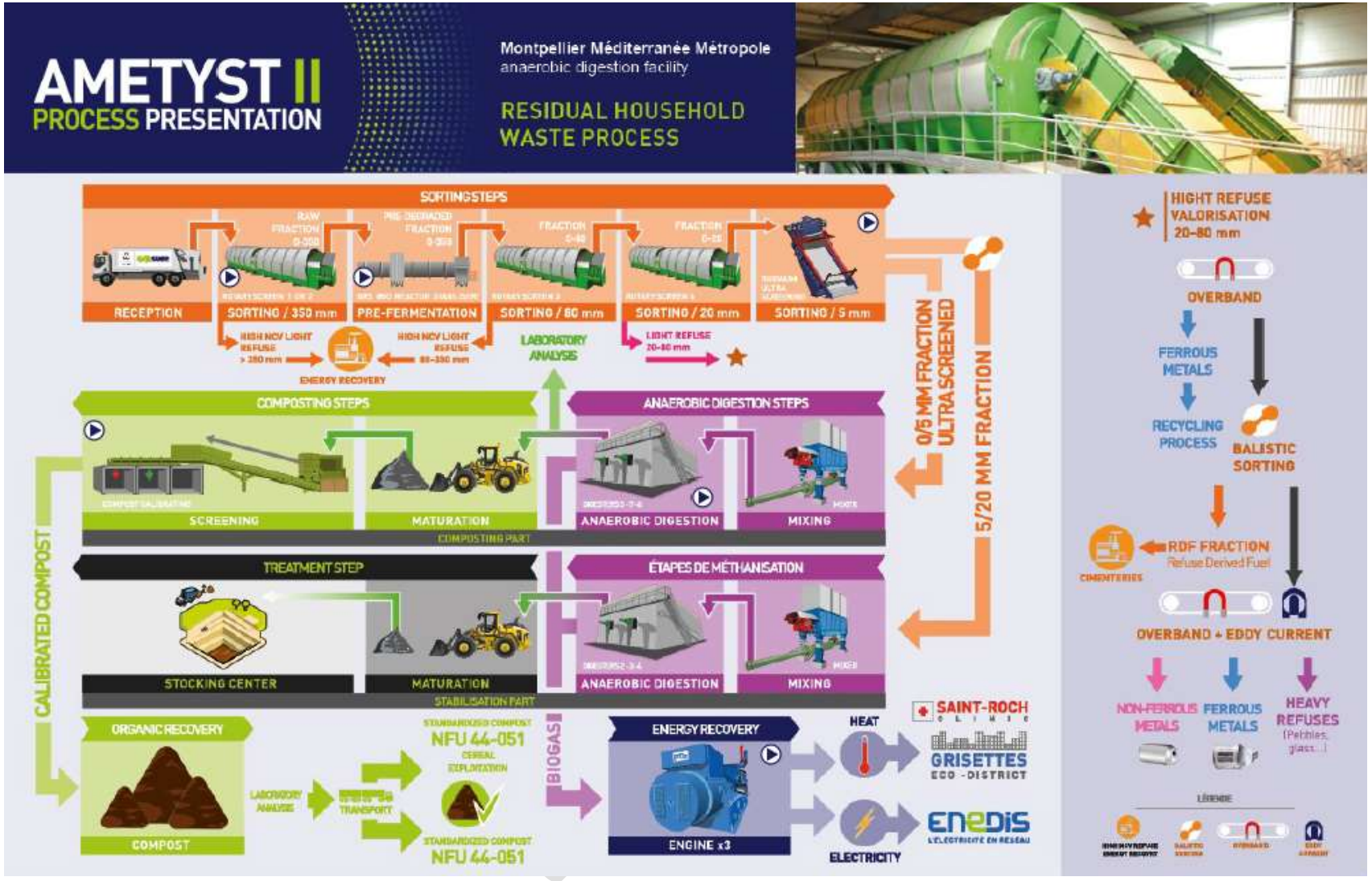


Figure 16: Residual household waste process, Amétyst in Montpellier (Source: SUEZ, associated partner of WASTE2ROAD).

3.2 Estimates of food waste generated in Europe

3.2.1 Data available in Eurostat

Eurostat has been used in this report as a starting point to collect information on waste generation and treatment in Europe. The data for waste generation (env_wasgen) can be sorted in a number of waste categories as illustrated in Table 1. Further, the data can be classified based on the type of activity including various industrial areas as well as households (Table 2).

Table 1: Waste categories in Eurostat database [env_wasgen].

Waste categories
Primary waste (TOTAL minus SEC)
Secondary waste (W033+W103+W128_13)
Chemical and medical wastes (subtotal)
Spent solvents
Acid, alkaline or saline wastes
Used oils
Chemical wastes
Industrial effluent sludges
Sludges and liquid wastes from waste treatment
Health care and biological wastes
Recyclable wastes (subtotal, W06+W07 except W077)
Metal wastes, ferrous
Metal wastes, non-ferrous
Metal wastes, mixed ferrous and non-ferrous
Glass wastes
Paper and cardboard wastes
Rubber wastes
Plastic wastes
Wood wastes
Textile wastes
Equipment (subtotal, W077+W08A+W081+W0841)
Waste containing PCB
Discarded equipment (except discarded vehicles and batteries and accumulators waste) (W08 except W081, W0841)
Discarded vehicles
Batteries and accumulators wastes
Animal and vegetal wastes (subtotal, W091+W092+W093)
Animal and mixed food waste
Vegetal wastes
Animal faeces, urine and manure
Mixed ordinary wastes (subtotal, W101+W102+W103)
Household and similar wastes
Mixed and undifferentiated materials
Sorting residues
Common sludges
Mineral and solidified wastes (subtotal)
Mineral waste from construction and demolition
Other mineral wastes (W122+W123+W125)
Combustion wastes
Soils
Dredging spoils
Mineral wastes from waste treatment and stabilised wastes
Metallic wastes (W061+W062+W063)
Animal and mixed food waste; vegetal wastes (W091+W092)
Mineral waste (except non-hazardous dredging spoils, valid up to 2008)
Mineral wastes (except combustion wastes, contaminated soils and polluted dredging spoils) (W121+122+W123+W125+W126, valid up to 2008)
Soils and dredging spoils (W126+W127, valid up to 2008)
Solidified, stabilised or vitrified wastes (valid up to 2008)
Waste excluding major mineral wastes

Table 2: Economic activities in Eurostat database [env_wasgen].

Economic activity

Agriculture, forestry and fishing
Mining and quarrying
Manufacturing
Manufacture of food products; beverages and tobacco products
Manufacture of textiles, wearing apparel, leather and related products
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
Manufacture of paper and paper products; printing and reproduction of recorded media
Manufacture of coke and refined petroleum products
Manufacture of chemical, pharmaceutical, rubber and plastic products
Manufacture of other non-metallic mineral products
Manufacture of basic metals and fabricated metal products, except machinery and equipment
Manufacture of computer, electronic and optical products, electrical equipment, motor vehicles and other transport equipment
Manufacture of furniture; jewellery, musical instruments, toys; repair and installation of machinery and equipment
Electricity, gas, steam and air conditioning supply
Water supply; sewerage, waste management and remediation activities
Water collection, treatment and supply; sewerage; remediation activities and other waste management services
Waste collection, treatment and disposal activities; materials recovery
Construction
Services (except wholesale of waste and scrap)
Wholesale of waste and scrap
Households
All NACE activities plus households

The total waste generated in households in different European countries in 2018 is shown in Figure 17 (in million tonnes) and in Figure 18 (in kg/capita). Not surprisingly, most waste is generated in the highly populated countries of Europe, such as Germany, France, Italy, United Kingdom and Turkey. The amount of waste generated in kg/capita varies from 215 in Romania to 1474 in Iceland, but typically ranges between 350 and 500 kg/capita with an average value of 425 kg/capita in EU28. The countries having the highest generation of waste in kg/capita are Iceland, Switzerland, Denmark, Portugal, Latvia, followed closely by the Netherlands, Italy and Austria.

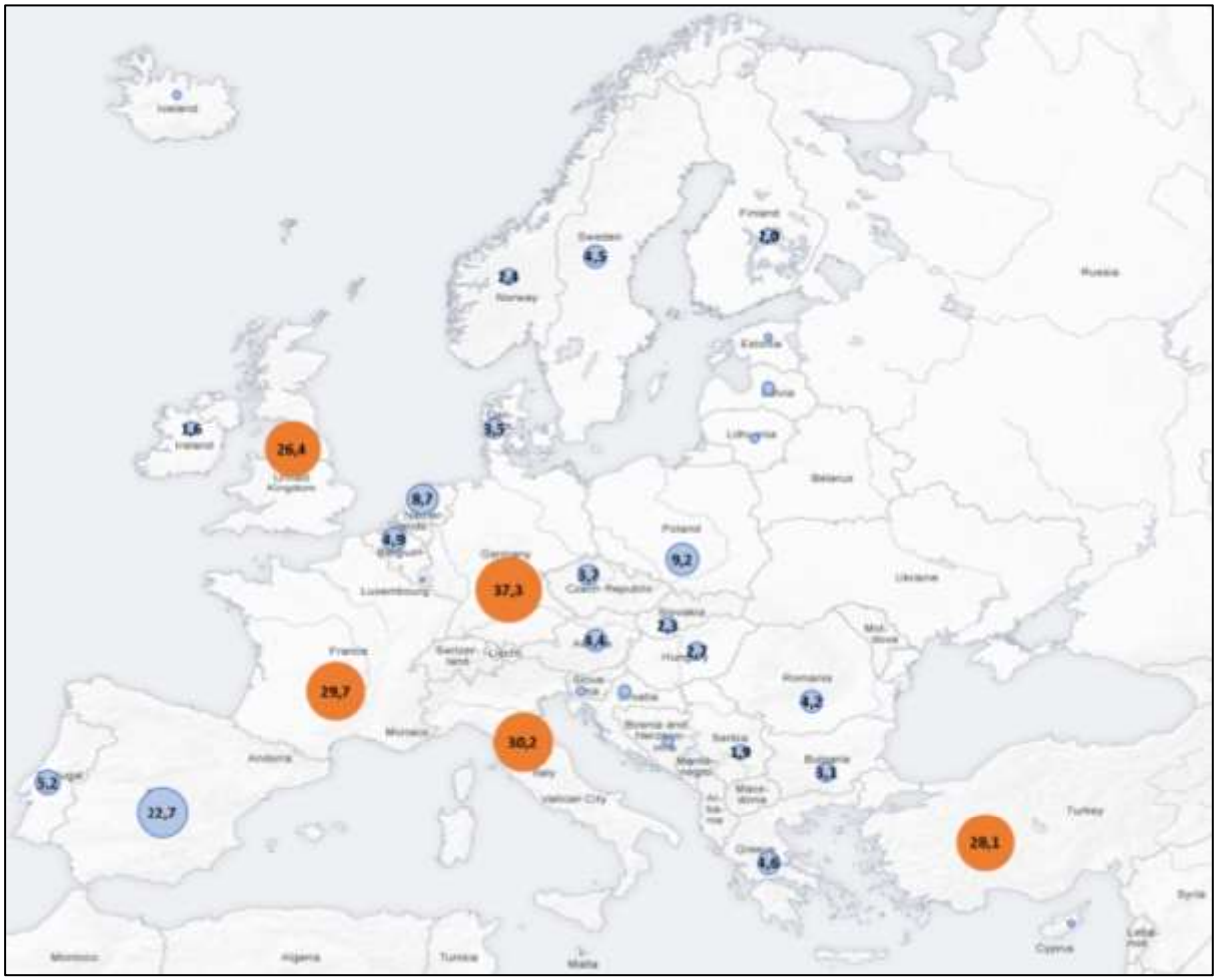


Figure 17: Total waste generated in households (in million tonnes) in 2018 (Source: env_wasgen [3], raw data available in Appendix).

Figure 18: Total waste generated in households (in kg/capita) in 2018 (Source env_wasgen [3], raw data available in Appendix).

The amount of food waste generated from households was obtained from the category of 'Animal and mixed food waste' (code 091). The type of waste included in this category is given in Table 3.

Table 3: Type of waste included in 'Animal and mixed food waste' [16].

Animal and mixed food waste (091)		
Animal waste of food preparation and products (0911)*	Vegetal waste of food preparation and products (0912)*	Mixed waste of food preparation and products (0913)*
- Animal tissue waste - Sludges from washing and cleaning - Fleshings and lime split waste - Liming waste - Organic matter from natural products (wax, grease)	- Sludges from washing and cleaning - Plant tissue waste - Sludges from washing, cleaning, peeling, centrifuging and separation - Materials unsuitable for consumption and processing - Wastes otherwise not specified - Wastes from washing, cleaning and mechanical reduction of the raw material - Sludges from on-site effluent treatment	- Materials unsuitable for consumption - Oil and fat - Organic compostable kitchen waste (including frying oil and kitchen waste from canteens and restaurants) - Wastes otherwise not specified

* - Only non-hazardous waste

While some countries seem to report the organic fraction present in household waste in the category of 'animal and mixed food waste' (e.g., Norway), for some countries (e.g., Germany) no data is available as they instead report food waste generated by households in the category of 'Household and similar waste' (code 101), which is essentially mixed municipal waste. This shows to inconsistency in the way the countries report the data in Eurostat. Both Norway and Germany implement separate food collection from households in some regions but not in others. This means that the generated food waste by the consumers will be partly represented in the separate food collection data and partly in the mixed municipal waste. While Norway seems to report data from separate food collection under 'animal and mixed food waste' from households, Germany chooses to report the separately collected food waste in the category of 'mixed municipal waste'[3].

The data that is available in the category 'animal and mixed food waste' from households is presented for some countries in Figure 19.

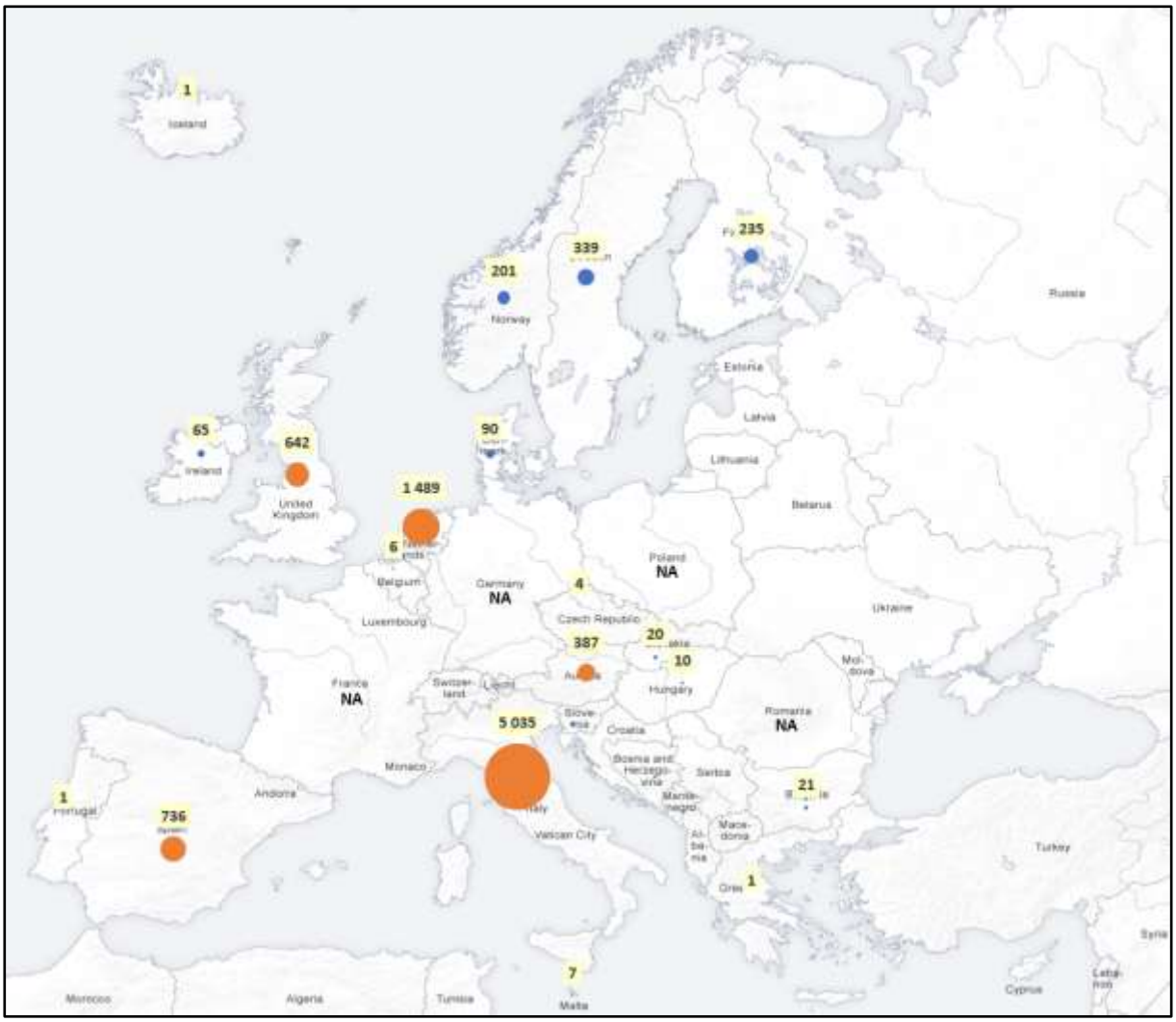


Figure 19: Amount of 'animal and mixed food waste' (in 1000 tonnes) generated by households in 2018 (Source: env_wasgen [3], raw data available in Appendix).

