Assessment of waste incineration capacity and waste shipments in Europe

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Content Overview

Executive summary

Objectives of the assessment

In January 2016, the European Commission's DG Environment initiated an exercise on 'Exploiting the potential of waste and energy under the Energy Union Framework Strategy and the circular economy', with the goal of publishing a Communication on waste-to-energy (WtE). The initiative is supported by the Joint Research Centre Institute for Prospective Technological Studies (JRC IPTS) and the European Environment Agency (EEA) in cooperation with the European Topic Centre on Waste and Materials in a Green Economy (ETC/WMGE).

This assessment is split into two thematic parts, Part A which focuses on waste incineration capacity in Europe and Part B which focuses on the trade in waste for energy recovery. Part C draws conclusions based on the analysis in parts A and B.

The objective of Part A is to provide an overview of the current situation in the European Union (EU), Norway and Switzerland, in regard to existing incineration plants for mixed municipal waste and their waste incineration capacity. The focus is on plants that are technically and legally suitable for handling mixed municipal waste without pre-treatment. Due to data and information limitations, the assessment focuses on mixed municipal waste incinerators with and without energy recovery, but excludes co-incineration plants – such as cement kilns, not primarily designed for waste treatment; it also excludes commercial and industrial waste.

In this assessment, waste incineration capacity can be understood as the "total permitted capacities of waste throughput expressed in tonnes per year", used for assessing implementation of the Waste Incineration Directive (WID) (2000/76/EC, repealed by the Industrial Emissions Directive 2010/75/EU). Based on this definition, over- or under-capacity is understood as an imbalance between existing incineration capacity and the generation of mixed municipal waste within a country (as rough approximation).

The objective of Part B is to provide a statistical overview of waste trade flows for incineration in the EU, Norway and Switzerland. In addition, it examines shipments of waste classified as waste collected from households (Y-46) according to the Basel Convention, as well as mixed municipal waste and combustible waste as defined in the European Waste Catalogue (EWC), based on Eurostat data on waste shipments.

Data availability

Data and information on incineration capacity are currently rather scarce. In particular, differentiating capacity according to type of waste poses a challenge. While treated waste is subdivided by type in the statistics, the total plant capacity is not usually documented in terms of the different waste throughputs. In other words, identifying the share of mixed municipal waste and non-municipal waste for the plants is not always possible. Moreover, it is often unclear whether the stated capacity is categorised as permitted or technical. Interpretation difficulties related to different data sources, as well as geographical and time coverage, are indicated where applicable.

Part A Assessment of waste incineration capacity

The total waste-dedicated incineration capacity for mixed municipal waste in the EU, Norway and Switzerland increased by 6 % between 2010 and 2014 to 81 million tonnes a year. The distribution is uneven, with three countries, France, Germany and the Netherlands, accounting for more than half the total incineration capacity. With Italy, Sweden and the United Kingdom included, this reaches 74 %. Particularly in the United Kingdom, incineration capacity has risen steeply. Many of the remaining countries depend heavily on landfill and have no mixed municipal waste incineration plants. In addition, plans for the construction of waste incineration plants in many of them have been halted due to the economic downturn.

The highest waste incineration capacity per person in 2014, at close to 600 kilograms per person, was in Sweden and Denmark, followed by the Netherlands, Switzerland, Austria and Finland. In several of these countries, mixed municipal waste incineration plays an important role in district heating systems.

Another parameter analysed is the ratio between the amount of mixed municipal waste generated and the existing incineration capacity. This roughly indicates the distribution of potential (over-) capacity across Europe. Countries where the amount of mixed municipal waste generated is close to existing incineration capacity, for example Sweden in 2014, may rely on waste imports to exploit their full incineration potential. This could potentially affect the implementation of waste hierarchy principles.

An overall environmental assessment would need to take into account the climate change mitigation effects of using less fossil fuel due to often energy-efficient district heating systems based on waste incineration. This is beyond the scope of this report.

Part B Assessment of waste trade for energy recovery

An imbalance between waste generation and recycling/recovery capacity in domestic markets is a potential driver of international trade in waste, assuming that the use of landfill is increasingly discouraged in all European countries. Rising waste incineration capacity, for example in any country, may thus influence future waste shipment patterns.

Imports and exports of mixed municipal waste for incineration were rather stable during the early years of the last decade, but flows increased substantially from 2008 onwards. Total reported waste imports grew close to five-fold to 1.4 million tonnes in 2013, while total reported exports grew six-fold to 2.3 million tonnes. In spite of this growth, traded flows of mixed municipal waste are still very low relative to a generated total of 242 million tonnes of mixed municipal waste in the EU in 2013.

PART A Assessment of waste incineration capacity

1 Policy context and objectives

1.1 Policy context

In January 2016, DG Environment ([1]) initiated an exercise on "Exploiting the potential of waste and energy under the Energy Union Framework Strategy and the circular economy". This initiative finds its political context in the Energy Union Framework Strategy adopted on 25 February 2015 (COM(2015) 80 final) and the Seventh Environment Action Programme Decision 1386/2013/EU of the European Parliament and Council (OJ L 354/171), which limits energy recovery to non-recyclable waste. The expected output at the end of the process is a Communication on Waste-to-Energy.

The starting point of the initiative involves the circular economy concept of "closing the loop" and the waste hierarchy, which prioritises waste prevention, preparation for reuse, recycling and other recovery over landfill and other forms of disposal. Waste that for technical, economic or environmental reasons cannot be prevented, reused or recycled, might be suitable for energy recovery operations.

Of the thematic areas covered by the initiative, several are assessed by the Joint Research Centre (JRC), namely making existing waste-to-energy (WtE) processes more energy efficient, and identifying untapped potential from waste streams and waste-derived fuels. An area – the unevenly spread WtE (over-) capacity with a focus on mixed municipal waste – is assessed by the European Environment Agency (EEA) and its European Topic Centre on Waste and Materials in a Green Economy (ETC/WMGE).

According to the 2016 DG Environment initiative, some Member States, including Denmark, Estonia and Sweden, appeared to have incineration with energy recovery (over)-capacity, especially for mixed municipal waste, while some countries in the south-eastern EU have no capacity at all and high landfill rates. Such uneven distribution can result in the shipment of waste for energy recovery across the EU. The planned Communication on WtE should thus consider to what extent shipments of combustible non-recyclable waste from Member States with high landfill rates and insufficient WtE capacity to Member States with WtE (over-) capacity might contribute to better waste management and to a more efficient use of the WtE facilities in the EU.

(Over-) capacity for waste incineration ([2]) has been mentioned as a barrier to the transition towards a more circular economy, inter alia by the EEA *State of the environment report* 2015 (EEA, 2015) and the European Commission's Circular Economy Action Plan (EC, 2015). Using spare capacity at waste incineration plants creates a low-cost alternative to material recycling, product reuse and waste prevention, thus counteracting the waste hierarchy.

At the same time, many EU Member States still dispose of considerable amounts of waste in landfill without prior treatment, potentially leading to severe impacts on the environment, for example by causing greenhouse gas emissions (EEA, 2015). These trade-offs between over- and under-capacity need to be systematically taken into account in order to define the role of waste incineration in a circular economy.

([1]) More specifically, unit A2 on waste management and recycling within DG Environment.
([2]) Although some countries do not meet the R1 criterion (with energy recovery) and just dispose of waste.

1.2 Objectives

The objective of Part A of the assessment is to analyse current mixed municipal waste management in Europe with regard to thermal treatment and incineration capacity. A complete overview is given of the capacity of existing incineration plants for mixed municipal waste – expressed as "total permitted capacities of waste throughput expressed in tonnes per year" ([3]) – within the EU, Norway and Switzerland, presented for each individual country. The focus is on waste incineration plants that are technically and legally suitable for treating mixed municipal waste without pre-treatment. The overview builds on work undertaken by the ETC/WMGE since 2014 and takes into account first discussions with DG Environment, JRC, EEA and other stakeholders.

([3]) The term is used in the Waste Incineration Directive (2000/76/EC) questionnaire; 1.1 (d). The Directive is repealed by the Industrial Emissions Directive (2010/75/EU).

2 Methodology

2.1 Key definitions

For a correct interpretation of the analysis, a few terms require explanation. The following definitions are taken from the Industrial Emissions Directive (2010/75/EU), Article 3:

- (39) "'mixed municipal waste' means waste from households as well as commercial, industrial and institutional waste which, because of its nature and composition, is similar to waste from households, but excluding fractions indicated under heading 20 01 of the Annex to Decision 2000/532/EC that are collected separately at source and excluding the other waste indicated under heading 20 02 of that Annex";

- (40) "'waste incineration plant' means any stationary or mobile technical unit and equipment dedicated to the thermal treatment of waste, with or without recovery of the combustion heat generated, through the incineration by oxidation of waste as well as other thermal treatment processes, such as pyrolysis, gasification or plasma process, if the substances resulting from the treatment are subsequently incinerated";

- (41) "'waste co-incineration plant' means any stationary or mobile technical unit whose main purpose is the generation of energy or production of material products and which uses waste as a regular or additional fuel or in which waste is thermally treated for the purpose of disposal through the incineration by oxidation of waste as well as other thermal treatment processes, such as pyrolysis, gasification or plasma process, if the substances resulting from the treatment are subsequently incinerated";

- (42) "'nominal capacity' means the sum of the incineration capacities of the furnaces of which a waste incineration plant or a waste co-incineration plant is composed, as specified by the constructor and confirmed by the operator, with due account being taken of the calorific value of the waste, expressed as the quantity of waste incinerated per hour".

In this report incineration capacity is broadly understood as "total permitted capacities of waste throughput expressed in tonnes per year" as described in the questionnaire designed to assess implementation of the Waste Incineration Directive (WID) (2000/76/EC); question 1.1 (d). The Directive was repealed by the Industrial Emissions Directive (2010/75/EU).

In addition, assessment of (over-) or (under-) capacity was carried out at country level by comparing the existing incineration capacity with the generation of mixed municipal waste designated for incineration.

2.2 Scope

This report focuses on assessing incineration capacity for mixed municipal waste in the EU, Norway and Switzerland.

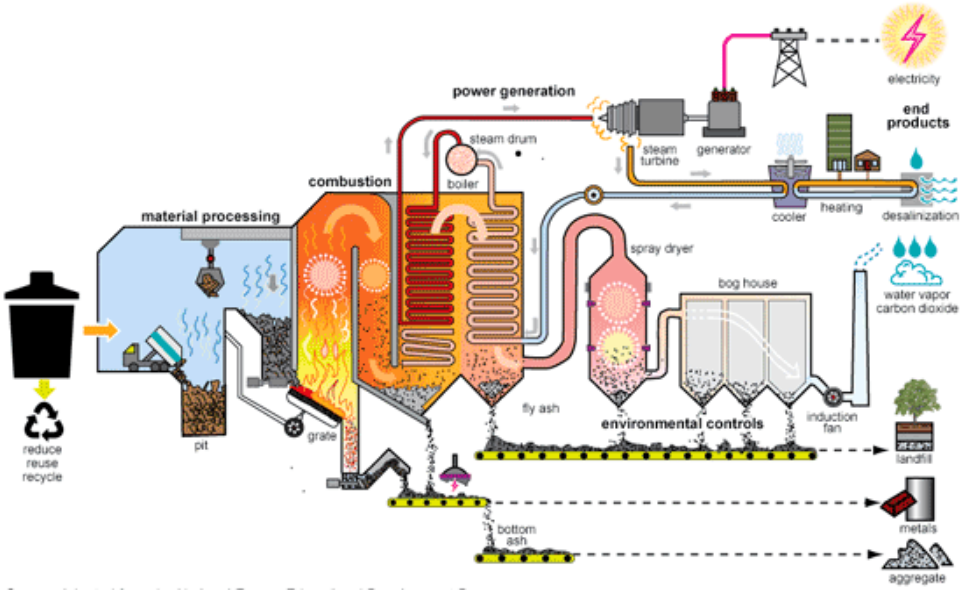
A key interpretation difficulty arising from the available data is the fact that even though the incineration plants under consideration are those designed for mixed municipal waste, such plants can also use other types of waste. Analysis of mixed municipal waste and waste management with and without energy recovery (R1 and D10 respectively) ([4]), does not give the full picture of all waste streams fed into incineration. The study excludes commercial and industrial waste, so is only a partial analysis.

In addition, other types of plants such as refuse-derived fuel (RDF) ([5]) and co-incineration plants also receive mixed municipal waste or municipal waste-derived waste. However, the available data do not provide a complete overview of how much mixed municipal waste is incinerated in RDF or co-incineration plants, nor of how much non-municipal waste is incinerated in plants originally dedicated to mixed municipal waste. In both cases, amounts are limited by quality requirements, especially with regard to the calorific value ([6]) required for input.

Incineration with energy recovery is one of several WtE technologies. Waste in the incineration plant is subjected to elevated temperatures for a predetermined amount of time under controlled conditions (Kranert et al., 2010). A schematic presentation of a mixed municipal waste incineration plant is given in Figure 1, though there is a broad range of plants currently operating across Europe.

([4]) As set out in Annex I on disposal operations (in particular D10) and Annex II on recovery operations (in particular R1) of the Waste Framework Directive (2008/98/EC).
([5]) Refuse-derived fuel (RDF) or solid recovered fuel/specified recovered fuel (SRF) is a fuel produced by shredding and dehydrating solid waste with a waste converter technology. RDF consists largely of combustible components of mixed municipal waste such as plastics and biodegradable waste.
([6]) The calorific value of a fuel is the quantity of heat produced by its combustion – at constant pressure and under standard conditions (i.e. at 0ºC and under a pressure of 1.013 mbar).

Figure 1 Example of a mixed municipal waste incineration plant



Source: EIA (2016).

As previously mentioned, in the Waste Framework Directive (2008/98/EC) the incineration of mixed municipal waste is classified as waste management operation with energy recovery (R1) or without it (D10), according to the energy efficiency criteria.

It should be noted that this report focuses on waste incineration plants that are technically and legally suitable for handling mixed municipal waste without pre-treatment. Accordingly, this report covers only WtE plants and mixed municipal waste treatment in incinerators with and without the R1 standard, but excludes co-incineration plants such as cement kiln and RDF plants.

Interpretation difficulties related to different data sources, as well as the geographical and temporal coverage of the data, are indicated where applicable.

2.3 Data availability

Information about the availability and current utilisation of incineration capacity is rather limited. In particular, differentiating capacity according to waste type is challenging. While treated waste is subdivided in the statistics by type of waste, total plant capacity is not usually documented by the different waste throughputs, so identifying the share of mixed municipal waste and non-municipal waste in specific plants is problematic. Moreover, it is often not clear whether the stated capacities are permitted or technical.

2.3.1 Data sources

This report draws on different studies and data sources that provide information on specific treatment capacities, such as incineration or waste streams.

- **Statistical data from Eurostat**: Eurostat has reported the number and capacity of recovery and disposal facilities under a Nomenclature of Territorial Units for Statistics (NUTS) 2 ([7]) for regions since 2008. These figures do not relate specifically to mixed municipal waste incineration plants, but rather include all different types of waste incineration plants, including specific plants for medical waste or industrial RDF plants. With regard to capacity as well as waste flows, Eurostat data referring to waste incineration is subdivided by the treatment types, D10 (incineration without energy recovery) and R1 (incineration with energy recovery), as set out in Annex I and II of the Waste Framework Directive (2008/98/EC).
- **Confederation of European Waste-to-Energy Plants (CEWEP) County Reports**: the CEWEP County Reports give an overview of waste management plants, in particular incineration plants across Europe. The data is classified by plant type: WtE and RDF plants. While information about the number of each type of plant is available, their respective capacities are only partially stated. In addition, the County Reports record each country's capacity development in comparison to the previous report. For the purposes of this assessment, CEWEP provided the latest information extracted from a survey conducted in 2016, which included incineration capacity figures for 2014.
- ***Waste to Energy State-of-the-Art Report*** **provided by the International Solid Waste Association (ISWA), (Haukohl 2012)**: 2011 data on WtE plants is available for about half of EU Member States. The data refer to all WtE plants the capacity of which exceeds 15 tonnes per day or 10 000 tonnes per year. The statistical data show the number of plants in each country and the percentage of plants for which further technical data is needed.
- ***Screening of Waste Management Performance of EU Member States*** **provided by the BiPRO consultancy for integrated solutions, 2012**: a report for the European Commission provides further information on incineration capacity as well as highlighting data gaps. The report screens the waste management performance of all EU Member States. Although no specific data have been documented, the report is a source of country-specific references, such as information available in national waste management plans (WMPs).
- **National waste management plans (WMPs)**: Article 28 of the Waste Framework Directive (Directive 2008/98/EC) states that "waste management plans shall contain […] sufficient information […] on the capacity of future disposal or major recovery installations". Thus EU Member States are obliged to develop WMPs that contain data on waste treatment capacity. For some countries, including Germany and Sweden, site-specific data is given for mixed municipal waste incineration plants.

The data analysed in this report are based on publicly available data as well as inputs from key stakeholders, including national environment protection agencies and associations of waste incineration plant operators. Key data sources include national inventories of mixed municipal waste incineration plants. These inventories have been analysed by the ETC/WMGE and cross-checked with the results of the 2016 CEWEP survey. Plant-specific figures have been described in detail in Wilts and von Gries 2014 and 2015. The overall results of the report do not, however, provide a comprehensive overview across all European countries, so general conclusions should be drawn with caution.

[7] The Nomenclature of Territorial Units for Statistics (NUTS) is a geographical nomenclature subdividing the economic territory of the EU into regions at three different levels: NUTS 1, 2 and 3, respectively moving from larger to smaller territorial units.

It should be noted that the 2016 CEWEP overview on European waste incineration plants shows different results for some countries when compared to previous editions. In the latest survey, some countries, especially Germany, include information on RDF plants. In this assessment, limited information on RDF incineration capacity in Europe is covered in Chapter 4.1.

The following Annexes of this report provide more details on the data analysed and the original data sources by country:

- Annex 1 National sources for data on incineration capacity for mixed municipal waste in Europe;
- Annex 2 Figures on total incineration capacity excluding co-incineration in Europe, by country, 2014;
- Annex 3 Figures on incineration capacity, mixed municipal waste recycling rates and mixed municipal waste landfill in Europe, by country, 2014;
- Annex 4 Number of plants in the EU-27, 2012–2013.
- Annex 5 Municipal solid waste incineration capacity taking into account sorting residues in Europe, by country, 2014

2.3.2 Data uncertainties

Assessment of the capacity of a waste incineration plant "is influenced by many factors such as heating values, optimized operations control systems or the mechanical pre-treatment of wastes […]" (Richers, 2010), and lack of information on these factors could limit the analysis. In reality, the "total capacity" of an incineration plant encompasses various types of capacity, including the amount of mixed municipal waste incinerated plus additional capacity that could be utilised for mixed municipal waste (based on price, availability, etc.), plus additional capacity that cannot be utilised for mixed municipal waste, due to long-term contracts, technical limitations, etc., and unused capacity that is usually kept to a minimum.