[3] Based on information provided by the German (Destatis) and the Norwegian statistical office (SSB).

The average food waste generation in EU28 was estimated to about 170-180 kg per capita per year [2, 4] and this value is estimated for the whole food supply chain [17]. With a share of 50 %, the food waste from consumption (primarily households) accounts for about 85-90 kg per capita per year. Taking into account the population, the data in Figure 19 can be shown in kg per capita. The values thus obtained are by far below the theoretical estimate of 85-90 kg/capita apart from Italy (83 kg/capita) and The Netherlands (86 kg/capita). This shows that the category of 'animal and mixed food waste' from households does not provide realistic and reliable figures. The data is incomplete as food waste is primarily reported as part of 'mixed municipal waste'. The following reasons were found that make estimation of available food waste in Europe based on data from Eurostat difficult. Similar observations were also made by others [2, 5, 17].

- Variable degree of separate food waste collection and complete lack of domestic sorting in some European countries make it difficult to track how much food waste is generated and therefore the data available today is not sufficient.
- Differences in methodology and inconsistency in how waste data is reported by different countries in Eurostat limits their comparability.
- According to Eurostat " Waste generation statistics has to collect data on the waste in the state that it is generated. That means, that certain materials in the mixed waste streams must not be estimated but published as such. So municipal mixed waste must not be disaggregated even if that was possible.[4]" This makes retrieval of information on general composition of municipal mixed waste (i.e., fractions of plastic, food, and other types of waste) impossible.
- Comparison between Eurostat data and national data reveals significant differences in some cases making the data again less reliable.

3.2.2 Theoretical estimates based on literature

Given the uncertainties and limitations in Eurostat data, theoretical estimates on food waste available in Europe have been calculated based on the values obtained from the literature. The paper by Bräutigam et al. [17] provides an overview of reports and national studies that have been published on food waste generation in the past years. Additionally, it also presents a method for theoretical calculation of food waste along the food supply chain. To estimate the amount of food waste generated in the different countries of Europe, the following approaches were used in this report:

Approach A

Household food waste accounts for about 11 % according [18] or 20 % according to [2] of total municipal waste. It should be noted that a distinction in Eurostat is made between 'municipal waste' and 'household waste'. Data for both categories is available in Eurostat in tables env_wasmun and env_wasgen, respectively [3]. Municipal waste is defined in Eurostat as waste mainly produced by households including similar wastes from sources such as commerce, offices and public institutions. Household waste refers to waste generated in households only. Table 4 shows the data available for household and municipal waste in 2018. On average, household waste represents about 86 % of municipal waste in Europe, however, large differences are observed between the countries. According to Eurostat, this is due to complexity in municipal waste management. National waste management and waste data collection systems vary from country to country which hampers comparability of the

[4] From communication with Eurostat Helpdesk.

data across countries [19]. Due to this, the data on municipal waste cannot be directly compared with the data obtained for household waste.

Table 4: Comparison of municipal and household waste in 2018 (Source: env_wasmun and env_wasgen, resp. in [3].

Geographical location	Total waste in households 2018	Municipal waste 2018	% household in municipal
EU27	189840	221093	86
EU28	216250	251879	86
Austria	4407	5119	86
Belgium	4885	4677	104
Bulgaria	3146	2862	110
Croatia	1294	1768	73
Cyprus	387	562	69
Czechia	3724	5248	71
Denmark	3500	4715	74
Estonia	548	535	102
Finland	2038	3041	67
France	29742	35889	83
Germany	37309	50260	74
Greece	4607	5523	83
Hungary	2743	3729	74
Iceland	520	NA	NA
Ireland	1591	2912	55
Italy	30165	30165	100
Latvia	578	785	74
Lithuania	1416	1301	109
Luxenbourg	191	488	39
Malta	18	321	6
Netherlands	8655	8806	98
Norway	2418	3927	62
Poland	9238	11969	77
Portugal	5213	5213	100
Romania	4178	5296	79
Slovakia	2254	2254	100
Slovenia	643	1009	64
Spain	22699	22229	102
Sweden	4505	4416	102
United Kingdom	26411	30786	86

For the purpose of estimating the theoretical amount of food waste, we have decided to use the data of household waste available in Eurostat and assumed the average fraction of food waste either 11% (Approach A11) or 20 % (Approach A20), as shown in Figure 20.

Approach B

Several studies refer to average food waste generation per capita of about 170-180 kg [2, 4, 17, 20]. This represents the amount of food waste generated along the whole food supply chain [17]. With a share of 50 % (see Figure 2), the food waste from consumption (primarily households) accounts for about 85-90 kg per capita per year. The EU project FUSION has estimated the average total amount of household food waste in Europe to 92 kg/capita/year, with 69 kg/capita/year ending up in municipal waste streams, 15 kg/capita/year in sewers and about 7 kg/capita/year being treated in home-composting [20]. Thus, assuming an average value of 90 kg/capita and multiplying this by the total population in European countries (Eurostat 2019), a theoretical value of food waste generation across

Europe is obtained as shown in Figure 20 (Approach B). Due to differences in dietary habits, the fraction of population living in cities, the level of home-composting, etc., the amount of food waste generated per capita most likely varies across Europe. Based on a study conducted in Portugal involving 44 families in the metropolitan area of Porto [12], the average food waste generation per capita was quantified to 0.2 kg/capita/day or 73 kg/capita/year. This is well below average for the EU27 estimated by Bräutigam et al. [17] (115 kg/capita) and the study in [5] (109 kg/capita). Assuming that the generation of food waste varies between 70 and 110 kg/capita/year, a range of confidence for Approach B is shown in Figure 20. Comparison shows that there is, in general, quite a good agreement between Approach A20 and B while the values of A11 are considerably underestimated. The values of Approach A20 and B are similar apart for some relatively large differences for some countries (e.g., Poland, Romania, Hungary).

Approach C

Approach C is based on data presented in [2], namely Figure 2.2 in [2] presenting the share of bio-waste (food and garden waste) in municipal waste and Figure 3.1 in the same report, presenting the percentage of food waste in municipal bio-waste. Taking the household waste data from 2018 and multiplying this by the percentage of bio-waste and food-waste as estimated in [2] for different European countries, the results indicated by the red curve in Figure 20 were obtained. The correspondence of Approach C compared to Approach A20 and B is relatively good in same cases (e.g., The Netherlands) while in other cases, the values fall completely outside of the confidence range, indicated that the food waste generated per capita per year is in some countries much higher or lower with respect to the confidence range. It is difficult to speculate on reasons behind the discrepancies, but it could be that the percentage of bio-waste and food waste presented in [2] is not accurately estimated for some countries.

Approach D

Approach D is entirely based on theoretical calculations of food waste generated per capita per year presented in Table 3 in [5]. The values of food waste generated range from 79 to 144 kg/capita/year with an average value at 109 kg/capita/year. Taking the calculated values in [5] and multiplying this by the population (Eurostat 2019) results in values given by the yellow curve in Figure 20. The values follow nicely the general trend of Approach B but are generally higher than the confidence range or close to its upper limit.

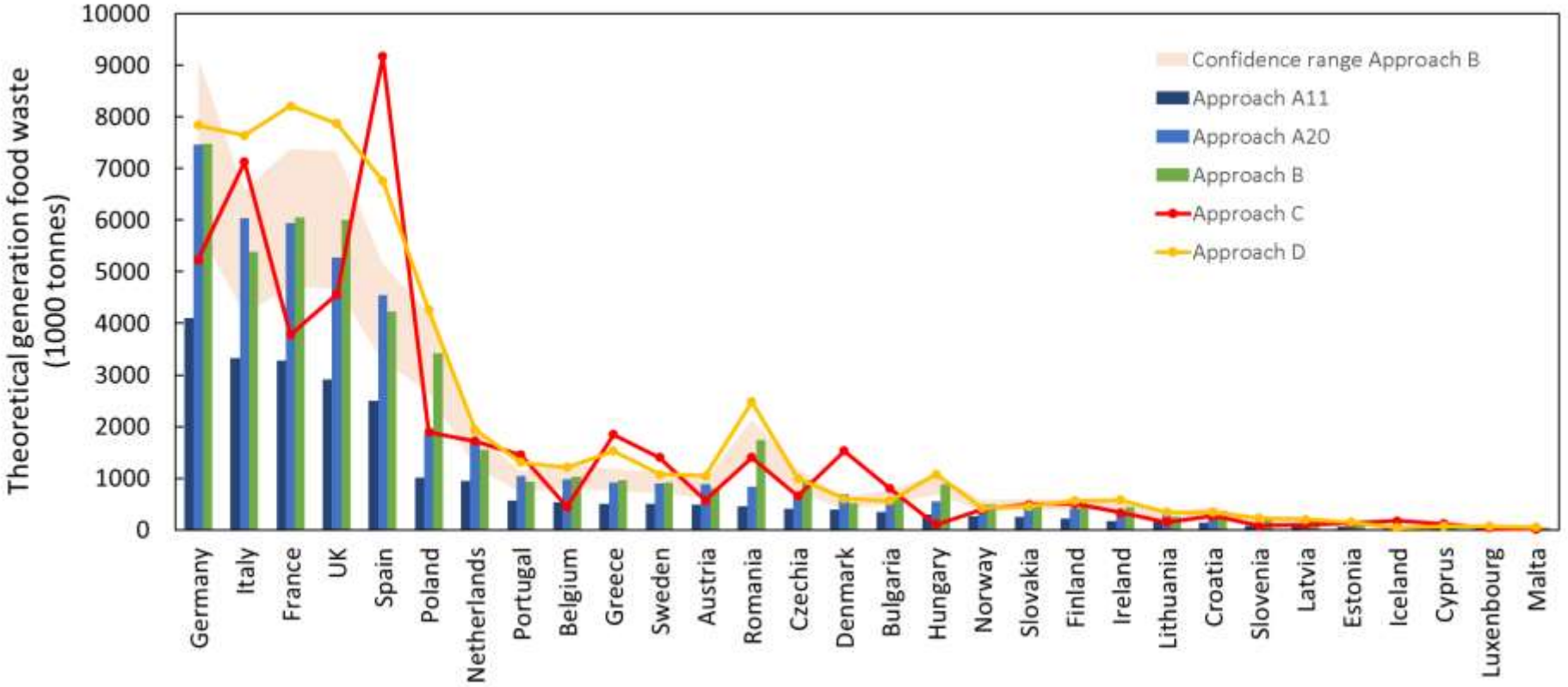


Figure 20: Estimates of generated food waste in European countries based on theoretical estimation combined with data available in Eurostat, confidence range is from 70 to 110 kg food waste generated per capita per year.

3.3 Estimates of food waste ready for biofuels deployment

The EU's Waste Framework Directive (2008/98/EC) sets the guiding principles for waste management. In the food waste hierarchy, the highest priority has waste prevention, followed by re-use, recycling, recovery, and disposal, as the least favourable option of waste treatment (Figure 21). Anaerobic digestion and composting are the most preferable options when it comes to waste treatment, whereas incineration with energy recovery is seen as sub-optimal due to inefficient energy recovery (high moisture content) and loss of nutrients in ashes. The percentage of food waste treated in anaerobic digestion and composting has been growing over the past years and the trend is expected to continue, diverting increasing amounts of food waste from incineration and landfilling in the future.

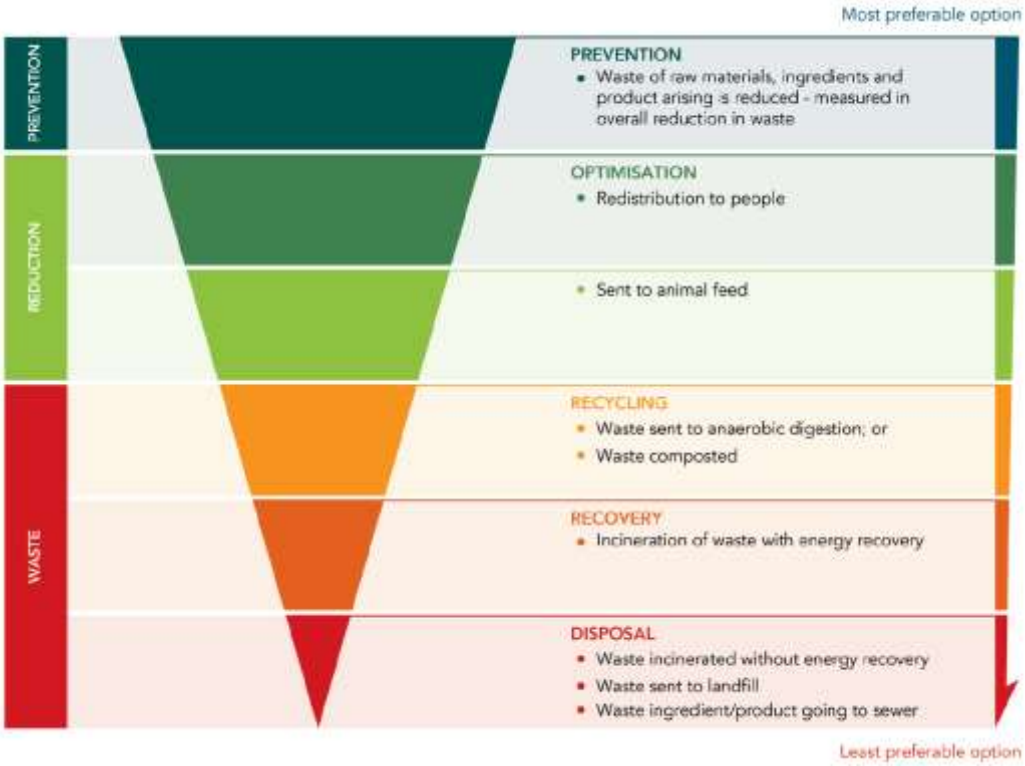


Figure 21: Food waste hierarchy (Source: [4]).

Data on how much household food waste is being treated in anaerobic digestion or composting today could not be found in the available literature. It is possible to find data on treatment of municipal waste in Eurostat (env_munwas) which shows share of waste treated by different methods (Figure 22). The share of municipal waste treated by digestion and composting varies from 2 % in Bulgaria to a maximum of about 30 % in Austria, The Netherlands and Lithuania. This probably covers some household food waste (which could be collectively separated or treated in MBT) but also other types of biodegradable waste like garden waste and sewage sludge. Information about how much household food waste ends up in incineration or landfills across Europe is thus impossible to extract.

Without reliable data on food waste generation, collection and treatment across Europe, estimation of food waste amounts potentially available for biofuel production is not feasible. Any attempts to provide theoretical estimates are only speculative and of limited value until they can be verified with

actual data. Nevertheless, based on an example from Norway, an attempt to provide qualified estimates of food waste available for Europe.

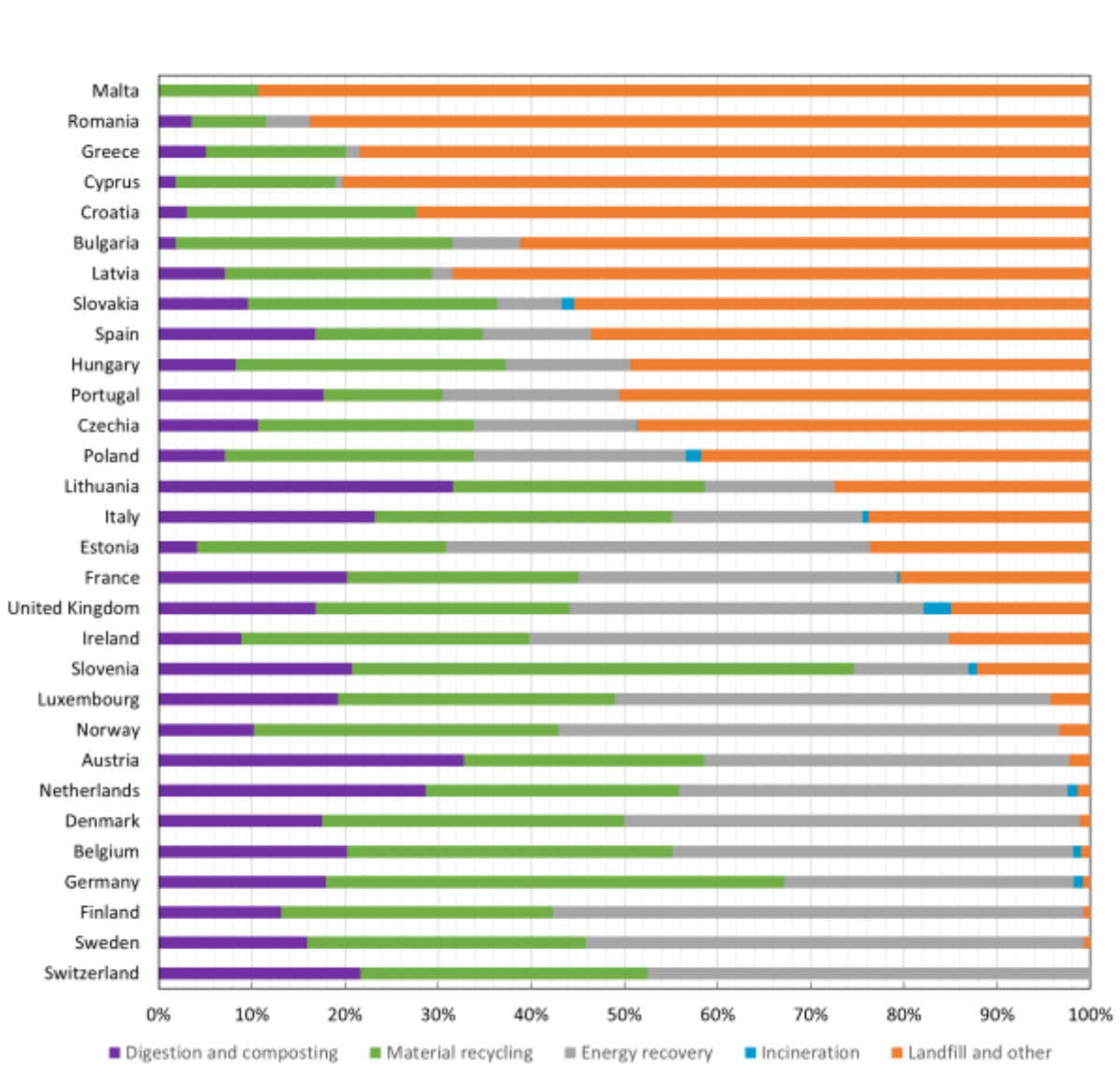


Figure 22: Municipal waste treatment in 2018 (Source: env_munwas [3]), raw data available in Appendix).