With regard to the calorific value of waste input, waste incineration plants for mixed municipal waste are usually designed to have a specific incineration capacity determined by the waste volumes requiring incineration and the amount of heat from the incineration process that can be used by surrounding industrial facilities or district heating schemes. The combustion chamber and boiler of the incineration plant are adjusted to the resulting heat and flue gas quantity (Richers, 2010). If heating temperatures are increased, waste throughput has to be reduced to avoid thermal overload. As such, waste volumes and incineration capacity may fluctuate over time (Richers, 2010).

Reasons for varying operating temperatures include changes in the material composition of generated waste within specific disposal areas, for example by introducing additional separate collection schemes for higher calorific-value waste streams, such as packaging, or lower calorific-value waste streams, such as bio-waste. In addition, the pre-sorting of waste streams can significantly influence temperatures during the incineration process, particularly the separation of secondary fuels and the separate incineration of waste wood and bulky waste. For example, for the Netherlands it has been reported that the average ratio of mixed municipal waste to other waste streams is about 70:30, and the average calorific value of the waste fed into the incinerators is in the range of 9–10 megajoules per kilo (MJ/kg) (Manders, 2013). For comparative purposes dry wood, for example, has a calorific value of 14.4–17.4 MJ/kg, while coal ranges from 15 to 27 MJ/kg.

Technical changes may also influence annual incineration capacity, including the addition of new boilers or replacement of old ones, improvement in control engineering or the operational control system enabled by technical progress, and the annual operating time which can be influenced by improved corrosion protection.

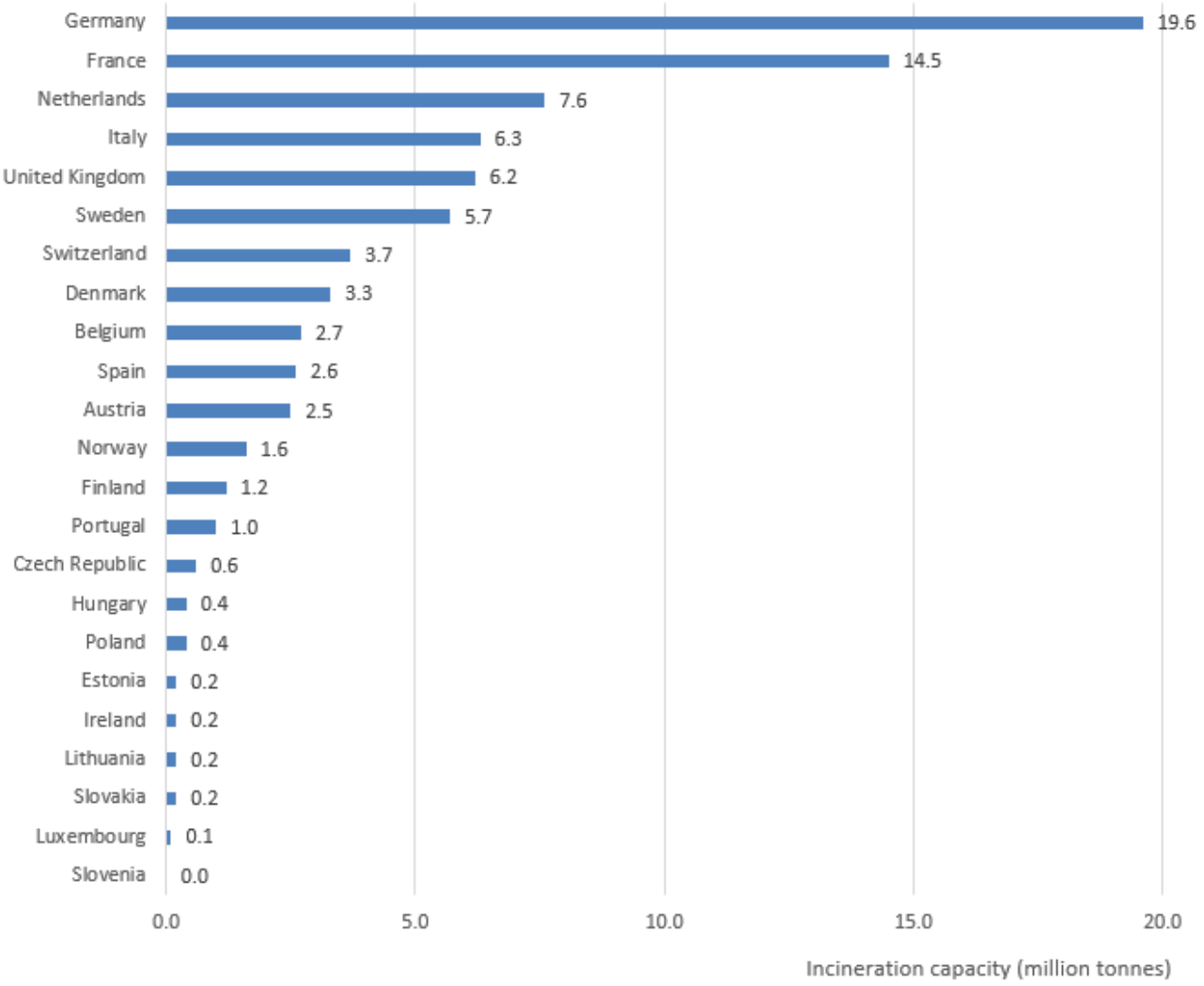
These and other factors can lead to differences between permitted and technical capacity, which should be taken into account for an assessment of (over-) or (under-)capacity.

3 Capacity assessment

3.1 Total capacity and capacity per person

Figure 2 shows the distribution of mixed municipal waste incineration capacity in the EU, Norway and Switzerland (expressed in million tonnes). In 2014, Germany and France had the largest, at 19.6 million tonnes and 14.5 million tonnes respectively. For the EU, Norway and Switzerland as a whole, total incineration capacity for mixed municipal waste was 81.3 million tonnes. Compared to 2010, this has increased by close to 6 % from 76.9 million tonnes.

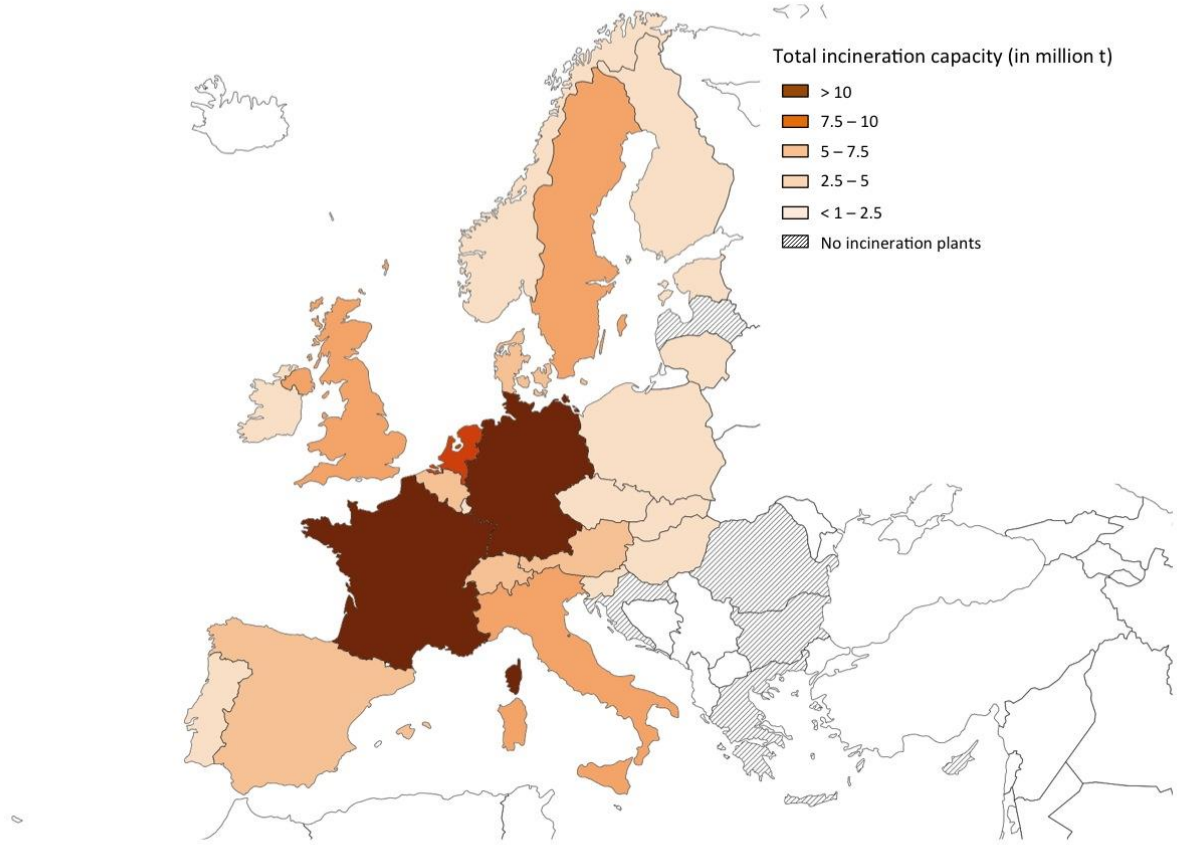
Figure 2 Incineration capacity for mixed municipal waste in the EU, Norway and Switzerland, by country, 2014



Sources: ETC/WMGE compilation based on CEWEP 2016 and sources stated in Annex 1.

Figure 3 presents the information given in Figure 2 in map form, and also shows countries that had no incineration capacity for mixed municipal waste in 2014, namely Bulgaria, Croatia, Cyprus, Greece, Latvia, Malta and Romania. However, in some of these countries plans are under way or plants are already under construction.

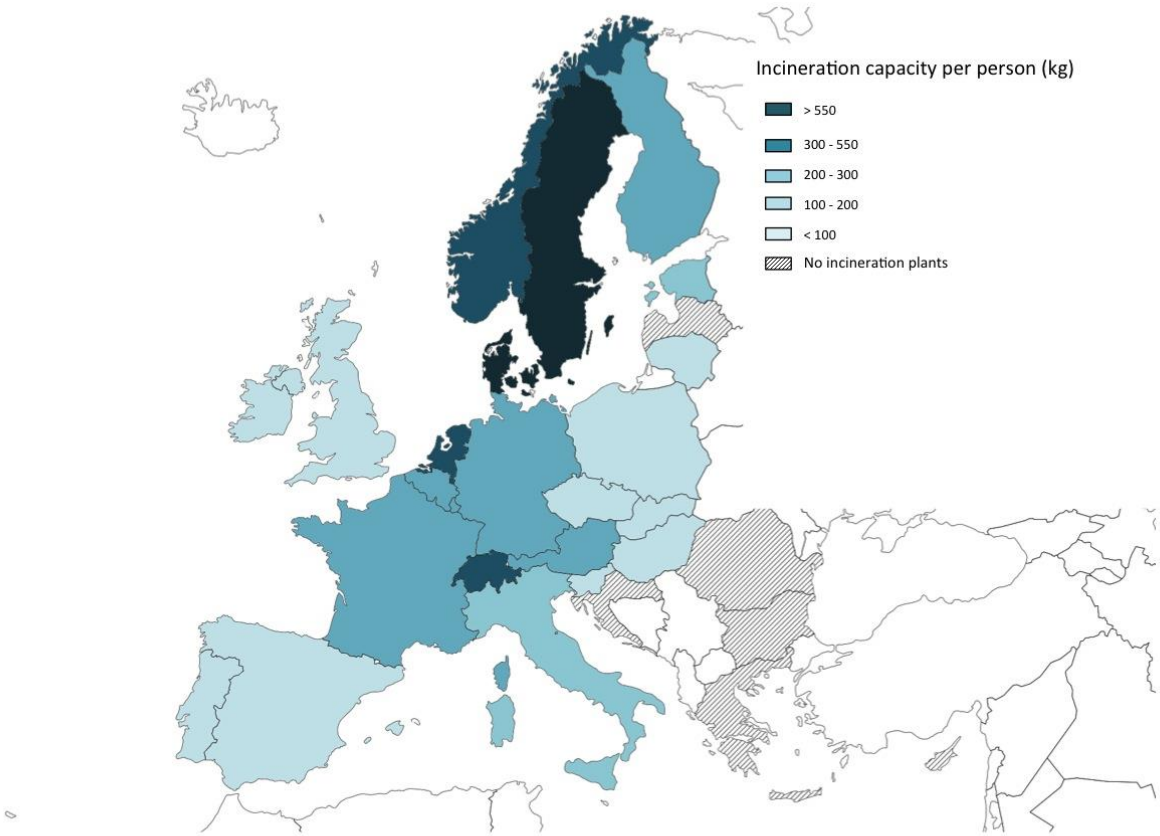
Figure 3 Incineration capacity for mixed municipal waste in the EU, Norway and Switzerland, by country, 2014



Sources: ETC/WMGE compilation based on CEWEP 2016 and sources stated in Annex 1.

Figure 4 shows annual waste incineration capacity per person in 2014. Sweden and Denmark have the highest, at 591 kg and 587 kg per person respectively, followed by the Netherlands, Switzerland, Austria and Finland. In Nordic countries, waste incineration feeds into district heating systems. In the city of Copenhagen in 2013, for example, around one third of district heating and 22 % of electricity came from waste incineration (Hofor, 2014). This assessment also needs to take into account that in some countries, such as Sweden, more than 50 % of non-hazardous industrial waste is also treated in these plants, while in other countries they are only fed with mixed municipal waste.

Figure 4 Incineration capacity per person in the EU, Norway and Switzerland, by country, 2014



Sources: ETC/WMGE compilation based on CEWEP 2016 and sources stated in Annex 1.

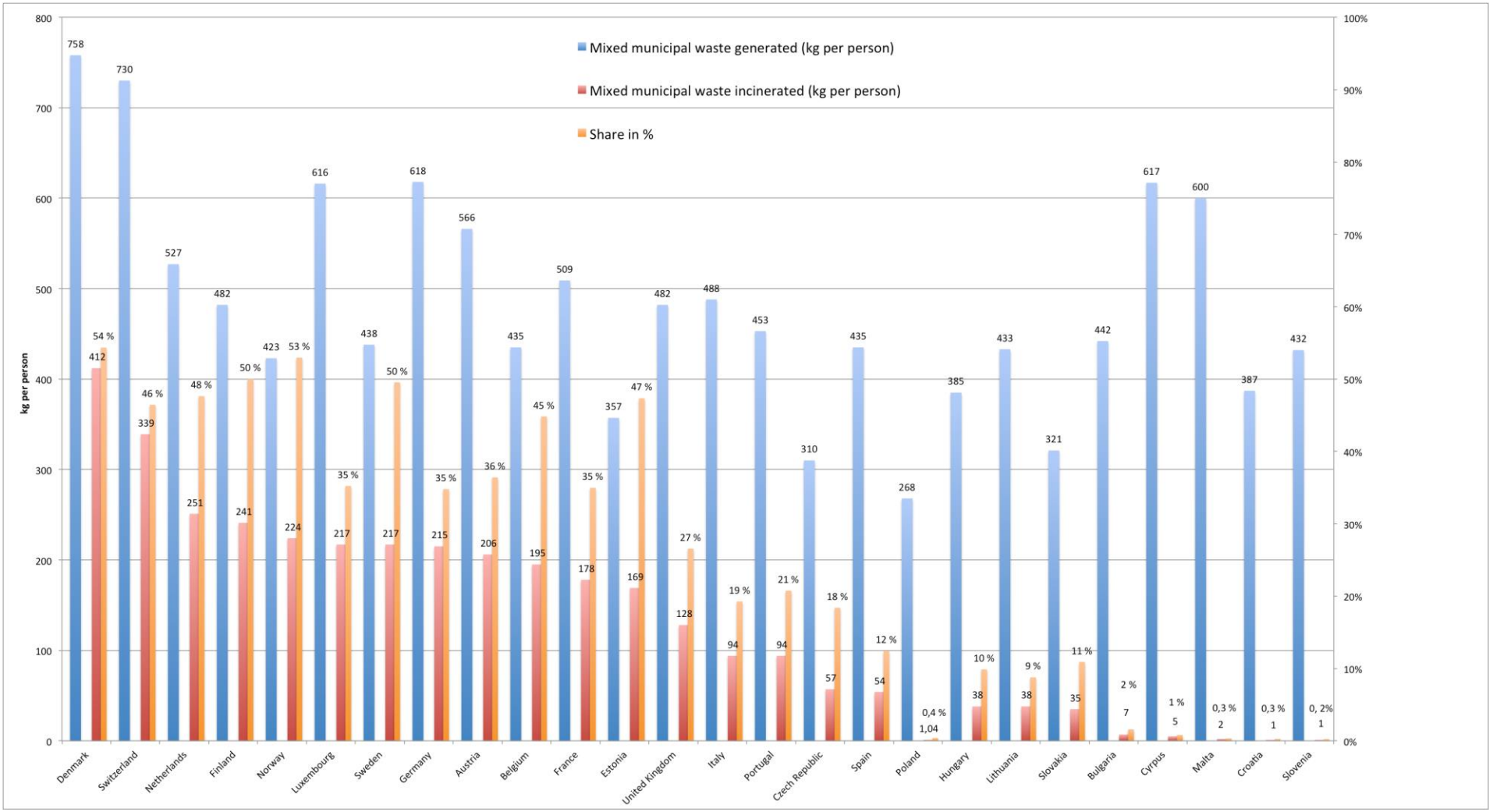
3.2 Capacity assessment in relation to waste generation

For the assessment of (over-) or (under-)capacity, permitted incineration capacity is compared to the total amount of mixed municipal waste generated[8]. The generation of mixed municipal waste per person differs significantly across the EU, Norway and Switzerland, which leads to differences in the treatment capacity required.

Figure 5 shows per person amounts of mixed municipal waste generated alongside the relevant incineration capacity for the EU, Norway and Switzerland. It also shows the share of incinerated mixed municipal waste as reported to Eurostat.

[8] The figure should be understood as an approximation rather than accurate account of the current status, as data for incineration capacity refer to total permitted capacity, while data on amounts of mixed municipal waste refer to generation.

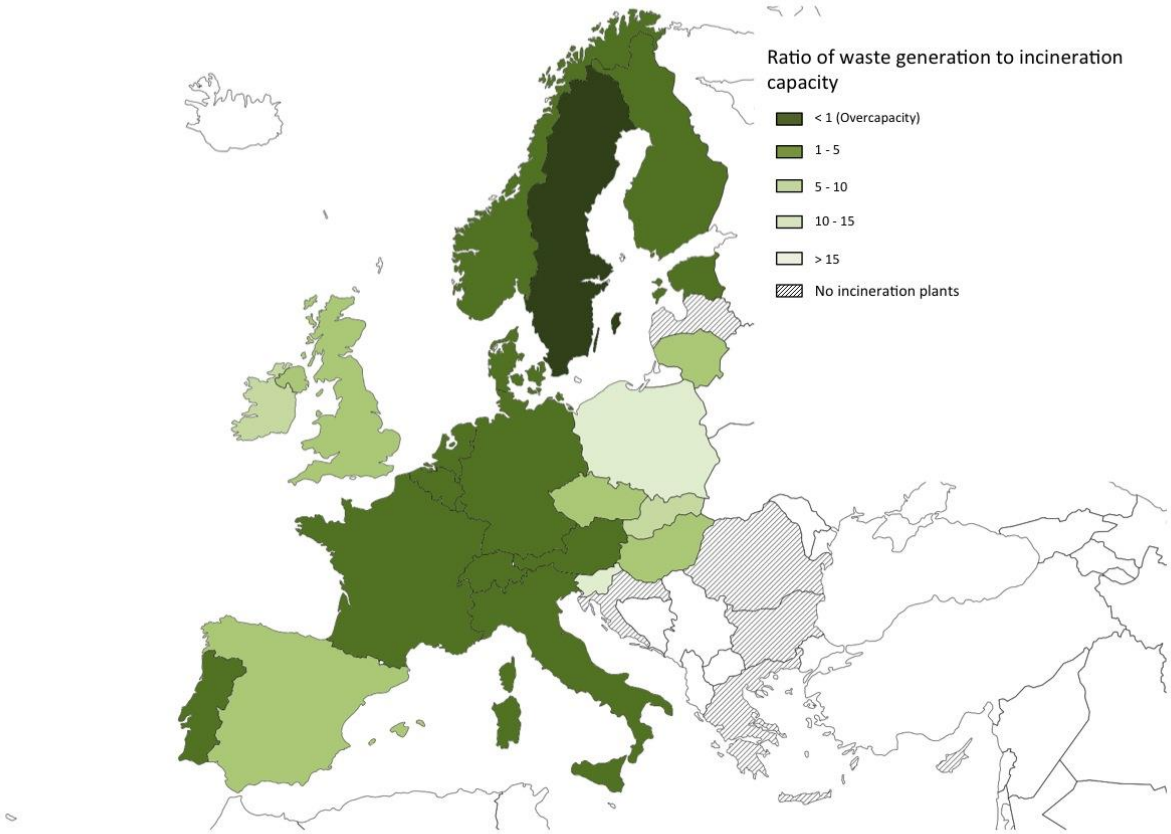
Figure 5 Generated and incinerated amounts of mixed municipal waste per person, and share of mixed municipal waste incinerated in the EU, Norway and Switzerland, by country, 2014



Sources: ETC/WMGE compilation based on CEWEP 2016, sources stated in Annex 1 and Eurostat 2016.

Figure 6 shows amounts of mixed municipal waste generated compared to incineration capacity in the EU, Norway and Switzerland in 2014. Theoretically, (over-)capacity exists where the total mixed municipal waste generated is less than the incineration capacity (ratio < 1:1). This appears only to be the case in Sweden (ratio 0.74:1) where waste management has been integrated with energy production and security and also commercial waste is incinerated. Also in other countries, such as the Netherlands, Denmark and Norway, incineration is a predominant mixed municipal waste management/treatment method (ratios of 1.16:1, 1.29:1 and 1.36:1 respectively).

Figure 6 Mixed municipal waste generation relative to permitted mixed municipal waste incineration capacity in the EU, Norway and Switzerland, by country, 2014



Note: The ratio for each country was calculated by dividing generated amounts of mixed municipal waste by total permitted mixed municipal waste incineration capacity for each country, using the data for 2014. Incinerated amounts of mixed municipal waste, in practice, could be much lower.

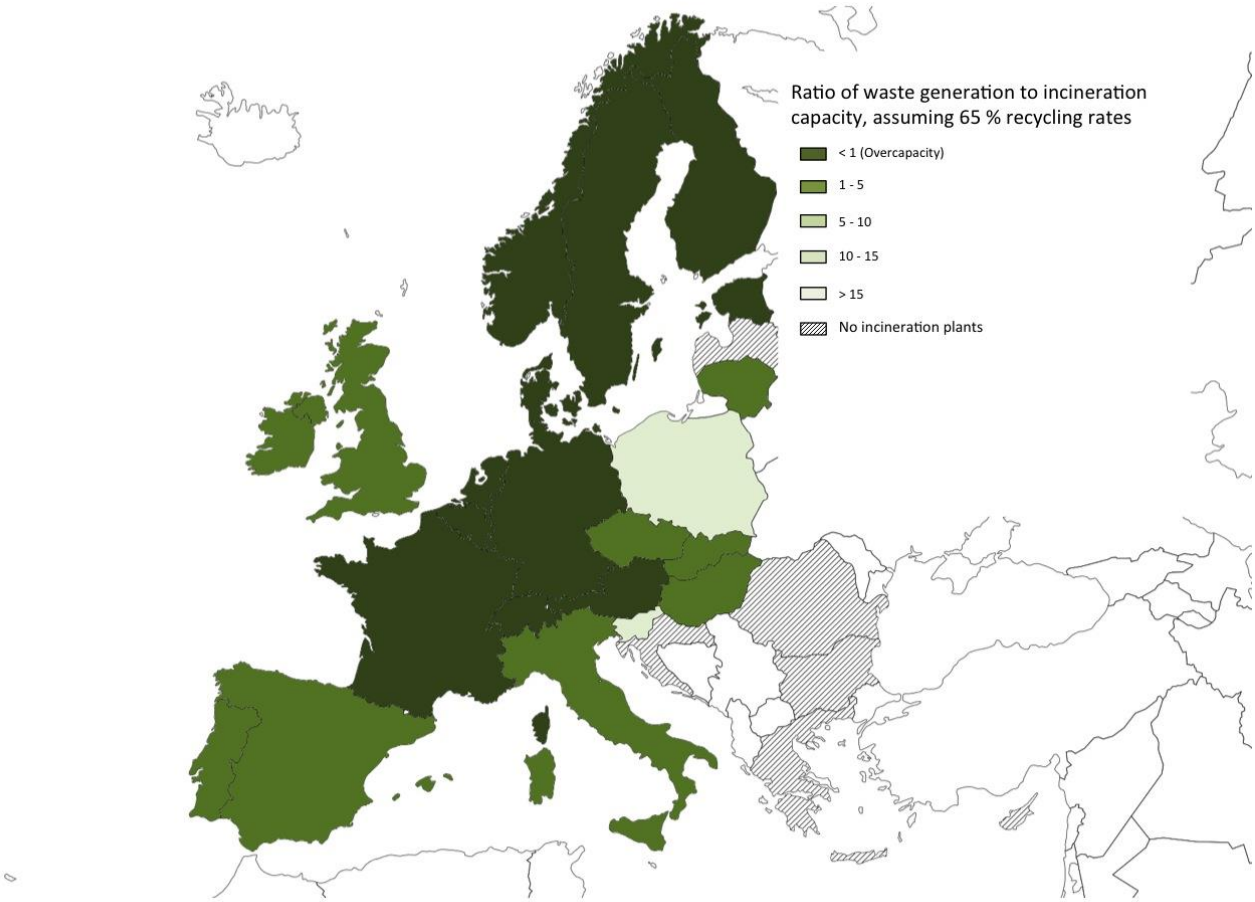
Sources: ETC/WMGE compilation based on CEWEP 2016, sources stated in Annex 1 and Eurostat 2016.

Figure 7 points to a potential trade-off between waste incineration and material recycling – a key element of a circular economy. For this hypothetical figure, it is assumed that all the EU Member States and

Norway ([9]) have already achieved the proposed target recycling rate of 65 % for mixed municipal waste. The recycling target rate, to be achieved by 2030, was proposed by the European Commission's Circular Economy Package in December 2015.

Data on mixed municipal waste generation for 2014 and a presumed mixed municipal waste recycling rate of 65 % were applied to the same data set. In this hypothetical case, more countries would show an incineration (over-)capacity. Increasing recycling rates and the corresponding risks of (over-)capacity should be taken into account in future policy developments.

Figure 7 Hypothetical residual mixed municipal waste amounts, assuming 65 % recycling rates, relative to permitted mixed municipal waste incineration capacity in the EU, Norway and Switzerland, by country, 2014



Sources: ETC/WMGE compilation based on CEWEP 2016, sources stated in Annex 1 and Eurostat 2016.

([9]) Switzerland is not bound to meet this target.

An assumed 65 % recycling rate for mixed municipal waste would reduce the amount of waste available for energy recovery. At the same time, as landfill is increasingly discouraged, higher recycling rates for other waste types could lead to higher sorting residues that will most likely have to be incinerated. In the case of waste plastic recycling, for example, sorting residues are almost completely sent for incineration. Considering the attempts by the European Commission to increase the collection and recycling of plastics, this could lead to increased utilisation of waste incineration capacity.

4 Other relevant waste streams and treatment options

As already indicated, for reasons of data availability this assessment focuses primarily on the incineration of mixed municipal waste and dedicated mixed municipal waste incineration plants. A comprehensive assessment of (over-) or (under-) capacity would also have to consider other thermal treatment options and waste streams that could or do find their way into incinerators. This chapter provides an overview of other thermal treatment options, as well as other waste streams that might be subject to incineration assessment. In addition, it indicates data sources that could be used in the future.

4.1 Other thermal treatment options

Besides mixed municipal waste incineration plants, there are several further treatment options.

- Refuse-derived fuel (RDF) power plants ([10]) have attracted particular interest, in particular during periods of high oil prices (Thiel, 2013). The capacity of RDF plants in European countries is very difficult to estimate as these plants are often part of private industry, there are no specific reporting obligations, and publicly available comprehensive statistics do not exist.

  According to the Confederation of European Waste-to-Energy Plants (CEWEP) (2016), in Germany alone, 31 RDF plants are currently under operation with a total input capacity of 5.5 million tonnes annually. The CEWEP has decided to include figures on RDF plants in their annual capacity assessment so that additional information might become available in the future.

- Cement kilns at industrial sites sometimes use mixed municipal waste, particularly mixed municipal waste with high calorific value, or municipal waste-derived RDF as a substitute for oil or other energy carriers in energy-intensive production processes. An assessment of total capacity is currently not possible due to lack of data, but some estimates indicate that roughly 9.7 million tonnes (ECOFYS, 2016)) of mixed municipal waste are co-incinerated in cement kilns ([11]).

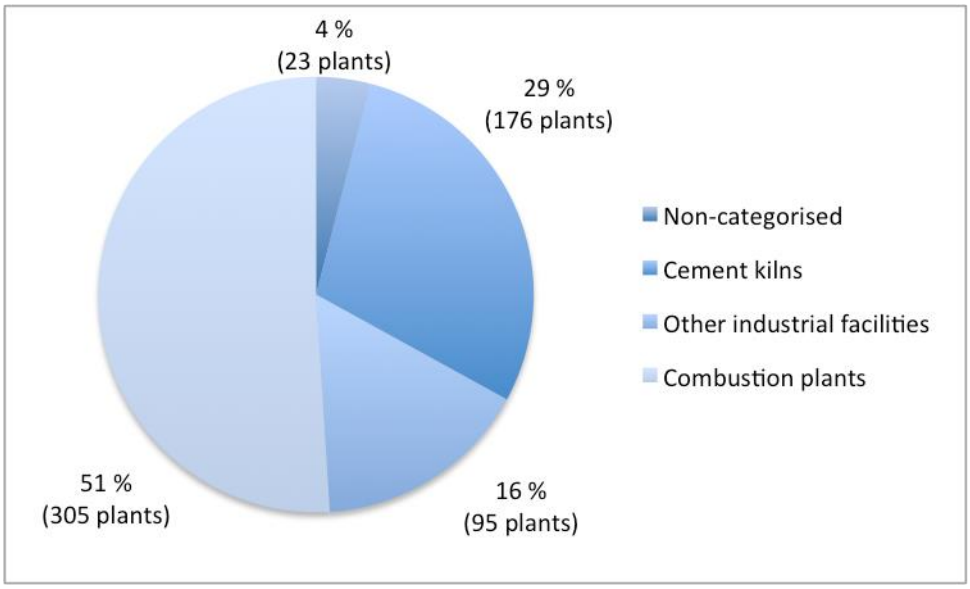
  Based on permits issued in the EU, the third report on implementation of the WID (2000/76/EC) for 2012–2013 recorded a total of 599 co-incineration plants (de Carlos and Menadue, 2016). Figure 8 shows the shares of different types of co-incineration plants, including cement kilns and combustion plants, in the EU. The 176 cement kilns co-incinerating waste make up 29 % of the total. Cement kilns were present in the majority of Member States, with Germany and France having the most – 33 and 29 respectively. In Bulgaria, Cyprus, Czech Republic, Estonia, Greece and Luxembourg, all co-incineration plants were reported to be cement kilns. Combustion plants co-incinerating waste accounted for half of co-incineration plants, 305, but were only reported in

([10]) An RDF power plant (or station) is used as a co-generation or tri-generation plant integrated in a plant. The incineration unit and additional components necessary for the plant's operation, as well as utilisation of energy, are located in close proximity to the consumers. This implies that energy is recovered (energy is never actually *produced* in WtE operations) and used in the same place. Before the feedstock (such as municipal or commercial waste) is introduced into the incineration unit, it is subject to mechanical treatment at an external station. The type of treatment determines the quality and composition of the feedstock, and can vary from an ordinary crushing and rough sorting to a milling process involving multiple steps with various product streams and a final briquetting. The final product of this step is RDF and is used in the RDF power plant (station) as a fuel. The plant (station) might generate heat and/or electricity.

([11]) It should be mentioned that cement kilns may also use some waste types as secondary raw materials, so that not all the permitted waste treatment capacity of a cement kiln may be incineration capacity.

14 Member States. The highest number of plants, 120, was recorded in Sweden, while Germany had 110 (de Carlos and Menadue, 2016).

Figure 8 Shares of different types of co-incineration plants in the EU, 2012–2013



Note: Some countries provided data for 2012, and others for 2013. More information on countries for particular years (2012 or 2013) is available in the *Assessment and Summary of the Member States' Implementation Reports for the IED, IPPCD, SED and WID* prepared by de Carlos and Menadue (2016). IED stands for Industrial Emissions Directive (2010/75/EU), IPPCD for Integrated Pollution Prevention and Control (96/61/EC), SED for Solvent Emissions Directive (1999/13/EC) and WID for WID (2000/76/EC).

Source: de Carlos and Menadue, 2016.

The situation is similar with lignite and hard-coal power plants where specific mixed municipal waste streams are used as energy carriers. For hard-coal power plants it is estimated that about 8–15 % of the necessary input is currently covered in this way, for example by wood pellets (DENA, 2012), but it is unknown how much of this is from waste wood, or wood from municipal waste. Undisclosed amounts of wood and other biomass are also used in large combustion plants; specific figures for total capacity in this area are not available.

The report by de Carlos and Menadue does not include figures for specific hazardous waste incineration plants. However, the JRC Institute for Prospective Technological Studies (IPTS) has estimated the dedicated incineration capacity for hazardous waste to be about 3 million tonnes.

4.2 Future options for increasing energy recovery of specific non-municipal waste streams

Initiated by the German Federal Environment Agency (UBA), a recent study by Faulstich et al. (2016) identified waste streams that could become economically viable for energy recovery in Germany. Several economic assessments included in this study are based on specific German market characteristics, but the list gives a comprehensive overview of which waste streams should be taken into account for a general assessment of (over-) or (under-)capacity for waste incineration.

Changing from classic mechanical-biological waste treatment to an increased (biological) drying and downstream fuel production could lead to growth of approximately 0.3–0.6 million tonnes per year of RDF in Germany and could contribute to reducing the deposition of residual material. Due to the planned

prohibition of agricultural use of sewage sludge in Germany, an additional 0.8–1.3 million tonnes per year of dry matter is expected. It is potentially interesting and technically possible to convert specific lines of waste incineration plants to mono-incineration of sludge. From the business perspective, incineration of sludge could be economically feasible (Faulstich et al. 2016).

Waste material contaminated with persistent organic pollutants – such as shredder fluff, contaminated plastics from the construction sector or from recycling waste electrical and electronic equipment (WEEE) – leads to an accumulation of pollutants during recycling. In order to avoid the increased concentration of hazardous substances, these materials could be directed towards thermal treatment, which is also economically attractive. Due to technical difficulties and possible restrictions on recycling owing to ash characteristics, inter alia owing to contamination with hazardous substances, acceptance is still limited. Overall, there is potential for approximately 0.6 million tonnes per year on the German market (Faulstich et al. 2016).

It might also be useful to incinerate fine fractions from construction waste recycling, particularly as a means of saving landfill space. This material does not have high calorific value because of a low carbonic component, but by mixing it with high calorific waste, the overall throughput of waste incineration plants could be increased. However, nationwide estimates of the amounts and quality of this waste stream are considered uncertain. Based on different assumptions, a potential of approximately 1.0 million tonne per year was identified (Faulstich et al. 2016).

It is important to take account of the fact that coal-fired power plants in Germany are expected to close over the coming decades of energy transition. As a result, the 0.7 million tonnes of RDF currently incinerated annually in these plants will be shifted to other plant types in the medium term (Faulstich et al. 2016).

4.3 Additional data sources

As outlined above also the implementation reports of the WID (2000/76/EC) should be taken into account as an important data source for mixed municipal waste incineration capacity in the EU is (de Carlos and Menadue, 2016). The aim of the Directive was to prevent and control pollution from incineration and co-incineration plants – including incineration plants for mixed municipal waste. The Directive was repealed by the Industrial Emissions Directive (2010/75/EC) in 2014. The new cycle of reporting will start on 1 October 2017.

One of the key elements of the WID was the requirement to issue permits under defined permit conditions, including emission limit values for the main pollutants and related monitoring obligations. Article 15 of the Directive set an obligation for EU Member States to submit reports on the status of implementation at installations falling within its scope following specific questions. Question 1 of the related questionnaire referred to the number and capacity of permitted facilities falling under the scope of the Directive ([12]).