Norway is among the leading countries in Europe in separate food waste collection, offering source sorting and door-to-door service to about 70 % of its population [5]. More than 99 % of 'food and wet organic waste' that was separately collected in 2019 (208 905 tonnes) was treated in biogas production (about 76 %) and composting (about 23 %). It has been estimated that about 56 % of the generated food waste by the Norwegian households ends up in mixed municipal waste and goes to incineration [8]. The theoretical generation of food waste by households was then more than twice as much, approximately 475 000 tonnes in 2019. This is in good agreement with the theoretically calculated value provided by Approach B in Figure 20 (480 000 tonnes), assuming an average of 90 kg of food waste generated per capita per year.

With optimized and effective separate collection systems, the maximum achievable amount of food waste that can be collected in urban settings (towns, cities and suburbs) is around 85 % [5, 21]. This

percentage is based on collection rate achieved in Milan, Italy, one of the first cities to implement separate food collection from households [4]. With a collection of up to 85 % of food waste from households, we could get additional 195 835 tonnes of food waste in Norway.

The target for share of energy from renewable sources used in transport has been set in the Renewable Energy Directive (2009/28/EC) to 10 % by 2020 and to 14 % by 2030 (RED update; 2018/2001/EC). In 2019, still many countries in Europe were far away from reaching the target [22]. Co-processing of intermediate bio-oils offers strategies to meeting the targets while contributing to further development of advanced biofuel technology, thus providing an additional method of food waste treatment beside the two current methods, anaerobic digestion and composting.

With the theoretical amount of collected food waste from Norwegian households at 403 750 tonnes/year, the current amounts treated by composting (48 900 tonnes in 2019) and digestion (159 015 tonnes in 2019) correspond to about 12 % and 39 %, respectively, leaving about 49 % potentially available for biofuel production.

Taking 85 % of the values representing theoretical generation of household food waste based on Approach B (green in Figure 20) and assuming about the same split between the treatment methods across the whole Europe (i.e., 10 % composting, 40 % anaerobic digestion, 50 % advanced biofuels), a total amount of about 19 843 ktonnes food waste could be potentially available for the production of advanced biofuels (Figure 23).

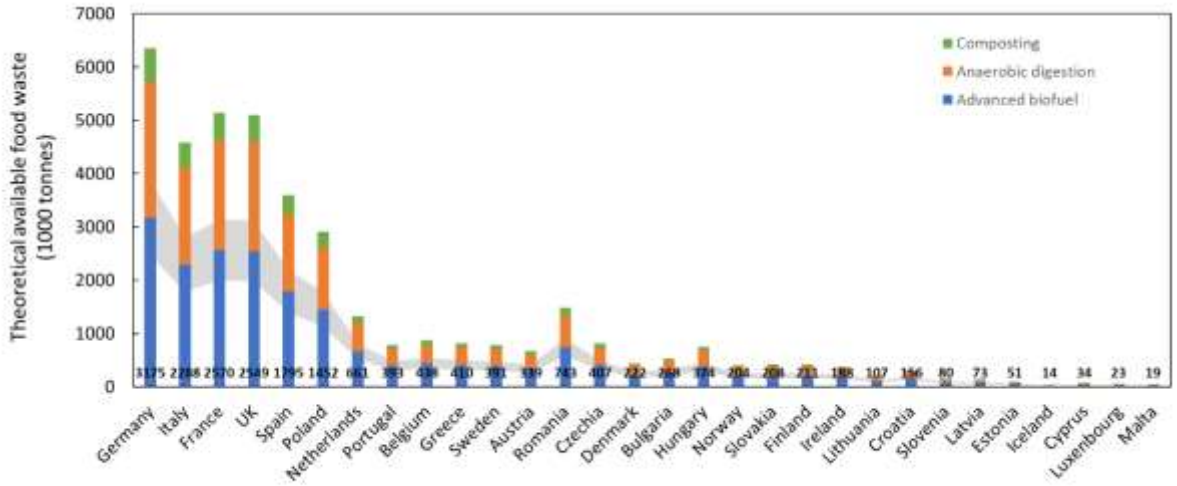


Figure 23: Theoretical available food waste and its potential treatment. Note, the data labels (in black) are shown only for food waste available for production of advanced biofuels (blue bars) with a confidence range (grey).

The Lower Heating Value (LHV) of food waste has been estimated in the WASTE2ROAD project to about 19.5 MJ/kg. Assuming the moisture and ash content in food waste to be 80 wt.% and 5 wt.%, respectively, the calorific value for food waste on as received basis is estimated to 3.7 MJ/kg ($LHV_{as\ received}$). The theoretical energy potential of food waste (TEP_{FW}) in Europe can be then calculated as:

$$TEP_{FW} = FW * LHV_{as\ received} \quad (1)$$

where FW is the amount of food waste in Europe (or any European country) in kg/year.
Thus, the calculated theoretical energy potential of food waste in Europe is about 1.8 Mtoe/year, this is 0.57 % of final energy consumption by road transport [23] and 0.16 % of final energy consumption in Europe in 2017 [3].

4 Contaminated wood

Contaminated wood is one of the feedstocks being tested for fast pyrolysis in the WASTE2ROAD project. It represents class B, which is wood that has received some level of chemical treatment (may contain residues of paint, varnish, glue, coating but no organic halogenated compounds or heavy metals). An example is shown in Figure 24. Contaminated wood, class B, essentially represents a fraction of the total wood waste. Estimating amounts of contaminated wood available across Europe is challenging, due to the different way that wood is classified in different European countries (more on this in Section 4.2). Data on amounts of wood waste generated in different categories ('clean wood', 'moderately treated wood', etc.) is not available in Eurostat but total amounts of wood waste generated on country level are reported.

a b

Figure 24: Examples of contaminated wood (B-type) in The Netherlands (photo BTG) (a) and contaminated wood (B-class) in Finland (photo VTT) (b) [27].

4.1 Wood waste (source Eurostat)

Wood waste is classified in Eurostat into "non-hazardous" and "hazardous". The amount of hazardous wood waste varies across Europe, but overall it represents only a minor fraction of the total amount of wood waste (3.18 % in EU28 in 2018 [3]). The non-hazardous waste is defined in Eurostat as waste coming from wood packaging, sawdust and shavings and other wood wastes [24].

The total amount of non-hazardous wood waste generated in EU28 was 54500 ktonnes in 2018. This represents about 2 % of the total waste generated. The share of wood waste with respect to the total waste varies across Europe from 0.17 % in Greece to 5.74 % in Belgium. The countries with the highest share of wood waste are Belgium, Norway, Slovakia, Finland and Bosna and Herzegovina.

About 5520 ktonnes of wood waste was generated by EU28 households in 2018. This represents about 10 % of total wood waste. The share of wood waste generated by households with respect to total wood waste varies across Europe, from 0 % (possibly because of no available data) up to 75 % in Malta, but in most countries ranging between 10 and 40 %.

The five top countries generating the highest amounts of non-hazardous wood waste are Germany, United Kingdom, France, Italy, and Finland (Figure 25). Apart from Finland, these countries also

generate the highest amounts of non-hazardous wood waste from households, the highest producer being France, followed by Italy, United Kingdom, Germany and Sweden (Figure 26).

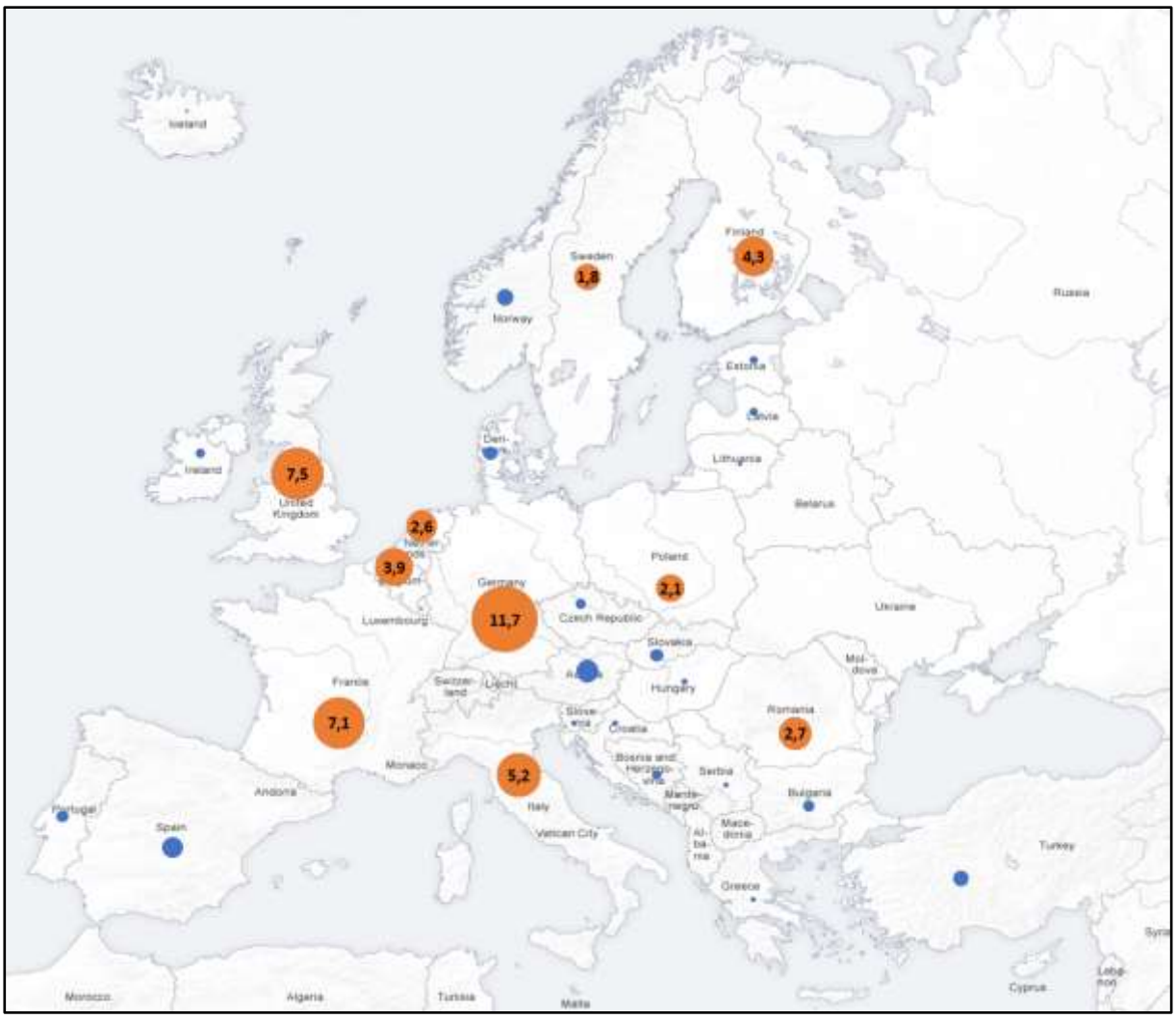


Figure 25: The total amount of non-hazardous wood waste (in Mtonnes) generated across Europe in 2018 (Source: env_wasgen [3], raw data available in Appendix).

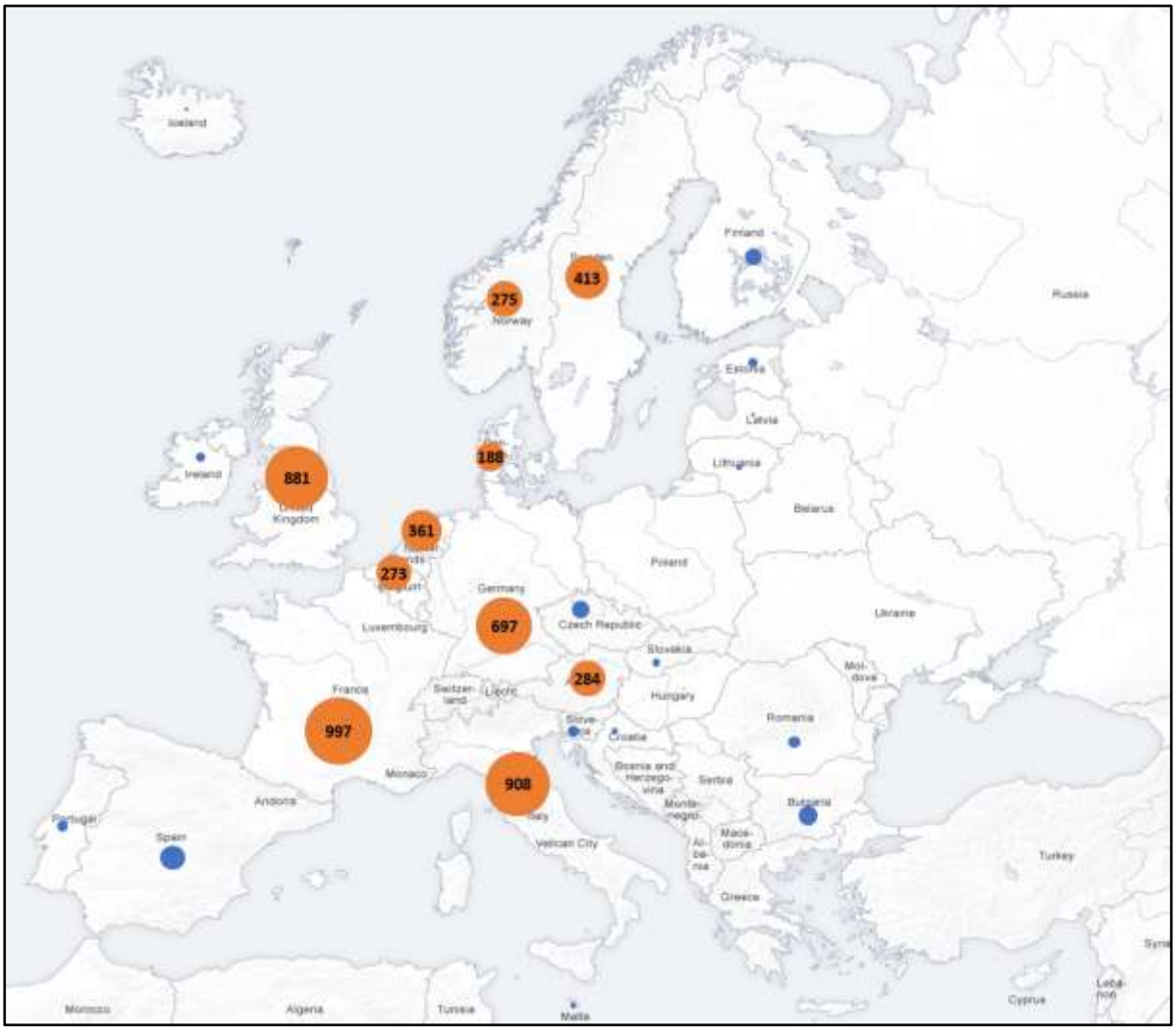


Figure 26: The amount of non-hazardous wood waste from households (in ktonnes) across Europe in 2018 (Source env_wasgen [3], raw data available in Appendix).

Overall, the amount of total wood waste generated seems to decrease in Europe in the years 2004-2018 (Table 5). In some countries, the amount of wood waste considerably increased or decreased, the reasons for this are difficult to speculate about, but it could be related to changes in waste management procedures (increased use or more efficient collection and sorting methods) or changes in industrial activities leading to less waste generated. On the other hand, the amount of wood waste generated by households in Europe seems to increase in the years 2004-2018 (Table 6).

Table 5: Total wood waste generated in Europe in the years 2004-2018, where EU27 and EU28 is without and with UK, resp., from February 1, 2020 (Source: env_wasgen [3]).

	2004	2006	2008	2010	2012	2014	2016	2018	change (%) 2004-2018
EU27	61820000	60900000	61830000	54550000	50190000	44380000	47330000	47040000	-31 %
EU28	66200000	68500000	66200000	58370000	54840000	50260000	53370000	54500000	-21 %
Belgium	1798672	1721002	1530924	2729827	2850516	3280248	3623422	3882374	54 %
Bulgaria	291502	159176	324749	113528	200967	265720	316578	333367	13 %
Czechia	902317	634130	234157	288685	235057	183479	237281	287604	-214 %
Denmark	721091	862325	891401	267993	273130	807167	505444	571406	-26 %
Germany	7064067	8261042	9473035	9729238	10404773	10863359	11697156	11674219	39 %
Estonia	3862773	1790517	1288145	871293	816028	551228	434266	182245	-2020 %
Ireland	556402	400875	147184	504393	203294	318204	293755	210853	-164 %
Greece	102073	745221	829982	349809	120971	91779	94996	78060	-31 %
Spain	2910834	1904383	1922535	1621081	1245091	1069673	1068116	1114863	-161 %
France	8051000	7410540	8609520	8868849	5963455	6122372	6716924	7147773	-13 %
Croatia	218987	133508	190236	155022	97053	91021	91293	95275	-130 %
Italy	2724534	2449793	3424526	3751288	3838139	4331845	4475395	5239390	48 %
Cyprus	54108	32689	17181	24032	6183	3882	4395	6525	-729 %
Latvia	169953	238946	86987	86218	55632	79075	70345	56670	-200 %
Lithuania	189872	219600	231363	300251	180965	125273	142661	156808	-21 %
Luxenbourg	100128	62569	42803	67930	48220	38151	49385	27399	-265 %
Hungary	384321	481504	335700	286568	241071	143259	159254	131839	-192 %
Malta	753	729	154	8172	13339	14601	10097	9738	92 %
Netherlands	1917227	1877834	2206478	2504472	2514371	2508480	2534898	2616516	27 %
Austria	5489860	6277259	6203358	1251661	856951	1130227	1627966	1348171	-307 %
Poland	2186762	2803384	3364628	3504032	3947318	3863632	2560395	2095240	-4 %
Portugal	2660405	1168974	695598	353215	274525	253614	332821	399965	-565 %
Romania	1322533	1458316	1802153	2337485	2072090	2288879	3283172	2731800	52 %
Slovenia	728065	1153821	469706	333720	337646	275464	148160	94146	-673 %
Slovakia	349790	768101	628989	238936	400697	253514	414023	449431	22 %
Finland	13397182	13222571	12403828	12238485	11926012	4227810	4728395	4320632	-210 %
Sweden	3666292	4664627	4473610	1766454	1069587	1194355	1707575	1775392	-107 %
United Kingdom	4377314	7595657	4374462	3812502	4644911	5881289	6039830	7466319	41 %
Iceland	20000	:	57031	16972	16058	17552	25138	27171	26 %
Liechtenstein	:	:	101	518	0	0	0	0	:
Norway	959600	1092606	1127740	1176058	1384579	727497	791645	769470	-25 %

Table 6: Total wood waste generated by households in Europe in the years 2004-2018, where EU27 and EU28 is without and with UK, resp., from February 1, 2020 (Source: env_wasgen [3]).

	2004	2006	2008	2010	2012	2014	2016	2018	change (%) 2004-2018
EU27	1880000	2410000	2670000	:	:	:	4140000	4640000	59 %
EU28	2170000	2950000	3220000	:	:	:	5040000	5520000	61 %
Belgium	27479	211495	235856	246612	167988	171684	234554	272929	90 %
Bulgaria	:	0	0	:	32134	6792	51400	82767	:
Czechia	8617	34273	10215	27866	29616	33641	55033	70399	88 %
Denmark	209974	265070	236657	76101	90575	327001	176429	188497	-11 %
Germany	581865	661304	720532	670517	624903	735461	665722	696884	17 %
Estonia	3764	3569	3919	1955	5359	7528	11859	19332	81 %
Ireland	16661	26882	:	9992	9197	9438	14613	17178	3 %
Greece	:	2713	0	0	0	0	0	846	:
Spain	117273	65747	120655	191545	130509	88583	95081	136153	14 %
France	0	0	0	624775	840381	916810	979676	996757	100 %
Croatia	:	0	0	:	685	8242	0	8817	:
Italy	475833	573402	667414	691793	614080	675449	739357	908217	48 %
Cyprus	0	0	0	7769	0	0	0	0	:
Latvia	:	124	:	0	3314	21927	15251	7361	:
Lithuania	196	1935	2793	9610	1425	1882	2483	3445	94 %
Luxenbourg	506	610	682	2335	649	49	321	250	-102 %
Hungary	25530	0	1464	2940	2071	2131	1311	1178	-2067 %
Malta	265	338	0	6696	9607	11763	7938	7290	96 %
Netherlands	263706	289505	290765	274968	269529	273736	317594	361437	27 %
Austria	121300	142900	162778	197184	220875	234163	253921	283611	57 %
Poland	:	:	0	:	:	:	:	12	:
Portugal	:	0	7813	5232	2634	3810	17133	26896	:
Romania	0	108417	130536	127466	150748	2115	23632	31544	100 %
Slovenia	4972	9402	9128	14189	14086	15998	20365	30103	83 %
Slovakia	:	890	1511	1556	2459	5272	8651	13382	:
Finland	23746	13094	60400	22696	30396	28473	29264	62734	62 %
Sweden	0	0	0	0	0	412000	420670	412870	100 %
United Kingdom	287087	541862	552344	742885	770401	836640	894592	880608	67 %
Iceland	3000	:	:	1905	1802	1930	2765	2989	0 %
Liechtenstein	:	:	0	0	0	0	0	0	:
Norway	94918	146378	176000	190765	234965	274111	283952	274929	65 %

4.2 Classification of wood waste

Classification of wood waste is not unified across Europe. Countries either have their own classification or they do not classify wood waste at all [25]. Most commonly, wood waste is classified in three or four categories to distinguish the level and character of contamination. Examples of wood waste classification followed by some European countries are described below:

The Netherlands

The Netherlands classifies wood waste into three categories [26]:

- A – type wood waste: Clean wood waste with no paint or hazardous substance.
- B – type wood waste: Wood waste with some paint or glue which can be easily cleaned, but no hazardous substances.
- C – type wood waste: Wood waste with hazardous substance(s) (e.g., arsenic or chrome) impregnated or treated for extending the lifetime of the product.

Finland

Finland uses four classes A, B, C and D for categorization of used wood and industrial wood residues and by-products [27]:

- A class: Chemically untreated by-products and residues, and used wood.
- B class: Chemically treated by-products and residues, and used wood – coated, lacquered or otherwise chemically treated but without organic halogenated compounds or heavy metals (no demolition wood).
- C class: Wood with halogenated organic compounds, for example PVC in the coating, which should be incinerated according to waste incineration legislation.
- D class: Preservative-treated wood (for example railway sleepers, transmission and telephone line poles), considered as hazardous waste.

Germany

Germany classifies wood waste into four categories [26]:

- Wood waste category A I: Wood waste in its natural state with no contamination.
- Wood waste category A II: Painted, lacquered or otherwise treated without any halogenated organic chemicals and no wood preservatives.
- Wood waste category A III: Wood waste with halogenated chemicals but no preservatives.
- Wood waste category A IV: Wood waste impregnated with wood preservatives.

Germany was one of the first countries in Europe to establish a wood waste ordinance, including the treatment of hazardous wood waste. This allowed Germany to become one of the highest importers of wood waste and the highest importer of hazardous wood waste in Europe.

United Kingdom

The United Kingdom classifies wood waste into four categories [28]:

- Grade A "Clean" Recycled Wood: Solid softwood and hardwood, packaging waste, scrap pallets, packing cases and cable drums with non-wood content such as nails and metal fixings, minor amounts of paint, and surface coatings.
- Grade B Industrial Feedstock: May contain up to 60 % Grade A plus building and demolition materials and domestic furniture made from solid wood with non-wood content such as nails/metal fixings, some paints, plastics, glass, grit, coatings, binders and glues.
- Grade C Fuel Grade: May contain all of the above (Grades A and B) plus fencing products, flat pack furniture made from board products and DIY (do-it-yourself) materials. High content of panel products such as chipboard, MDF (medium density fibreboard), plywood, OSB (oriented strand board) and fibreboard. with non-wood content such as nails/metal fixings, paints, coatings, glues, paper, plastics, rubber, glass, grit.
- Grade D Hazardous waste: Examples are fencing, transmission poles, railway sleepers, cooling towers with copper/chrome/arsenic preservative treatments, and creosote.

Norway

In Norway, non-hazardous wood waste can be categorized into four fractions, 'clean wood waste', 'treated wood waste', 'wood chips, shavings and bark' and 'mixed processed wood waste', each defined by its own waste code. Examples of types of waste belonging to each category are described

in the Norwegian standard NS9431 [29]. In addition, there is a separate category for hazardous wood waste.

The municipalities in Norway commonly sort wood waste into three categories:

- **Clean wood waste** – wood in its natural state, without any contamination from paints, varnish, or metal.
- **Mixed wood waste** – with residues of paint, glue, varnish, etc.
- **Impregnated wood waste** – hazardous waste containing copper, chrome, or arsenic, treated with creosote.

In some municipalities, wood waste is sorted only in the two latter categories, mixed wood (containing both "clean" and treated and processed but non-hazardous wood) and impregnated wood. An example is Oslo Municipality; Figure 27 shows the type of waste categorized as 'mixed processed wood'. This is a low-quality waste stream because it contains many different types of wood waste, as old furniture, cardboard, painted wood, etc., limiting its potential for material recycling or energy recovery other than incineration. However, it requires extra resources for sorting out the "clean" wood waste fraction, such as employees supervising the reception of waste at the waste management site to ensure correct sorting into different wood waste categories and maintaining the quality of "clean" wood waste well enough. The wood waste collected by municipalities is mostly grounded into wood chips and incinerated with energy recovery.

Figure 27: Two containers with 'mixed processed wood' collected at the recycling station at Haraldrud, City of Oslo (Source: [29]).

4.3 Treatment of wood waste

4.3.1 Data available in Eurostat

Some data on the treatment of wood waste is available in Eurostat. Apart from the total amount of wood waste treated, it is possible to sort the data into different waste management operations (treatment methods) such as landfill and other types of disposal, incineration without energy recovery, energy recovery and recycling and backfilling. According to Eurostat: *"The information on the generation of waste cannot be directly linked to the information on the treatment of waste for several reasons. The generation of waste concerns the waste produced in the country, the treatment of waste the waste treated in the country, so differences can occur due to import and export of waste. Moreover, the generation of waste includes the waste produced by waste treatment activities (sorting, composting, incineration), whereas the treatment table only includes the final treatment. Waste treatment is a process which takes time and in the meanwhile some of the weight might be lost (drying). Also, waste undergoes dismantling and sorting between generation and (final) treatment. A discarded vehicle may not be displayed as such in waste treatment data, but the materials it was composed of like metal, glass, textiles etc. In short, the two components of waste statistics, generation and treatment, will be equal rather by coincidence."*

Although the data on generated and treated wood waste cannot be directly compared for the reasons above, it seems that on average, about 86 % of wood waste generated in EU28 in 2018 was treated in waste management operations [3]. Out of this, about 95 % of wood waste was used for energy recovery or recycled while the rest was disposed of by landfilling or incineration without energy recovery. Figure 28 presents data on wood waste treatment in Europe in 2018, indicating different distribution of waste management operations. Apart from relatively high landfilling in Iceland, Malta and Cyprus and incineration without energy recovery in the United Kingdom, the most common methods of wood waste treatment are energy recovery or recycling. Luxembourg, Sweden, Finland and Norway treat more than 90 % of wood waste in energy recovery while in Portugal, Hungary, Spain, Italy and Poland, wood waste is mostly recycled (close to 80 % or above). This reflects the general waste management approach followed by the countries. Wood waste is primarily incinerated in countries which use incineration (with or without energy recovery) as the primary method of waste treatment to avoid landfilling. Examples are countries especially in North-Western Europe. Finland, Sweden, Norway, Netherlands, and Belgium have the highest amount of waste incinerated (considering waste management operations D10 and R1), ranging from 1151 kg/capita in Finland to 634 kg/capita in Belgium in 2018 [3]. In contrast, the countries in South-Eastern Europe do not have high incineration capacity and are rather dependent on landfilling [30]. To avoid landfilling, these countries are in a way forced and motivated to look for recycling solutions and this could also be one of the reasons for the higher rate of recycling of wood waste seen in, for example, Portugal, Spain and Italy.

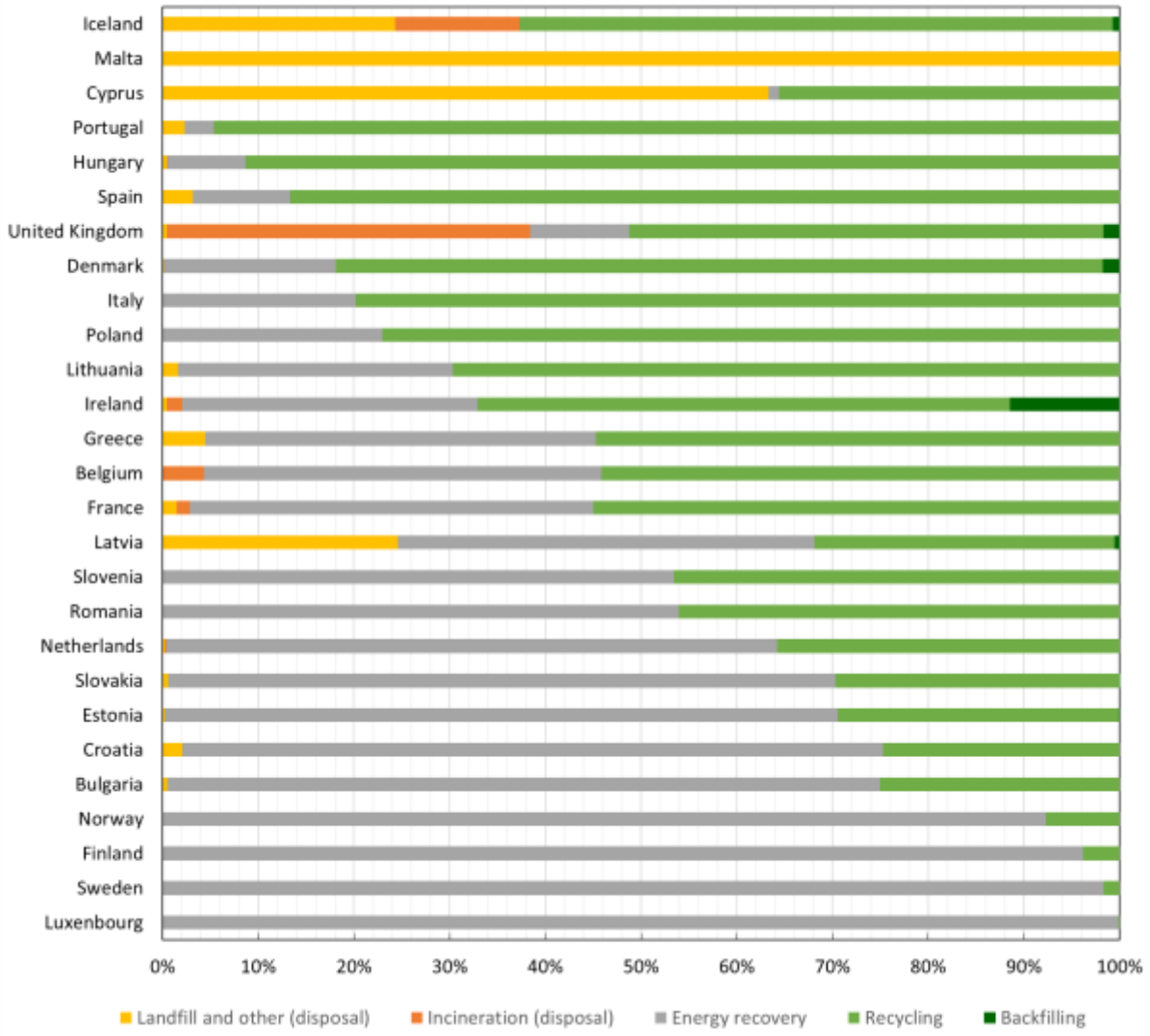


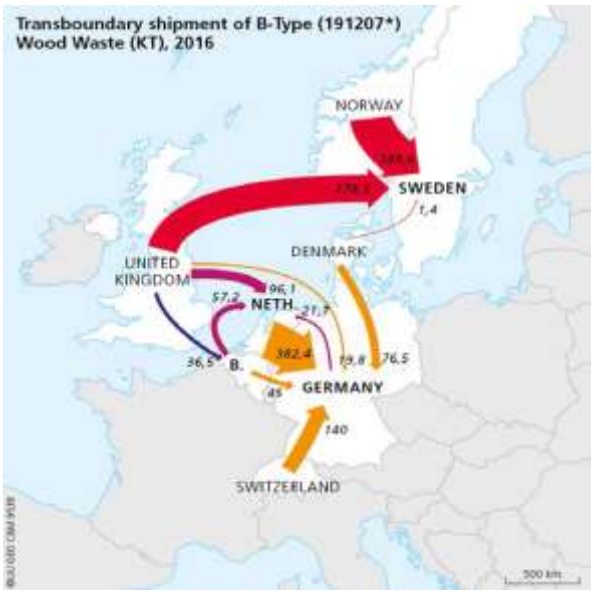
Figure 28: Non-hazardous wood wastes treatment in 2018. Data on Germany, Austria and Czechia were not available for some waste management operations and therefore were not included (Source: env_wastr [3]), raw data available in Appendix).