During the reporting period 2009–2011, EU Member States reported 1 714 plants within the scope of the WID, of which 58 % were identified as waste incinerators, 40 % as co-incinerators and the rest as

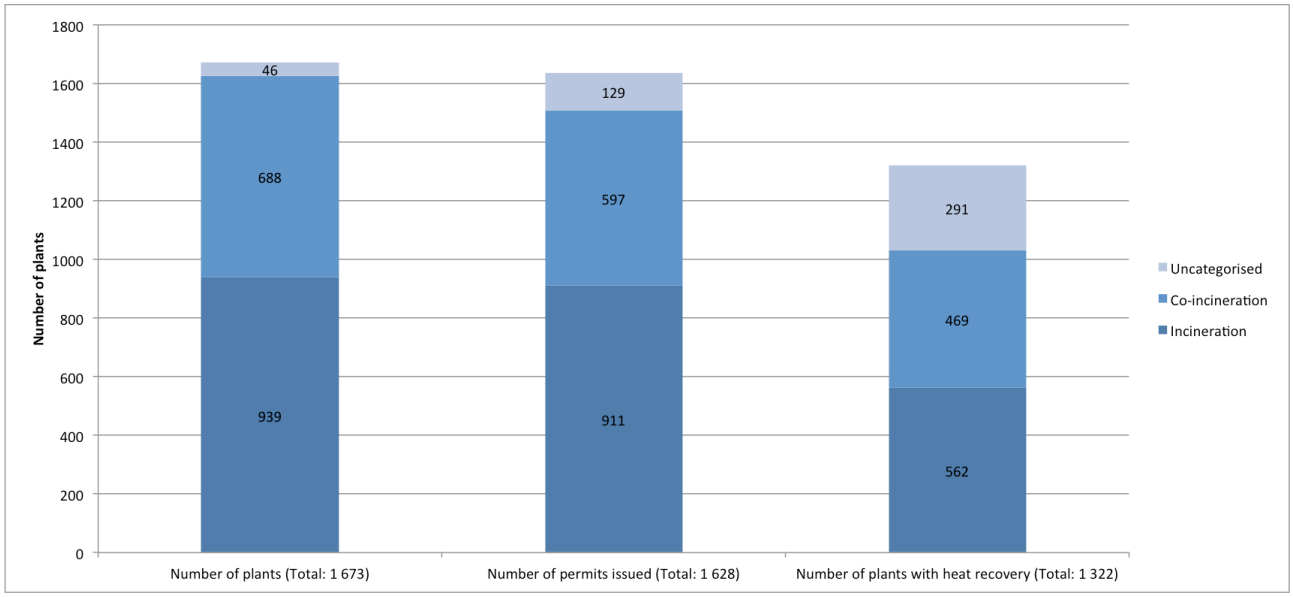
([12]) Question No. 1: “Please give information on number of (a) plants, (b) permits issued in accordance with Article 4(1), (c) plants that recover heat generated by the incineration process heat recovery, and (d) the total permitted capacities of waste throughput (tonnes/year) (broken down between incineration and co-incineration plants). Responding to 1(d) was optional for Member States.”

uncategorised. France, Germany, Italy, Poland, Sweden and the United Kingdom accounted for 70 % of the total number of plants (Lawton et al., 2014).

In 2016, the European Commission published the third and last report analysing the data submitted by Member States. Between 2012 and 2013, Member States reported a total of 1 673 plants under the WID (Figure 9), of which 56 %, or 939 plants, were identified as incineration plants and 41%, 688 plants, as co-incineration plants. The remaining 3 %, 46 plants, were not categorised.

Most plants were located in Germany (22 %), 15 % in France, 10 % in the United Kingdom, 8 % in Sweden, 7 % in Italy and 7 % in Poland. Together, these countries accounted for 69 % of the total number of plants ([13]).

Figure 9 Number and type of incineration plants and permits in the EU, 2012–2013



Source: de Carlos and Menadue 2016.

Out of 27 Member States, 12 responded to the optional question under 1.1.d on total permitted waste throughput capacity. This reported capacity amounted to a total of around 46 million tonnes of waste treated per year in 964 plants; information and data are presented in Table 1. More specific data and information were not available for mixed municipal waste, so this is not included at this stage of the analysis.

([13]) Flanders submitted data for the total number of plants but did not distinguish between incineration and co-incineration plants. It remarked that this issue will be addressed for future reporting. For the United Kingdom and Finland it was unclear how many plants were falling within the scope of the Directive. Finland only reported plants that incinerated more than 2 tonnes of waste per hour during the reporting period, and the United Kingdom reported figures which are significantly lower than the previous period and not consistent with the remarks provided. In view of this, the analysis of this question refers to the response given for the previous reporting period (2009–2011) for the United Kingdom.

Table 1 Data and information available on total permitted waste throughput capacity, reported under the WID for the period 2012–2013

Country	Total permitted waste throughput capacity	Comments
Belgium	450 000 tonnes/year	Relevant only for Brussels; no response was provided for Wallonia, and the question is not relevant to Flanders
Czech Republic	1 205 463 tonnes/year	35 % is allocated to co-incineration plants
Denmark	One co-incineration plant (25 250 tonnes/year); 35 950 tonnes of dry matter for three sludge incineration plants; 3 591 500 tonnes of waste in 2012 and 3 676 500 tonnes in 2013 for 30 of the 34 incineration plants	
Estonia	402 000 tonnes/year	
Italy	5 189 184 tonnes in incinerators and 3 561 335 tonnes in co-incinerators	
Latvia	322 106 tonnes/year	
Lithuania	180 000 tonnes/year	
Luxembourg	208 548 tonnes/year	
Malta	12 910 tonnes/year	
Slovenia	61 337 tonnes/year for incineration plants and 114 010 tonnes/year for co-incineration plants	
Sweden	11 200 000 tonnes/year	
United Kingdom	895 000 tonnes/year	Information on total permitted waste throughput capacity is only available for Scotland and Northern Ireland

Source: de Carlos and Menadue, 2016.

PART B Assessment of waste trade for energy recovery

1 Policy context and objectives

1.1 Policy context

The movement of hazardous waste across borders was one of the first issues to be regulated by the EU. Although the Dangerous Waste Directive (78/319) mainly focused on defining hazardous waste and how it is to be handled or managed, it did not cover hazardous waste shipments; that came later with the Directive on Transfrontier Shipment of Hazardous Waste (84/631), which required authorities in receiving countries to be informed about movements of hazardous waste across borders – within or beyond the EU. This Directive did not, however, consider the disposal facilities at the final location or the consent of the receiving country – two concepts that were subsequently introduced by the United Nations Environment Programme (UNEP) and the Organisation for Economic Co-operation and Development (OECD) through the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention) (Haigh, 2016).

Following the adoption of the Basel Convention in 1989, the EU produced its first Communication Strategy for Waste Management, which was an introduction to the 1992 Single EU Act and anticipated a rise in waste movements. It encouraged the introduction of high waste disposal standards and a reduction in waste movements – the proximity principle.

Several years later, in 1996, the second Communication Strategy marked a shift in the main focus of EU waste policy – away from pure waste management to the recovery of resources, including energy, from waste. The Strategy reconfirmed the importance of the proximity principle.

The 1984 Directive on Transfrontier Shipment of Hazardous Waste (84/631) was replaced by the Regulation on the supervision and control of shipments, which was, in turn, replaced by Regulation 1013/2006 on shipments of waste, which lays down conditions for the movement of waste from one country to another, and includes provisions from the Basel Convention and the OECD Decision concerning the Control of Transboundary Movements of Wastes Destined for Recovery Operations (EEA, 2012).

The EU Regulation was further amended in 2014 (660/2014) in order to strengthen inspection systems in Member States.

1.2 Objectives

Available data on waste shipments underpin the growing importance of the international waste trade, both between European countries and beyond, as a result of different drivers. One of them has been the establishment of the European Single Market and consequently notification of waste shipments. Another driver is the imbalance between available waste and recycling/recovery capacity in domestic markets and the increasing discouragement of landfill in all Member States.

This assessment aims to provide a statistical overview of waste trade flows for incineration, with and without energy recovery, in the EU, Norway and Switzerland, with a focus on mixed municipal waste. Due to the complexity of available data, waste classified as waste collected from households (Y-46) according

to the Basel Convention is examined, as well as waste defined in the European Waste Catalogue as mixed municipal waste and combustible waste, based on Eurostat data on waste shipments ([14]).

The analysis is followed by a discussion on the possible drivers of increasing waste trade flows.

([14]) Eurostat data are available at: http://appsso.eurostat.ec.europa.eu/nui/show.do

2 Methodology

2.1 Key definitions and data

Description of key definitions by the Basel Convention and the European Waste Catalogue is provided in Annex 6, due to the existence of different waste codes.

This section of the report examines transboundary shipments of different waste flows and quantities reported under different legal obligations. Its focus is on mixed municipal waste.

The assessment is based on the formal notifications for transboundary waste shipment/movement made every year by the Member States to the European Commission ([15]) and reported by Eurostat. Shipments are subject to prior written notification-consent requirements: the notifier submits a prior written notification to the competent authority of dispatch, and notifications cover the shipment of waste from its initial place of dispatch and include its interim and non-interim recovery or disposal. With few exceptions, only one waste identification code may be used for each notification. The main stages of the notification procedure are described in Annex 7.

Different waste classification codes have to be filled in for the notification procedure on transboundary waste shipments and related waste movements, including the Basel Convention codes, Y-codes ([16]), and the codes of the European Waste Catalogue (LoW).

- In the case of the Basel Convention, data used for this assessment are covered by Annex II on categories of waste requiring special consideration – data is available for 1999–2013. Non-hazardous waste is addressed by Y-46, waste collected from households, and Y-47, residues arising from the incineration of household waste.

- In the case of the European LoW, most of the notifying countries include codes in their notifications, although it is not a legally binding requirement ([17]). For 2010–2013, 82 % of the notified waste shipments between the countries of the EU, Norway and Switzerland destined for incineration, with or without energy recovery, and including hazardous waste, provided an LoW code.

The notification documentation also has to provide information on the treatment operation to which the waste shipment is destined. Although many more categories are available, this assessment focuses on:

- R1 – used principally to generate fuel or other means to generate energy, i.e. energy recovery;
- D10 – incineration on land, i.e. incineration without energy recovery.

Nevertheless, these categories are sometimes notified as “mix”, “not specified” or “unknown”.

The notification and movement documents also address the total quantity of waste for shipment. It should be noted that the intended amount provided by the notification document is not necessarily the same as

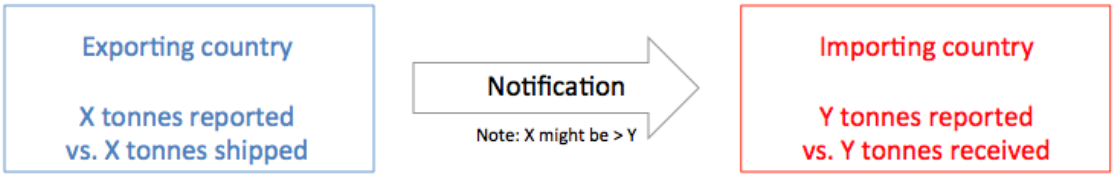
([15]) In particular shipments of: 1) waste destined for disposal; 2) hazardous waste destined for recovery; 3) mixed municipal waste independently from the destination; 4) unlisted waste independently from the destination based on the EC Regulation No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste (WSR) Art. 3.1.
([16]) Y-codes between Y-1 and Y-47 or otherwise classified as “mix”, “unknown” and “not specified” on the notification/movement documents are filled out by the notifying countries.
([17]) The LoW code on the notification/movement documents can be “unfilled” or “unknown”.

the actual quantity shipped and/or received at the disposal or recovery facility, which is reported to the authorities concerned through the movement document (Figure 10). The notified amount can, rather, be understood as the amount permitted to be shipped.

The notified trade flows of mixed municipal waste for incineration, with or without energy recovery, cannot easily be identified by looking at Y-codes and LoW codes. After careful consideration of the features of different notified shipments related to incineration in household-waste incineration plants, the flows classified under code Y-46 of the Basel Convention have been selected as significantly representative (ETC/SCP, 2014).

More details on the methodology used for data classification and aggregation are provided in Annex 8.

Figure 10: Illustration of waste quantities reported by exporting and importing country



Source: EEA.

3 Waste shipments assessment

3.1 Waste shipments

3.1.1 Shipments of Y-46 waste for incineration in Europe

As noted, a significant proportion of the mixed municipal waste destined for incineration, with or without energy recovery, is traded under code Y-46 of the Basel Convention. The analysis of export and import data can take advantage of long time-series, compared to the more recent use of LoW codes.

Figure 11 presents the trends in exports and imports of Y-46 waste for incineration shipped in the EU, Norway and Switzerland between 2001 and 2013, according to Eurostat data ([18]).

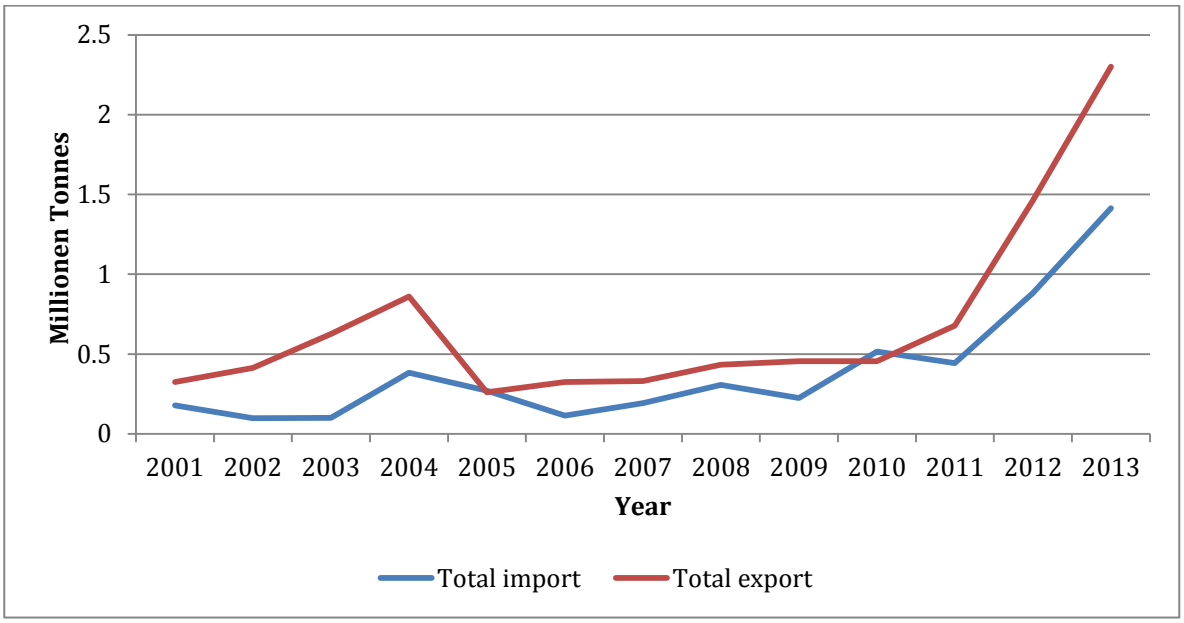
There is a systematic mismatch between total export and import flows for different reasons.

- The intended amount for shipment provided by the notification document is not necessarily the same as the actual quantity shipped and received at the disposal or recovery facility, which is reported by the movement document.
- The same shipment of waste can be identified using different Y-codes by the exporting and importing countries. The existence of only two Y-codes covering non-hazardous waste amplifies the problem of inconsistent classification of mixed municipal waste.
- Norway and Switzerland are among origin and destination countries but are not notifying countries.

Trends in both exports and imports were rather stable in the early years of the last decade, but flows increased substantially as of 2011. Between 2008 and 2013, total imports increased by more than a factor of four, from 0.3 million tonnes to around 1.4 million tonnes, while total reported exports increased six-fold, from 0.38 million tonnes to 2.3 million tonnes. As a total of 242 million tonnes of mixed municipal waste was generated in the EU in 2013, only a very small proportion was traded.

([18]) Updated on 3 February 2016.

Figure 11 Total import and export of mixed municipal waste for incineration with and without energy recovery, intra-EU, Norway and Switzerland, 2001–2013



Note: Data refer to each single flow and are recorded separately for export and import. Export represents flows reported by the exporting states and import shows flows as reported by importing states.

Source: ETC/WMGE elaborations on Eurostat data, 2016 ([19]).

3.1.2 Shipments of Y-46 waste for incineration by country

The number of European countries contributing to the increasing trends in mixed municipal waste flows for energy is limited, though geographical coverage is well defined and relevant changes have been identified in recent years.

Table 2 presents imports and exports of Y-46 waste destined for incineration (R1 and D10) in the EU, Norway and Switzerland in 2013. More information on the data used is provided in Annex 9.

A comparison of data for 2010 (EEA, 2012) and 2013 shows that there has been an increase in total imports and exports, but the number of trading countries has remained the same. This analysis highlights the pivotal role of some countries and the strong ties between them.

Data reported by exporting countries

In 2013, according to data provided by exporting countries, 14 countries imported mixed municipal waste. The highest quantities were imported by Germany, the Netherlands, Sweden and Switzerland. In particular, Germany and Sweden together represented 57 % of total import flows, mainly for D10

([19]) Eurostat – Transboundary waste shipments – Waste shipments across borders: http://ec.europa.eu/eurostat/web/waste/transboundary-waste-shipments (accessed 10 October 2016).

operations in Germany, with flows coming from a wide range of countries, and only for R1 operations in Sweden, with the largest flows coming from Norway and the United Kingdom.

In the same year, according to data supplied by exporting countries, 13 countries exported waste. A dominant role was played by Germany, the Netherlands, in both countries mainly for D10 operations, and in particular the United Kingdom, but only for R1 operations, which alone accounted for more than 71 % of total exports or 1.6 out of 2.3 million tonnes.

Data reported by importing countries

When examining the data notified by importing countries, the Netherlands, Norway and the United Kingdom together accounted for 86 % of the total export flow of Y-46 waste; Norway and the United Kingdom only exported Y-46 waste destined for R1, while exports from the Netherlands were mainly destined for D10.

Table 2 Import and export of Y-46 waste for incineration (R1 + D10), EU, Norway and Switzerland, tonnes

Exporting country	R1+D10	R1	D10	Importing country	R1+D10	R1	D10
Austria	62 723	38 046	24 677	Austria	10 024	10 024	
	8 045	3 809	4 236		2 589	2 589	
Belgium				Belgium			
	6 064	6 064					
Bulgaria				Bulgaria			
					5 108	5 108	
Czech Rep.	144	144		Czech Rep.			
	144		144				
Denmark				Denmark	90 491	90 491	
					152 967	152 967	
Estonia				Estonia	28 945	28 945	
					27 972	27 972	
Finland	27 554	27 554		Finland			
	23 842	23 842					
France	1 553		1 553	France			
	33 122	1 710	31 412		5 998	5 998	
Germany	156 274	102	156 172	Germany	335 778	18 309	317 469
	469	469			485 327	211 941	273 385
Ireland	80 316	79 935	381	Ireland	123	123	
	112 379	112 379			122	122	
Italy	7 320	2 548		Italy			
	10 024	10 024					
Latvia				Latvia	115 423	115 423	
					87 384	87 384	
Luxembourg				Luxembourg	1 710	1 710	
	1 023	1 023					
Netherlands	324 156	54 999	269 157	Netherlands	294 176	294 176	
	291 241	9 563	281 677		1 145 946	1 145 946	
Norway	295 957	295 957		Norway	50 265	50 265	
Sweden	596	596		Sweden	470 769	470 769	

Exporting country	R1+D10	R1	D10	Importing country	R1+D10	R1	D10
	3 132	3 132			188 977	188 977	
Switzerland				Switzerland	216 179	38 006	178 174
United Kingdom	1 645 850	1 645 850		United Kingdom			
	629 498	629 498			381		381
Total export	**2 301 713**	**1 849 773**	**451 940**	**Total import**	**1 414 942**	**1 097 472**	**317 470**
Total import	**1 414 942**	**1 097 472**	**317 470**	**Total export**	**2 301 714**	**1 849 773**	**451 940**

Note: Yellow rows report data notified by exporting and importing countries, while white rows report export and import data based on shipments notified by, respectively, importing and exporting countries.