A considerable amount of wood waste is traded especially in North-Western Europe, between countries that export wood waste and countries that import it either for energy recovery (bio-energy plants) or material recycling (particleboard, panel board, etc.). The transboundary flows of wood biomass have been analysed in an IEA Bioenergy study [26]. The study focused mainly on wood trades in North-Western Europe in the years 2010-2016. Figure 29 shows transboundary flows of non-hazardous (B-type) and hazardous waste in 2016. The figure indicates that Sweden and Germany are major importers of both non-hazardous and hazardous wood waste. Both Germany and Sweden have high incineration capacity in their CHP-plants and the required facilities to deal with hazardous wood waste, which the neighbouring countries lack. The Netherlands is both an exporter of wood waste to Germany and an importer of wood waste from UK and Belgium. The export of wood waste from the Netherlands has decreased after the country established several bioenergy plants in 2012. The major exporters of non-hazardous wood waste are UK and Norway. The amount of wood waste exported from UK has also declined in the past years due to new biomass plants being installed in 2015. The

decline of pulp and paper industry in Norway in the past has led to an increased export of wood biomass (both virgin and used wood chips) [29].

According to an article by wbpi [31], most European countries have particleboard industry but the use of wood waste in the production varies across Europe, from 0 % in Sweden to 95 % in Italy. The average use of wood waste in production of particleboard is 33 % on average in Europe [32]. Belgium uses wood waste in chipboard industry [26].

a



b

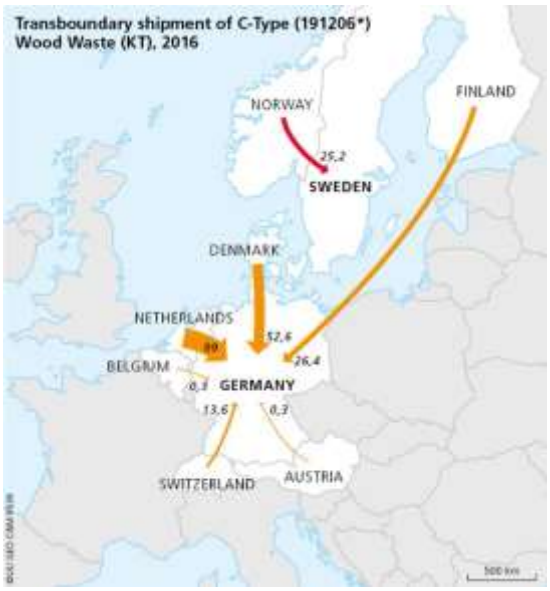


Figure 29: Transboundary shipments of non-hazardous B-type (a) and hazardous (b)wood waste in north-western Europe (Source: [26]).

4.3.2 European strategy for wood biomass

The Waste Framework Directive (2008/98/EC) has introduced the waste hierarchy that acts as a general guideline for waste management strategy, where the top priority is given to waste prevention, followed by preparation for re-use, recycling, recovery and last of all disposal (e.g., landfill). In general, this means that the amount of waste being disposed of by landfills or by incineration without energy recovery should be minimized. The main aim of the directive is to reduce negative effects of waste management on the environment (emission of GHGs and other pollutants) and to promote sustainable and efficient use of resources. Wood biomass represents a renewable feedstock that can replace fossil fuels and it is traditionally used as solid fuel in both private households as well as industrial operations. In terms of waste hierarchy, re-processing of waste into materials which can be used as solid, liquid or gaseous fuels is considered as energy recovery and equivalent to incineration with energy recovery [30]. Thus, the use of wood waste in bio-energy plants and in production of transport fuels can be seen as two competing waste management operations. Diverting wood waste from bio-energy plants to production of transport fuels would mean less wood waste available in bio-energy plants and this would have to be in some way compensated, ideally by renewable resources. It is therefore difficult to estimate amounts of wood waste available for production of transport fuels, when it today represents an important feedstock in bio-energy plants.

Nevertheless, due to the EU requirement of the biofuel share in transport fuels, the production of transport fuels from biomass (including wood) may be in the future the preferred waste management operation, resulting in at least some wood waste diverted from incineration.

The European Panel Federation [5] together with Zero Waste Europe [6] formulated a few recommendations under the new Circular Economy Action Plan, to promote competitiveness of the forest-based sector while ensuring circularity and innovation in wood waste management [33]. The recommendations [33] are listed below:

- *Broaden the application of the waste hierarchy principle to wood materials*
- *Stimulate the cascading use of woody biomass for better resource efficiency throughout the value chain to achieve biomass circularity*
- *Ensure a level playing field by discontinuing financial incentives for biomass energy*
- *Increase recycling targets for all wood wastes and facilitate waste separation*
- *Facilitate sound consumption choices for wood-based products by considering substitution into the carbon accounting*
- *Assess the biogenic carbon storage and substitution into wood-based materials and products for enhancing the life span of carbon sinks*

It is apparent that increase of recycling rate and alternative waste management to wood biomass energy are encouraged. In relation to recycling of woody biomass, the term "cascading use" is often used. Mantau [34] defines cascading use "as multiple use of the wood resources from trees by using residues, recycling (utilization in production) resources or recovered (collected after consumption) resources". The wood flows from resource to end-use in the three main sectors, 'pulp and paper', 'wood production' and 'energy'), have been quantified by Mantau in 2010 for EU27 [34]. According to his analysis, in 2010, the wood resources from trees accounted for 577.1 Mm^3 swe (solid wood equivalent). Wood resources from trees were mostly used in wood production (45 %), followed by energy sector, such as biomass power plants and households (36 %), and pulp and paper industry (19 %). Processing of wood into products and pulp and paper industry resulted together in generation of 176.3 Mm^3 swe industrial residues. These were partly recycled back to pulp and paper sector (19 %), partly in wood production (22 %), and mostly sent to energy use (59 %). The amount of wood biomass sent to energy use accounted for 337.2 Mm^3 swe in 2010. This included from major part wood resources from trees (62 %), followed by industrial residues (31 %) and end-of-life wood products (only 6 %). About 50 % of the consumed wood biomass was used for heat generation in households, 25 % in biomass power plants in the wood industries and 25 % in other biomass power plants (Figure 30). This analysis shows that the recycling rate of industrial residues was 41 % (72.8 Mm^3 swe) in 2010. This corresponds quite well with Eurostat data on recycling rate of wood waste, which was 48 % in EU27 in 2018 [3].

[5] The European Panel Federation represents the manufacturers of wood-based panels being particleboard, dry process fibreboard (MDF), oriented strand board (OSB), hardboard, softboard and plywood.
[6] Zero Waste Europe is the European network of communities, local leaders, businesses, experts, and change agents working towards the same vision: phasing out waste from our society.

According to a report prepared for the European Commission under CASCADES project [35], there is currently stronger focus on the recovery of post-consumer wood (wood products at the end of its life cycle) while there is a disbalance in material and energy uses of industrial residues and a potential to increase cascading in line with the principles of waste hierarchy. On the other hand, it is also mentioned that strict following of the waste hierarchy may not always ensure the best environmental outcome due to technical feasibility, economic viability and environmental protection (cleaning of contaminated waste streams not feasible or due to content of hazardous compounds) [30]. This is also suggested by Knauf [32] who points out that increasing the share of wood waste in material recycling (e.g., production of particleboard) could lead to higher use of fresh wood that would be likely used for energy recovery instead of wood waste. Due to lower calorific value of fresh wood compared to wood waste (wood waste is drier), the environmental benefits of increased recycling of wood waste could be offset by increased burning of fresh wood with a lower calorific value. Close examination is needed to evaluate environmental benefits of increased material recycling and its impact on the energy sector.

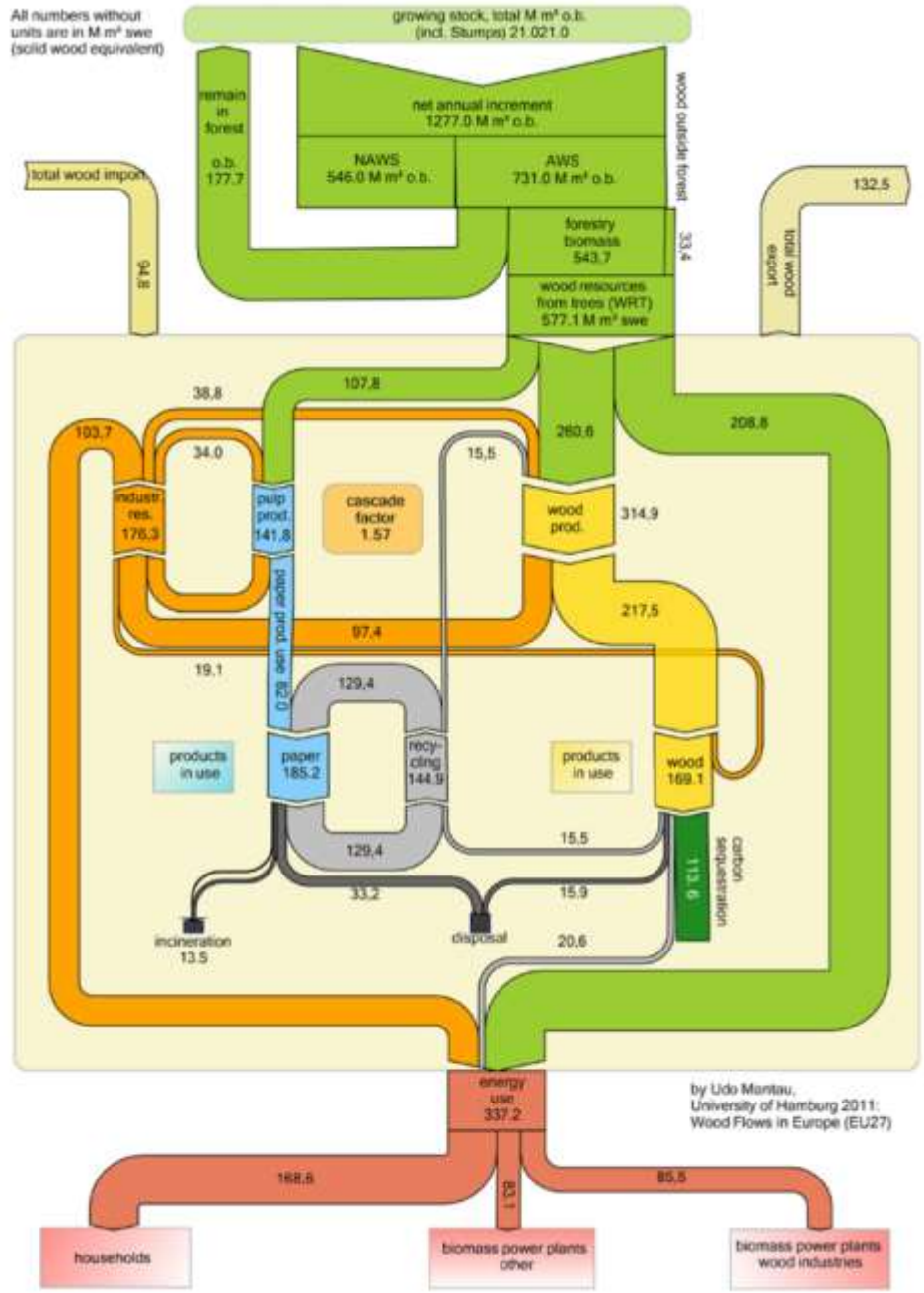


Figure 30: Wood flow chart from resource to end-use (EU27, 2010) (Source: [34]).

4.4 Estimates of wood waste ready for biofuels deployment

According to Eurostat, 22.5 Mtonnes (48 %) of non-hazardous wood waste was used in recycling in EU28 in 2018. It is possible that following the waste hierarchy, the amount of wood waste use in recycling will increase in the future. However, this is difficult to predict. The theoretical potential of wood waste for production of advanced biofuels is thus assumed to be the difference between the total amount of wood waste treated and the amount of wood waste used in recycling (24.4 Mtonnes). About 90 % of this amount is today used in energy recovery. Diverting this feedstock from the use in bio-energy plants to production of transport fuels assumes that the feedstock can be replaced by another renewable source of energy.

The Lower Heating Value (LHV) of contaminated wood was estimated in the WASTE2ROAD project to about 18.5 MJ/kg. Assuming the same value, the theoretical energy potential of wood waste (TEP_{WW}) in Europe can be calculated as:

$$TEP_{WW} = WW * LHV \quad (2)$$

where WW is the amount of wood waste in Europe (or any European country) in kg/year.

The amounts of wood waste available in the different countries are shown in Table 7. It should be noted that the theoretical amounts available in different countries are based on the country's reported **treated** wood waste data. Hence, this does not represent the amount of wood waste that is generated in a country but the amount that is treated, thus also including wood waste that is imported to a country from abroad. The five top countries highlighted in Table 7 are the countries where the amount of wood waste recycled is relatively low compared to the total amount of wood waste treated, resulting in high amounts of wood potentially available for production of transport fuels. These values are thus only theoretical, based on the current amounts generated, imported, and recycled for a given country. Diverting wood waste from incineration would probably alter the import and export of wood waste between the European countries and consequently the theoretical amounts of wood waste available on a country level could be somewhat different from the values shown in Table 7.

The calculated theoretical energy potential of wood waste in EU28 (based on values from 2018) is 451 215 TJ/year or 10.8 Mtoe/year, this is 3.5 % of final energy consumption by road transport [23] and about 1 % of final energy consumption in Europe in 2017 [3].

Table 7: Theoretical energy potential in wood waste (based on Eurostat data from 2018).

	Total non-hazardous WW treated (tonnes)	Non-hazardous WW recycled (tonnes)	Theoretical amounts WW available (tonnes)	Theoretical energy potential (MJ/year)
EU27	41 640 000	19 890 000	21 750 000	402 375 000 000
EU28	46 880 000	22 490 000	24 390 000	451 215 000 000
Belgium	1 529 109	827 548	701 561	12 978 878 500
Bulgaria	445 831	111 658	334 173	6 182 200 500
Czechia	565 971	:	:	:
Denmark	373 952	299 665	74 287	1 374 309 500
Germany	9 963 380	:	:	:
Estonia	112 869	33 164	79 705	1 474 542 500
Ireland	128 202	71 293	56 909	1 052 816 500
Greece	21 891	11 988	9 903	183 205 500
Spain	1 114 863	966 534	148 329	2 744 086 500
France	**7 147 773**	**3 930 241**	**3 217 532**	**59 524 342 000**
Croatia	52 781	13 045	39 736	735 116 000
Italy	3 986 156	3 181 979	804 177	14 877 274 500
Cyprus	6 991	2 488	4 503	83 305 500
Latvia	15 099	4 733	10 366	191 771 000
Lithuania	87 721	61 100	26 621	492 488 500
Luxenbourg	8 479	12	8 467	156 639 500
Hungary	201 364	183 881	17 483	323 435 500
Malta	9 388	0	9 388	173 678 000
Netherlands	**2 282 287**	**817 145**	**1 465 142**	**27 105 127 000**
Austria	1 459 634	1 190 784	268 850	4 973 725 000
Poland	3 582 894	2 760 446	822 448	15 215 288 000
Portugal	172 825	163 581	9 244	171 014 000
Romania	2 561 825	1 180 741	1 381 084	25 550 054 000
Slovenia	71 765	33 419	38 346	709 401 000
Slovakia	333 507	99 101	234 406	4 336 511 000
Finland	**3 261 207**	**124 609**	**3 136 598**	**58 027 063 000**
Sweden	**2 138 880**	**36 250**	**2 102 630**	**38 898 655 000**
United Kingdom	**5 248 321**	**2 600 381**	**2 647 940**	**48 986 890 000**
Iceland	27 170	16 842	10 328	191 068 000
Liechtenstein	:	:	:	:
Norway	769 472	59 144	710 328	13 141 068 000
Montenegro	2 766	1	2 765	51 152 500
North Macedonia	4 092	2 794	1 298	24 013 000
Albania	:	:	:	:
Serbia	50 840	29 292	21 548	398 638 000
Turkey	1 298 288	:	:	:
Bosnia and Herzegovina	:	:	:	:

':' means there is no data available, WW means wood waste.

The revised Waste Framework Directive sets higher targets for material recycling especially for municipal/household waste. Wood waste represents on average 10 % of total household waste in Europe. The share of wood waste generated by households with respect to total wood waste varies across Europe, but typically ranges between 10 and 40 %. The theoretical energy potential of urban wood waste (i.e., wood waste collected from the household sector) is presented in Table 8. The total theoretical energy potential in EU28 is 102 120 TJ/year or 2.4 Mtoe/year. Country-wise, the highest theoretical potential is obviously in countries which generate most wood waste in the household sector, such as France, Italy, United Kingdom, Poland, and Romania.

Table 8: Theoretical energy potential in non-hazardous wood waste generated by households (based on Eurostat data from 2018).

	Non-hazardous WW generated households (tonnes)	Theoretical energy potential (MJ/year)
EU27	4 640 000	85 840 000 000
EU28	5 520 000	102 120 000 000
Belgium	272 929	5 049 186 500
Bulgaria	82 767	1 531 189 500
Czechia	70 399	1 302 381 500
Denmark	188 497	3 487 194 500
Germany	**696 884**	**12 892 354 000**
Estonia	19 332	357 642 000
Ireland	17 178	317 793 000
Greece	846	15 651 000
Spain	136 153	2 518 830 500
France	**996 757**	**18 440 004 500**
Croatia	8 817	163 114 500
Italy	**908 217**	**16 802 014 500**
Cyprus	0	0
Latvia	7 361	136 178 500
Lithuania	3 445	63 732 500
Luxenbourg	250	4 625 000
Hungary	1 178	21 793 000
Malta	7 290	134 865 000
Netherlands	361 437	6 686 584 500
Austria	283 611	5 246 803 500
Poland	12	222 000
Portugal	26 896	497 576 000
Romania	31 544	583 564 000
Slovenia	30 103	556 905 500
Slovakia	13 382	247 567 000
Finland	62 734	1 160 579 000
Sweden	**412 870**	**7 638 095 000**
United Kingdom	**880 608**	**16 291 248 000**
Iceland	2 989	55 296 500
Liechtenstein	0	0
Norway	274 929	5 086 186 500
Montenegro	166	3 071 000
North Macedonia	0	0
Albania	:	:
Serbia	0	0
Turkey	0	0
Bosnia and Herzegovina	399	7 381 500

':' means there is no data available, WW means wood waste.

5 Conclusion

WASTE2ROAD is an EU H2020 funded project, aiming at development of advanced biofuels from selected low-cost, widely available and diverse biogenic wastes. The project looks into the biofuel potential of a number of feedstocks from different waste categories. The waste categories considered are contaminated wood, food (and food-processing) residues and black liquor.

The main aim of deliverable D2.6 is to provide qualified estimates of waste amounts available and ready for biofuel deployment in Europe. One of the WASTE2ROAD's goals is to develop, integrate and optimize 4 complete value chains from a range of diversified organic waste feedstocks to biofuels at relevant industrial scale. The feedstocks currently considered in the project for value chains are:

- for fast pyrolysis contaminated wood and sunflower seed husk, and
- for hydrothermal liquefaction, and food residues (from restaurants and/or households) and black liquor.

The value chains developed for deployment of contaminated wood and food residues appear, at this stage of the project, as most promising and therefore this deliverable focuses mainly on amounts of contaminated wood and food residues from households available in Europe to provide the theoretical potential. Preliminary analysis of amounts of black liquor available in Europe and potential siting of a conversion plant was addressed in WASTE2ROAD's public deliverable D5.2. Amounts of sunflower seed husks available in Europe and potential siting of a fast pyrolysis plant has been addressed in the H2020 Bio4Products project (GA no. 723070).

The presented report provides examples of how waste is handled in some European countries for both food waste and wood waste. The European perspective on how waste should be handled in the context of circular economy transition to ensure maximum resource efficiency while preserving the environment is given. This provides an insight into future directions in waste management in Europe, with higher focus on re-use, recycling, and energy recovery to replace fossil fuels and thereby contribute to reduction of GHG emissions. Taking into account the latest (2018, Eurostat) data on amounts of waste generated in Europe, the currently used treatment methods (recycling, landfilling, incineration, energy recovery), and information available in published reports and literature, an attempt is made to estimate theoretical amounts of food waste and wood waste potentially available for biofuels deployment in Europe in the future.

- **Food waste:** The theoretical amount of food waste potentially available in EU28 has been estimated to 19 843 ktonnes. Taking into account the humidity and ash content, the theoretical energy potential has been estimated to about 1.8 Mtoe/year.

- **Wood waste (total):** The potential amount of wood waste available in EU28 is estimated to 24.4 Mtonnes/year, corresponding to a theoretical energy potential of 10.8 Mtoe/year. This wood waste represents the total amount of wood waste from different industrial sectors including households.

- **Wood waste households:** The amount of wood waste generated in only the household sector represents on average about 10 % of the total wood waste generated in Europe. In 2018, 5520 ktonnes wood waste were generated in EU28. This corresponds to a theoretical energy potential of 2.4 Mtoe/year.

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7 Appendix: Eurostat raw data

Generation of waste by waste category, hazardousness and NACE Rev. 2 activity [env_wasgen]

UNIT	Tonne
HAZARD	Hazardous and non-hazardous - Total
WASTE	Total waste
NACE_R2	Households

GEO/TIME	2004	2006	2008	2010	2012	2014	2016	2018
European Union - 27 countries (from 2020)	179 960 000	183 070 000	188 040 000	192 590 000	185 970 000	180 780 000	187 250 000	191 980 000
European Union - 28 countries (2013-2020)	210 970 000	215 540 000	219 580 000	219 980 000	212 440 000	207 610 000	214 550 000	218 390 000
Belgium	5 325 207	4 745 161	4 459 161	5 862 032	5 294 743	5 419 042	5 041 207	4 885 123
Bulgaria	2 633 592	2 928 981	2 907 121	3 529 458	2 754 523	2 683 016	2 840 316	3 145 709
Czechia	2 841 428	3 482 017	3 176 176	3 334 240	3 232 642	3 260 580	3 579 613	5 804 841
Denmark	2 016 209	2 069 635	2 514 155	3 550 267	3 332 998	3 580 549	3 480 305	3 517 972
Germany (until 1990 former territory of the FRG)	38 007 849	34 626 019	35 754 996	36 311 611	36 471 810	36 887 634	37 409 896	37 308 892
Estonia	401 989	411 633	439 973	430 499	436 420	482 244	429 882	548 242
Ireland	1 702 345	1 978 711	1 677 338	1 730 028	1 656 670	1 524 356	1 513 544	1 591 220
Greece	4 212 962	4 132 645	3 954 486	5 197 519	4 859 163	4 508 249	4 788 941	4 607 377
Spain	24 409 990	24 078 307	24 431 321	23 198 185	21 224 354	20 159 648	21 689 437	22 699 262
France	25 688 700	26 832 200	29 310 520	29 306 586	29 996 157	28 374 300	29 055 944	29 784 969
Croatia	:	183 162	0	0	1 190 553	1 162 112	1 144 199	1 293 535
Italy	31 149 585	32 522 650	32 471 571	32 478 921	29 993 530	29 651 721	30 116 606	30 158 281
Cyprus	367 353	356 520	432 858	1 068 282	369 586	323 859	394 911	386 668
Latvia	543 490	853 889	606 077	694 013	1 213 193	709 118	870 177	577 587
Lithuania	601 749	1 298 932	1 362 620	1 261 400	1 176 825	1 161 764	1 119 279	1 416 112
Luxembourg	221 014	191 580	276 272	250 061	249 010	242 849	639 586	190 568
Hungary	4 442 050	2 978 311	3 466 071	2 864 896	2 680 573	2 951 303	2 886 891	2 742 656
Malta	132 387	130 208	145 817	149 564	149 267	154 478	165 852	185 302
Netherlands	9 455 209	9 416 499	9 434 770	9 084 649	8 862 530	8 523 482	8 549 762	8 654 844
Austria	3 441 041	3 711 839	3 819 277	4 622 626	4 020 113	4 170 023	4 268 278	4 407 376
Poland	6 768 077	6 885 997	6 879 294	8 889 685	9 324 197	8 240 413	9 534 484	9 237 540
Portugal	4 582 610	4 641 103	5 466 307	5 440 930	4 731 431	4 710 465	4 897 262	5 213 148
Romania	3 638 200	6 368 670	6 503 356	5 164 479	4 525 388	3 823 053	4 098 427	4 178 208
Slovenia	660 980	1 088 875	714 165	727 708	641 449	562 375	642 022	643 342
Slovakia	1 475 121	1 623 306	1 772 426	1 719 012	1 656 571	1 732 983	1 889 523	2 254 089
Finland	1 164 497	1 191 220	1 674 400	1 680 763	1 733 525	1 602 959	1 791 659	2 037 761
Sweden	4 079 432	4 340 669	4 393 002	4 038 272	4 193 105	4 172 574	4 410 872	4 505 131
Iceland	141 487	:	:	232 256	232 921	299 413	430 925	519 927
Liechtenstein	:	:	0	0	316 274	26 988	27 167	29 402
Norway	1 933 939	2 199 862	2 224 522	2 228 608	2 437 776	2 426 530	2 444 305	2 418 104
United Kingdom	31 007 480	32 466 328	31 539 338	27 393 710	26 469 736	26 838 419	27 300 581	26 410 926
Montenegro	:	:	:	:	0	187 289	227 055	261 154
North Macedonia	:	:	:	451 382	0	0	0	0
Albania	:	:	:	:	:	:	:	:
Serbia	:	:	:	0	0	1 637 251	1 589 709	1 863 029
Turkey	29 224 710	30 081 820	28 454 025	29 587 465	30 785 436	31 230 000	27 985 092	28 099 214
Bosnia and Herzegovina	:	:	:	:	0	:	:	920 541
Kosovo (under United Nations Security Council Resolution 1244/99)	:	:	:	:	490 045	490 045	302 741	:

Generation of waste by waste category, hazardousness and NACE Rev. 2 activity [env_wasgen]

UNIT	Kilograms per capita
HAZARD	Hazardous and non-hazardous - Total
WASTE	Total waste
NACE_R2	Households

GEO/TIME	2004	2006	2008	2010	2012	2014	2016	2018
European Union - 27 countries (from 2020)	415	419	428	437	422	408	421	430
European Union - 28 countries (2013-2020)	427	433	438	437	421	409	420	426
Belgium	511	450	416	538	477	483	445	428
Bulgaria	341	385	388	477	377	371	398	448
Czechia	279	340	306	318	308	310	339	546
Denmark	373	381	458	640	596	634	608	607
Germany (until 1990 former territory of the FRG)	461	420	435	444	453	456	454	450
Estonia	295	306	329	323	330	367	327	415
Ireland	418	463	374	379	360	327	318	327
Greece	385	375	357	467	440	414	444	429
Spain	569	542	532	498	454	434	467	485
France	411	423	457	452	458	428	435	444
Croatia	:	42	0	0	279	274	274	316
Italy	540	559	552	548	504	488	497	499
Cyprus	505	475	550	1 288	428	380	464	444
Latvia	240	385	278	331	596	356	444	300
Lithuania	178	397	426	407	394	396	390	505
Luxembourg	482	405	565	493	469	437	1 099	313
Hungary	439	296	345	286	270	299	294	281
Malta	330	321	356	361	355	355	364	382
Netherlands	581	576	574	547	529	505	502	502
Austria	421	449	459	553	477	488	489	499
Poland	177	181	180	234	245	217	251	243
Portugal	437	441	518	515	450	453	474	507
Romania	170	300	317	255	226	192	208	215
Slovenia	331	543	353	355	312	273	311	310
Slovakia	275	302	329	319	306	320	348	414
Finland	223	226	315	313	320	294	326	369
Sweden	454	478	476	431	440	430	445	443
Iceland	484	:	:	730	726	915	1 285	1 474
Liechtenstein	:	:	0	0	8 628	725	720	769
Norway	421	472	467	456	486	472	467	455
United Kingdom	517	534	510	436	416	415	416	397
Montenegro	:	:	:	:	0	301	365	420
North Macedonia	:	:	:	220	0	0	0	0
Albania	:	:	:	:	:	:	:	:
Serbia	:	:	:	0	0	230	225	267
Turkey	432	434	400	405	410	405	353	345
Bosnia and Herzegovina	:	:	:	:	0	:	:	263
Kosovo (under United Nations Security Council Resolution 1244/99)	:	:	:	:	271	270	170	:

Generation of waste by waste category, hazardousness and NACE Rev. 2 activity [env_wasgen]

UNIT	Tonne
HAZARD	Hazardous and non-hazardous - Total
WASTE	Animal and mixed food waste
NACE_R2	Households

GEO/TIME	2004	2006	2008	2010	2012	2014	2016	2018
European Union - 27 countries (from 2020)	:	:	:	4 880 000	5 810 000	6 620 000	7 680 000	8 490 000
European Union - 28 countries (2013-2020)	:	:	:	5 220 000	6 300 000	7 090 000	8 240 000	9 140 000
Belgium	:	:	:	7 186	8 828	7 010	6 949	6 379
Bulgaria	:	:	:	0	0	3 791	12 542	21 044
Czechia	:	:	:	2 640	2 612	4 073	5 321	4 367
Denmark	:	:	:	5 191	16 628	21 671	52 216	90 400
Germany (until 1990 former territory of the FRG)	:	:	:	0	0	0	0	0
Estonia	:	:	:	4 743	5 399	4 629	5 780	9 367
Ireland	:	:	:	50 542	56 038	46 839	64 774	65 334
Greece	:	:	:	0	0	0	0	1 160
Spain	:	:	:	558 430	547 564	539 685	596 985	736 377
France	:	:	:	0	0	0	0	0
Croatia	:	:	:	0	0	0	3 815	2 717
Italy	:	:	:	2 484 783	3 077 010	3 719 392	4 483 289	5 035 474
Cyprus	:	:	:	0	0	0	0	0
Latvia	:	:	:	0	18 340	0	0	0
Lithuania	:	:	:	2 969	0	0	4	0
Luxembourg	:	:	:	19 544	25 113	27 361	278	221
Hungary	:	:	:	3 416	4 012	529	9 796	9 508
Malta	:	:	:	0	0	1	2 183	7 433
Netherlands	:	:	:	1 255 689	1 304 361	1 340 373	1 400 097	1 489 135
Austria	:	:	:	170 023	358 804	363 505	385 315	387 027
Poland	:	:	:	0	0	0	0	0
Portugal	:	:	:	28	0	2 268	420	786
Romania	:	:	:	0	0	0	0	0
Slovenia	:	:	:	10 897	19 886	21 036	27 117	32 714
Slovakia	:	:	:	1 540	2 196	3 334	27 206	19 679
Finland	:	:	:	168 474	165 165	222 542	261 041	235 139
Sweden	:	:	:	134 000	199 000	292 313	331 380	339 465
Iceland	:	:	:	2 129	2 654	353	475	602
Liechtenstein	:	:	:	0	1	8	0	15
Norway	:	:	:	171 649	174 264	181 918	189 313	200 561
United Kingdom	:	:	:	343 787	491 494	465 428	561 230	641 727
Montenegro	:	:	:	:	0	4 429	4 738	4 844
North Macedonia	:	:	:	0	0	0	0	0
Albania	:	:	:	:	:	:	:	:
Serbia	:	:	:	0	0	5 555	4 157	0
Turkey	:	:	:	180	2 889	574	:	0
Bosnia and Herzegovina	:	:	:	:	0	:	:	10 351
Kosovo (under United Nations Security Council Resolution 1244/99)	:	:	:	:	0	0	0	:

Municipal waste by waste management operations [env_wasmun]

WST_OPER Waste generated
UNIT Thousand tonnes

GEO/TIME	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
European U	222 000	219 826	214 965	211 477	211 845	213 409	218 027	220 642	221 093	224 503
European U	253 955	250 892	245 378	242 367	242 975	244 884	249 737	251 554	251 879	:
Austria	4 701	4 807	4 883	4 905	4 833	4 836	4 928	5 018	5 119	5 220
Belgium	4 972	5 023	4 944	4 867	4 762	4 643	4 746	4 672	4 677	4 779
Bulgaria	4 094	3 732	3 364	3 135	3 192	3 011	2 881	3 080	2 862	:
Croatia	1 630	1 645	1 670	1 721	1 637	1 654	1 680	1 716	1 768	1 812
Cyprus	576	575	574	532	513	525	539	537	562	566
Czechia	3 334	3 358	3 233	3 228	3 261	3 337	3 580	5 177	5 248	5 338
Denmark	:	4 803	4 508	4 564	4 558	4 671	4 757	4 728	4 715	4 907
Estonia	406	399	371	386	470	473	494	514	535	490
Finland	2 519	2 719	2 738	2 682	2 630	2 738	2 768	2 812	3 041	3 123
France	34 609	34 790	34 484	34 176	34 260	34 344	35 356	35 817	35 889	36 740
Germany	49 237	50 237	49 759	49 570	51 102	51 625	52 133	51 790	50 260	50 612
Greece	5 917	5 586	5 463	5 284	5 315	5 277	5 367	5 415	5 523	5 613
Hungary	4 033	3 809	3 988	3 738	3 795	3 712	3 721	3 768	3 729	3 780
Ireland	2 846	2 823	2 693	:	2 619	:	2 763	2 768	2 912	:
Italy	32 440	31 386	29 994	29 573	29 652	29 524	30 112	29 572	30 165	30 079
Latvia	680	721	658	704	726	798	802	798	785	840
Lithuania	1 253	1 339	1 330	1 280	1 270	1 300	1 272	1 286	1 301	1 319
Luxembourg	344	345	346	335	348	346	474	476	488	491
Malta	249	245	248	247	257	285	292	312	321	350
Netherlands	9 484	9 479	9 203	8 840	8 894	8 866	8 861	8 792	8 806	8 806
Norway	2 295	2 403	2 392	2 518	2 175	2 187	3 946	3 949	3 927	4 151
Poland	12 032	12 129	12 084	11 295	10 330	10 863	11 654	11 654	11 969	12 753
Portugal	5 457	5 178	4 766	4 598	4 710	4 769	4 891	5 007	5 213	5 281
Romania	6 343	5 216	5 044	5 071	4 956	4 904	5 143	5 333	5 296	5 430
Slovakia	1 719	1 679	1 657	1 645	1 733	1 784	1 890	2 058	2 254	2 299
Slovenia	1 004	852	744	853	892	926	943	974	1 009	1 052
Spain	23 774	22 672	21 896	21 184	20 836	21 158	21 542	22 018	22 229	22 438
Sweden	4 140	4 278	4 324	4 371	4 295	4 422	4 439	4 551	4 416	4 611
Switzerland	5 565	5 478	5 576	5 708	6 006	6 030	6 050	5 992	6 012	6 079
United King	31 955	31 066	30 413	30 890	31 129	31 475	31 710	30 912	30 786	:

Municipal waste by waste management operations [env_wasmun]