More detailed information on trade flows under Y-46 code for R1 and D10 operations in 2013 is given in Annex 9 in the form of a trade matrix. The matrix collects all bilateral flows between countries as notified by Member States: for each country, the first row presents the notified export flows to the countries in column as reported by the country itself as an exporter; the second row presents the import flows from the same country, as notified by the country in column as an importer.

Figures may not sum due to rounding.

Source: ETC/WMGE elaboration on Eurostat data, 2016 ([20]).

3.1.3 Shipments of LoW mixed municipal waste and refuse-derived fuel for incineration

This section illustrates the trends in selected waste types, identified by specific LoW codes, shipped in the EU, Norway and Switzerland, for incineration (R1 and D10), namely mixed municipal waste ([21]) and refuse-derived fuel (RDF) ([22]). The data were notified by importing and exporting countries between 2008 and 2013.

The Member States started to significantly use LoW codes in their reporting to Eurostat in 2011 ([23]).

In 2013, shipped quantities of combustible waste for incineration (R1 and D10) – 5.5 million tonnes exported and 5.3 million tonnes imported – were larger than shipped quantities of mixed municipal waste – 1.9 million tonnes exported and 1.8 million tonnes imported.

Figure 12 shows an increasing trend in exports and imports of mixed municipal waste to be incinerated in both R1 and D10 operations. The same applies to combustible waste in terms of trends in exports and imports destined for R1 (Figure 13) while data for D10 show high fluctuation (Figure 14) and indicate that there were no shipments of combustible waste destined for incineration without energy recovery in 2012 and 2013.

([20]) Eurostat – Transboundary waste shipments – Waste shipments across borders: http://ec.europa.eu/eurostat/web/waste/transboundary-waste-shipments (accessed 10 October 2016).
([21]) Under the code 200301.
([22]) Under the code 191210.
([23]) Waste shipments to be notified are: 1) waste destined for disposal; 2) hazardous waste destined for recovery; 3) mixed municipal waste independently from the destination; 4) unlisted waste independently from the destination.

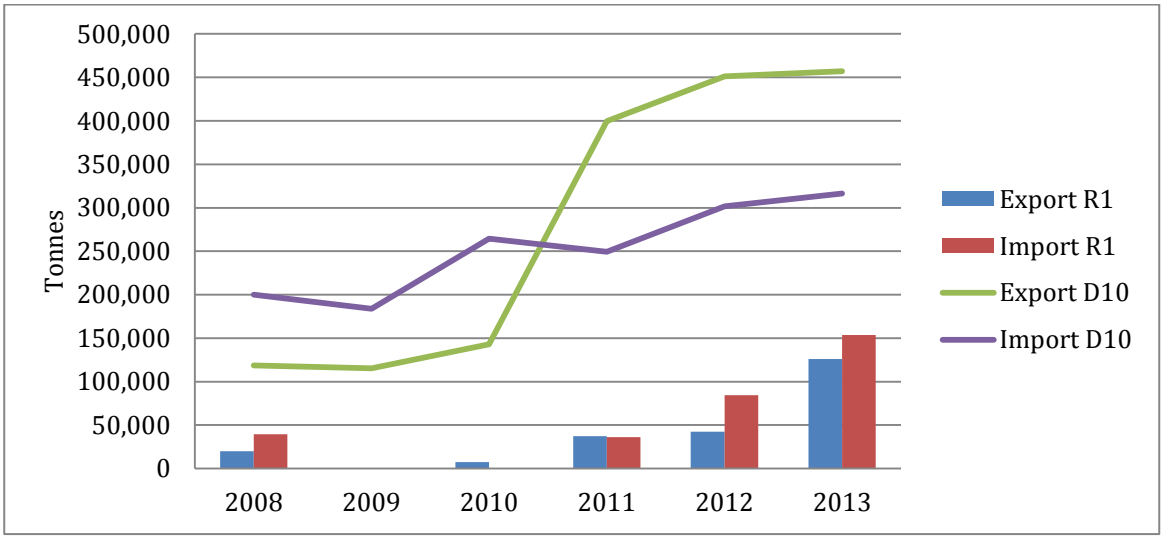
Imports and exports of mixed municipal waste destined for D10

Looking at the data on a country-by-country basis, most of the shipped mixed municipal waste is destined for incineration on land (D10). In 2013, exported mixed municipal waste destined for incineration on land was 456 000 tonnes. According to notification data, exporting countries were the Netherlands, with around 264 000 tonnes; Germany, 156 000 tonnes; France, 33 000 tonnes; and Austria, 3 000 tonnes. The only country that notified imports of mixed municipal waste was Germany, 316 000 tonnes, but, according to data reported by exporting countries, waste was also exported to Switzerland, 158 000 tonnes.

Imports and exports of mixed municipal waste destined for R1

In 2013, 2.2 million tonnes of mixed municipal waste were exported to be incinerated with energy recovery and 1.6 million tonnes were imported for the same purpose. There were eight exporting countries, the most significant being Ireland, 112 000 tonnes; Finland, 7 000 tonnes; and the Netherlands, 6 000 tonnes, while importing countries included the Netherlands, 79 000 tonnes; Sweden, 36 000 tonnes; Estonia, 25 000 tonnes; and Germany, 14 000 tonnes.

Figure 12 Import and export of mixed municipal waste for incineration (R1 + D10), EU, Norway and Switzerland, 2008–2013



Source: ETC/WMGE elaboration on Eurostat data, 2016 ([24]).

In summary, in 2013, the Netherlands notified 58 %, by weight, of overall exports of mixed municipal waste destined for D10 and 51 % of overall imports of mixed municipal waste destined for R1. All exported mixed municipal waste for incineration on land was shipped to Germany and Switzerland. The most important exporter of mixed municipal waste for incineration with energy recovery was Ireland – 89 %, by weight, of the overall shipments notified by exporting countries (Annexes 10 and 11).

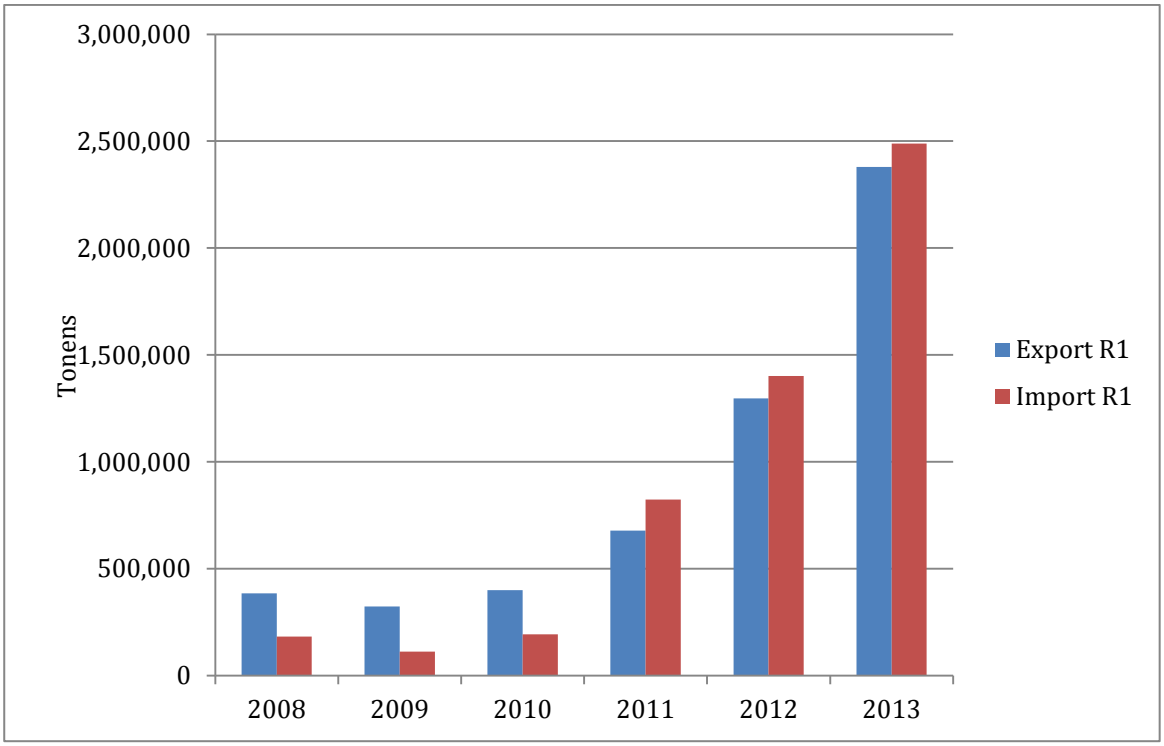
([24]) Eurostat – Transboundary waste shipments – Waste shipments across borders: http://ec.europa.eu/eurostat/web/waste/transboundary-waste-shipments (accessed 10 October 2016).

Imports and exports of refuse-derived fuel destined for R1

Most shipped RDF is incinerated with energy recovery (R1) (Figures 13 and 14; Annex 12). In 2013, there was no export of RDF for incineration on land (D10). Exported and imported RDF destined for R1 reached, respectively, 2.4 million tonnes and 2.5 million tonnes in 2013. Eleven countries notified exports of RDF, the most prominent being the United Kingdom, 1.6 million tonnes; the Netherlands, 0.2 million tonnes; and Belgium, 0.15 million tonnes. The existence of five further exporting countries can be drawn from data reported by the importing countries.

There were 17 notifying importing countries, and five others imported RDF destined for R1, according to data reported by exporting countries. The most important were the Netherlands, 1.1 million tonnes; Germany, 0.5 million tonnes; and Sweden, 0.4 million tonnes. Data for all the countries is provided in Table 4.

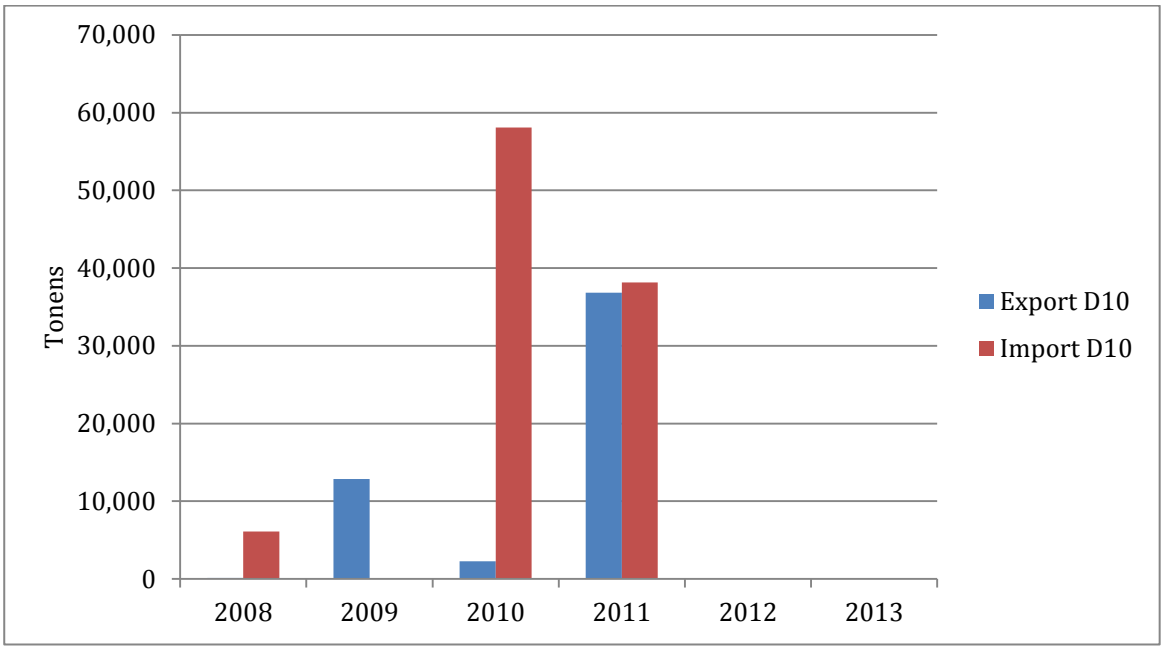
Figure 12 Import and export of RDF (191210) for incineration with energy recovery (R1), EU, Norway and Switzerland, 2008–2013



Source: ETC/WMGE elaboration on Eurostat data, 2016 ([25]).

([25])Eurostat – Transboundary waste shipments – Waste shipments across borders: http://ec.europa.eu/eurostat/web/waste/transboundary-waste-shipments (accessed 10 October 2016).

Figure 13 Total import and export of RDF for incineration (D10), EU, Norway and Switzerland, 2008–2013



Source: ETC/WMGE elaboration on Eurostat data, 2016 ([26])

In summary, in 2013, based on data notified by, respectively, exporting and importing countries, the export of RDF for R1 was dominated by the United Kingdom, which represented 69 % of the total export flow, while the imports pattern was less concentrated, with Germany, the Netherlands and Sweden accounting together for 80 % of the total flow.

The above analysis largely confirms the conclusions reached in the previous paragraph on shipments of Y-46 waste. When using LoW codes, the mismatch between import and export data significantly decreases, meaning that part of the gap is due to the application of inconsistent classifications to the same shipment of waste by the importing and exporting countries. This supports the conclusion that the use of LoW codes significantly improved the quality and usefulness of waste shipments data (EEA, 2012; ETC/SCP, 2012b and 2009)

[26] Eurostat – Transboundary waste shipments – Waste shipments across borders: http://ec.europa.eu/eurostat/web/waste/transboundary-waste-shipments (accessed 10 October 2016).

Table 3: Import and export of RDF for incineration (R1 only*), EU plus Norway and Switzerland, 2013 (tonnes)

Exporting country	R1*	Importing country	R1*
Austria	36 280	Austria	17 023
	47 153		18 074
Belgium	145 794	Belgium	3 392
	143 714		3 785
Bulgaria		Bulgaria	21 290
			25 777
Czech Rep.		Czech Rep.	53 610
			53 425
Denmark		Denmark	154 660
			151 463
Estonia		Estonia	2 777
			29
Finland	1 522	Finland	1 698
	1 552		1 698
France	1 906	France	20 792
			18 096
Germany	108 052	Germany	510 387
	58 736		465 274
Greece		Greece	
	3 485		
Hungary		Hungary	38 478
	311		24 212
Ireland	117 509	Ireland	14 625
	126 788		15 009
Italy	101 278	Italy	
	96 380		
Latvia		Latvia	115 423
			115 500
Luxembourg		Luxembourg	
	2 136		11 426
Netherlands	220 628	Netherlands	1 057 875
	222 495		1 053 924
Norway	167 805	Norway	59 549
Poland		Poland	
	22 8167		22 794 75
Portugal		Portugal	11 518 28
			133 26
Romania		Romania	
			4 000
Slovakia		Slovakia	41 071
			37 608
Slovenia	8 178	Slovenia	2 465
	7 674		12 399

Exporting country	R1*	Importing country	R1*
Spain	133	Spain	
	11 518		213
Sweden		Sweden	420 960
			268 041
Switzerland		Switzerland	16 591
United Kingdom	1 637 744	United Kingdom	
	1 575 480		
Total export	**2 379 024**	**Total import**	**2 488 043**
Total import	**2 488 043**	**Total export**	**2 379 024**

Note: Yellow rows report data notified by exporting and importing countries, while white rows report export and import data based on shipments notified by, respectively, importing and exporting countries.

* No RDF was shipped for incineration on land in 2013.

Figures may not sum due to rounding.

Source: ETC/WMGE elaboration on Eurostat data, 2016 ([27]).

3.2 Drivers of waste trade

To better understand what drives the increase in European trade in waste for incineration both with and without energy recovery, an extensive literature study of the political and economic factors involved was carried out (ETC/SCP, 2012a), and practitioners consulted about the outcome. In general, cost-saving emerged as the major driver behind waste trade. In this regard, the cost of increasing treatment capacity can be seen as prohibitive (Mazzanti and Zoboli, 2013).

Most of the available empirical studies focus on the waste trade in general and not on the trade for incineration, with and without energy recovery, and for most of these studies the geographical scope is global, not European.

Kellenberg (2010), for example, using international COMTRADE data for 92 countries and bilateral trade flows in hazardous and non-hazardous waste, highlights the importance of market price (gate fees) and technology/capacity factors, as well as regulatory stringency and enforcement to explain the trade in waste. In general, lower management/disposal prices and greater incineration and recycling capacity, reflecting economies of scale and comparative advantages in recycling and disposal, should attract waste flows.

A study by Baggs (2009) analyses the international trade in hazardous waste using a gravity model that includes country characteristics. It concluded that a significant pollution-haven effect can be observed: rising income per person reduces the amount of hazardous waste that countries import. This effect is outweighed by high-income countries' relative capital abundance, and by the fact that greater gross domestic product (GDP) creates larger disposal capacity than waste production. In other words, national technology/capacity intensity can attract imports of hazardous waste.

([27])Eurostat – Transboundary waste shipments – Waste shipments across borders: http://ec.europa.eu/eurostat/web/waste/transboundary-waste-shipments (accessed 10 October 2016).

Several studies have investigated the considerable transboundary movements of certain types of waste between Asian countries and highlight the importance of drivers such as costs and treatment capacity (Fuse and Kashima, 2008). Hints for understanding international flows emerge from analyses at the in-country or region level. De Jaeger (2010), studying Flanders municipalities, finds that for some waste – bulky household, demolition and garden waste – the quantities collected at local recycling centres depend on the prices charged at recycling centres in neighboring municipalities.

In short, the main conclusion from the literature is that the more the features of waste systems (production, management) differ across countries, the more likely it is that waste trade will occur because heterogeneity drives trade to get a potentially win-win exchange.

From literature and interviews, the emerging list of waste trade drivers – elements that stimulate or justify exports – is as follows (ETC/SCP 2012a):

- differences in gate fees – for example, higher gate fees in the waste exporting country than in the importing country;
- transport costs – for example, international transport is less expensive than long-distance transport inside the exporting country;
- administrative costs – for example, cost of export/import practices; existence of bans on export to non-OECD countries;
- difference in environmental taxes and policy stringency – for example, having an incineration tax in the exporting country and not in the importing one;
- tariff and non-tariff barriers at the borders;
- difference in treatment capacity – for example, the capacity in the exporting country is lower than that in the importing country;
- different incentives for recycling/recovery – for example, if the incentives for energy from waste in the exporting country is lower than in the importing one;
- differences in legislation/classification – for example, greater stringency of legislation in the exporting country that in the importing one;
- need for specific technologies – for example, the availability of a specific technology in the importing country only;
- geographical characteristics of a country – for example, islands, small counties, long borders, or the distance to a facility in the exporting country being greater than to one in the importing country;
- the introduction of recycling and recovery requirements in EU Directives;
- other drivers for specific categories of waste – for example, high dismantling costs encouraging the trading of end-of-life vehicles and waste electrical and electronic equipment (WEEE) as products rather than waste.

Evidence from both the literature and the available data on the waste trade offer limited scope for the systematic testing of the relative importance of these drivers for the specific case of mixed municipal waste traded for energy recovery. At least three drivers, however, are likely have an important role:

(i) differences in gate fees and incineration taxes, in combination with transport costs;
(ii) differences in the level of support for energy production from “renewable waste” in the framework of renewable energy source (RES) policies;
(iii) imbalances (excess/lack) in the treatment capacity in different countries.

For all these drivers, in particular their differences across Member States, information is neither systematic nor regularly updated, and data comparability is limited.

It can be even more difficult to detect the role of relative support/incentives for RES across countries as a driver of waste trade flows in a direct and reliable way. Even though different Member States have introduced specific support for energy from waste, the E-RES and H-RES incentive schemes in each Member State are different for different waste types, and the definition of a renewable waste eligible for support may differ from country to country, thus preventing a clear picture of relative support across countries (IEA Bioenergy, 2012).

Even though it is still rather unclear, this emerging picture of the limited role of economic drivers suggests the importance of domestic capacity constraints/excess – in general a country's imbalances in capacity, including in geographical terms – as a possible driver of waste trade flows in Europe.

PART C Conclusions

The analysis of waste incineration capacity underlines the importance of energy recovery in Europe, and the role of the international network of waste treatment facilities against a background of increasing waste flows between European countries. At the same time it highlights the challenges related to the availability of data, capacity assessments and especially to an integrated approach that takes into account the role of waste incineration with regard to the waste hierarchy as well as the European Energy Union.

Data availability

Despite the importance of the role that waste infrastructures will play in a transition to a circular economy, the available data for an assessment of mixed municipal waste incineration capacity are limited and subject to high levels of uncertainty. The CEWEP annual survey is a useful starting point, although this is mainly based on information provided by CEWEP members and does not provide a full overview of dedicated mixed municipal waste incineration capacities, which, for such an assessment, should be differentiated from other incineration options for pre-treated waste, such as RDF. The WID Implementation Reports are another source, but the provision of capacity-related information is voluntary for Member States, is limited to facilities beyond certain capacity thresholds, and, importantly, the classification of incineration and co-incineration seems to vary between Member States. Furthermore, the lack of reporting obligations for the incineration of commercial and industrial waste can be seen as an important barrier to the production of a comprehensive analysis of WtE capacity in Europe.

National inventories can also provide useful information but, again, these vary significantly in terms of structure and level of detail; most of them do not explicitly state whether they are concerned with technical or permitted capacities. Compared with municipal solid waste incineration, data availability for co-incineration or RDF capacity is even more challenging, and they have therefore been excluded from this report. The on-going revision of reporting obligations under the new Directive 2010/75/EU on Industrial Emissions might offer an opportunity for further harmonising definitions and concepts.

Capacity assessments

This capacity assessment points to an increasing prominence of waste incineration in Europe. For 2014, a total of 464 dedicated mixed municipal waste incineration plants have been identified, with a total annual capacity of about 81.3 million tonnes. This represents an increase of close to 6 % since 2010, when the estimated incineration capacity was 76.9 million tonnes.

The analysis shows an uneven distribution of capacity across Europe. The three countries with the biggest total capacities, Germany, France and the Netherlands, together account for just more than half of Europe's total capacity, and the next three largest, Italy, the United Kingdom and Sweden, together add a further 13 %. Thus these six countries, which together make up 59 % of the EU's population and generate 72 % of its GDP, account for almost three-quarters of Europe's incineration capacity. Many of the other countries still depend heavily on landfill for municipal solid waste disposal and do not have municipal solid waste incineration facilities, or have stopped their development due to the economic crisis in Europe.

An assessment of national per person incineration capacity, and especially the relationship between per person capacity and municipal solid waste generation, indicates the existence of, at least, regional (over-) capacity in Europe. Countries in which the incineration capacity equals or exceeds the total national generation of municipal solid waste may depend on waste imports, which raises questions of whether waste streams that could otherwise be recycled are being incinerated (Dehne et al. 2011) – obviating the waste hierarchy.

An overall environmental assessment should, however, take account of the climate change mitigation effects of using less fossil fuel due to often very energy-efficient district heating systems based on waste incineration, as well as lost material recycling or recovery of the waste incinerated. A total assessment of European municipal solid waste incineration capacity is also challenging due to the extremely dynamic

market development in the United Kingdom, where capacity has increased rapidly and many additional plants are under construction or planned. High-quality district heating systems in Demark and Sweden highlight that new energy recovery capacity is being developed mainly because of drivers in the energy sector – these countries also decided to include mixed municipal waste in the EU Emission Trading System.

Waste shipments

Available data suggest an increasing waste trade between European countries and beyond, as a result of different drivers. The imbalance between available generation and recycling and recovery capacity in domestic markets may be of particular importance, given that the use of landfill is increasingly discouraged in all European countries.

Looking at household waste shipped for incineration on land, the level of both imports and exports remained relatively stable in the early years of the past decade but flows, particularly of notified exports, started to increase from 2009–2010 and increased substantially in 2012–2013. Total imports increased by more than a factor of four between 2008 and 2013, from around 300 000 tonnes to around 1.4 million tonnes, while total exports increased six-fold in the same period, from around 380 000 to 2.3 million tonnes. Although this sharp upswing corresponds to the worst years of the economic crisis in Europe, the main specific reason seems to have been the surge of the United Kingdom as a major exporter to other European countries. In spite of this growth, traded flows of mixed municipal waste are still very low compared to a total of 242 million tonnes generated in the EU in 2013.

Need for further research

A better understanding of the role of waste incineration in a circular economy is needed, and particularly of existing (over-) or (under-)capacity, to steer investment to the most efficient waste infrastructures, both in environmental and economic terms.

The uneven geographic distribution of incineration capacity raises the question of the environmental benefits that could be gained from additional waste shipments, for example, from those countries in south-eastern Europe that do not have any incineration capacity, to other countries where the heat from existing waste incineration plants can be utilised. This would require integrated assessment of associated emissions, including the environmental impacts of transport, switching from fossil fuels to energy recovery from waste, and landfill, which might differ significantly depending on technical standards.

From a planning and policy perspective, the increasing perception of waste as a resource also brings the need for a better understanding of incentives for WtE as a contribution to reducing import dependency on fossil fuels. It would also be interesting to analyse whether increased waste shipments have led to less ambitious waste treatment or waste prevention policies in exporting countries.

There is, in any case, a clear need for innovative and transparent assessment tools to improve coordination of incineration capacity. Non-municipal waste flows and energy recovery capacities for such wastes are heavily intertwined with municipal solid waste flows. Analysis of such flows, potentially significantly larger than municipal solid waste flows, is severely hampered by a lack of consistent data across Europe. Better data are expected to become available in the future and would merit analysis.

References

Baggs, J., 2009, 'International trade in hazardous waste', *Review of International Economics*, 1(17), 1–16.

Bio Intelligence Service, 2012, *Use of Economic Instruments and Waste Management Performances*, Final Report for DG Environment, 10 April 2012, Contract ENV.G.4/FRA/2008/0112.

CEWEP, 2016, MW statistics with Circular Economy Targets 2030 based on Eurostat 2014 data, Personal communication, 22 April 2016, Confederation of European Waste-to-Energy Plants, Brussels, Belgium.

De Carlos, A. and Menadue, H., 2016, *Assessment and Summary of the Member States' Implementation Reports for the IED, IPPCD, SED and WID*, WID Final Report, prepared by Amec Foster Wheeler Environment & Infrastructure UK Ltd. (https://circabc.europa.eu/sd/a/4bb6a793-e3d3-4d0d-a660-04c5ee8283bb/WID%20implementation%20final%20report.pdf) accessed 24 June 2016.

De Jaeger, S. and Eyckmans, J., 2010, 'Do Households Export their Recyclable Waste?', Paper prepared for the Association of Environmental and Resource Economists (AERE) World Conference, Montreal 28 June–2 July, Special session on Waste management in decentralized settings: spatial issues and policy.

DENA , 2012, Biomasse in Kohle- und Graskraftwerken Ein wichtiger Baustein zur bedarfsgerechten und klimafreundlichen Energieerzeugung, Deutsche Energie-Agentur GmbH (http://www.dena.de/fileadmin/user_upload/Publikationen/Erneuerbare/Dokumente/Biomasse_in_Kohle-_und_Gaskraftwerken.pdf) accessed 29 April 2016.

EC, 2006, Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste.

EC, 2015, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Closing the loop – An EU action plan for the Circular Economy**,** COM/2015/0614 final.

ECOFYS, 2016, *Market opportunities for use of alternative fuels in cement plants across the EU*, Utrecht, The Netherlands.

EEA, 2012, *Movements of waste across the EU's internal and external borders*, EEA Report No 7/2012, European Environment Agency, Copenhagen, Denmark.

EEA, 2015, *The European environment — state and outlook 2015: synthesis report*, European Environment Agency, Copenhagen, Denmark.

EIA, 2016, *How waste-to-energy plants work*, (http://www.eia.gov/energyexplained/index.cfm/data/index.cfm?page=biomass_waste_to_energy) accessed 29 November 2016.

ETC/SCP, 2009, *Data availability on transboundary shipments of waste based on the European Waste List*, ETC/SCP Working Paper, 3/2009, prepared by Fischer, C. and Davidsen, C., European Topic Centre on Sustainable Consumption and Production.

ETC/SCP, 2012a, *Drivers and impacts of transboundary shipments of waste – a methodology for analysis*, ETC/SCP Working Paper, prepared by Fischer, C., Junker, H., Mazzanti, M., Paleari, S., Volpi, M., Wuttke, J. and Zoboli, R., European Topic Centre on Sustainable Consumption and Production.

ETC/SCP, 2012b, *Transboundary shipments of waste in the European Union. Reflections on data, environmental impacts and drivers*, ETC/SCP Working Paper 2/2012, November 2012, prepared by

Fischer, C., Junker, H., Mazzanti, M., Paleari, S., Wuttke J. and Zoboli, R., European Topic Centre on Sustainable Consumption and Production.

ETC/SCP, 2014, *Municipal solid waste management capacities in Europe*, ETC/SCP Working Paper No 8/2014, June 2014, Desktop Study, European Topic Centre on Sustainable Consumption and Production.

Eunomia, 2014, *Residual Waste Infrastructure Review*, 7th Issue (http://www.eunomia.co.uk/reports-tools/residual-waste-infrastructure-review-7th-issue/) accessed 29 April 2016.

Eurostat, 2016, *Waste generation and treatment,* (http://ec.europa.eu/eurostat/web/environment/waste/database) accessed 29 November 2016.

Faulstich, M., Vodegel, S., Fedianina, E., Franke, M., Degener, P., Aginer, J. and Reh, K., 2016, Umweltschutzgerechte Verwertung nicht etablierter Stoffströme in Abfallverbrennungsanlagen, Umweltbundesamt, Dessau-Roßlau.

Fuse, M. and Kashima, S., 2008, 'Evaluation method of automobile recycling systems for Asia considering international material cycles: application to Japan and Thailand', *Journal of Material Cycles and Waste Management*, 10, 153–64.

Haigh, N., 2016, *EU Environmental Policy*, Routledge, London.

Haukohl, J., (ed.) (2012), *Waste to Energy State-of-the-Art Report*, 6th edition, International Solid Waste Association, Copenhagen, Denmark.

Hofor, 2014, Miljødeklaration 2013 for fjernvarme i Hovedstadsområdet, (http://www.hofor.dk/wp-content/uploads/2014/05/miljoedekl_2013_hofor.pdf) accessed 31 October 2016.

IEA Bioenergy, 2012, *Energy recovery from renewable content of waste: incentives and methodology for analysing biogenic content of mixed waste, Topic 1 – Policy Support, Final Report, Task 36, Integrating energy recovery into solid waste management*, RSE Report N.12003964, November 2012.

Lawton, K., Corden, C., de Carlos, A. and Zglobidz, N., 2014, *Assessment and Summary of Member States' Implementation Reports for the Waste Incineration Directive (2000/76/EC) covering the period 2009–11*, prepared by Amec Foster Wheeler Environment & Infrastructure UK Ltd.

Manders, J., 2013, *Integrated waste management of MSW across Europe – Waste to Energy as a professional route to treat residual waste*, CEWEP, Houthalen Helchteren, Belgium.

Mazzanti M. and Zoboli R., 2013, 'International waste trade: impacts and drivers', in: D'Amato, A., Mazzanti, M. and Montini, A*., Waste Management in Spatial Environments*, Routledge, London, UK, pp. 99–136.

OECD, 2008, *Transboundary Movements of Wastes Destined for Recovery Operations,* (C(2001)107/FINAL) amended in 2002 - C(2001)107/ADD1; 2004 - C(2004)20; 2005 - C(2005)141 & 2008 - C(2008)156. Paris.

Richers, U., 2010, *Abfallverbrennung in Deutschland – Entwicklungen und Kapazitäten*, KIT Scientifc Reports 7560, KIT Scientific Publishing, Karlsruhe, Germany.

Spohn, C., 2015, Capacity and legal steering of Waste-to-Energy in Germany, 9th Beacon Conference on Waste-to-Energy, November 18–19 2015, Malmö, Sweden.

Thiel, S., 2013, *Ersatzbrennstoff-Kraftwerke in Deutschland und Österreich* (http://www.vivis.de/phocadownload/2013_eaa/2013_EaA_835_852_Thiel.pdf) accessed 29 April 2016.

Wilts, H. and von Gries, N., 2014, *Municipal solid waste management capacities in Europe*, Desktop Study, ETC/SCP Working Paper No 8/2014 (http://scp.eionet.europa.eu/publications/wp2014_8/wp/wp2014_8) accessed 29 April 2016.

Wilts, H. and von Gries, N., 2015, 'Europe's waste incineration capacities in a circular economy', in: *Proceedings of the Institution of Civil Engineers – Waste and Resource Management*, Volume 168, Issue 54, pp.166-176.

Annex 1 National sources for data on incineration capacity for mixed municipal waste in Europe

Country	Source(s)
Austria	Statusbericht 2015 zum Bundes-Abfallwirtschafsplan 2011 ([28])
Belgium	OVAM Cewep ([29])
Czech Republic	Termizo Cewep Wtert ([30]) AEA Technology plc ([31]) Pražské služby ([32])
Denmark	Dansk Affaldsforening, DI og Dansk Energi ([33])
Finland	Ecoprog Cewep Yle ([34]) Turku Energia ([35]) JLY ([36]) Finnish Environment Institute ([37])
France	Sinoe ISWA WtE State of the Art Report 2135 Usine d'incinération des déchets ménagers du Grand Dijon Evere Inoteq Vals Aunis ([38])
Germany	Umweltbundesamt ([39])
Hungary	Cewep ([40]) REC ([41])
Iceland	ExpertPC ([42])

([28]) BMLFUW, 2015, Bestandsaufnahme der Abfallwirtschaft in Österreich – Statusbericht 2015. www.bundesabfallwirtschaftsplan.at
([29]) http://www.ovam.be/sites/default/files/atoms/files/T%20%26%20C%202014.pdf
http://www.cewep.eu/media/www.cewep.eu/org/med_734/1090_belgium_2012.pdf
([30]) http://tmz.mvv.cz/de/
http://www.cewep.eu/media/www.cewep.eu/org/med_734/1076_czech_republic_2012.pdf
http://www.cewep.eu/media/www.cewep.eu/org/med_709/1397_czech_republic.pdf
http://www.wtert.eu/Default.asp?Menue=18&NewsPPV=8613
([31]) http://www-1.sysnet.cz/projects/env.web/zamest.nsf/5eafc5e970f63e14c1256c5500784c48/4d44a8a4a28f03a6c1256afc0045b098/$FILE/PWaste%20-%20final%20report%20volume%202%20eng.doc
([32]) http://www.psas.cz/index.cfm/sluzby-firmam/zarizeni-pro-energeticke-vyuzivani-odpadu/energeticke-vyuzivani-odpadc5af/
([33]) http://www.ens.dk/sites/ens.dk/files/undergrund-forsyning/affald/benchmarking_forbraending_2013.pdf
([34]) http://www.ecoprog.com/en/show/article/finland-andritz-equips-new-wte-plant-in-leppaevirta.htm
http://www.cewep.eu/media/www.cewep.eu/org/med_709/1398_finland.pdf
http://yle.fi/uutiset/finlands_biggest_waste-to-energy_plant_opens_in_vantaa/7476864
([35]) http://www.turkuenergia.fi/tietoa-meista/ymparisto/energiantuotanto-ja-alkupera/tuotantolaitokset/orikedon-jatteenpolttolaitos/
([36]) http://www.jly.fi/energia5.php?order=kunta.nimi
([37]) Nikander H and Säynätkari T (2014) Waste incineration capacities in Finland. E-mail message from the Finnish Environment Institute, 5th March. European Environment Agency, Copenhagen, Denmark.
([38]) http://www.sinoe.org/filtres/index/thematique
http://evere.fr/evere/chiffres-cles.html
http://www.inoteq.fr/Projets-334
http://www.vals-aunis.com/page.php?P=56
([39]) https://www.umweltbundesamt.de/themen/abfall-ressourcen/entsorgung/thermische-behandlung
([40]) http://www.cewep.eu/media/www.cewep.eu/org/med_709/1399_hungary.pdf
([41]) http://www.rec.org.tr/dyn_files/32/650-4-HungarianWasteManagementPolicy.pdf
([42]) http://expertpc.org/gasifier/icelandicenergyfromwaste.pdf

Country	Source(s)
	Icelandic Association of Local Authorities ([43])
Italy	AER S.p.A. Cewep ([44]) FISE Assoambiente ([45]) ENEA / Federambiente ([46]) Martino associatiassociate ([47])
Luxembourg	EEW ([48])
Netherlands	Afvalwerking in nederland, gegevens 2014 Cewep ([49])
Norway	BIR Avfalssbehandling Frevar KF Hafslund Eidsiva Senja Avfallselskap ÅRS- OG MILJØRAPPORT 2014 Forus Energigjenvinning Cewep ([50])
Poland	Personal communication Beata Klopotek, MOS Poland
Portugal	Lipor Valorsul Cewep ([51]) European Commission ([52])
Slovakia	Olo Kosit ([53])
Spain	Magrama ([54])
Sweden	Kapacitetsutredning 2014

([43]) http://www.samband.is/media/urgangsmal/Tolfraedi_urgangs_ISLAND_1995_2008_heimasida.pdf
([44]) http://www.aerspa.it/i-servizi
http://www.cewep.eu/media/www.cewep.eu/org/med_709/1401_italy.pdf
([45]) http://www.fondazionesvilupposostenibile.org/f/Documenti/Rapporto_Assoambiente_08_09.pdf
([46]) http://www.assoelettrica.it/wp-content/uploads/2013/01/ENEA-Rapporto-sul-recupero-di-energia-dai-rifiuti-2012.pdf
([47]) http://martinoassociati.it/node/19
([48]) https://www.eew-energyfromwaste.com/en/our-sites/leudelange.html
([49])
http://www.verenigingafvalbedrijven.nl/fileadmin/user_upload/Documenten/PDF2015/Afvalverwerking_in_Nederland_gegevens_2014_1.0.pdf
http://www.cewep.eu/media/www.cewep.eu/org/med_734/1079_netherlands_2012.pdf
([50]) http://www.bir.no/biravfallsbehandling/Sider/Startside.aspx
http://www.frevar.no/vare-anlegg/energigjenvinningsanlegg/
https://www.hafslund.no/omhafslund/varme/3081
https://www.eidsivaenergi.no/p/Fjernvarme/Hamar/Aktuelt/
http://www.senja-avfall.no/om_oss
https://www.oslo.kommune.no/getfile.php/Innhold/Politikk%20og%20administrasjon/Etater%20og%20foretak/Energigjenvinningsetaten/Dokumenter%20Energigjenvinningsetaten/Års-%20og%20miljørapport%202014%20Energigjenvinningsetaten.pd f
http://forusenergi.no/energi
http://www.cewep.eu/media/www.cewep.eu/org/med_734/1083_norway_2012.pdf
http://www.cewep.eu/media/www.cewep.eu/org/med_709/1403_norway.pdf
([51]) http://www.lipor.pt/en/municipal-solid-waste/energy-recovery/unit-description/
http://www.valorsul.pt/pt/valorizacao-energetica/ctrsu.aspx
http://www.cewep.eu/media/www.cewep.eu/org/med_709/1404_portugal.pdf
([52]) http://ec.europa.eu/regional_policy/sources/docgener/presenta/rup2012/brochure_rup_en.pdf
([53]) https://www.olo.sk/aktualny-stav-v-energetickom-zhodnocovani-odpadov/
http://kosit.sk/profil-spolocnosti/modernizacia/
([54])http://www.magrama.gob.es/es/calidad-y-evaluacion-ambiental/publicaciones/memoriadegeneracionygestiondecompetenciamunicipal2013_tcm7-410396.pdf

Country	Source(s)
	Cewep ([55])
Switzerland	VBSA ACR Tridel ([56])
United Kingdom	Incineration of Municipal Solid Waste Report 2013 Ecoprog BBC Resource Yorkshire Evening Post Sita Cornwall Plymouth Herald Let's recycle Amey ([57])
Bulgaria, Cyprus, Greece, Latvia, Liechtenstein, Lithuania, Malta, Romania, Slovenia	Jofra Sora, M. (2013). *Incineration overcapacity and waste shipping in Europe: the end of the proximity principle?* Fortum ([58])
Croatia, Estonia, Ireland	EEA (2013). *Managing municipal solid waste – a review of achievements in 32 European countries.* Wtert Eco-Innovation Baltic Course Cewep Irish Times ([59])

([55]) http://www.avfallsverige.se/fileadmin/uploads/Rapporter/E2014-03.pdf
http://www.cewep.eu/media/www.cewep.eu/org/med_709/1405_sweden.pdf
([56]) http://vbsa.ch/anlagegruppen/kva/
http://www.aziendarifiuti.ch/Desktopdefault.aspx?tabId=82&languageId=1
http://www.tridel.ch/exploitation/fonctionnement/eclate-usine.html#
[57] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/221036/pb13889-incineration-municipal-waste.pdf
http://www.ecoprog.com/en/show/article/uk-voelund-might-construct-gloucestershire-wte-plant.htm
http://www.bbc.com/news/uk-england-york-north-yorkshire-29349904
http://www.bbc.com/news/uk-england-beds-bucks-herts-23973922
http://resource.co/government/article/construction-begins-polmadie-recycling-centre
http://www.yorkshireeveningpost.co.uk/news/latest-news/top-stories/is-the-cross-green-incinerator-the-final-piece-in-leeds-s-recycling-jigsaw-1-6685010
http://www.sitacornwall.co.uk/managing-your-waste/energy-from-waste
http://www.plymouthherald.co.uk/MVV-responds-questions-Devonport-waste/story-18522284-detail/story.html
http://www.letsrecycle.com/news/latest-news/work-begins-on-peterborough-efw-plant/
http://wasteservices.amey.co.uk/where-we-work/milton-keynes/about-us/
([58]) http://www.no-burn.org/downloads/Incineration%20overcapacity%20and%20waste%20shipping%20in%20Europe%20the%20end%20of%20the%20proximity%20principle%20-January%202013-1.pdf
http://www.fortum.com/en/mediaroom/pages/fortum-inaugurates-the-first-waste-to-energy-combined-heat-and-power-plant-in-the-baltics.aspx
([59]) http://www.eea.europa.eu/publications/managing-municipal-solid-waste
http://www.wtert.eu/Default.asp?Menue=18&NewsPPV=8613
http://www.eco-innovation.eu/index.php?option=com_content&view=article&id=149%3Awaste-incineration-plants-to-produce-electricity-and-heat&catid=56%3Aestonia&Itemid=56
http://www.baltic-course.com/eng/good_for_business/?doc=35444
http://www.cewep.eu/media/www.cewep.eu/org/med_734/1089_ireland_2012.pdf
http://www.cewep.eu/media/www.cewep.eu/org/med_709/1400_ireland.pdf
http://www.irishtimes.com/news/environment/work-begins-on-construction-of-poolbeg-incinerator-1.1970738

Annex 2 Figures on total incineration capacity excluding co-incineration in Europe, by country, 2014

Country	Incineration capacity (tonnes)	Incineration capacity per person (kg per person)*	Incineration capacity in relation to waste generation**	Incineration capacity in relation to waste generation assuming 65 % recycling rates***	Incineration capacity taking into account sorting residues****
Austria	2 500 000	294	1.93	0.68	2.58
Belgium	2 700 000	241	1.80	0.63	2.43
Czech Rep.	646 000	61	5.04	1.76	5.59
Denmark	3 300 000	587	1.29	0.45	1.45
Estonia	250 000	190	1.88	0.66	2.46
Finland	1 200 000	220	2.19	0.76	2.43
France	14 500 000	220	2.32	0.81	2.72
Germany	19 600 000	243	2.55	0.89	3.39
Hungary	381 000	39	9.96	3.48	10.55
Ireland	225 000	49	11.96	4.18	14.14
Italy	6 300 000	104	4.70	1.64	6.85
Lithuania	230 000	78	5.52	1.93	6.47
Luxembourg	131 000	238	2.61	0.91	2.87
Netherlands	7 600 000	452	1.16	0.40	1.35
Norway	1 594 000	312	1.36	0.47	1.36
Poland	40 000	1	258.25	90.39	399.53
Portugal	974 000	93	4.83	1.69	5.20
Slovakia	170 000	31	10.24	3.58	10.70
Slovenia	4 000	2	223	78.05	243.20
Spain	2 645 000	57	7.64	2.67	10.48
Sweden	5 698 000	591	0.74	0.26	1.03
Switzerland	3 683 000	452	1.63	0.57	
United Kingdom	6 180 000	96	5.03	1.76	5.99

Bulgaria, Croatia, Cyprus, Greece, Latvia, Liechtenstein, Malta and Romania do not have incineration plants.

* Incineration capacity per person is calculated as [(incineration capacity/inhabitants)*1000].
** Incineration capacity in relation to waste generation is calculated as [MSW generation/incineration capacity].
*** Incineration capacity in relation to waste generation assumitng 65 % recycling rates is calculated as [(MSW generation – MSW generation*0,65)/incineration capacity].
**** Incineration capacity taking into account sorting residues is calculated as [(MSW generation+sorting residues)/incineration capacity].

Source: Eurostat, 2016.

Annex 3 Figures on incineration capacity, mixed municipal waste recycling rates and mixed municipal waste landfill in Europe, by country, 2014

Country	Incineration capacity (tonnes)	Recycling rate (%)	Landfill (tonnes)
Austria	2 500 000	59	194 000
Belgium	2 700 000	57	47 000
Czech Rep.	646 000	23	1 827 000
Denmark	3 300 000	45	57 000
Estonia	250 000	32	30 000
Finland	1 200 000	33	458 000
France	14 500 000	39	8 691 000
Germany	19 600 000	64	691 000
Hungary	381 000	25	2 181 000
Ireland	225 000	44	1 028 000
Italy	6 300 000	38	9 332 000
Lithuania	230 000	20	748 000
Luxembourg	131 000	47	61 000
Netherlands	7 600 000	49	128 000
Norway	1 594 000	40	60 000
Poland	40 000	20	5 437 000
Portugal	974 000	26	2 307 000
Slovakia	170 000	13	1 158 000
Slovenia	4 000	40	208 000
Spain	2 645 000	27	11 138 000
Sweden	5 698 000	48	27 000
Switzerland	3 683 000	50	0
United Kingdom	6 180 000	46	8 656 000

Source: Eurostat, 2016.

Annex 4 Number of plants in the EU-27, 2012–2013

Country	Number of plants			
	Total	Incineration	Co-incineration	Uncategorised
Austria	67	17	50	0
Belgium	72	10	16	46
Bulgaria	10	3	7	0
Cyprus	1	0	1	0
Czech Rep.	42	37	5	0
Denmark	37	34	3	0
Estonia	4	3	1	0
Finland	24	10	14	0
France	249	210	39	0
Germany	365	176	186	0
Greece	5	2	3	0
Hungary	28	22	6	0
Ireland	20	15	5	0
Italy	123	68	55	0
Latvia	11	6	5	0
Lithuania	3	2	1	0
Luxembourg	3	2	1	0
Malta	1	1	0	0
Netherlands	41	36	5	0
Poland	119	51	68	0
Portugal	14	6	8	0
Romania	29	20	9	0
Slovakia	23	17	6	0
Slovenia	6	3	3	0
Spain	78	27	51	0
Sweden	138	2	136	0
United Kingdom	159	116	43	0
EU	1 672	939	688	46

Source: de Carlos and Menadue, 2016.

Annex 5 Municipal solid waste incineration capacity taking into account sorting residues in Europe, by country, 2014

Country	Incineration capacity (tonnes)	Municipal solid waste generation (tonnes)	Sorting residues (tonnes)	Incineration capacity taking into account sorting residues*
Austria	2 500 000	4 833 000	1 610 578	2.58
Belgium	2 700 000	4 886 000	1 700 481	2.43
Czech Rep.	646 000	3 261 000	351 990	5.59
Denmark	3 300 000	4 279 000	510 461	1.45
Estonia	250 000	470 000	143 997	2.46
Finland	1 200 000	2 630 000	293 057	2.43
France	14 500 000	33 703 000	5 856 813	2.72
Germany	19 600 000	50 064 000	16 395 642	3.39
Hungary	381 000	3 795 000	227 835	10.55
Ireland	225 000	2 693 000	490 654	14.14
Italy	6 300 000	29 655 000	13 535 829	6.85
Lithuania	230 000	1 270 000	219 238	6.47
Luxembourg	131 000	343 000	33 773	2.87
Netherlands	7 600 000	8 890 000	1 411 898	1.35
Norway	1 594 000	2 175 000	0	1.36
Poland	40 000	10 330 000	5 651 185	399.53
Portugal	974 000	4 710 000	357 392	5.20
Slovakia	170 000	1 742 000	77 653	10.70
Slovenia	4 000	892 000	80 810	243.20
Spain	2 645 000	20 217 000	7 505 074	10.48
Sweden	5 698 000	4 246 000	1 655 999	1.03
Switzerland	3 683 000	6 006 000	N/A	
United Kingdom	6 180 000	31 131 000	5 944 146	5.99

* Incineration capacity taking into account sorting residues is calculated as [(Municipal solid waste generated+sorting residues)/incineration capacity].

Source: ETC/WMGE calculation based on Eurostat data for 2014.

Annex 6 Key definitions

For a correct interpretation of the analysis, a few terms require explanation.

Basel Convention definitions

The **Basel Convention**, Article 2 on definitions provides the following (Basel Convention, 1989):

1. ***Wastes*** are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law;
3. ***Transboundary movement*** means any movement of hazardous wastes or other wastes from an area under the national jurisdiction of one State to or through an area under the national jurisdiction of another State or to or through an area not under the national jurisdiction of any State, provided at least two States are involved in the movement;
4. ***Disposal*** means any operation specified in Annex IV of the Convention;
10. ***State of export*** means a Party from which a transboundary movement of hazardous wastes or other wastes is planned to be initiated or is initiated;
11. ***State of import*** means a party to which a transboundary movement of hazardous wastes or other wastes is planned or takes place for the purpose of disposal therein or for the purpose of loading prior to disposal in an area not under the national jurisdiction of any State;
15. ***Exporter*** means any person under the jurisdiction of the State of export who arranges for hazardous wastes or other wastes to be exported;
16. ***Importer*** means any person under the jurisdiction of the State of import who arranges for hazardous wastes or other wastes to be imported.

Annex I of the Basel Convention lists **categories of wastes to be controlled**, including waste streams (Y1-Y18) and wastes having specific constituents (Y19-Y45).

In **Annex II Categories of waste requiring special consideration**, the Convention lists:

- Y46 Waste collection from households;
- Y47 Residues arising from the incineration of household wastes.

Annex III of the Convention provides a **list of hazardous characteristics.**

Annex IV Disposal operations, **Section A** categorises operations that do not lead to the possibility of resource recovery, recycling, reclamation, direct reuse or alternative uses ([60]):

- D10 Incineration on land.

And **Section B** of the same Annex describes operations that may lead to resource recovery, recycling, reclamation, direct reuse or alternative uses ([61]):

- R1 Use as a fuel (other than in direct incineration) or other means to generate energy.

[60]) Section A encompasses all such disposal operations that occur in practice.
([61]) Section B encompasses all such operations with respect to materials legally defined as or considered to be hazardous wastes and which otherwise would have been destined for operations included in Section A.

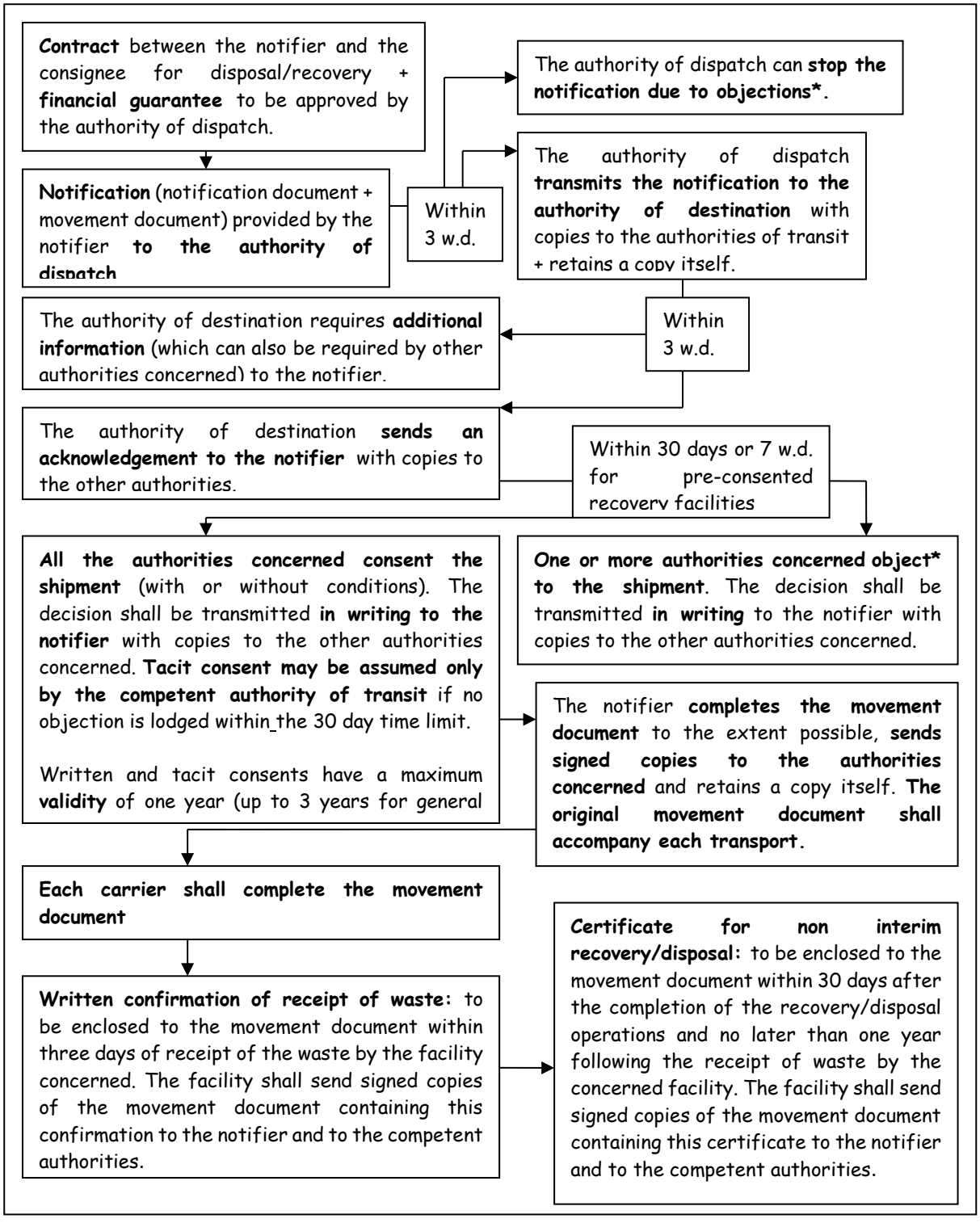
European Waste Catalogue definitions

Following Table provides definitions of important terms.

Term	Definition	Source
Waste	… any substance or object in the categories set out in Annex I which the holder discards or intends or is required to discard.	Article 1(1)(a) of Directive 2006/12/EC
Mixed municipal waste	▪ Municipal waste consists of waste collected by or on behalf of municipal authorities and disposed of through waste management systems. Municipal waste consists mainly of waste generated by households, although it also includes similar waste from sources such as shops, offices and public institutions. ▪ Mixed waste (mixture of wastes) means waste that results from an intentional or unintentional mixing of two or more different wastes and for which mixture no single entry exists in Annexes III, IIIB, IV and IVA. Waste shipped in a single shipment of wastes, consisting of two or more wastes, where each waste is separated, is not a mixture of wastes.	http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Municipal_waste http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32006R1013&from=EN Article 2
D10	Incineration on land: Disposal Operations (D1–D15): In accordance with Article 4, waste must be disposed of without endangering human health and without the use of processes or methods likely to harm the environment.	Directive 2006/12/EC, Annex II A Disposal Operations
R1	Use principally as a fuel or other means to generate energy.	Directive 2006/12/EC, Annex II B Recovery Operations
Notifier	a. In the case of a shipment originating from a Member State, any natural or legal person under the jurisdiction of that Member State who intends to carry out a shipment of waste or intends to have a shipment of waste carried out and to whom the duty to notify is assigned. The notifier is one of the persons or bodies listed below, selected in accordance with the ranking established in this listing: i. the original producer; or ii. the licensed new producer who carries out operations prior to shipment; or iii. a licensed collector who, from various small quantities of the same type of waste collected from a variety of sources, has assembled the shipment which is to start from a single notified location; or iv. a registered dealer who has been authorised in writing by the original producer, new producer or licensed collector specified in (i), (ii) and (iii) to act on his/her behalf as notifier; v. a registered broker who has been authorised in writing by the original producer, new producer or licensed collector specified in (i), (ii) and (iii) to act on his/her behalf as notifier; vi. where all of the persons specified in (i), (ii), (iii), (iv) and (v) if applicable, are unknown or insolvent, the holder. Should a notifier specified in (iv) or (v) fail to fulfil any of the take-back obligations set out in Articles 22 to 25, the original producer, new producer or licensed collector specified in (i), (ii) or (iii) respectively who authorised that dealer or broker to act on his/her behalf shall be deemed to be the notifier for the purposes of the said take-back obligations. In	Regulation (EC) No. 1013/2006, shipments of waste Article 2 (15)

	circumstances of illegal shipment notified by a dealer or broker specified in (iv) or (v), the person specified in (i), (ii) or (iii) who authorised that dealer or borker to act on his/her behalf shall be deemed to be the notifier for the purposes of this Regulation. b. In the case of import into, or transit through, the Community of waste that does not originate in a Member State, any of the following natural or legal persons under the jurisdiction of the country of destination who intends to carry out a shipment of waste or intends to have, or who has had, a shipment of waste carried out, being either: i. the person designated by the law of the country of destination; or, in the absence of any such designation; ii. the holder at the time the export took place.	
Competent authority	a. In the case of Member States, the body designated by the Member State concerned in accordance with Article 53; or b. in case of a non-Member State that is a Party to the Basel Convention, the body designated by that country as the competent authority for the purposes of that Convention in accordance with Article 5 thereof; or c. in the case of any country not referred to in either (a) or (b), the body that has been designated as the competent authority by the country or region concerned or, in the absence of such designation, the regulatory authority for the country or region, as appropriate, which has jurisdiction over shipments of waste for recovery or disposal or transit, as the case may be. There are additional definitions of “competent authority of dispatch”, “competent authority of destination”, and “competent authority of transit”.	REGULATION (EC) No 1013/2006, shipments of waste Article 2 (18)
Import	any entry of waste into the Community but excluding transit through the Community	REGULATION (EC) No 1013/2006, shipments of waste Article 2 (30)
Export	the action of waste leaving the Community but excluding transit through the Community.	REGULATION (EC) No 1013/2006, shipments of waste Article 2 (31)

Annex 7 Main stages of the notification procedure



Note: * If, within the 30-day time limit, the competent authorities consider that the problems which gave rise to their objections have been resolved, they shall immediately inform the notifier in writing, with copies to the consignee and other competent authorities concerned. If the problems in question have not been resolved, the notification shall cease to be valid.

Source: EU, 2006.

Annex 8 Non-hazardous List of Waste (LoW) codes corresponding to Y-46, 'mix' and 'not specified' Y-codes only for waste destined to R1 and D10

Y-code	Correlated LoW code	European Waste Catalogue Sub-chapter	European Waste Catalogue Chapter
Y-46	150102: plastic packaging	15 01: packaging (including separately collected municipal packaging waste)	15: waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified
	150106: mixed packaging	See above	See above
	190501: non-composted fraction of municipal and similar wastes	19 05: wastes from aerobic treatment of solid wastes	19: wastes from waste management facilities, off-site wastewater treatment plants and the preparation of water intended for human consumption and water for industrial use
	190805: sludges from treatment of urban waste water	19 08: wastes from waste water treatment plants not otherwise specified	See above
	191204: plastic and rubber	19 12: wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified	See above
	191207: wood not containing hazardous substances	See above	See above
	191210: combustible waste (refuse-derived fuel)	See above	See above
	191212: other wastes (including mixtures of materials) from mechanical treatment of wastes not containing hazardous substances	See above	See above
	200138: wood not containing hazardous substances	20 01: separately collected fractions (except 15 01)	20: municipal wastes (household waste and similar commercial, industrial and institutional wastes) Including separately collected fractions
	200199: other fractions not otherwise specified	See above	See above
	200301: mixed municipal waste	20 03: other municipal wastes	See above
	200307: bulky waste	See above	See above
	Mix (non-hazardous)		

	Unfilled (N. 27/273)		
Mix	020704: materials unsuitable for consumption or processing	02 07: wastes from the production of alcoholic and non-alcoholic beverages (except coffee, tea and cocoa)	02: wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing
	150101: paper and cardboard packaging	15 01: packaging (including separately collected municipal packaging waste)	15: waste packaging; absorbents, wiping cloths, filter materials and protective clothing not other wise specified
	180109: medicines other than those mentioned in 18 01 08 ([62])	18 01: wastes from natal care, diagnosis, treatment or prevention of disease in humans	18: wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care)
	180204: (previously 'discarded chemicals'; now superseded([63]))	18 02: wastes from research, diagnosis, treatment or prevention of disease involving animals	See above
	191210: combustible waste (refuse-derived fuel)	19 12: wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified	19: wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use
	191212: other wastes (including mixtures of materials) from mechanical treatment of wastes not containing hazardous substances	See above	See above
	200132: medicines other than those mentioned in 20 01 31([64])	20 01: separately collected fractions (except 15 01)	20: municipal wastes (household waste and similar commercial, industrial and institutional wastes) Including separately collected fractions.
	Mix (non-hazardous) ([65])		
	Unfilled/Total mix including hazardous waste (N 84/802)		

([62]) Cytotoxic and cytostatic medicines.
([63]) Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Directive 91/689/EEC on hazardous waste, replaced by Commission Decision 2000/532/EC.
([64]) Cytotoxic and cytostatic medicines.
([65]) Apart for a few cases (6), all shipments of mix waste report as waste category code Y1-Y45.

Not specified ([66])	191207: wood not containing hazardous substances	19 12: wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified	19: wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use
	191210: combustible waste (refuse-derived fuel)	See above	See above
	191212: other wastes (including mixtures of materials) not containing hazardous substances from mechanical treatment of wastes	See above	See above
	Unfilled (N 226/2.408)		

Source: ETC/WMGE elaborations of Eurostat, 2016.

([66]) Since 'not specified' shipments have been provided with more than 90 non-hazardous LoW codes (as well as several hazardous ones), only the three most important non-hazardous LoW codes (by weight of the overall shipments of waste with a 'not specified' Y-code, including hazardous waste) are reported.

Annex 9 Trade matrix for Y-46 waste for incineration (R1 + D10), EU-27, Norway and Switzerland, 2013 (tonnes)

EXPORTING COUNTRY	IMPORTING COUNTRY																		
	Austria	Belgium	Bulgaria	Czech Republic	Denmark	Estonia	Finland	France	Germany	Ireland	Italy	Latvia	Luxembourg	Netherlands	Norway	Sweden	Switzerland	United Kingdom	Total to/from
Austria to	40.0								4 227.8								58 454.8		**62 722.7**
from Austria									8 045.4										**8 045.4**
Belgium to																			**0.0**
from Belgium								5 998.2						66.1					**6 064.3**
Bulgaria to																			**0.0**
from Bulgaria																			**0.0**
Czech Rep. to									143.6										**143.6**
from Czech Rep.									143.6										**143.6**
Denmark to																			**0.0**
from Denmark																			**0.0**
Estonia to																			**0.0**
from Estonia																			**0.0**
Finland to						20 841.6										6 712.0			**27 553.7**
from Finland						17 127.8										6 714.5			**23 842.3**
France to																	1 552.6		**1 552.6**
from France									31 412.2				1 710.0						**33 122.2**
Germany to														102.2			156 172.1		**156 274.3**
from Germany														469.4					**469.4**
Ireland to						8 073.5			10 561.6					47 408.5		13 891.5		381.0	**80 316.1**
from Ireland					10 117.0	8 067.6			4 771.1					78 076.8		11 346.5			**112 378.9**
Italy to	2 548.5																		**2 548.5**
from Italy	10 024.1																		**10 024.1**
Latvia to																			**0.0**
from Latvia																			**0.0**
Luxembourg to																			**0.0**
from Luxembourg									1 023.4										**1 023.4**
Netherlands to					25.0				324 131.1										**324 156.1**
from Netherlands					3 990.4				287 250.2										**291 240.6**
Norway to																			**0.0**
from Norway					25 193.0											270 764.4			**295 957.5**
Sweden to															596.0				**596.0**
from Sweden									3 132.5										**3 132.5**
Switzerland to																			**0.0**
from Switzerland																			**0.0**

EXPORTING COUNTRY	IMPORTING COUNTRY																		
	Austria	Belgium	Bulgaria	Czech Republic	Denmark	Estonia	Finland	France	Germany	Ireland	Italy	Latvia	Luxembourg	Netherlands	Norway	Sweden	Switzerland	United Kingdom	Total to/from
United Kingdom to			5 107.9		90 466.3	29.4			146 262.3	122.4		87 384.0		1 098 435.0	49 669.3	168 373.2			**1 645 849.8**
from United Kingdom					113 668.2	2 776.5				123.3		115 422.7		215 563.6		181 943.7			**629 497.9**
Total to	**2 588.5**	**0.0**	**5 107.9**	**0.0**	**90 491.3**	**28 944.5**	**0.0**	**0.0**	**485 326.6**	**122.4**	**0.0**	**87 384**	**0.0**	**1 145 945.8**	**50 265.3**	**188 976.8**	**216 179.4**	**381.0**	**2 301 713.4**
Total from	**10 024.1**	**0.0**	**0.0**	**0.0**	**152 968.6**	**27 971.8**	**0.0**	**5 998.2**	**335 778.4**	**123.3**	**0.0**	**115 422.7**	**1 710.0**	**294 175.9**	**0.0**	**470 769.1**	**0.0**	**0.0**	**1 414 942.0**

Note: country X to = export flow from country x as notified by exporting country; from country X = import flow from country X as notified by importing country.

Source: ETC/WMGE elaboration on Eurostat data, 2016.

Annex 10 Import and export of mixed municipal waste (200301) for incineration (R1 + D10), EU-27 plus Norway and Switzerland, 2013 (tonnes)

Exporting country	R1+D10	R1	D10	Importing country	R1+D10	R1	D10
Austria	3 444.35		3 444.35	Austria			
	7 258.70	3 809	3 449.70				
Czech Rep.	143.64	143.64		Czech Rep.			
	143.64		143.64				
Denmark				Denmark			
					25	25	
Estonia				Estonia	25 195.32	25 195.32	
					8 073.5	8 073.5	
Finland	6 712.04	6 712.04		Finland			
	23 842.26	23 842.26					
France	33 339.02	75.78	33 263.24	France			
	31 412.16		31 412.16				
Germany	156 274.30	102.24	156 172.06	Germany	330 377.73	14 152.90	316 224.83
	469.41	469.41			310 190.38	10 814.74	299 375.64
Ireland	112 379.13	112 379.13		Ireland			
	102 261.93	102 261.93					
Netherlands	269 891.39	5 886.10	264 005.29	Netherlands	78 546.21	78 546.21	
	286 792.13	5 572.80	281 219.33		85 706.36	85 706.36	
Norway	17 644.50			Norway	596	596	
Sweden	596.00	596.00		Sweden	35 705.47	35 705.47	
		.			20 603.55	20 603.55	
Switzerland						75.78	157 509.30
Total export	**582 779.87**	**125 894.93**	**456 884.94**	**Total import**	**469 824.73**	**316 224.83**	**153 599.90**
Total import	**469 824.73**	**153 599.90**	**316 224.83**	**Total export**	**582 779.87**	**456 884.94**	**125 894.93**

Note: Yellow rows report data notified by exporting and importing countries, while white rows report export and import data based on shipments notified by, respectively, importing and exporting countries.

Source: ETC/WMGE elaboration on Eurostat data, 2016.

Annex 11 Trade matrix for mixed municipal waste for incineration (R1 +D10) in the EU-27, Norway and Switzerland, 2013 (tonnes)

EXPORTING COUNTRY	IMPORTING COUNTRY												
	Austria	Czech Republic	Estonia	Denmark	Finland	France	Germany	Ireland	Netherlands	Norway	Sweden	Switzerland	**Total to/from**
Austria to							3 444.35						**3 444.35**
From Austria							7 258.70						**7 258.70**
Czech Rep. to							143.64						**143.64**
From Czech Rep.							143.64						**143.64**
Denmark to									102.24			156 172.06	**156 274.30**
From Denmark									469.41				**469.41**
Finland to											6 712.04		**6 712.04**
From Finland			17 127.76								6 714.50		**23 842.26**
France to							31 926.00					1 413.02	**33 339.02**
From France							31 412.16						**31 412.16**
Ireland to			8 073.50				4 810.00		85 604.12		13 891.51		**112 379.13**
From Ireland			8 067.56				4 771.10		78 076.80		11 346.47		**102 261.93**
Netherlands to				25.00			269 866.39						**269 891.39**
From Netherlands							286 792.13						**286 792.13**
From Norway											17 644.50		**17 644.50**
Sweden to										596.00			**596.00**
From Sweden													
Total to			**8 073.50**	**25.00**			**310 190.38**		**85 706.36**	**596.00**	**20 603.55**	**157 585.08**	**582 779.87**
Total from			**25 195.32**				**330 377.73**		**78 546.21**		**35 705.47**		**469 824.73**

Note: country X to = export flow from country x as notified by exporting country; from country X = import flow from country X as notified by importing country.
Source: ETC/WMGE elaboration on Eurostat data, 2016.

Annex 12: Trade matrix for refuse-derived fuel for incineration (only R1*), EU-27, Norway and Switzerland, in 2013 (tonnes)

EXPORTING COUNTRY	IMPORTING COUNTRY																						
	Austria	Belgium	Bulgaria	Czech Republic	Denmark	Estonia	Finland	France	Germany	Hungary	Ireland	Latvia	Luxembourg	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	Switzerland	Total to/from
Austria to				27 323 .88															6 383. 44	2 573. 11				36 280.43
From Austria				27 380 .22					10 945 .94										6 361. 93	2.465. 12				**47 153.21**
Belgium to								7 529. 50	112 42 6.61					25 838 .27										145.794.3 7
From Belgium								8 065. 02	109 99 6.07					25 653 .11										**143 714.2 0**
Estonia to																								
From Estonia			3 48 4.71																					**3 484.71**
Finland to																						1 521.64		1 521.64
from Finland																						1 551.96		**1 551.96**
France to													1 906. 00											1 906.00
from France																								
Germany to		66.9 2		24 562 .46	13 497 .82			1 157. 04					9 519. 82	4 356. 86		22 794 .75			89.44			15 416.33	16 590. 80	108 052.2 4
From Germany		66.9 0		24 805 .12	14 339 .97			1 157. 00						4 401. 67					66.22			13 898.86		**58 735.74**
Hungary to																								
From Hungary																			311.32					**311.32**
Ireland to					23 248 .00				69 064 .65					22 680 .71							96.42	2 418.78		117 508.5 7
From Ireland					4 120. 00				76 091 .59					46 576 .49										**126 788.0 8**
Italy to	18 0 74.3 4		20 6 69.0 0	1 538. 89						16 034 .38								4.000. 00	31 135 .00	9.825. 97				101 277.5 8

EXPORTING COUNTRY	IMPORTING COUNTRY																							
	Austria	**Belgium**	**Bulgaria**	**Czech Republic**	**Denmark**	**Estonia**	**Finland**	**France**	**Germany**	**Hungary**	**Ireland**	**Latvia**	**Luxembourg**	**Netherlands**	**Norway**	**Poland**	**Portugal**	**Romania**	**Slovakia**	**Slovenia**	**Spain**	**Sweden**	**Switzerland**	**Total to/from**
From Italy	17 023.00		12 697.74	1 424.36					99.46	30 804.55									34 331.09					**96 380.20**
Luxembourg to																								
From Luxembourg		638.00						1 498.00																**2 136.00**
Netherlands to		3 683.06			3 897,36		46,32	9 409,58	118 179.67						22.48							85 389.26		220 627.73
From Netherlands		2 687.30			3 990.36		46.32	10 072.00	109 186.21													96 512.50		**222 494.70**
Norway to																								
From Norway					25 193.04																	142 611.77		**167 804.81**
From Poland									22 816.91															**22 816.91**
Slovenia to										8 177.92														8 177.92
From Slovenia										7 673.50														**7 673.50**
Spain to																	133.26							133.26
From Spain																	11 518.28							**11 518.28**
United Kingdom to		35.20	5 107.87		110 820.08	29.40	1 651.92		165 602.64		15 009.36	115 500.47		1 001 048.25	59 526.30						116.96	163 295.40		1 637 743.85
from United kingdom			5 107.87		107 016.21	2 776.52	1 651.95		181 250.32		14 625.12	115 422.70		981 243.89								166 384.95		**1 575 479.54**
Total to	**18 074.34**	**3 785.18**	**25 767.87**	**53 425.23**	**151 463.26**	**29.40**	**1 698.24**	**18 096.12**	**465 273.57**	**24 212.30**	**15 009.36**	**115 500.47**	**11 425.82**	**1 053 924.09**	**59 548.78**	**22 794.75**	**133.26**	**4 000.00**	**37 607.88**	**12 399.08**	**213.38**	**268 041.41**	**16 590.80**	**2 379 023.59**
Total from	**17 023.00**	**3 392.20**	**21 290.32**	**53 609.70**	**154 659.59**	**2 776.52**	**1 698.27**	**20 792.02**	**510 386.50**	**38 478.05**	**14 625.12**	**115 422.70**		**1 057 875.16**			**11 518.28**		**41 070.56**	**2 465.12**		**420 960.04**		**2 488 043.15**

Note: country X to = export flow from country x as notified by exporting country; from country X = import flow from country X as notified by importing country.

* No RDF was shipped in 2013 for incineration on land.

Source: ETC/WMGE elaboration on Eurostat data, 2016.