WST_OPER Waste treatment
UNIT Thousand tonnes

GEO/TIME	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
European U	216 126	214 277	209 136	206 622	207 688	209 326	214 423	216 961	216 955	220 662
European U	247 791	244 946	239 076	237 018	238 169	240 085	246 208	247 956	247 873	:
Austria	4 582	4 632	4 718	4 744	4 673	4 728	4 825	4 944	5 041	5 149
Belgium	4 746	4 778	4 716	4 743	4 684	4 574	4 752	4 632	4 677	4 779
Bulgaria	4 044	3 547	3 164	3 110	3 004	2 960	2 877	3 071	2 859	:
Croatia	1 604	1 633	1 627	1 671	1 582	1 617	1 642	1 649	1 619	1 621
Cyprus	561	539	540	508	479	497	514	511	491	469
Czechia	3 186	3 346	3 233	3 228	3 261	3 337	3 580	4 949	5 028	5 146
Denmark	:	4 803	4 507	4 563	4 559	4 671	4 757	4 728	4 707	4 907
Estonia	340	332	247	336	398	411	453	492	505	458
Finland	2 519	2 718	2 738	2 682	2 630	2 738	2 768	2 812	3 041	3 123
France	34 609	34 790	34 484	34 176	34 260	34 344	35 356	35 817	35 889	36 740
Germany (u	49 236	50 238	49 759	49 570	51 102	51 626	52 133	51 791	50 260	50 612
Greece	5 917	5 586	5 463	5 284	5 315	5 277	5 367	5 415	5 523	5 613
Hungary	4 033	3 809	3 988	3 738	3 713	3 710	3 734	3 752	3 746	3 791
Ireland	2 622	2 558	2 439	:	2 473	:	2 718	2 724	2 865	:
Italy	30 505	29 928	28 765	28 538	27 537	26 926	27 374	26 949	27 488	27 874
Latvia	680	601	615	715	722	738	737	737	676	854
Lithuania	1 143	1 309	1 283	1 246	1 247	1 283	1 211	1 275	1 167	1 157
Luxembourg	344	345	346	335	348	346	474	476	488	491
Malta	239	231	232	230	238	335	259	283	299	352
Netherlands	9 483	9 480	9 202	8 841	8 893	8 866	8 861	8 793	8 806	8 806
Norway	2 258	2 356	2 343	2 485	2 127	2 155	3 946	3 949	3 927	4 151
Poland	10 040	9 828	9 582	9 474	10 331	10 864	11 654	11 654	11 969	12 753
Portugal	5 457	5 178	4 766	4 598	4 710	4 586	4 647	4 783	4 984	5 027
Romania	5 645	4 713	4 261	4 270	4 338	4 288	5 085	5 324	5 134	5 007
Slovakia	1 666	1 609	1 601	1 502	1 528	1 683	1 875	2 057	2 253	2 293
Slovenia	805	796	639	526	530	869	790	773	795	867
Spain	23 774	22 672	21 896	21 184	20 836	21 158	21 542	22 018	22 229	22 438
Sweden	4 140	4 278	4 324	4 371	4 295	4 422	4 439	4 551	4 416	4 611
Switzerland	5 565	5 478	5 576	5 708	6 006	6 030	6 050	5 992	6 012	6 079
United King	31 665	30 669	29 940	30 397	30 481	30 760	31 785	30 995	30 918	:

Municipal waste by waste management operations [env_wasmun]

WST_OPER Disposal - landfill and other (D1-D7, D12)
UNIT Thousand tonnes

GEO/TIME	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
European U	78 615	73 611	67 421	62 897	59 208	56 528	53 955	54 011	53 206	53 397
European U	93 300	86 185	78 702	73 430	67 914	63 745	60 223	59 224	57 819	:
Austria	153	230	207	199	194	144	132	103	113	106
Belgium	81	41	32	42	46	40	38	41	46	44
Bulgaria	3 041	2 568	2 323	2 167	2 217	1 994	1 851	1 903	1 750	:
Croatia	1 537	1 496	1 380	1 413	1 310	1 319	1 288	1 243	1 171	1 073
Cyprus	498	476	467	434	399	410	410	423	393	379
Czechia	2 162	2 167	1 828	1 815	1 827	1 755	1 789	2 355	2 430	2 467
Denmark	:	124	98	78	66	61	56	48	53	46
Estonia	267	239	129	53	30	35	51	99	115	85
Finland	1 136	1 093	901	672	458	315	90	26	22	30
France	10 078	9 731	9 281	8 830	8 490	8 151	7 936	7 681	7 342	7 211
Germany (u	206	247	107	684	682	646	522	450	410	413
Greece	4 903	4 578	4 507	4 421	4 470	4 426	4 415	4 335	4 330	4 359
Hungary	2 838	2 563	2 609	2 415	2 181	1 991	1 888	1 825	1 851	1 918
Ireland	1 496	1 344	1 028	:	537	:	711	623	418	:
Italy	15 015	13 206	11 720	10 914	9 332	7 819	7 432	6 927	6 486	6 283
Latvia	617	531	516	521	515	494	516	518	462	482
Lithuania	1 079	1 034	971	798	748	702	379	421	320	301
Luxembourg	55	50	50	48	50	26	22	21	21	22
Malta	226	207	208	209	218	300	218	248	267	321
Netherlands	145	151	138	131	128	125	127	124	125	124
Norway	137	56	44	52	60	74	167	138	124	154
Poland	8 037	8 400	8 085	6 997	6 031	5 897	5 331	5 331	5 000	5 487
Portugal	3 381	3 048	2 593	2 320	2 307	2 221	2 185	2 335	2 518	2 505
Romania	4 813	4 057	3 427	3 503	3 558	3 522	3 568	4 304	4 269	4 120
Slovakia	1 325	1 240	1 211	1 152	1 158	1 226	1 236	1 246	1 248	1 197
Slovenia	571	481	316	224	208	210	78	99	97	108
Spain	14 789	14 276	13 263	11 801	12 023	12 129	11 658	11 263	11 917	12 116
Sweden	38	33	27	28	27	35	28	20	30	35
Switzerland	0	0	0	0	0	0	0	0	0	0
United King	14 686	12 574	11 281	10 533	8 706	7 217	6 267	5 213	4 613	:

Municipal waste by waste management operations [env_wasmun]

WST_OPER Recovery - energy recovery (R1)
UNIT Thousand tonnes

GEO/TIME	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
European U	40 102	43 551	44 838	49 359	50 375	48 972	53 218	57 333	57 822	58 605
European U	44 220	48 586	50 489	55 773	58 503	58 578	63 855	68 611	69 531	:
Austria	1 636	1 678	1 693	1 716	1 756	1 833	1 855	1 944	1 977	2 004
Belgium	1 850	1 863	1 909	2 031	2 039	2 014	2 065	1 964	1 983	2 021
Bulgaria	0	0	0	49	51	82	109	103	208	:
Croatia	0	0	2	1	3	0	1	1	1	1
Cyprus	0	0	0	0	4	0	2	2	4	5
Czechia	495	607	652	628	600	586	584	901	875	868
Denmark	:	2 643	2 495	2 510	2 424	2 396	2 402	2 429	2 302	2 333
Estonia	0	0	47	214	222	243	242	217	221	221
Finland	441	678	925	1 137	1 316	1 312	1 515	1 646	1 732	1 735
France	11 634	11 832	11 790	11 747	11 852	11 957	12 063	12 195	12 287	12 461
Germany (u	7 722	8 074	8 863	11 471	11 553	12 068	14 260	15 946	15 646	15 980
Greece	0	16	29	29	25	18	27	58	83	74
Hungary	406	408	364	336	373	525	554	608	501	515
Ireland	108	196	427	:	893	:	811	881	1 243	:
Italy	5 387	5 552	5 529	5 970	5 868	2 969	3 866	5 378	5 576	5 711
Latvia	0	0	3	12	11	15	19	21	15	28
Lithuania	1	6	0	91	113	150	221	236	163	179
Luxembourg	130	135	132	132	132	156	221	222	228	229
Malta	0	2	1	1	1	4	1	0	0	0
Netherlands	2 841	3 956	4 405	4 200	4 141	4 057	3 901	3 775	3 668	3 577
Norway	1 154	1 341	1 346	1 446	1 148	1 145	2 113	2 088	2 006	2 053
Poland	0	0	0	563	1 162	1 318	2 114	2 114	2 724	2 742
Portugal	1 058	1 088	930	1 091	974	941	950	989	946	996
Romania	21	47	89	97	133	116	220	227	241	251
Slovakia	171	182	164	174	186	191	197	197	157	125
Slovenia	8	11	9	3	2	158	169	74	98	136
Spain	2 044	2 342	2 112	2 492	2 394	2 685	2 589	2 804	2 580	2 533
Sweden	2 124	2 236	2 271	2 236	2 149	2 284	2 263	2 400	2 362	2 427
Switzerland	2 757	2 732	2 786	2 798	2 790	2 850	2 876	2 846	2 856	2 857
United King	4 119	5 035	5 651	6 414	8 128	9 606	10 637	11 278	11 710	:

Municipal waste by waste management operations [env_wasmun]

WST_OPER Recycling - material
UNIT Thousand tonnes

GEO/TIME	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
European U	55 318	56 472	57 505	56 435	59 383	62 676	64 874	66 014	66 634	68 082
European U	63 387	64 606	65 678	64 894	67 849	71 234	73 513	74 338	75 020	:
Austria	1 272	1 146	1 168	1 202	1 231	1 241	1 254	1 296	1 301	1 363
Belgium	1 669	1 704	1 600	1 539	1 590	1 584	1 575	1 593	1 611	1 631
Bulgaria	1 003	895	749	787	677	573	654	827	849	:
Croatia	53	123	220	228	236	270	322	366	398	484
Cyprus	63	63	65	66	60	69	71	79	84	77
Czechia	452	496	665	686	736	851	958	1 134	1 156	1 175
Denmark	:	1 364	1 215	1 247	1 275	1 356	1 421	1 362	1 525	1 646
Estonia	41	58	52	49	125	117	125	127	130	139
Finland	495	592	589	510	474	770	808	771	886	916
France	6 937	7 184	7 293	7 402	7 605	7 808	8 257	8 706	8 909	9 606
Germany (u	22 476	23 135	23 596	23 094	24 302	25 155	25 435	25 355	24 704	24 293
Greece	872	832	747	647	652	698	743	798	829	898
Hungary	641	654	832	799	923	963	998	1 010	1 085	1 005
Ireland	910	861	829	:	863	:	935	872	851	:
Italy	6 107	7 149	7 177	7 335	7 472	7 864	8 093	8 218	8 675	9 048
Latvia	60	62	84	142	170	182	121	141	150	302
Lithuania	43	244	261	261	268	298	312	311	315	363
Luxembourg	93	98	96	95	99	101	136	141	145	146
Malta	13	19	19	21	19	31	36	34	32	31
Netherlands	2 354	2 291	2 196	2 112	2 112	2 176	2 291	2 327	2 395	2 441
Norway	609	598	620	590	567	572	1 105	1 138	1 217	1 241
Poland	1 783	1 173	1 244	1 499	2 180	2 867	3 243	3 243	3 199	3 192
Portugal	619	595	549	594	765	678	699	604	638	643
Romania	162	173	165	215	256	284	337	393	406	386
Slovakia	98	113	141	108	88	136	291	433	603	616
Slovenia	203	258	270	239	259	430	380	412	429	447
Spain	4 175	3 782	4 277	3 284	3 526	3 892	3 945	4 033	4 009	4 038
Sweden	1 414	1 408	1 405	1 445	1 420	1 418	1 435	1 426	1 320	1 497
Switzerland	1 878	1 895	1 939	1 919	1 960	1 924	1 874	1 846	1 856	1 817
United King	8 069	8 134	8 173	8 460	8 466	8 558	8 640	8 324	8 386	:

Municipal waste by waste management operations [env_wasmun]

WST_OPER Recycling - composting and digestion
UNIT Thousand tonnes

GEO/TIME	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
European U	28 987	28 967	30 335	31 367	32 551	33 122	36 441	37 706	37 675	38 943
European U	33 773	33 889	35 123	36 261	37 595	38 194	41 740	42 913	42 866	:
Austria	1 520	1 578	1 650	1 627	1 492	1 511	1 584	1 601	1 651	1 677
Belgium	1 057	1 028	1 038	1 030	970	900	966	924	932	982
Bulgaria	0	84	92	107	59	311	263	238	52	:
Croatia	13	14	26	29	34	28	31	39	49	63
Cyprus	0	0	7	8	16	18	16	8	9	8
Czechia	76	74	85	96	93	141	245	525	534	602
Denmark	:	672	699	728	794	858	879	889	827	882
Estonia	33	35	19	20	22	17	14	19	20	12
Finland	332	355	323	362	382	341	355	369	400	442
France	5 536	5 610	5 719	5 828	6 007	6 186	6 921	7 079	7 259	7 394
Germany (u	8 298	8 498	8 864	8 536	9 242	9 298	9 523	9 429	9 019	9 442
Greece	142	160	180	187	168	135	182	224	281	283
Hungary	148	184	183	188	236	231	294	309	309	353
Ireland	107	157	156	:	180	:	190	246	245	:
Italy	3 943	3 980	4 339	4 319	4 865	5 203	5 721	5 903	6 334	6 387
Latvia	4	8	13	40	26	47	81	57	48	42
Lithuania	19	23	51	95	119	132	299	308	368	289
Luxembourg	67	62	68	61	67	63	97	91	94	94
Malta	0	3	5	0	0	0	0	0	0	0
Netherlands	2 310	2 360	2 353	2 294	2 415	2 414	2 449	2 474	2 527	2 569
Norway	358	361	333	397	351	365	404	395	382	455
Poland	181	210	202	212	560	661	814	814	848	1 153
Portugal	399	447	694	593	665	745	814	854	881	883
Romania	650	436	580	455	391	365	352	353	181	239
Slovakia	59	69	81	69	91	130	143	181	215	269
Slovenia	22	45	42	58	62	71	144	151	165	176
Spain	2 767	2 272	2 245	3 607	2 894	2 452	3 350	3 918	3 724	3 751
Sweden	564	602	621	663	699	684	715	704	704	653
Switzerland	930	851	851	991	1 256	1 256	1 300	1 300	1 300	1 405
United King	4 786	4 922	4 788	4 894	5 044	5 073	5 299	5 207	5 191	:

Municipal waste by waste management operations [env_wasmun]

WST_OPER Disposal - incineration (D10)
UNIT Thousand tonnes

GEO/TIME	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
European U	13 105	11 675	9 037	6 565	6 172	8 028	4 906	1 348	1 122	1 121
European U	13 110	11 680	9 084	6 661	6 309	8 334	5 766	2 222	2 027	:
Austria	0	0	0	0	0	0	0	0	0	0
Belgium	90	141	138	100	39	36	48	38	39	25
Bulgaria	0	0	0	0	0	0	0	0	0	:
Croatia	0	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0
Czechia	2	3	3	3	4	4	4	4	5	4
Denmark	:	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	0
Finland	115	0	0	0	0	0	0	0	1	1
France	424	433	401	369	306	242	198	155	92	69
Germany (u	10 534	10 284	8 329	5 785	5 324	4 459	2 392	612	480	484
Greece	0	0	0	:	:	:	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0	0
Ireland	1	0	0	:	0	:	0	0	0	:
Italy	53	41	0	0	0	3 071	1 999	256	180	178
Latvia	0	0	0	0	0	0	0	0	0	0
Lithuania	0	2	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	1	0	0
Netherlands	1 833	722	110	104	97	94	94	93	91	95
Norway	0	0	0	0	0	0	0	0	0	0
Poland	39	45	51	203	398	121	152	152	198	179
Portugal	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0
Slovakia	12	4	4	0	4	0	0	0	30	85
Slovenia	1	0	1	1	0	0	19	37	7	1
Spain	0	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0
Switzerland	0	0	0	0	0	0	0	0	0	0
United King	6	5	48	96	137	306	860	874	905	:

Treatment of waste by waste category, hazardousness and waste management operations [env_wastrt]

UNIT	Tonne
HAZARD	Non-hazardous
WASTE	Wood wastes
WST_OPER	Waste treatment

GEO/TIME	2004	2006	2008	2010	2012	2014	2016	2018
European Union - 27 countries (from 2020)	23 670 000	22 680 000	21 470 000	48 240 000	48 480 000	39 850 000	42 810 000	41 640 000
European Union - 28 countries (2013-2020)	26 390 000	25 430 000	23 740 000	51 360 000	51 500 000	43 200 000	46 770 000	46 880 000
Belgium	989 440	440 232	564 543	1 623 547	1 449 848	1 255 340	1 656 923	1 529 109
Bulgaria	0	229	19 159	102 218	154 938	265 723	307 502	445 831
Czechia	225 978	120 338	113 104	65 861	47 742	305 487	540 819	565 971
Denmark	721 093	862 322	891 401	186 342	189 162	256 278	321 763	373 952
Germany (until 1990 former territory of the FRG)	2 221 251	2 501 625	2 641 725	8 770 387	9 373 178	9 557 041	9 831 903	9 963 380
Estonia	180 249	397 816	318 817	719 963	706 816	388 216	379 492	112 869
Ireland	155 017	180 024	158 545	260 531	160 435	185 243	127 961	128 202
Greece	24 000	62 560	87 827	328 468	116 300	59 675	12 887	21 891
Spain	278 626	573 312	1 736 776	1 621 081	1 245 092	1 069 673	1 068 116	1 114 863
France	4 261 000	3 727 120	4 583 175	6 830 653	5 944 917	6 121 636	6 381 724	7 147 773
Croatia	35 372	36 107	19 419	96 007	73 633	26 568	18 295	52 781
Italy	4 247 558	4 378 000	1 789 866	4 240 961	3 847 057	3 651 850	4 880 361	3 986 156
Cyprus	233	2 164	2 303	24 032	11 767	12 569	7 732	6 991
Latvia	1 835	214	450	7 515	18 262	24 589	13 403	15 099
Lithuania	16 981	34 145	59 996	290 255	143 019	94 058	97 039	87 721
Luxembourg	69 716	171 560	68 637	11 971	14 796	805	637	8 479
Hungary	182 882	173 795	134 855	120 483	134 603	128 017	217 710	201 364
Malta	0	0	0	94	940	124	8 850	9 388
Netherlands	1 161 926	652 680	790 757	1 872 495	1 972 929	2 110 915	2 180 529	2 282 287
Austria	2 935 244	2 281 613	3 564 508	988 807	949 642	1 247 577	2 042 446	1 459 634
Poland	930 029	419 349	2 194 249	5 036 676	5 678 070	4 717 366	3 607 281	3 582 894
Portugal	1 109 364	681 178	343 910	261 233	190 813	144 688	129 304	172 825
Romania	79 666	114 491	779 096	2 405 205	3 034 042	3 203 749	3 283 371	2 561 825
Slovenia	74 568	150 179	165 393	330 004	242 074	159 836	99 392	71 765
Slovakia	125 650	420 767	150 580	188 644	331 683	169 733	330 600	333 507
Finland	3 472 000	4 122 000	114 647	10 445 832	11 242 675	3 099 018	3 279 411	3 261 207
Sweden	178 000	178 000	177 745	1 413 833	1 208 296	1 590 267	1 982 916	2 138 880
Iceland	23 000	:	50 000	15 197	14 358	17 550	25 140	27 170
Liechtenstein	:	:	:	:	:	:	:	:
Norway	384 062	358 140	417 744	426 514	1 316 551	725 547	791 642	769 472
United Kingdom	2 715 332	2 746 947	2 271 850	3 113 832	3 016 235	3 356 611	3 959 847	5 248 321
Montenegro	:	:	:	:	:	296	1 896	2 766
North Macedonia	:	:	0	1 861	1 926	3 186	:	4 092
Albania	:	:	:	:	:	0	:	:
Serbia	:	:	:	10 953	52 113	50 534	88 758	50 840
Turkey	77 834	391	117 243	158 597	:	224 126	:	1 298 288
Bosnia and Herzegovina	:	:	:	:	:	:	:	:
Kosovo (under United Nations Security Council Resolution	:	:	:	:	:	:	0	:

Treatment of waste by waste category, hazardousness and waste management operations [env_wastrt]

UNIT	Tonne
HAZARD	Non-hazardous
WASTE	Wood wastes
WST_OPER	Disposal - landfill and other (D1-D7, D12)

GEO/TIME	2004	2006	2008	2010	2012	2014	2016	2018
European Union - 27 countries (from 2020)	:	:	:	700 000	460 000	440 000	390 000	190 000
European Union - 28 countries (2013-2020)	:	:	:	770 000	490 000	460 000	420 000	210 000
Belgium	:	:	:	1 644	163	172	122	92
Bulgaria	:	:	:	7 683	25 832	259	636	2 197
Czechia	:	:	:	18 746	9 870	4 809	5 800	10 420
Denmark	:	:	:	5 099	5 236	1 233	2 013	525
Germany (until 1990 former territory of the FRG)	:	:	:	261	320	0	:	0
Estonia	:	:	:	1 524	134	198	236	242
Ireland	:	:	:	955	0	0	4 310	564
Greece	:	:	:	206 609	79 824	40 959	396	971
Spain	:	:	:	122 554	25 842	42 959	17 640	35 337
France	:	:	:	266 066	274 289	282 442	315 004	102 890
Croatia	:	:	:	8 128	1 130	887	1 086	1 071
Italy	:	:	:	1 923	1 469	720	658	475
Cyprus	:	:	:	17 481	10 589	8 769	5 415	4 426
Latvia	:	:	:	3 752	4 271	4 344	4 429	3 711
Lithuania	:	:	:	975	450	1 448	1 586	1 412
Luxembourg	:	:	:	0	0	0	0	0
Hungary	:	:	:	1 420	1 414	331	528	916
Malta	:	:	:	82	899	49	8 829	9 388
Netherlands	:	:	:	7 241	2 351	1 111	21 691	5 928
Austria	:	:	:	2 746	2 909	0	0	0
Poland	:	:	:	751	345	236	32	256
Portugal	:	:	:	6 696	3 335	532	962	3 975
Romania	:	:	:	1 830	1 264	276	291	101
Slovenia	:	:	:	5 267	275	192	13	13
Slovakia	:	:	:	4 896	4 434	2 591	1 755	1 842
Finland	:	:	:	5 692	1 861	36 207	41	1 056
Sweden	:	:	:	57	6 459	4 389	0	719
Iceland	:	:	:	1 155	2 608	3 968	8 709	6 598
Liechtenstein	:	:	:	:	:	:	:	:
Norway	:	:	:	38 222	44	3 982	4 973	436
United Kingdom	:	:	:	67 151	25 466	24 503	28 291	22 186
Montenegro	:	:	:	:	:	:	23	442
North Macedonia	:	:	:	1 596	1 269	2 918	:	0
Albania	:	:	:	:	:	:	:	:
Serbia	:	:	:	0	0	605	153	0
Turkey	:	:	:	:	:	:	:	:
Bosnia and Herzegovina	:	:	:	:	:	:	:	:
Kosovo (under United Nations Security Council Resolution	:	:	:	:	:	:	0	:

Treatment of waste by waste category, hazardousness and waste management operations [env_wastrt]

UNIT	Tonne
HAZARD	Non-hazardous
WASTE	Wood wastes
WST_OPER	Disposal - incineration (D10)

GEO/TIME	2004	2006	2008	2010	2012	2014	2016	2018
European Union - 27 countries (from 2020)	:	:	:	790 000	910 000	270 000	230 000	170 000
European Union - 28 countries (2013-2020)	:	:	:	790 000	910 000	440 000	970 000	2 160 000
Belgium	:	:	:	313 735	736 352	110 208	110 264	66 161
Bulgaria	:	:	:	153	135	94	466	116
Czechia	:	:	:	323	:	239	48	:
Denmark	:	:	:	0	0	0	0	0
Germany (until 1990 former territory of the FRG)	:	:	:	101 030	4 243	:	:	:
Estonia	:	:	:	18	18	0	0	0
Ireland	:	:	:	16 951	30	0	0	2 033
Greece	:	:	:	0	0	0	5	0
Spain	:	:	:	324	0	0	0	0
France	:	:	:	266 065	89 442	92 100	95 376	97 087
Croatia	:	:	:	948	0	0	0	0
Italy	:	:	:	44 783	12 708	2 788	2 379	278
Cyprus	:	:	:	2 537	0	0	0	0
Latvia	:	:	:	0	472	50	0	0
Lithuania	:	:	:	0	0	0	0	0
Luxembourg	:	:	:	0	0	0	0	0
Hungary	:	:	:	416	45	43	110	57
Malta	:	:	:	12	42	75	0	0
Netherlands	:	:	:	17 305	10 699	790	1 930	1 921
Austria	:	:	:	3 790	:	:	:	:
Poland	:	:	:	2 749	1 561	121	227	497
Portugal	:	:	:	2 330	169	63	223	3
Romania	:	:	:	82	114	14	5 769	76
Slovenia	:	:	:	810	140	1	4	7
Slovakia	:	:	:	318	5 030	1 857	72	77
Finland	:	:	:	15 140	43 814	58 593	3 201	0
Sweden	:	:	:	0	0	0	5 550	65
Iceland	:	:	:	0	0	1 700	1 700	3 538
Liechtenstein	:	:	:	:	:	:	:	:
Norway	:	:	:	61 155	0	561	178	180
United Kingdom	:	:	:	0	0	176 717	745 645	1 993 281
Montenegro	:	:	:	:	:	2	0	0
North Macedonia	:	:	:	265	312	2	:	1 298
Albania	:	:	:	:	:	:	:	:
Serbia	:	:	:	17	20	0	0	0
Turkey	:	:	:	0	0	:	:	192
Bosnia and Herzegovina	:	:	:	:	:	:	:	:
Kosovo (under United Nations Security Council Resolution	:	:	:	:	:	:	0	:

Treatment of waste by waste category, hazardousness and waste management operations [env_wastrt]

UNIT	Tonne
HAZARD	Non-hazardous
WASTE	Wood wastes
WST_OPER	Recovery - energy recovery (R1)

GEO/TIME	2004	2006	2008	2010	2012	2014	2016	2018
European Union - 27 countries (from 2020)	:	:	:	23 960 000	24 490 000	20 890 000	21 100 000	21 370 000
European Union - 28 countries (2013-2020)	:	:	:	24 210 000	24 830 000	21 510 000	21 710 000	21 910 000
Belgium	:	:	:	717 317	53 811	797 178	802 607	635 308
Bulgaria	:	:	:	89 249	79 335	84 343	185 587	331 860
Czechia	:	:	:	34 022	25 441	18 701	14 057	:
Denmark	:	:	:	15 409	17 299	28 561	50 401	67 094
Germany (until 1990 former territory of the FRG)	:	:	:	5 885 420	6 897 337	6 895 823	6 940 983	6 725 316
Estonia	:	:	:	264 755	288 556	206 089	200 048	79 370
Ireland	:	:	:	72 739	18 423	55 991	42 120	39 593
Greece	:	:	:	38 539	10 711	5 496	5 224	8 932
Spain	:	:	:	2 594	1 180	108 117	73 464	112 992
France	:	:	:	1 598 032	1 598 032	1 645 535	1 708 611	3 017 555
Croatia	:	:	:	56 651	21 189	24 360	4 525	38 666
Italy	:	:	:	866 978	775 497	690 596	873 711	803 423
Cyprus	:	:	:	1 544	0	0	130	77
Latvia	:	:	:	3 633	5 552	10 198	6 700	6 575
Lithuania	:	:	:	100 867	84 558	31 627	16 215	25 209
Luxembourg	:	:	:	:	:	:	:	8 467
Hungary	:	:	:	35 979	29 242	10 495	16 051	16 510
Malta	:	:	:	0	0	0	0	0
Netherlands	:	:	:	856 095	996 779	1 240 072	1 279 794	1 457 293
Austria	:	:	:	328 395	438 937	:	:	:
Poland	:	:	:	2 582 366	2 285 781	2 388 993	1 426 384	821 695
Portugal	:	:	:	51 831	26 657	19 159	4 001	5 266
Romania	:	:	:	1 171 254	1 013 974	1 568 543	1 708 530	1 380 907
Slovenia	:	:	:	171 655	202 092	147 636	91 881	38 325
Slovakia	:	:	:	66 658	56 170	56 524	222 396	232 478
Finland	:	:	:	7 630 000	8 417 000	2 889 097	3 153 603	3 135 542
Sweden	:	:	:	1 320 459	1 143 608	1 555 863	1 955 130	2 101 846
Iceland	:	:	:	620	311	0	0	0
Liechtenstein	:	:	:	:	:	:	:	:
Norway	:	:	:	4 057	1 182 362	667 797	715 157	709 711
United Kingdom	:	:	:	247 624	347 466	627 814	609 329	543 691
Montenegro	:	:	:	:	:	287	1 873	2 323
North Macedonia	:	:	:	0	45	107	:	0
Albania	:	:	:	:	:	:	:	:
Serbia	:	:	:	10 846	22 049	13 660	25 889	21 548
Turkey	:	:	:	32 137	38 699	:	116 094	:
Bosnia and Herzegovina	:	:	:	:	:	:	:	:
Kosovo (under United Nations Security Council Resolution	:	:	:	:	:	:	0	:

Treatment of waste by waste category, hazardousness and waste management operations [env_wastrt]

UNIT	Tonne
HAZARD	Non-hazardous
WASTE	Wood wastes
WST_OPER	Recovery - recycling

GEO/TIME	2004	2006	2008	2010	2012	2014	2016	2018
European Union - 27 countries (from 2020)	:	:	:	22 760 000	22 600 000	18 230 000	21 080 000	19 890 000
European Union - 28 countries (2013-2020)	:	:	:	25 560 000	25 180 000	20 680 000	23 510 000	22 490 000
Belgium	:	:	:	590 851	659 522	347 782	743 930	827 548
Bulgaria	:	:	:	5 133	49 636	181 027	120 813	111 658
Czechia	:	:	:	11 843	10 669	281 118	520 523	:
Denmark	:	:	:	165 834	166 627	226 484	269 349	299 665
Germany (until 1990 former territory of the FRG)	:	:	:	2 783 676	2 471 278	:	:	:
Estonia	:	:	:	453 666	418 109	181 929	178 901	33 164
Ireland	:	:	:	142 043	113 675	105 075	69 439	71 293
Greece	:	:	:	83 320	25 765	13 220	7 262	11 988
Spain	:	:	:	1 495 609	1 218 070	918 597	977 012	966 534
France	:	:	:	4 700 490	3 983 154	4 101 559	4 262 733	3 930 241
Croatia	:	:	:	30 280	51 314	1 321	12 684	13 045
Italy	:	:	:	3 327 277	3 057 383	2 957 746	4 003 596	3 181 979
Cyprus	:	:	:	2 470	1 178	3 800	2 187	2 488
Latvia	:	:	:	130	7 966	9 998	2 232	4 733
Lithuania	:	:	:	188 413	58 011	60 983	79 238	61 100
Luxembourg	:	:	:	:	:	:	:	12
Hungary	:	:	:	82 668	103 903	117 148	201 021	183 881
Malta	:	:	:	0	0	0	21	0
Netherlands	:	:	:	991 854	963 100	868 942	877 114	817 145
Austria	:	:	:	653 876	507 772	839 433	1 725 089	1 190 784
Poland	:	:	:	2 450 810	3 390 383	2 328 016	2 180 638	2 760 446
Portugal	:	:	:	200 376	160 652	124 934	124 118	163 581
Romania	:	:	:	1 232 039	2 018 690	1 634 916	1 568 781	1 180 741
Slovenia	:	:	:	151 865	39 552	12 007	7 494	33 419
Slovakia	:	:	:	116 772	266 049	108 761	106 377	99 101
Finland	:	:	:	2 795 000	2 780 000	115 121	122 566	124 609
Sweden	:	:	:	91 958	58 229	30 015	22 236	36 250
Iceland	:	:	:	13 422	11 439	11 591	14 526	16 842
Liechtenstein	:	:	:	:	:	:	:	:
Norway	:	:	:	317 200	134 145	49 007	71 334	59 144
United Kingdom	:	:	:	2 799 057	2 581 136	2 447 482	2 439 508	2 600 381
Montenegro	:	:	:	:	:	:	0	1
North Macedonia	:	:	:	0	300	158	:	2 794
Albania	:	:	:	:	:	:	:	:
Serbia	:	:	:	90	30 044	36 269	62 715	29 292
Turkey	:	:	:	125 457	:	117 278	279 760	:
Bosnia and Herzegovina	:	:	:	:	:	:	:	:
Kosovo (under United Nations Security Council Resolution	:	:	:	:	:	:	0	:

Treatment of waste by waste category, hazardousness and waste management operations [env_wastrt]

UNIT	Tonne
HAZARD	Non-hazardous
WASTE	Wood wastes
WST_OPER	Recovery - backfilling

GEO/TIME	2004	2006	2008	2010	2012	2014	2016	2018
European Union - 27 countries (from 2020)	:	:	:	:	:	20 000	10 000	20 000
European Union - 28 countries (2013-2020)	:	:	:	:	:	100 000	150 000	110 000
Belgium	:	:	:	0	0	0	0	0
Bulgaria	:	:	:	0	0	0	0	0
Czechia	:	:	:	927	:	620	391	:
Denmark	:	:	:	0	0	0	0	6 669
Germany (until 1990 former territory of the FRG)	:	:	:	0	0	0	0	0
Estonia	:	:	:	0	0	0	307	92
Ireland	:	:	:	27 843	28 307	24 177	12 092	14 719
Greece	:	:	:	0	0	0	0	0
Spain	:	:	:	0	0	0	0	0
France	:	:	:	0	0	0	0	0
Croatia	:	:	:	0	0	0	0	0
Italy	:	:	:	0	0	0	17	1
Cyprus	:	:	:	0	0	0	0	0
Latvia	:	:	:	:	0	0	42	80
Lithuania	:	:	:	0	0	0	0	0
Luxembourg	:	:	:	0	0	0	0	0
Hungary	:	:	:	0	0	0	0	0
Malta	:	:	:	0	0	0	0	0
Netherlands	:	:	:	0	0	0	0	0
Austria	:	:	:	0	0	0	0	0
Poland	:	:	:	0	0	0	0	0
Portugal	:	:	:	0	0	0	0	0
Romania	:	:	:	0	0	0	0	0
Slovenia	:	:	:	407	15	0	0	0
Slovakia	:	:	:	:	:	0	0	8
Finland	:	:	:	0	0	0	0	0
Sweden	:	:	:	1 359	0	0	0	0
Iceland	:	:	:	0	0	291	205	192
Liechtenstein	:	:	:	:	:	:	:	:
Norway	:	:	:	5 880	0	4 200	0	0
United Kingdom	:	:	:	0	62 167	80 096	137 073	88 781
Montenegro	:	:	:	:	:	:	0	0
North Macedonia	:	:	:	:	0	0	:	0
Albania	:	:	:	:	:	:	:	:
Serbia	:	:	:	:	:	:	0	0
Turkey	:	:	:	13	:	:	0	0
Bosnia and Herzegovina	:	:	:	:	:	:	:	:
Kosovo (under United Nations Security Council Resolution	:	:	:	:	:	:	0	: