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Determining climate protection potentials in the circular economy for Germany and the EU

Partial report EU

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Abstract: Determining climate protection potentials in the circular economy for Germany and the EU – Partial report EU

Climate protection potentials of the circular economy are determined holistically by means of the life cycle assessment method of waste management in this study. It includes emissions from all waste treatments as well as the benefits from the generation of secondary raw materials and energy and the resulting possible substitution of primary products.

For Germany and the EU, the given greenhouse gas (GHG) mitigation potential is shown for the base year 2017, and for the target year 2030, it is outlined how contributions can also be achieved in the future. In addition to municipal solid waste (MSW), food waste is considered in more detail as a special balance, and commercial and industrial waste as well as construction and demolition waste are considered roughly. Also considered are possibilities to include preparation for re-use and waste prevention. This partial report presents the results for the EU.

All balance areas show GHG reduction potentials in the net result. These are lowest for MSW due to the continued share of landfilling. This is also the reason that two defined Clusters within the EU27 show net debits. Conversely, in the 2030 scenarios, MSW has by far the highest GHG reduction potential through diversion from landfill. Further relevant contributions can be achieved by increasing the recycling of dry recyclables. The conclusion is that there is important climate protection potential and joint efforts are needed to quickly end landfilling and to increase separate collection and recycling.

Kurzbeschreibung: Ermittlung der Klimaschutzpotentiale in der Kreislaufwirtschaft für Deutschland und die EU – Teilbericht EU

Klimaschutzpotenziale der Kreislaufwirtschaft sind in dieser Studie mittels Ökobilanzmethode der Abfallwirtschaft ganzheitlich ermittelt. Es ist die Gesamtheit der Emissionen aus der Abfallbehandlung umfasst sowie auch die Leistungen durch die Erzeugung von Sekundärrohstoffen und Energie und die damit mögliche Substitution von Primärprodukten.

Für Deutschland und die EU wird das gegebene Treibhausgas (THG)-Minderungspotenzial für das Basisjahr 2017 aufgezeigt und für das Zieljahr 2030 dargelegt wie auch künftig Beiträge erzielt werden können. Neben Siedlungsabfällen sind Lebensmittelabfälle als Sonderbilanzraum eingehender und Produktions- und Gewerbeabfälle sowie Bau- und Abbruchabfälle überschlägig betrachtet. Betrachtet sind zudem Möglichkeiten die Vorbereitung zur Wiederverwendung sowie die Abfallvermeidung einzubeziehen. Dieser Teilbericht stellt die Ergebnisse für die EU vor.

Alle Bilanzräume zeigen im Nettoergebnis THG-Entlastungspotenziale. Am geringsten sind diese für Siedlungsabfälle aufgrund der weiterhin bestehenden Anteile zur Deponierung. Dies ist auch der Grund dafür, dass zwei definierte Cluster innerhalb der EU27 Nettobelastungen aufweisen. In den Szenarien 2030 besteht umgekehrt für Siedlungsabfälle das mit Abstand höchste THG-Minderungspotential durch die Abkehr von der Deponierung. Weitere relevante Beiträge können durch Steigerung des Recyclings trockener Wertstoffe erreicht werden. Fazit ist, es bestehen wichtige Klimaschutzpotenziale und es bedarf gemeinsamer Anstrengungen zu einer schnellen Beendung der Deponierung und zur Steigerung der getrennten Erfassung und des Recyclings.

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AD	Anaerobic digestion
C&D waste	Construction and demolition waste
CEWEP	Confederation of European Waste-to-Energy Plants
CHP	Combined heat and power
C&I waste	Commercial and industrial waste
CO2	Carbon dioxide
COP	Conference of the Parties
ECN	European Compost Network
EEA	European Environment Agency
EEA-model	European Reference Model on Municipal Waste Generation and Management
EU	European Union
EU-ETS	EU Emissions Trading Scheme
EU27 (w/o) DE	EU27 without Germany
EWC-Stat	European Waste Classification for Statistics
EWC-Stat code	European Waste Classification for Statistics code
FEAD	European Waste Management Association
FW	Food waste
GHG	Greenhouse gas
HC	Home composting
INC	Incineration
kg/cap	kilogram per capita
LCA	Life Cycle Assessment
LF	Landfill
LoW	European List of Waste
LoW-code	European List of waste code
LS	Lead Scenario
LWP	Lightweight Packaging
MBT	Mechanical biological treatment
MS	EU Member States
MT	Mechanical treatment
MSW	Municipal solid waste
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne/Statistical Classification of Economic Activities in the European Community
NDC	Nationally Determined Contributions (in Paris-Agreement)
NIR	National Inventory Report
N_2O	Nitrous oxide (laughing gas)

OECD	Organisation for Economic Co-operation and Development
RDF	Refuse Derived Fuel
SS	Special Scenario
t	Tons
UBA	Deutsches Umweltbundesamt / German Environment Agency
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WEEE	Waste electrical and electronic equipment
WFD	Waste Framework Directive
WStatR	Waste Statistics Regulation (2150/2002/EC)

Summary

With the Paris Agreement of December 2015, following the Kyoto Protocol, member states have again committed to reducing anthropogenic greenhouse gas (GHG) emissions and limiting the global warming well below 2°C compared to pre-industrial levels. This requires extensive efforts across all the climate relevant sectors and source groups, including the waste sector.

According to the common reporting format of the Kyoto Protocol, the waste sector is limited to direct and non-energy GHG emissions in order to avoid double reporting. The entirety of the contribution to climate protection achieved and achievable can be demonstrated by the life cycle assessment (LCA) method for the waste sector (e.g. documented in (Dehoust et al. 2010; Vogt et al. 2015)).

In this study, the waste management situation in 2017 is examined and it forms the baseline for the GHG balances. For the target year 2030, the potential climate protection contribution of the circular economy is shown against the background of the further developed political and legal framework conditions. Also, in this study an approach could be shown to include waste prevention in the LCA method for the waste sector.

This partial report on the project "Climate Protection Potentials in the Circular Economy – Germany, EU"[1] documents the work and results for the EU. It describes the methodological procedure for the data collection, the basis for the GHG balances as well as the results and recommendations derived from the findings of the study. The results for Germany are published separately ("partial report Germany"). Both reports contemplate the following waste types:

- Municipal solid waste (MSW)
- Food waste (special balance)
- Commercial and industrial waste (C&I waste)
- Construction and demolition (C&D waste)

A separate quantity survey and GHG balancing was carried out for each waste type. Methodologically, the balancing areas for MSW, C&I waste, and C&D waste are complementary, while food waste is investigated as a special balancing area, which includes food waste from the MSW sector as well as from the C&I waste sector.

For MSW and food waste, detailed GHG balances are presented, whereas only a rough assessment is conducted for C&I and C&D waste. For MSW and food waste, the actual situation in the base year 2017 is analysed for Germany, for the current EU27, the previous EU28 (including the UK) and for two clusters defined from the EU member states. For C&I and C&D waste, the analysis is limited to Germany and the EU27. The future GHG reduction potentials for the target year 2030 are also analysed more comprehensively for MSW and food waste with two scenarios for each: Germany, the EU27 and the two EU clusters. For the C&I and the C&D waste, there are two scenarios for Germany and one scenario for the EU27.

For MSW and for the special balance area food waste, larger effort was put into integrating the more detailed results for Germany (partial report Germany) with the data available for other EU countries. As a result, all evaluations were initially carried out separately for the EU27 without Germany (EU27 w/o DE) and Germany and then combined. On average the data for Germany are more detailed than for the other 26 EU Member States, for which only limited investigations into the national circumstances could be carried out within the framework of this study.

1 Long title: Determining climate protection potentials in the circular economy for Germany and the EU as a contribution to achieving the goals of national and international climate protection commitments

Data situation, procedure for collecting data

The most recent data were used to form a consistent data set for all four waste flows referring to the same reference year (2017). This is challenging because

- the two main sources for statistical waste data at EU level, i.e. the MSW data set and the Waste Statistics Regulation[2] (WStatR) data, are based on different concepts that are difficult to reconcile;
- the frequency of data collection for both data sets differs; whereas MSW data are collected on an annual basis, the WStatR data are reported biannually for even years only. For MSW, data for the agreed reference year 2017 were available already at the beginning of the study, whereas the latest WStatR data refer to 2016.

It was agreed to use the latest MSW data for the reference year 2017 and to extrapolate the WStatR data for the other waste streams to 2017 in order to achieve a consistent data set for the GHG balances. The extrapolation of WStatR data is described in Chapter 3.3.

In addition to the MSW and WStatR data reported to Eurostat, further data sets had to be used for the compilation of the base data, in particular the European Reference Model on Municipal Waste Generation and Management (hereafter referred to as the EEA-model[3]).

The respective data sources are described in more detail in Chapter 3.2.

Determination of the two EU Clusters

For the GHG emissions accounting of the waste streams 'municipal waste' and 'food waste', two country clusters were defined. The two clusters are intended to cover countries with a backlog/catch-up demand in view of a climate-friendly waste management and in view of the EU's waste management targets with a high potential for reducing GHG emissions related to waste management.

Different indicators and country characteristics were investigated to identify suitable criteria for the clustering. Based on the analysis, the two clusters were defined as follows:

- **Cluster 1** comprises all countries that are entitled to postpone the deadline for the WFD re-use/recycling targets for 2025, 2030 and 2035 period by five years, on account of their low recycling rate in 2013 and/or their high landfill rate in 2013 respectively. The cluster includes the **12 countries** Bulgaria, Estonia, Greece, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, and Slovakia.
- **Cluster 2** comprises all countries that reported an MSW recycling rate for 2017 below or equal to the recycling rate of the EU27 (w/o UK) and that are not included in Cluster 1. Cluster 2 includes the **8 countries** Czech Republic, Denmark, Ireland, Spain, France, Portugal, Finland, and Sweden.

Not covered by the two clusters are the countries that reported for 2017 a recycling rate above the EU27 rate of 47% and the UK. UK is not considered as the country is not an EU member state any more, and therefore is not subject to the development of recommendations.

2 Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 November 2002 on waste statistics (OJ L 332, 9.12.2002, p. 1, last amended by OJ L 253, 28.9.2010, p. 2).

3 European Reference Model on Municipal Solid Waste Management, 2018 version, produced by the European Union, The EEA was so kind as to provide the model to the contractor already in March 2019, prior to the official publication. It is now available at Eionet, European Environment Information and Observation Network: https://www.eionet.europa.eu/etcs/etc-wmge/etc-wmge-files/eurm_mswm.zip.

Background for the GHG balances

The climate protection potentials of the circular economy are determined using the Life Cycle Assessment (LCA) method of waste management based on ISO 14040/14044, which has already been applied and described in detail in many studies (e.g. Dehoust et al. (2010) and Vogt et al. (2015)). It permits a holistic approach, since it includes not only the direct emissions from waste treatment (debits) but also the potentially avoided emissions through the substitution of primary products and conventionally generated energy (credits). To evaluate the impact from GHG emissions on climate change the global warming potential for the 100 year horizon (GWP100) according to IPCC (2013) was used.

Certain rules apply to the LCA method of waste management, such as that system comparisons may only be carried out for the same absolute waste quantities and qualities. The balancing includes all emissions arising from the treatment of a defined amount of waste, and thus also those that occur over several decades in the future when landfilled. Another relevant aspect for LCA of waste management is that the technical substitution potential is taken into account for material recycling, not the substitution potential according to the market mix. In case of co-incineration of waste in cement kilns or coal power plants the substitution of standard fossil fuels is accounted for. The generation of electricity and heat from waste by thermal treatment is credited by substituting the average electricity and heat generation in order to be able to understand the dynamics from the energy transition in future scenarios.

For reasons of consistency, generally average electricity and heat emission factors for the EU27 are used for all balance areas. This also accounts for the separately calculated balances for Germany that are combined with the results for the EU27 (w/o DE). In the separate study on Germany (partial report Germany) national values were used. For the two Clusters the influence of regional electricity emission factors was investigated in sensitivities. The generally used average EU27 emission factors are adjusted to a changed energy source mix for the 2030 scenarios. Since changed emission factors for electricity also have an impact on primary production, an estimate was also made for correspondingly reduced substitution potential for the electricity-intensive production processes for paper and aluminium. In general, harmonised emission factors were used for substituted primary production processes following the approach from the previous study Vogt et al. (2015).

For the calculation of waste treatment options for residual waste, dry and organic recyclables and wood an attempt was made to use national data as far as possible. Research at national level could only be carried out to a limited extent as part of the study. The national inventory reports were evaluated to obtain parameters for landfilling, composting and anaerobic digestion. Weighted energy efficiencies for thermal treatment could be derived based on country specific capacities of thermal treatment plants in Scarlat et al. (2019). The initial attempt to use weighted efficiencies based on the data and MSW mass flows derived from the EEA-model led to implausible results. Relevant parameters for residual waste (calorific value, fossil and biogenic carbon content) were calculated based on waste compositions from the EEA-model. For Germany data from a recent nationwide sorting analysis for residual waste from households were available. For commercial MSW and bulky waste, less representative data had to be used as approximation. In the cases where no EU data could be derived from the EEA-model or the other sources, the calculations for Germany were also used for the EU or plausible assumptions were derived based on the German data.

Municipal solid waste

The **baseline data for MSW** were calculated from the data sources EEA-model (specifics, see Chapter 3.2.2) and MSW data reported to Eurostat (specifics, see Chapter 3.2.1). The amounts and composition of MSW generation and treatment were calculated for the EU27 (w/o DE) and for the two clusters, and were then merged with the data sets from the separate report covering Germany. The following approach (see Chapter 5.1) for the data compilation was taken:

- Calculate the model baseline scenario as most likely development for all 28 countries,
- Use the Eurostat data 2017 (actually reported by the member states) to adjust the major streams calculated by the model,
- Take the breakdowns by major waste streams in the EEA-model and the treatment split reported by the countries to Eurostat as a means to adjust the major streams of the EEA-model data with the reported trends, and
- Use the breakdowns of materials and the detailed treatment splits in % (e.g. 5 MBT-types and related outputs) to apply them on the adjusted major streams.

To proceed like this, similarities between the Eurostat data and those of the EEA-model were identified, which were helpful to adjust the EEA-model data (prognosis) with the real developments reflected in the Eurostat data for organic waste and dry recyclables.

The further proceeding consists in the validation of the calculations. The validation covered the following:

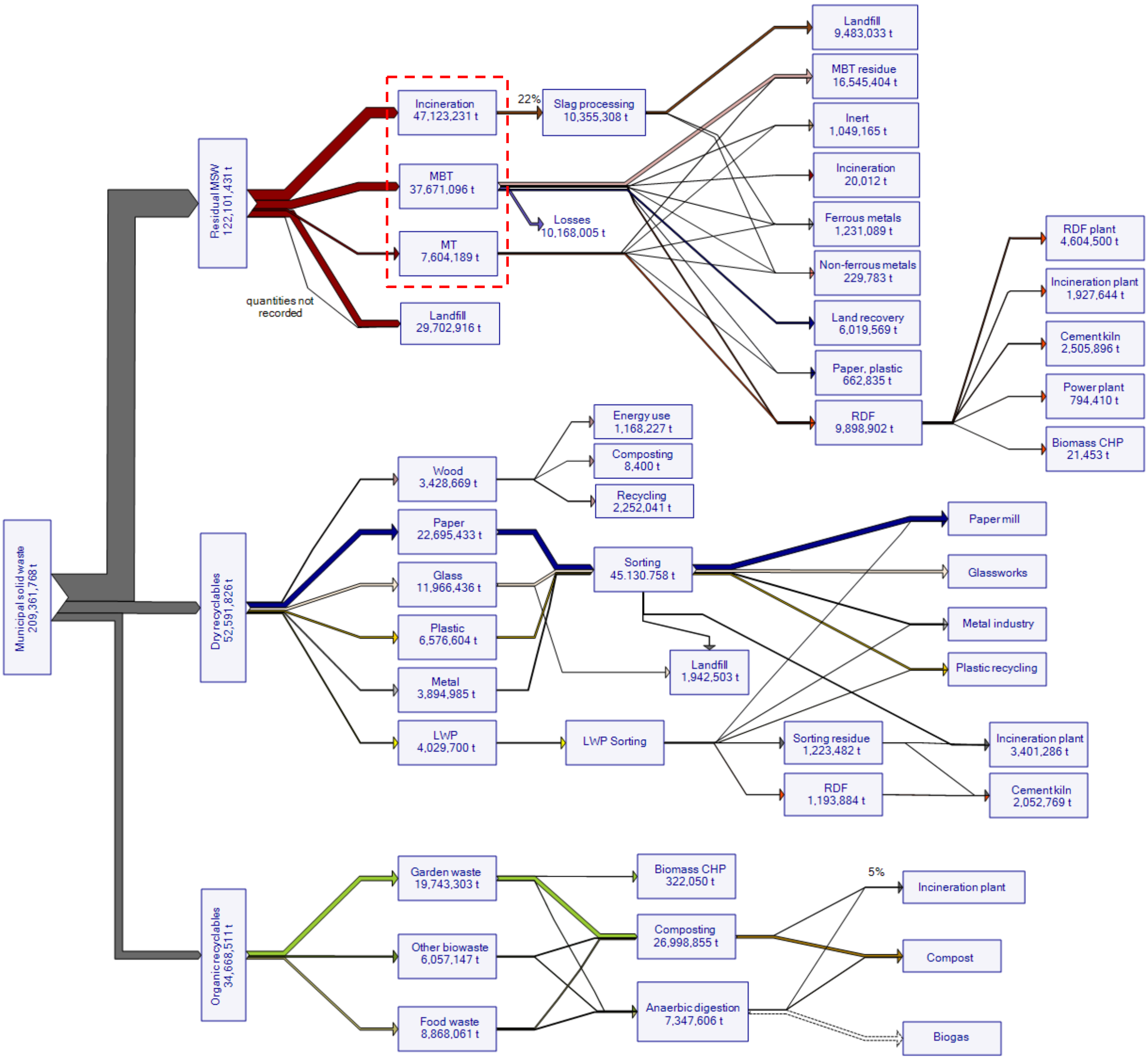
1. Quick check of Eurostat metadata for methodological changes and of the adjustment factors; corrections of obvious inconsistencies (e.g. extreme different trends caused by methodological breaks such as the exclusion of MBT amounts from composting/digestion in the Eurostat data in 2017 compared to 2015).
2. Comparison of all relevant breakdowns in % used in the model 2017 and 2015 and adjustment of major inconsistencies (total MSW composition by materials, breakdown of residual waste treatment, breakdown of organic waste treatment, capture rates for dry recyclables and organic wastes, and loss rates to calculate the rejects for dry recyclables and organic wastes).
3. Compare the calculated residual waste composition with the composition data from literature research (e.g. from national waste management plans).
4. Comparison of the amounts calculated by the model for final treatment with the Eurostat data, where the reporting to Eurostat is known to be close to the concept of final treatment.

The validations 1 and 2 needed to be performed for all countries, while the remaining validations were only applied to the larger countries covering 80% of the clusters and EU aggregates.

The baseline data for MSW generation and treatment are shown in Figure 1 for the EU27. Similar illustrations were completed for the EU28 including the UK, as well as for Cluster 1 and Cluster 2. The material streams *WEEE*, *batteries and accumulators, hazardous waste (excl. WEEE), rubble and soil* and, within dry recyclables, *textiles*, are not in the scope of this study but needed to be kept in the calculations in order to be coherent with the Eurostat data, which contain these streams. Taking these streams out of the calculations would have resulted in wrong adjustment factors. Therefore, these streams are used in the overall calculations of the MSW data but are disregarded in the finally presented amounts and the GHG balances.

Figure 1 shows that the majority of waste in the EU is still residual MSW. Its share amounts to 58% for the EU27 (or 59% for the EU28, 77% for Cluster 1 and 67% for Cluster 2). For comparison, the share for Germany is 42%. The separately collected dry recyclable materials (including wood) account for 25% of the total MSW for the EU27 as well as for the EU28, but only for 16% for Cluster 1 and 20% for Cluster 2. By comparison, Germany's share is 35%. The share of the separate collected organic waste is 17% for the EU27 or 16% for the EU28, but amounts only to 7% for Cluster 1 and 12% for Cluster 2. For Germany a share of 23% was considered for the separate collected organic waste.

Figure 1: Sankey diagram MSW EU27 2017



Source: own illustration, ifeu.

The share of residual MSW for treatment and to landfill is:

- EU27: 24% landfill, 76% treatment (thereof 51% incineration)
- EU28: 25% landfill, 75% treatment (thereof 51% incineration)
- Cluster 1: 50% landfill, 50% treatment (thereof 9% incineration)
- Cluster 2: 29% landfill, 71% treatment (thereof 58% incineration)

For comparison, in Germany 0% is landfilled, residual MSW for treatment is incinerated to 67%.

For MSW, two **scenarios** are developed for the year 2030 for the EU balance areas of EU27, Cluster 1 and Cluster 2. The first scenario for all three balance areas is named “lead scenario”. The lead scenarios follow the goals of the Waste Framework Directive (WFD), i.e., they assume that all countries comply with the legislative targets and consider likely developments in MSW treatment in the future. The second scenario differs for the EU27 and for the Clusters, although all have the goal to investigate on a lower level of ambitiousness. For the EU27, a model-theoretical scenario was considered taking home composting into account for the recycling targets. For the clusters, special scenarios were developed to test the effect of non-compliance with the recycling rates.

The model-theoretical scenario “with home composting in the RC rate” for the EU27, is less ambitious but still complies with the legal recycling target. The assessed amount home composted for the EU27 – about 40.2 million tons (or about 90 kg/cap/year) – is added to the MSW generation in 2017 and 2030 (equal total waste quantities as prerequisite of the LCA method for system comparisons), and contributes to the recycling rate. As a result, the residual waste is reduced only by 27% in 2030 in the scenario with home composting in the RC rate, instead of the 42% in the lead scenario without home composting. The higher amounts of “residual MSW for treatment” are assigned according to the same split of treatment technologies as in the lead scenario, and compliance with the landfill directive is still considered (amount of residual MSW to landfill in 2030 is nearly the same). However, it should be considered that the scenario has high data uncertainties. Furthermore, the scope of the study did not enable to discuss the potential interferences between separate collection of organic waste and home composting.

In addition to the scenarios, the influence of regional electricity emission factors was investigated for the two Clusters in sensitivities.

The **results of the GHG balance for the EU27 for the base** year 2017 and for the lead scenario 2030, are shown in Table 1. In total, both scenarios result in absolute net emission savings potentials (negative values, credits higher than debits). The net emission savings potential for 2017 is -3.53 million tons CO_2eq. This small emission saving potential is mainly due to the high waste quantities still landfilled in the EU27 (“Res. MSW to landfill”), which are responsible for an absolute net debit of 27.59 million tons CO_2eq. The results of the other waste fractions are associated with net savings potentials, although this is small in the case of organic waste (food waste, garden waste, other biowaste from the EEA-model, and waste from the bio bin and kitchen/canteen waste from the German waste statistic).

The specific net results per ton show that especially the recycling of dry recyclables, especially metals and followed by light weight packaging (LWP, only Germany), plastics, glass, and paper, is associated with higher net emission savings potentials. The recycling of wood shows a lower net savings potential, and the recycling of organic waste is almost zero due to the high share of composting. The specific net savings potential for residual MSW for treatment (“Res. MSW for treatment”), which includes incineration, mechanical-biological treatment (MBT) and mechanical treatment (MT) (see red dashed-border box in Figure 1), is also rather low. The specific emission savings potential is higher when the produced RDF is also proportionately co-incinerated in coal power plants and cement kilns where it replaces fossil fuels. However, there are high data uncertainties about the share of RDF, and both the composition of the input material and the characteristics and quality of the RDF produced. Additionally, this result includes a correction for Hungary, where amounts attributed to MT from the EEA-model are lastly landfilled without further treatment according to the national inventory report (NIR HU 2019).

In the lead scenario 2030 (WFD) the absolute net savings potential is increased to -29.99 million tons CO_2eq. The most distinctive difference in the results is the reduction of the net debits from landfilling, which is cut down to 3.96 million tons CO_2eq. The remaining GHG debits result from Cluster 1 countries, where the possible derogation according to the landfill directive was taken into account[4]. The absolute net emission savings potentials of dry recyclables are mainly increased due to more separate collection and recycling in order to achieve the recycling rate of the WFD. Paper is an exception, the reduced absolute net emissions savings potential is a result of the estimated reduced GHG impacts from primary production of paper (electricity demand calculated with the lower electricity emission factor for 2030, see results per ton). Such an estimate was also conducted for the electricity-intensive production of aluminium, which is the reason for the slightly reduced per ton result for metals.

Table 1: Absolute and specific net results by waste fraction – base comparison MSW EU27: base year 2017 and lead scenario, WFD, 2030

Waste fraction	Absolute		Specific per capita[1]		Specific per ton	
MSW	**2017**	**2030 WFD**	**2017**	**2030 WFD**	**2017**	**2030 WFD**
	Million tons CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
Res. MSW for treatment	-2.21	2.30	-5.0	5.2	-24	35
Organic waste	-0.03	-0.80	-0.1	-1.8	-1	-13
Paper	-10.05	-5.39	-22.6	-12.1	-443	-169
Glass	-5.43	-7.43	-12.2	-16.7	-454	-450
Plastics	-3.43	-9.03	-7.7	-20.3	-522	-695
LWP	-3.44	-3.60	-7.7	-8.1	-854	-893
Metals	-5.95	-9.32	-13.4	-20.9	-1527	-1413
Wood	-0.59	-0.67	-1.3	-1.5	-172	-132
Res. MSW to landfill	27.59	3.96	61.9	8.9	929	928
Sum/average	**-3.53**	**-29.99**	**-7.9**	**-67.3**	**-17**	**-143**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27).

The slightly lower specific net result per ton for wood waste in the 2030 scenario is also due to defossilisation effects, where lower emission savings potentials from electricity and heat generation are only partly compensated by the higher net efficiencies for biomass CHP assumed for 2030. The small quantity for which pyrolysis is assumed, has hardly any influence. The specific net result is in the same range as for wood recycling. Conversely, the effects of defossilisation are also mainly responsible for the higher net specific result per ton for plastic (and plastic in LWP). The lower GHG debits for electricity demand lead to lower specific net debits for plastic recycling. The emission savings potentials (credits) for plastic waste change little. Increases in the emission savings potentials could be achieved primarily through better qualities and the resulting greater substitution of virgin plastics instead of applications as wood and concrete as substitutes (see also partial report Germany).

The net emission savings potential from organic waste is slightly higher in 2030 WFD, which is primarily achieved through the assumed increase of anaerobic digestion and biogas utilisation. The GHG emissions of biological treatment, derived from the national inventory reports, were not changed in the 2030 WFD scenario. Composting results in a net debit for the EU27, both for

[4] 5-years derogation for Member States that landfilled more than 60% in 2013; instead of only 10% landfilling, 25% are allowed by 2035.

2017 and 2030. The soldier fly larvae treatment additionally considered for the food waste has hardly any influence on the result with the small quantities considered. The net result based on ton of waste is similar to that from composting. This treatment method could be an alternative to landfilling. However, data uncertainty is high and it was assumed that 75% of the heat demand can be covered by ambient temperatures due to the climate conditions in the south of Europe.

The specific net result for residual MSW for treatment changes from the slight net credit in 2017 into a slight net debit in the lead scenario 2030. On the one hand, this is due to the reduced emission savings potentials from electricity and heat generation from waste (defossilisation). On the other hand, the increase of the fossil carbon content in the residual MSW is of relevance (especially higher share of plastics)[5]. Another reason for less credits is also due to the climate goals of the EU and results from the diversion of RDF from co-incineration by coal power plants to incineration in thermal treatment plants. This is slightly counteracted by the higher net energy efficiencies assumed for thermal treatment plants in 2030.

The model-theoretical **scenario with home composting in the RC rate for the EU27** allows consideration at a reduced ambition level of separate collection. However, the data uncertainties on home composting are very high, both with respect to the amount and the associated GHG emissions. The purpose of this scenario is to investigate the effect of a less ambitious increase in separate collection, and due to high data uncertainties, home composting was rated as zero in the GHG balance (although net debits are expected as a trend, see Annex, partial report Germany).

The scenario with home composting in the RC rate 2017 (MSW EU27 HC 2017) results in an absolute net emission savings potential of about -3.5 million tons CO_2eq. A comparison at the absolute level with the baseline is not possible because of the different total waste quantities (209.4 million tons in the base comparison and 249.6 million tons in the scenario with home composting in the RC rate). However, as the GHG emissions from home composting are excluded from the study, the GHG balance with absolute results for 2017 is identical with the absolute results of the 2017 base scenario (MSW EU27 2017).

For the year 2030, the scenario with home composting in the RC rate (MSW EU27 HC 2030) results in an absolute net emission savings potential of -25.2 million tons CO_2eq. Again, it is true that a comparison with the base comparison (lead scenario 2030) is not possible at the absolute level. However, if home composting was considered to be virtually emission neutral, it could be stated that the scenario with lower ambition level for the increased separate collection would lead to reduced emission savings potential of around 5 million tons CO_2eq compared to the lead scenario 2030. A qualitative comparison for 2030 shows that the recycling of dry recyclables in particular achieves lower absolute net emission savings potentials, due to the reduced separately collected quantities. The results for residual MSW differ slightly due to different amounts treated and different waste compositions and thus characteristics. On a specific level per ton the results for the waste fractions are unchanged or slightly changed either due to changed treatment splits or changed compositions and characteristics of residual MSW. The clearest difference at the specific level arises in relation to the total waste quantities. The total specific net emission savings potential is significantly lower, as the results refer to around 250 million tons (including the 40.2 million tons of home composting).

- MSW EU27 HC 2017: -14 kg CO_2eq/t MSW (16% lower than base year 2017)

[5] This is different in the separately calculated balance for Germany, where the fossil carbon content in residual waste for treatment is lower in the lead scenario, which is one reason why the specific net result is still a net savings potential (with EU27 emission factors, cf. partial report Germany).

- MSW EU27 HC 2030: -101 kg CO_2eq/t MSW (30% lower than lead scenario 2030)

The calculation for **Cluster 1 and Cluster 2** was done in the same way as for the EU27 (w/o DE). However, country specific aspects were adapted. In addition to the waste treatment flows, this applies for parameters for landfilling, composting and anaerobic digestion derived from the national inventory reports as well as for the weighted energy efficiencies for thermal treatment. In addition, the different waste compositions for residual waste from the EEA-model and resulting characteristics were calculated specifically for the country Clusters. Other than for the EU27 (and EU28), the absolute results for the two Clusters in the base year 2017 show a net debit, which is largely caused by the high shares of residual MSW to landfill (more relevant in Cluster 1 than in Cluster 2). In addition, in Cluster 1, the correction for Hungary (amounts attributed to MT from the EEA-model, which are lastly landfilled without further treatment) leads to a specific net debit for residual MSW for treatment (net credit in all other balance areas).

For **Cluster 1**, the net results for the three scenarios are as follows:

- Base year, 2017: +10.5 million tons CO_2eq (102.6 kg CO_2eq/cap; 300 kg CO_2eq/t)
- Lead scenario 2030 (WFD): -0.93 million tons CO_2eq (-9.1 kg CO_2eq/cap; -27 kg CO_2eq/t)
- Special scenario 2030: -0.36 million tons CO_2eq (-3.5 kg CO_2eq/cap; -10 kg CO_2eq/t)

In 2017, residual MSW to landfill clearly dominates the debits. Both scenarios 2030 show a shift in the net result from a net debit to a slight net credit. In both scenarios this is mainly due to diversion from landfill (which was also proportionally assumed for the corrected amount for Hungary). In addition, the increased amount of separately collected dry recyclables and technical optimisations are responsible for the net credit in both 2030 scenarios. These aspects counteract the effects from defossilisation. The amount of separate collected dry recyclables in the special scenario 2030 is more moderate than in the lead scenario 2030, which mainly explains the lower net emission savings potential. The treatment of organic waste is combined with a net debit in 2017 due to the high share of composting (94%). The net debit per ton of waste is lower in the 2030 scenarios primarily because of the assumption of higher quantities of food waste been treated by anaerobic digestion. The treatment with soldier fly larvae has a minor contribution to the specific net debits.

The sensitivity analysis with the higher electricity emission factor 2017 for Cluster 1 has hardly any effect on the results. The higher credits for electricity generation from waste (which is not of high relevance in Cluster 1) are counteracted by the higher debits for electricity demand especially for recycling.

For **Cluster 2**, the net results for the three scenarios are as follows:

- Base year, 2017: +3.06 million tons CO_2eq (19.1 kg CO_2eq/cap; 39 kg CO_2eq/t)
- Lead scenario 2030 (WFD): -12.63 million tons CO_2eq (-78.8 kg CO_2eq/cap; -163 kg CO_2eq/t)
- Special scenario 2030: -4.18 million tons CO_2eq (-26.1 kg CO_2eq/cap; -54 kg CO_2eq/t)

The results for Cluster 2 are again dominated by the impact of residual MSW to landfill. The shift to a net credit in the lead scenario in Cluster 2 is mainly due to the assumed complete diversion from landfill. In the special scenario 2030, the net credit is 8.4 million tons CO_2eq lower than in the WFD 2030 scenario, because it was assumed that Cluster 2 countries are not diverting waste from landfill completely, as they may still landfill MSW in accordance with the landfill directive.

The treatment of organic waste results in a net debit for 2017 due to the high share of composting (90%). For the 2030 scenarios, a slight net emission savings potential can be achieved as it is assumed that more food waste is treated by anaerobic digestion instead of only composting. Again, the treatment with soldier fly larvae has a minor contribution to the specific net debits.

The sensitivity analysis with the lower electricity emission factor 2017 for Cluster 2 leads to a 33% higher absolute net debit. In Cluster 2, in contrast to Cluster 1, the share of residual MSW for thermal treatment is much higher. Reduced credits for electricity generation have higher impact, and are not compensated by the lower debits of electricity demand for recycling.

Special balance food waste

Regarding **food waste**, the study applies the food waste definition of the Waste Framework Directive which stipulates that „*'food waste' means all food as defined in Article 2 of Regulation (EC) No 178/2002 of the European Parliament and of the Council that has become waste*. No distinction is made between edible and non-edible food waste. Excluded from the scope of this study is food waste that arises in NACE section A *'Agriculture, forestry and fishing.'*

The availability of reliable **data on food waste generation and treatment** is poor, in particular for food waste from commercial and industrial sources. Food waste is part of the organic waste and therefore not separately measurable. The total food waste generation was estimated on the basis of WStatR data. Food waste is mostly contained in the EWC-Stat categories W091 "animal and mixed food waste", W092 "vegetal wastes" and in W101 "household and similar wastes". The shares of food waste within these waste categories were determined based on information from literature, national statistical data, information from the validation of WStatR data carried out by the contractor and estimates. In addition, the amount of food waste from MSW was determined by means of the EEA-model in the course of the MSW data analysis. The amount of food waste from commercial and industrial sources was calculated as difference between the WStatR-based estimate for the generated food waste total and MSW food waste from the EEA-model calculation. The food waste was determined at country level and the results were then aggregated at Cluster and EU27 level.

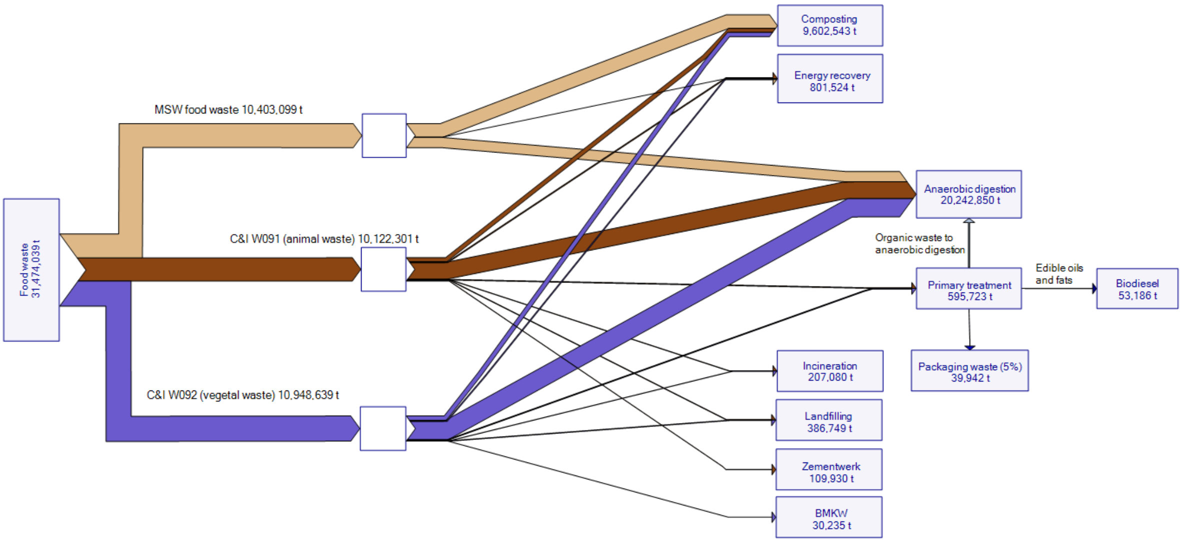
The food waste total in the EU27 is estimated at 70.1 million tons or 157 kg/cap respectively. Around 55% of the generated food waste (38.6 million tons) are found in the 'household and similar waste' (W101) and 45% (31.6 million tons) are contained in the waste categories 'animal and vegetal waste' (W091, W092). Production waste from the food processing industry accounts for 13.8 million tons or 20% of the food waste in total.

The base data for the GHG balance are shown in Figure 2. For methodological reasons, food waste contained in the 'household and similar waste' (W101) was not considered in the GHG balance. The data in Figure 2 therefore refer to the food waste contained in the waste categories 'animal and vegetal wastes' (W091, W092) only.

The Sankey diagram shows that in the EU27 in 2017 about two thirds of the food waste contained in the 'animal and vegetal waste' (W091, W092) originates from commercial and industrial sources whereas one third is municipal food waste (derived from the EEA-model).

Food waste is mainly treated via anaerobic digestion as shown in the Sankey diagram. This is based on the assumption that the share of anaerobic digestion in the EU27 (w/o DE) is similar but lower than for Germany. The total share of anaerobic digestion of food waste (from MSW and from C&I waste) for the EU27 accounts for 64%. The remaining share is mainly composted. Other treatment options, such as incineration (with or without energy recovery), landfill and other disposal are of minor importance. The food waste from MSW is mainly treated by anaerobic digestion in Germany, whereas for the EU balance areas composting dominates.

Figure 2: Sankey diagram Food waste EU27 2017



Source: own illustration, ifeu.

For each of the three balance areas (EU27, Cluster 1 and Cluster 2), two **scenarios** were developed for the year 2030. The lead scenarios consider similar assumptions as for the lead scenarios for MSW, focusing on waste diversion from landfill and technical optimisations. The additional scenarios also take waste prevention into account, which allows to show the climate impact of food waste reduction versus food waste treatment measures.

The scenario assumptions on food waste originating from MSW need to be consistent with the assumptions for food waste in the MSW 2030 lead scenarios:

- Food waste treatment is shifted from composting towards anaerobic digestion;
- A small share of food waste in Cluster 1 and 2 is treated by solider fly larvae installations.

For food waste from industrial and commercial sources (C&I waste) the following assumptions were made:

- Food waste will be completely diverted from composting, mainly towards anaerobic digestion and partly towards energy recovery;
- A share of 1.5% of the total C&I food waste is assumed to be edible oils and fats that are used for biodiesel production;
- In Cluster 1 and 2 a share of 2% of the total C&I food waste is treated in solider fly larvae installations.

For this study, a methodological approach was developed to integrate waste prevention (for Germany also preparation for re-use), which is usually not part of the LCA in waste management mainly due to data restrictions. The requirements for the inclusion are that the prevented products are known and that the effects of avoiding their production can be quantified. For food waste, this means that only consumer products can be considered. No original products can be identified for sludges, slops, peeling residues, etc. or the "substances unsuitable for consumption or processing" that predominate in C&I waste according to the German waste statistic. Accordingly, waste prevention is considered only for MSW food waste. The prevented amount is set to 50% for EU27 and Cluster 2 and to 30% for Cluster 1.

The calculation of the **GHG balances** for MSW food waste corresponds to the calculation for the MSW balance. For the calculation of the food waste from C&I waste, more assumptions were necessary. The two statistical waste categories W091 and W092 consist of very different waste types which in many cases are not further specified. Therefore, the GHG balance for food waste has relevant uncertainties and needs to be understood as an approximation. Food waste from C&I waste had to be estimated based on the calculations for Germany (partial report Germany), which are based on more differentiated data in the German waste statistic.

The results of the GHG balance for the EU27 in the base comparison are shown in Table 2. In total, both scenarios result in absolute net emission savings potentials. The net emission savings potential for 2017 is around -2.19 million tons CO_2eq. Food waste from C&I waste mainly contribute to the result, which also account the highest share. In addition, especially animal and mixed food waste (W091) contribute to the emission savings potential.

The lead scenario 2030 shows an absolute net emission savings potential of about -3.79 million tons CO_2eq mainly due to the diversion from landfills, from incineration[6] ,the shift from composting to anaerobic digestion and the share of processing of edible oils and fats into biodiesel.

Table 2: Absolute and specific net results by waste category – base comparison FW EU27: base year 2017 and lead scenario 2030

Waste category	Absolute	Absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
FW	**2017**	**2030 LS**	**2017**	**2030 LS**	**2017**	**2030 LS**
	1,000 t CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
MSW food waste	-128	-392	-0.3	-0.9	-12	-38
C&I W091	-1,557	-2,315	-3.5	-5.2	-154	-229
C&I W092	-501	-1,079	-1.1	-2.4	-46	-99
Sum/average	**-2,186**	**-3,786**	**-4.9**	**-8.5**	**-69**	**-120**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27).

The calculations for the base year 2017 and the lead scenario 2030 for **Cluster 1 and Cluster 2** are done in the same way as for the EU27 (w/o DE). For MSW food waste, the same differences apply as for food waste in the MSW balance. Small differences in the per ton results for food waste from C&I waste result from country specific data on energy efficiencies for thermal treatment plants and on parameters for landfilling (from national inventory reports).

For **Cluster 1**, the net results for the two scenarios are as follows:

- Base year, 2017: -0.11 million tons CO_2eq (-1.1 kg CO_2eq/cap; -37 kg CO_2eq/t)
- Lead scenario 2030: -0.36 million tons CO_2eq (-3.5 kg CO_2eq/cap; -118 kg CO_2eq/t)

For **Cluster 2**, the net results for the two scenarios are as follows:

- Base year, 2017: -0.48 million tons CO_2eq (-3.0 kg CO_2eq/cap; -48 kg CO_2eq/t)
- Lead scenario 2030: -1.22 million tons CO_2eq (-7.6 kg CO_2eq/cap; -124 kg CO_2eq/t)

For the scenario that takes waste prevention into account, the approach developed in this study is followed (for more details please refer to partial report Germany). A weighted average

[6] „incineration“ means incineration without energy generation, otherwise the term “energy recovery” is used in the EU statistic.

emission value for food waste prevention of -1.61 kg CO_2eq/kg food is applied based on the proportion of different food products in the food waste and the derived GHG emission factors for their production. The results for the scenarios taking waste prevention into consideration show significantly higher net emission savings potentials. Despite data uncertainties, it demonstrates that food waste prevention has a significant contribution to climate protection.

The absolute net emission savings potentials were estimated to:

- around -12 million tons CO_2eq for the EU27 (ca. 3 times higher than lead scenario)
- around - 0.7 million tons CO_2eq for Cluster 1 (ca. 2 times higher than lead scenario)
- around - 3.2 million tons CO_2eq for Cluster 2 (ca. 2.6 times higher than lead scenario)

Commercial and industrial waste

For the purpose of this study, commercial and industrial waste is defined as non-hazardous waste from the economic activities 'manufacturing' (NACE C) and 'service activities' (NACE sectors G –U excl. G46.77). The scope of the study includes in addition:

- Household and similar wastes (W101) from all economic activities;
- Animal and vegetal wastes (W091, W092) from all economic activities except from *'Agriculture, forestry and fishing'* (NACE A).

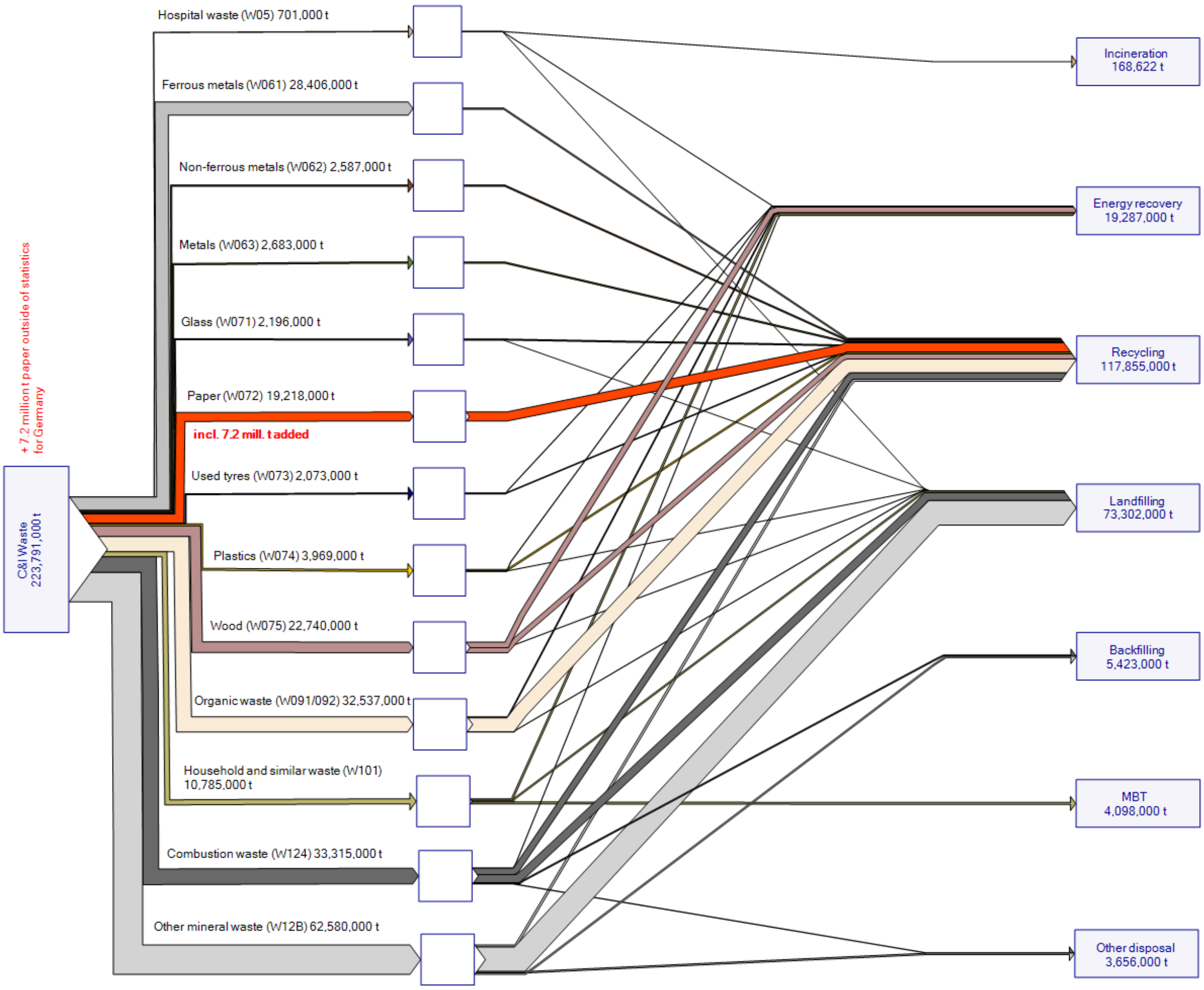
The study is limited to primary waste and excludes the waste categories textile wastes (W076), discarded vehicles (W081), discarded equipment (W08A), batteries and accumulators (W0841), common sludges (W11) and industrial effluent sludges (W032). For the GHG balances further waste categories were excluded for methodological reasons.

The **generation and treatment of C&I waste** was determined on the basis of the WStatR data. In a second step, the waste stream C&I waste had to be delineated from the MSW because the two waste streams are partly overlapping due to the different concept of the data sources used. MSW comprises mainly waste from households but also waste from industrial and commercial sources that is similar to household waste. In order to ensure a clear allocation of GHG emissions and to avoid double-counting, the amount of C&I waste that is managed as MSW was estimated and subtracted from the C&I waste stream. The scope of the study allowed only a rough data estimate that is less detailed than the one for MSW.

The resulting base data for the GHG balances are shown in Figure 3. The C&I waste generation in the EU27 considered for the balances amounts to 224 million tons. The main waste generating sector is the metal industry (NACE C24-C25) followed by the chemical industry (NACE C20-C22), the service sector (NACE G-U) and the food and drinks industry (NACE C10-C12).

The waste category 'other mineral waste" (W12B) is the most relevant fraction by mass. This waste fraction takes up to 28% of the total amount. This is followed by the combustion waste and organic waste (W091 and W092) with each 15% mass fraction, and by ferrous metals with 13%. Most of the other waste fractions comprise between 1% and 10% of the total mass. Hospital waste, glass and used tyres have shares below 1%.

Figure 3: Sankey diagram C&I waste EU27 2017



Source: own illustration, ifeu.

For C&I waste, one future **scenario** for the EU27 had to be developed for the target year 2030. The assumptions for the EU27 (w/o DE) were developed separately and merged with the separately derived scenario 2 for Germany (see partial report Germany). For the EU27 (w/o DE) it was assumed that waste generation remains constant until 2030, both overall (requirement for the LCA method) and at the level of the individual waste categories.

For the future development of waste management, the mix of treatment options in countries with less and more developed waste management systems were compared for each waste category. For the establishment of the 2030 scenario, it was assumed that all EU Member States will establish a mix of treatment options for C&I waste of similar to the EU countries with more developed waste management systems and therefore will be on the same level by 2030. These assumptions result in the following developments:

- A shift from landfilling of household and similar waste (W101) mainly towards energy recovery and to a lesser extent to MBT;
- A shift from landfilling of animal and vegetal wastes (W091, W092) towards energy recovery and recycling;
- An increase of recycling for wood waste (W075), plastic waste (W074) and rubber waste (W073) mainly at the expense of energy recovery.

The results of the GHG balance for the EU27 are shown in Table 3. In total, both scenarios result in absolute net emission savings potentials. For 2017 it is ca. -84.1 million tons CO_2eq. Dry recyclables, including metals in particular, make a significant contribution to the result. Despite of the high mass, combustion waste and other mineral waste do not have influence on the result because of their inert character. The scenario 2030 shows a reduced net emission savings potential of -76.6 million tons CO_2eq. The difference in the results – the overall lower net emissions savings potential compared to base year 2017 – is mainly due to the defossilisation of the energy system. Not only do the GHG debits from the energy demand decrease, but also the substitution potential for energy and primary products declines (electricity-intensive primary. production of paper and aluminium). Nevertheless, the optimisation for 2030, specifically the shift from landfilling to recycling and/or energy recovery and the shift from energy recovery to recycling, counteract the above-mentioned effects.

Table 3: Absolute and specific net results by waste fraction – C&I waste EU27 2017 and 2030

Waste fraction	Absolute	Absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
C&I waste	**2017**	**2030**	**2017**	**2030**	**2017**	**2030**
	Million tons CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
Hospital waste	0.18	0.22	0.4	0.5	257	319
Ferrous metals	-43.70	-43.70	-98.1	-98.1	-1,538	-1,538
Non-ferrous metals	-13.01	-8.79	-29.2	-19.7	-5,029	-3,398
Metals	-4.91	-4.54	-11.0	-10.2	-1,830	-1,694
Glass	-1.01	-1.01	-2.3	-2.3	-461	-459
Paper	-8.85	-3.47	-19.9	-7.8	-461	-180
Used tyres	-2.77	-2.89	-6.2	-6.5	-1,338	-1,392
Plastics	-2.18	-3.09	-4.9	-6.9	-550	-779
Wood	-5.76	-4.97	-12.9	-11.2	-253	-219
Organic waste	-3.18	-5.24	-7.1	-11.8	-98	-161
Combustion waste	0.22	0.23	0.5	0.5	7	7
Other mineral waste	0.38	0.38	0.9	0.9	6	6
Household & similar waste	0.54	0.27	1.2	0.6	50	25
Sum/average	**-84.06**	**-76.60**	**-188.7**	**-171.9**	**-376**	**-342**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27)

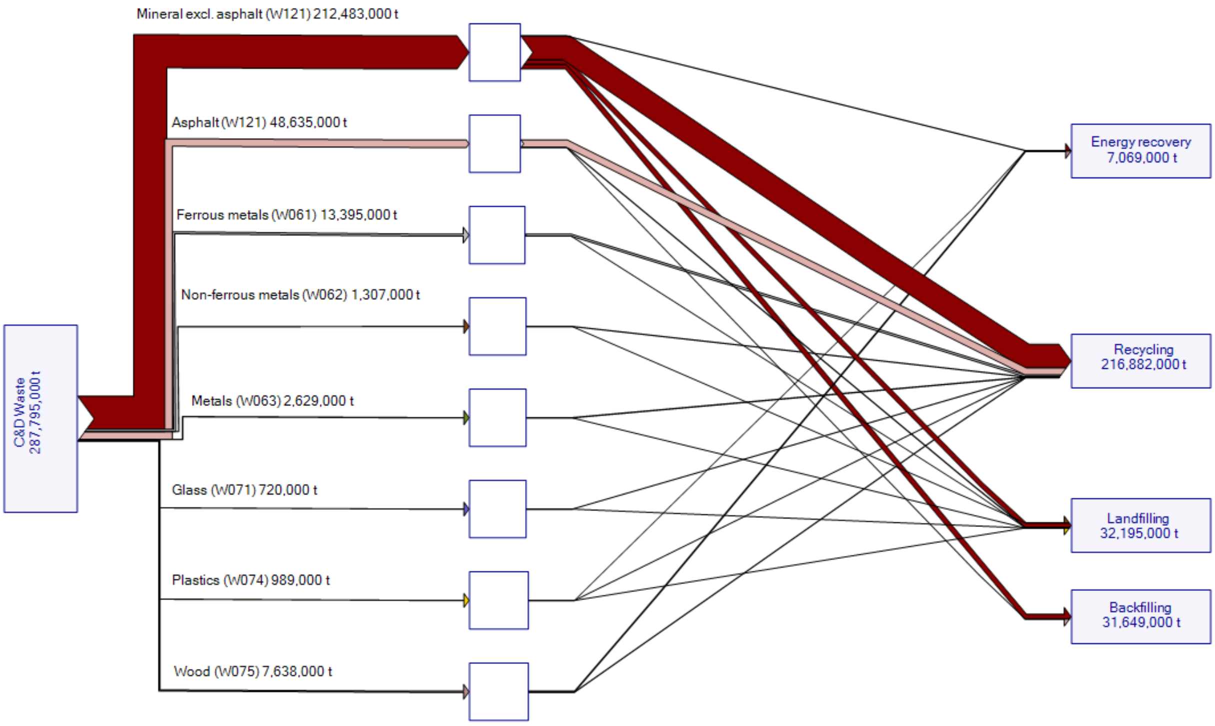
Construction and demolition waste

For the purpose of this study, construction & demolition (C&D) waste is defined as all non-hazardous wastes listed in chapter 17 of the List of Wastes, except 'soil and stones' (LoW 17 05 04) and 'dredging spoil' (17 05 06).

In the scope of this study only a rough determination of **C&D waste generation and treatment** was conducted. C&D waste generation and treatment are determined based on WStatR data. C&D waste generation comprises mineral C&D waste (W121) from all economic activities and households as well as metal wastes (W06), glass wastes (W071), plastic wastes (W074) and wood wastes (W075) generated by companies of NACE section F (Construction). Furthermore, an estimate was produced on the generation and treatment of reclaimed asphalt based on annual statistics of the European Asphalt Pavement Association (EAPA).

The base data derived for the GHG balancing are shown in Figure 4. The C&D waste total in the EU27 in 2017 was determined at 288 million tons. With 90 million tons, Germany accounts for nearly one third of the EU27 total. Mineral C&D waste (excl. asphalt) accounts for around 212 million tons or 74% of the total. The share of reclaimed asphalt is estimated at 49 million tons or 17% of the C&D waste total. Metal waste (W06) and wood waste (W075) contribute 6% and 3% respectively. Plastic and glass wastes account each for 0.3% of the generated C&D waste.

Figure 4: Sankey diagram C&D waste EU27 2017



The amounts shown in the Sankey diagram are rounded values. Source: own illustration, ifeu.

For C&D waste, a single **scenario** for the EU27was developed for the target year 2030. The assumptions for the EU27 (w/o DE) were developed and merged with the separately derived scenario 2 for Germany (see partial report Germany). For the EU27 (w/o DE) it was assumed that the C&D waste generation in the EU27 remains constant until 2030.

In order to assume the future development of waste management, the waste treatment mixes in member states with less and with more developed waste management systems for each waste category were compared. The comparison shows that the countries with more advanced waste systems usually report a higher proportion of metals, wood and glass in the construction waste. It is assumed that the better separation of recyclables at source is the reason for that. For the scenario 2030, it was assumed that the separation of these recyclable materials in the

EU27 (w/o DE) is on a level which the EU countries with more advanced waste systems had reached already in 2017.

For the scenario the following is assumed:

- an increase of recycling for all C&D waste categories;
- an increase of energy recovery of wood waste (075).

The results of the GHG balance for the EU27 are shown in Table 4. In total, both scenarios result in absolute net emission savings potentials. For 2017 it is ca. -30.3 million tons CO_2eq. Especially metals make a significant contribution to the result. The treatment of the inert waste streams, which represent the main mass flow, is not associated with relevant GHG emissions. The scenario 2030 in total shows a slightly higher net emission savings potential of -30.7 million tons CO_2eq. The difference between the scenarios is hardly significant, which is due to the fact that ferrous metals have the main influence in the result and that recycling of ferrous metals is hardly influenced by defossilisation. The increase of the net emissions savings potential can mainly be attributed to ferrous metals diversion from mineral C&D waste in the 2030 scenario.

Table 4: Absolute and specific net results by waste fraction – C&D waste EU27 2017 and 2030

Waste fraction	Absolute	Absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
C&D waste	**2017**	**2030**	**2017**	**2030**	**2017**	**2030**
	Million tons CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
Mineral waste (excl. asphalt)	1.46	2.01	3.3	4.5	7	10
Asphalt	-0.43	-0.46	-1.0	-1.0	-9	-9
Ferrous metals	-18.62	-20.43	-41.8	-45.9	-1,390	-1,406
Non-ferrous metals	-4.78	-3.89	-10.7	-8.7	-3,657	-2,678
Metals	-4.26	-4.02	-9.6	-9.0	-1,623	-1,534
Glass	-0.31	-0.36	-0.7	-0.8	-430	-433
Plastics	-0.47	-0.65	-1.0	-1.4	-471	-650
Wood	-2.87	-2.88	-6.4	-6.5	-376	-323
Sum/average	**-30.28**	**-30.68**	**-68.0**	**-68.9**	**-105**	**-107**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27)

Overview results EU

The absolute, per capita and net specific results for the balances – MSW, C&I waste and C&D waste – are summarized in Table 5. The results presented for MSW are from the base comparison (base year 2017 and lead scenario 2030). The overall GHG balance of the waste treatment in the three areas of origin results in a total absolute net emission savings potential of -117.9 million tons CO_2eq for the EU27 for the balance year 2017. For the 2030 scenarios, the total absolute net emission savings potential is calculated to around -137.3 million tons CO_2eq, which represents an improvement by about 19.4 million tons of CO_2eq in potential net emission savings for the EU27.

In the total net emission savings potentials in 2017, the three areas of origin differ significantly with C&I waste presenting by far the highest contribution. The emission contributions of the landfilled MSW almost completely outweigh the saving potential of recycling and recovery for MSW. Consequently, for the EU27 an important optimisation measure is the diversion of MSW from landfill. In combination, the efforts to separately collect dry and organic recyclables, should be increased and, especially the treatment of organic recyclables should be optimised. In this way, the total net emission savings potential increases from -3.5 million tons CO_2eq to about -30 million tons CO_2eq in 2030. However, in the WFD scenario still about 4.3 million tons of residual MSW is landfilled. If diversion from landfill could be completely implemented until 2030 in the EU27 further about 4 million tons CO_2eq would be avoided.

By far the highest net savings potentials result from C&I waste, which is dominated by metals accounting for 15% by mass (33.7 million tons). Also, the results for C&D waste are dominated by metals. However, for C&D waste the amount of metals is half as high as for C&I waste, which yields correspondingly to lower results.

Table 5: Waste EU27 – Amounts and absolute as well as specific net results by area of origin

Balance area	Amount	GHG absolute	GHG absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
		2017	2030	2017	2030	2017	2030
	million tons	million tons CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
MSW	209.4	-3.5	-30.0	-8	-67	-17	-143
C&I waste	223.8	-84.1	-76.6	-189	-172	-376	-342
C&D waste	287.8	-30.3	-30.7	-68	-69	-105	-107
Total	**720.9**	**-117.9**	**-137.3**	**-265**	**-308**	**-163**	**-190**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27)

Conclusions and recommendations

The study is a comprehensive investigation with regard to both the waste flows and the GHG balancing. About 25 scenarios and sensitivities were calculated for the EU. The data on waste generation and treatment were determined at member state level. The GHG balancing was carried out for the individual waste fractions for each of the four waste types (MSW, Food waste, C&I, C&D). Country-specific data were included as far as possible for the different balance areas. For Germany, a separate detailed study was carried out. However, it has to be noted that a relevant data uncertainty remains and the results especially for food waste, C&I waste and C&D waste are to be understood as orienting. Regardless of this, important findings could be obtained, and the complex relationships and opposing influences on the GHG balance analysed.

With regard to the GHG mitigation potential the main findings are:

- The study shows that in the EU27 MSW has by far the largest GHG mitigation potential. The low net saving potential in 2017 of -3.5 million tons CO_2eq can be increased by a factor 8 to about -30 million tons CO_2eq in the lead scenario 2030 mainly through diversion of MSW from landfill and increased separate collection for recycling. For 2017 the overall GHG emission from landfilling of residual MSW is about 13.5 million tons CO_2eq in Cluster 1 and 13 million tons CO_2eq in Cluster 2. In the lead scenario these emissions are cut down to zero in Cluster 2, and to about 4 million tons CO_2eq in Cluster 1, which demonstrates the high relevance of diversion from landfill and that this significantly shapes the GHG mitigation potential in the EU27 for MSW. In addition, this shows that a further 4 million tons CO_2eq could be mitigated if MSW landfilling would be also stopped completely in Cluster 1 by 2030. To achieve the GHG mitigation potential the following aspects should be considered:

- Support for those EU Member States, which still landfill residual MSW. Landfilling of untreated MSW should be stopped completely and as soon as possible. Derogation periods should be avoided.
- Financial measures like a landfill fee or funding seem most promising options to support diversion from landfill.

► The model-theoretical scenario with home composting in the RC rate indicates how a low level of ambition in separate collection and recycling decreases the emission savings potentials. From the climate protection point of view, it is important not to be content with a low ambition level.

► The lead scenario 2030 (WFD) calculated in this study assumes a high ambition level with regard to implementing separate collection and of alternative treatment capacities needed. Here, politics is called upon to identify and implement supporting measures together with the waste management actors. The waste management associations proposed in the interview a regulatory framework with regard to need of outlets for the separately collected dry recyclables, public (financial) support for separate collection and treatment options for rejects. From the point of view of the authors of this study most relevant aspects and ideas for improvement are:

- Support for the organisation and infrastructure of separate collection and the development of treatment capacities especially for organic waste. Anaerobic digestion, the combined material and energy use of organic waste, should be preferred, suitability given. Support, especially for Cluster 1 countries, in analysing the composition of the residual MSW and identifying suitable options for the treatment of organic waste.
- Incentives for citizens to increase separate collection of organic waste while sustaining low impurities, such as a cost-free, adequate collection system and frequency, accompanied by public relation campaigns.
- An ambitious increase in separate collection for dry recyclables from MSW also needs supportive measures for knowledge improvement. As base data is key to proper planning most relevant initial measures are analysis of the current situation, investigations to optimise the collection systems and pilot projects.

► For C&I and C&D waste, the orienting GHG results show that, from a climate protection perspective, it is mainly metals (and thereof ferrous metals) that define the net emission saving potential. For C&I waste, further on, dry recyclables, wood and organic waste also offer net emission savings potentials. The main mass, mineral and other inert waste types, have only minor GHG effects. In general, the data base is insufficient, especially for C&I waste with the large variety of waste types, and the data gaps on treatment. In order to determine the climate protection potentials from C&I and C&D waste, it is recommended for future studies to focus on the GHG-relevant waste types, mainly the metals. Information is needed on type and quality of the metals for C&I waste, and the potential of metals in the mineral waste fraction for C&D waste. Furthermore, for C&I waste, waste streams should be kept in focus that are also thermally treated (especially plastics).

► Thermal waste treatment is vital for a functional waste management system, as it eliminates the non-recyclable and more contaminated parts of MSW, C&I and C&D wastes. In this function it is essential for a circular economy. The contribution to climate protection through the assumed increased net efficiency for 2030 in this study is no self-fulfilling scenario. For thermal treatment plants as well as for biomass power plants, possibilities to increase net efficiency would need to be further examined and their implementation supported. For example, the implementation or expansion of local and district heating networks can help to increase heat utilisation. The co-incineration of refuse-derived fuels in cement kilns offers a relevant – and, compared to thermal treatment, higher – contribution to climate protection as long as coal may still be used as a regular fuel, which can be substituted by RDF. In this respect, it is also important to support MBT plants in optimisation efforts such as mitigating GHG emissions from biological treatment or increase of efficiency.

- Waste prevention as shown for food waste is highly relevant and can contribute significantly to climate protection. With food waste prevention the primary production of foods is avoided, which is combined with much higher GHG emissions than the savings potentials which can be derived from treatment of food waste. For the EU27, the assumed prevention of 50% or about 5.2 million tons of MSW food waste leads to a net emission savings potential that is higher by a factor 3 compared to the lead scenario 2030. In case of Cluster 1, where a 30% reduction of MSW food waste was assumed (about 200,000 tons), the net emission savings potential would be 2 times higher than in the lead scenario. The calculated GHG emission savings potential through food waste prevention are sufficiently valid for Germany, where data are available for both the MSW food waste composition and the GHG impact for its production. For the EU countries similar studies are to be recommended for MSW food waste composition based on which a prevention factors can be derived as for Germany.

The most relevant findings and recommendations from the study regarding the data on waste at EU level are:

- The data collection under the WStatR should be further developed conceptually, especially with regard to a better linking of the data on generation and treatment and a more complete representation of waste treatment, e.g. the inclusion of pre-treatment operations in the data collection.

- Sorting analyses of the residual waste are generally a prerequisite in order to be able to identify the potential for increasing separate collection and recycling. This applies to all EU Member States. Representative waste analyses on national level are necessary to allow a better understanding of not only the recycling and collection, but especially the climate mitigation potentials. Even in Germany, where a comprehensive household waste analysis has been carried out to improve the data base on MSW considerably, there is still a lack of information on the composition of commercial MSW and bulky waste.

Finally, it is recommended that future investigations into the circular economy should also consider the environmental impact of resource conservation in addition to GHG emissions. As more measures are implemented in order to achieve the goal of zero emissions and avert the climate catastrophe, simultaneously the climate protection potentials diminish, and GHG balances will become zero. However, the goal of climate neutrality is not only accompanied by decreasing potential climate protection contributions, but conversely also by a demand for raw materials, especially for renewable energy production plants. This should be kept in view. The aspect of resource conservation is essentially linked to the circular economy. In future projects, it should first be determined which areas and/or resources are relevant for an investigation of resource conservation and how these should be evaluated.

Zusammenfassung

Mit dem Übereinkommen von Paris vom Dezember 2015 haben sich in Nachfolge des Kyoto-Protokolls erneut Mitgliedstaaten verpflichtet, die anthropogenen Treibhausgas (THG-) Emissionen zu reduzieren und die globale Erwärmung auf deutlich unter 2 °C gegenüber vorindustriellen Werten zu beschränken. Dazu sind eingehende Anstrengungen notwendig über alle klimarelevanten Sektoren und Quellgruppen hinweg, so auch im Abfallbereich.

Der Sektor Abfall ist nach den allgemeinen Berichterstattungspflichten des Kyoto-Protokolls auf direkte und nicht-energetische THG-Emissionen beschränkt, um eine Doppelberichterstattung zu vermeiden. Die Gesamtheit des erzielten und erzielbaren Beitrags zum Klimaschutz kann durch die Methode der Ökobilanzierung (LCA) für den Abfallsektor nachgewiesen werden (z. B. dokumentiert in (Dehoust et al. 2010; Vogt et al. 2015)).

In dieser Studie wird die abfallwirtschaftliche Situation im Jahr 2017 untersucht und bildet die Basis für die THG-Bilanzen. Für das Zieljahr 2030 wird der mögliche Klimaschutzbeitrag der Kreislaufwirtschaft vor dem Hintergrund der weiterentwickelten politischen und rechtlichen Rahmenbedingungen aufgezeigt. Zudem konnte in dieser Studie ein Ansatz gezeigt werden, die Abfallvermeidung in die Ökobilanzmethode der Abfallwirtschaft einzubeziehen.

Der vorliegende Teilbericht zum Projekt "Klimaschutzpotenziale in der Kreislaufwirtschaft – Deutschland, EU"[7] dokumentiert die Arbeiten und Ergebnisse für die EU. Er beschreibt das methodische Vorgehen bei der Datenerhebung, die Grundlagen für die THG-Bilanzen sowie die aus den Erkenntnissen der Studie abgeleiteten Ergebnisse und Empfehlungen. Die Ergebnisse für Deutschland sind separat veröffentlicht ("Teilbericht Deutschland"). In beiden Berichten werden die folgenden Abfallarten betrachtet:

- Siedlungsabfälle (SiAbf.)
- Lebensmittelabfälle (LMA, als Sonderbilanzraum)
- Produktions- und Gewerbeabfälle (P&G-Abfälle)
- Bau- und Abbruchabfälle (B&A)

Für jede der Abfallarten wurde eine eigene Mengenerhebung und THG-Bilanzierung durchgeführt. Methodisch sind die Bilanzräume für Siedlungsabfälle, P&G-Abfälle sowie B&A-Abfälle komplementär, während Lebensmittelabfälle als Sonderbilanzraum, die Lebensmittelabfälle aus dem Bereich der Siedlungsabfälle und dem Bereich der P&G-Abfälle umfassen.

Für Siedlungsabfälle und Lebensmittelabfälle sind detaillierte THG-Bilanzen abgebildet, für P&G- und B&A-Abfälle erfolgt eine überschlägige Betrachtung. Für Siedlungsabfälle und LMA ist die Ist-Situation im Basisjahr 2017 für Deutschland, für die aktuelle EU27, die vorige EU28 (mit UK) und zudem für zwei aus den EU-Mitgliedstaaten definierte Cluster untersucht. Für P&G- und B&A-Abfälle beschränkt sich die Untersuchung auf Deutschland und die EU27. Künftige THG-Minderungspotenziale für das Zieljahr 2030 sind für die Siedlungsabfälle und LMA mit je zwei Szenarien für Deutschland, die EU27 und die beiden EU-Cluster umfassender analysiert. Für P&G- und B&A-Abfälle sind es zwei Szenarien für Deutschland und ein Szenario für die EU27.

Für Siedlungsabfälle und die Sonderbilanz Lebensmittelabfälle wurde ein größerer Aufwand betrieben, um die detaillierteren Ergebnisse für Deutschland (Teilbericht Deutschland) mit den für die anderen EU-Länder verfügbaren Daten zusammenzuführen. Es wurden alle Berechnungen zunächst getrennt für die EU27 ohne Deutschland (EU27 ohne DE) und

[7] Langtitel: Ermittlung von Klimaschutzpotenzialen in der Kreislaufwirtschaft für Deutschland und die EU als Beitrag zur Erreichung der Ziele der nationalen und internationalen Klimaschutzverpflichtungen.

Deutschland durchgeführt und anschließend die Ergebnisse zusammengeführt. Im Durchschnitt sind die Daten für Deutschland detaillierter als für die anderen 26 EU-Mitgliedstaaten, für die im Rahmen dieser Studie nur begrenzt Untersuchungen zu den nationalen Gegebenheiten durchgeführt werden konnten.

Datenlage, Verfahren zur Datenerhebung

Die neuesten Daten wurden verwendet, um einen konsistenten Datensatz für alle vier Abfallströme zu bilden, der sich auf dasselbe Bezugsjahr (2017) bezieht. Dies ist eine Herausforderung, weil

- Die beiden Hauptquellen für statistische Abfalldaten auf EU-Ebene, d. h. der Datensatz für Siedlungsabfälle und die Daten der Abfallstatistikverordnung[8] (WStatR), beruhen auf unterschiedlichen Konzepten, die nur schwer miteinander in Einklang zu bringen sind;
- die Häufigkeit der Datenerhebung für beide Datensätze unterscheidet sich; während die SiAbf-Daten jährlich erhoben werden, werden die WStatR-Daten nur für gerade Jahre zweijährlich gemeldet. Für Siedlungsabfälle lagen die Daten für das vereinbarte Bezugsjahr 2017 bereits zu Beginn der Studie vor, während sich die neuesten WStatR-Daten auf 2016 beziehen.

Es wurde vereinbart, die neuesten SiAbf-Daten für das Bezugsjahr 2017 zu verwenden und die WStatR-Daten für die anderen Abfallströme auf 2017 zu extrapolieren, um einen einheitlichen Datensatz für die THG-Bilanzen zu erhalten. Die Extrapolation der WStatR-Daten wird in Kapitel 3.3. erläutert.

Zusätzlich zu den an Eurostat gemeldeten SiAbf- und WStatR-Daten mussten für die Erstellung der Basisdaten weitere Datensätze verwendet werden, insbesondere das Europäische Referenzmodell zum Aufkommen und zur Behandlung von Siedlungsabfällen (im Folgenden als EEA-Modell[9] bezeichnet).

Die jeweiligen Datenquellen werden in Kapitel 3.2. zusammenfassend dargestellt.

Bestimmung der beiden EU-Cluster

Für die THG-Bilanzierung der Abfallströme "Siedlungsabfälle" und "Lebensmittelabfälle" wurden zwei Ländercluster definiert. Die beiden Cluster sollen Länder mit Nachholbedarf im Hinblick auf eine klimafreundliche Abfallwirtschaft und im Hinblick auf die abfallwirtschaftlichen Ziele der EU abdecken, die ein hohes Potenzial zur Reduzierung der THG-Emissionen im Zusammenhang mit der Abfallwirtschaft aufweisen.

Es wurden verschiedene Indikatoren und Ländermerkmale untersucht, um geeignete Kriterien für die Clusterbildung zu ermitteln. Auf der Grundlage der Analyse wurden die beiden Cluster wie folgt definiert:

- **Cluster 1** umfasst alle Länder, die berechtigt sind, die Frist für die Wiederverwendungs-/Recyclingziele der ARRL für die Jahre 2025, 2030 und 2035 um fünf Jahre aufzuschieben, weil sie 2013 eine niedrige Recyclingquote und/oder eine hohe Deponierungsquote aufwiesen. Zu dieser Gruppe gehören die **12 Länder** Bulgarien, Estland, Griechenland, Kroatien, Zypern, Lettland, Litauen, Ungarn, Malta, Polen, Rumänien und die Slowakei.

[8] Verordnung (EG) Nr. 2150/2002 des Europäischen Parlaments und des Rates vom 25. November 2002 zur Abfallstatistik (ABl. L 332 vom 9.12.2002, S. 1, zuletzt geändert durch ABl. L 253 vom 28.9.2010, S. 2).

[9] Europäisches Referenzmodell zum Aufkommen und zur Behandlung von Siedlungsabfällen, Version 2018, erstellt von der Europäischen Umweltagentur (EEA). Die EEA war so freundlich, dem Auftragnehmer das Modell bereits im März 2019, vor der offiziellen Veröffentlichung, zur Verfügung zu stellen. Es ist jetzt bei Eionet, dem Europäischen Umweltinformations- und Umweltbeobachtungsnetz, verfügbar: https://www.eionet.europa.eu/etcs/etc-wmge/etc-wmge-files/eurm_mswm.zip.

- **Cluster 2** umfasst alle Länder, die für 2017 eine Recyclingquote für Siedlungsabfälle meldeten, die unter oder gleich der Recyclingquote der EU27 (ohne Vereinigtes Königreich) lag und die nicht in Cluster 1 enthalten sind. Zu Cluster 2 gehören die **8 Länder** Tschechische Republik, Dänemark, Irland, Spanien, Frankreich, Portugal, Finnland und Schweden.

Nicht in den beiden Clustern enthalten sind die Länder, die für 2017 eine Recyclingquote über der EU27-Quote von 47 % gemeldet haben, sowie das Vereinigte Königreich. Das Vereinigte Königreich wird nicht berücksichtigt, da das Land kein EU-Mitgliedstaat mehr ist und daher nicht Gegenstand der Entwicklung von Empfehlungen ist.

Grundlagen der THG-Bilanzierung

Die Ermittlung der Klimaschutzpotenziale der Kreislaufwirtschaft erfolgt mittels der Ökobilanzmethode der Abfallwirtschaft in Anlehnung an ISO 14040/44. Die Methode wurde bereits vielfach in Studien angewendet und ausführlich beschrieben (z. B. (Dehoust et al. 2010), (Vogt et al. 2015)). Sie erlaubt eine ganzheitliche Betrachtung des Sektors Abfall, da neben den direkten Emissionen der Abfallbehandlung (Belastungen) auch die potenziell vermiedenen Emissionen (Gutschriften) durch die Substitution von Primärprodukten und konventionell erzeugter Energie einbezogen werden. Zur Bewertung der Klimawirkung von THG-Emissionen werden die Charakterisierungsfaktoren für den 100-Jahreshorizont (GWP100) nach IPCC (2013) verwendet.

Für die Ökobilanzmethode der Abfallwirtschaft gelten bestimmte Regeln, wie z. B. dass Systemvergleiche nur für gleiche Gesamtabfallmengen und -qualitäten durchgeführt werden dürfen. In die Bilanzierung werden alle Emissionen einbezogen, die bei der Behandlung einer definierten Abfallmenge anfallen und damit auch die über mehrere Jahrzehnte entstehenden Emissionen aus der Deponierung. Ein weiterer relevanter Aspekt ist, dass für die stoffliche Verwertung das technische Substitutionspotenzial angerechnet wird und nicht das Substitutionspotenzial nach Marktmix. Bei der Mitverbrennung von Abfällen in Zement- oder Kohlekraftwerken wird die Substitution fossiler Regelbrennstoffe berücksichtigt. Die Erzeugung von Strom und Wärme aus Abfall in thermischen Abfallbehandlungsanlagen (TAB) wird durch Substitution der durchschnittlichen Strom- und Wärmeerzeugung angerechnet, um die Dynamik aus der Energiewende in Zukunftsszenarien nachvollziehen zu können.

Aus Gründen der Konsistenz werden für alle Bilanzräume generell die durchschnittlichen Emissionsfaktoren für Strom und Wärme der EU27 verwendet. Dies gilt auch für die separat berechneten Bilanzen für Deutschland, die mit den Ergebnissen für die EU27 (ohne DE) zusammengeführt werden. In der separaten Studie für Deutschland (Teilbericht Deutschland) wurden nationale Werte verwendet. Für die beiden Cluster wurde der Einfluss regionaler Emissionsfaktoren für Strom in Sensitivitätsanalysen untersucht. Für die 2030 Szenarien sind die einheitlich verwendeten EU27-Emissionsfaktoren an einen veränderten Energieträgermix angepasst. Da sich veränderte Emissionsfaktoren für Strom auch auf die Primärproduktion auswirken, wurde auch ein entsprechend reduziertes Substitutionspotenzial für die stromintensive Primärproduktion von Papier und Aluminium abgeschätzt. Grundsätzlich wurden wie in der Vorgängerstudie (Vogt et al. 2015) harmonisierte Emissionsfaktoren für substituierte Primärprozesse verwendet.

Bei der Bilanzierung der Abfallbehandlungsoptionen für Restmüll, trockene und organische Wertstoffe sowie Holz wurde versucht, so weit möglich nationale Daten zu verwenden. Recherchen auf nationaler Ebene konnten im Rahmen der Studie nur in begrenztem Umfang durchgeführt werden. Die nationalen Inventarberichte wurden ausgewertet, um Parameter für die Deponierung, Kompostierung und Vergärung zu erhalten. Gewichtete Nutzungsgrade für erzeugte Energie aus der thermischen Behandlung konnten auf der Grundlage länderspezifischer Kapazitäten von thermischen Behandlungsanlagen in Scarlat et al. (2019) abgeleitet werden. Der anfängliche Versuch, gewichtete Wirkungsgrade auf der Grundlage der Daten und Massenströme von Siedlungsabfällen aus dem EEA-Modell zu verwenden, führte zu unplausiblen Ergebnissen. Relevante Parameter für den Restmüll (Heizwert, fossiler und biogener Kohlenstoffgehalt) wurden auf Basis der Abfallzusammensetzungen aus dem EEA-Modell berechnet. Für Deutschland lagen Daten aus einer aktuellen bundesweiten Sortieranalyse für Restmüll aus Haushalten vor. Für gewerbliche Siedlungsabfälle und Sperrmüll mussten weniger repräsentative Daten als Näherungswerte verwendet werden. In den Fällen, in denen keine EU-Daten aus dem EEA-Modell oder den anderen Quellen abgeleitet werden konnten, wurden die Berechnungen für Deutschland auch für die EU verwendet oder es wurden plausible Annahmen auf der Grundlage der deutschen Daten abgeleitet.

Feste Siedlungsabfälle

Die **Basisdaten für Siedlungsabfälle** wurden aus den Daten des EEA-Modells (Einzelheiten siehe Kapitel 3.2.2) und den an Eurostat gemeldeten Siedlungsabfalldaten (Einzelheiten, siehe Kapitel 3.2.1) berechnet. Die Mengen und die Zusammensetzung des Aufkommens und der Behandlung von Siedlungsabfällen wurden für die EU27 (ohne DE) und für die beiden Cluster berechnet und dann mit den Datensätzen aus dem Teilbericht über Deutschland zusammengeführt. Der folgende Ansatz (siehe Kapitel 5.1) für die Datenzusammenstellung wurde gewählt:

- Berechnung das EEA-Modell-Basisszenarios als wahrscheinlichste Entwicklung für alle 28 Länder,
- Verwenden der Eurostat-Daten 2017 (tatsächlich von den Mitgliedstaaten gemeldet), um die vom Modell berechneten Hauptströme anzupassen,
- Verwendung der Aufschlüsselung nach den wichtigsten Abfallströmen im EEA-Modell und der von den Ländern an Eurostat gemeldete Aufteilung der Behandlung als Mittel zur Anpassung der wichtigsten Ströme der Daten des EEA-Modells an die gemeldeten Trends, und
- Verwendung der Aufschlüsselung nach Materialien und der detaillierten Aufteilung der Behandlungen in % (z. B. 5 MBA-Typen und zugehörige Outputs), um sie auf die angepassten Hauptströme anzuwenden.

Um so vorzugehen, wurden Ähnlichkeiten zwischen den Eurostat-Daten und denen des EEA-Modells identifiziert, die hilfreich waren, um die Daten des EEA-Modells (Prognose) an die realen Entwicklungen anzupassen, die sich in den Eurostat-Daten für Organikabfälle (Variable: Kompostierung und Vergärung) und trockene Wertstoffe (Variable: stoffliche Verwertung) widerspiegeln.

Das weitere Vorgehen bestand in der Validierung der Berechnungen. Die Validierung umfasste Folgendes:

1. Überprüfung der Eurostat-Metadaten auf methodische Änderungen; Korrekturen offensichtlicher Unstimmigkeiten (z. B. unterschiedliche Trends aufgrund methodischer Brüche wie z. B. der Ausschluss von MBA-Mengen aus der Kompostierung/Vergärung in den Eurostat-Daten 2017 im Vergleich zu 2015).
2. Vergleich aller relevanten Untergliederungen in %, die im Modell 2017 und 2015 verwendet wurden, und Bereinigung größerer Unstimmigkeiten (Gesamt-SiAbf-Zusammensetzung nach Materialien, Aufschlüsselung der Behandlung von Restmüll, Aufschlüsselung der Behandlung von Organikabfall, Erfassungsquoten für trockene Wertstoffe und Organikabfall sowie

Verlustraten zur Berechnung der Rückstandsmengen für trockene Wertstoffe und Organikabfall).
3. Vergleich der berechneten Restmüllzusammensetzung mit den Zusammensetzungsdaten aus der Literaturrecherche (z. B. aus nationalen Abfallwirtschaftsplänen).
4. Vergleich der vom Modell für den Letztverbleib berechneten Beträge mit den Eurostat-Daten in denjenigen Fällen, wo die Meldung an Eurostat bekanntermaßen dem Konzept des Letztverbleibs sehr nahekommt.

Die Validierungen 1 und 2 mussten für alle Länder durchgeführt werden, während die übrigen Validierungen nur auf die größeren Länder angewendet wurden, die 80 % der Cluster und EU-Aggregate abdecken.

Die Ausgangsdaten für das Aufkommen und die Behandlung von Siedlungsabfällen sind in Abbildung 1 für die EU27 dargestellt. Ähnliche Abbildungen wurden für die EU28, einschließlich des Vereinigten Königreichs, sowie für Cluster 1 und Cluster 2 erstellt. Die Materialströme *Elektro- und Elektronik-Altgeräte, Batterien und Akkumulatoren, gefährliche Abfälle (ohne Elektro- und Elektronik-Altgeräte), Schutt und Böden* sowie bei den trockenen Wertstoffen *Textilien* sind nicht Gegenstand dieser Studie, mussten aber in den Berechnungen beibehalten werden, um mit den Eurostat-Daten, die diese Ströme enthalten, kohärent zu sein. Die Herausnahme dieser Ströme aus den Berechnungen hätte zu falschen Anpassungsfaktoren geführt. Daher werden diese Ströme bei den Gesamtberechnungen der Siedlungsabfalldaten verwendet, aber bei den schließlich vorgelegten Mengen und den Treibhausgasbilanzen nicht berücksichtigt.

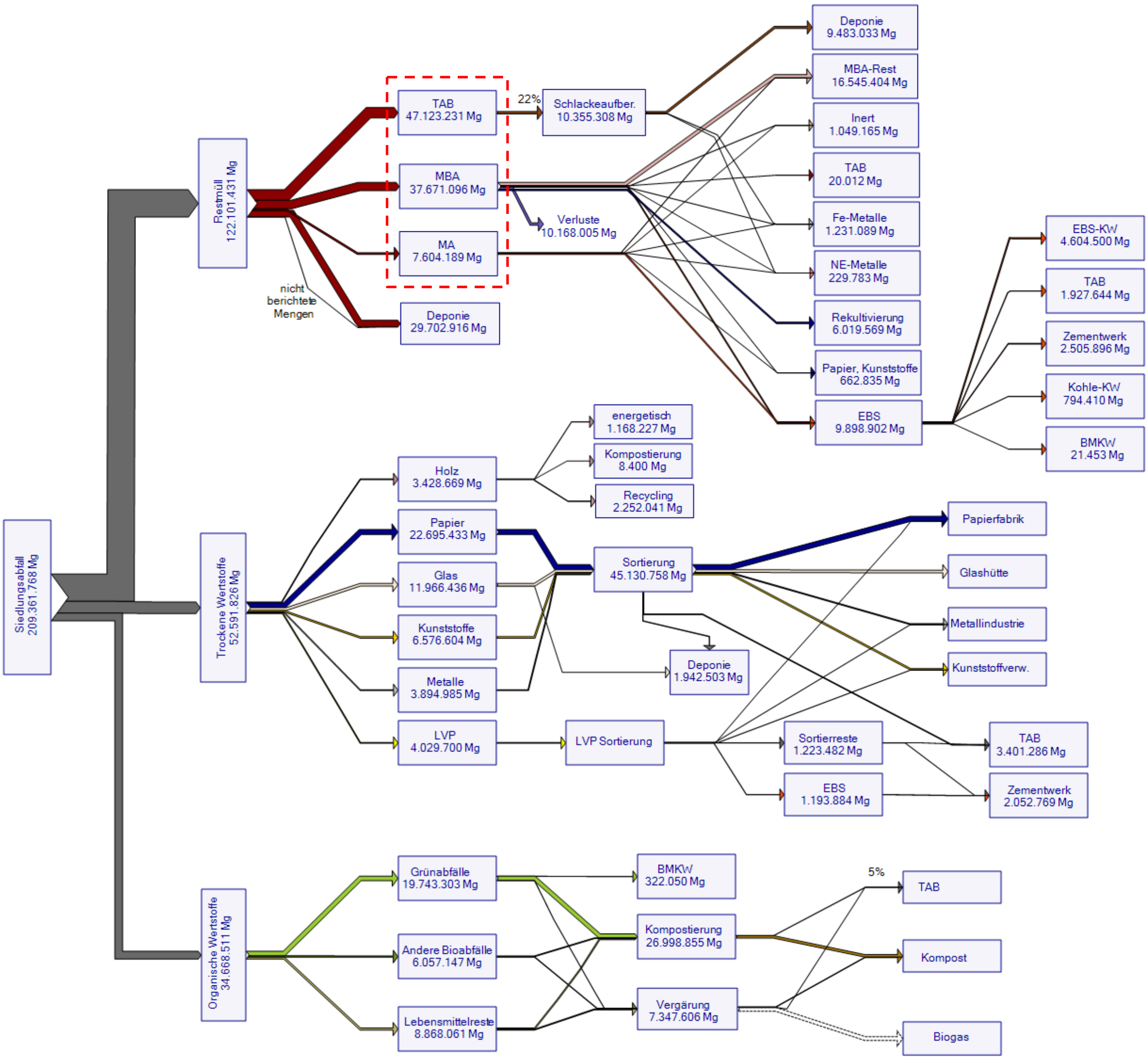
Abbildung 1 zeigt, dass der größte Teil der Abfälle in der EU nach wie vor aus Restmüll besteht. Der Anteil beläuft sich auf 58 % für die EU27 (bzw. 59 % für die EU28, 77 % für Cluster 1 und 67 % für Cluster 2). Zum Vergleich: In Deutschland liegt der Anteil bei 42 %. Die getrennt gesammelten trockenen Wertstoffe (einschließlich Holz) machen sowohl in der EU27 als auch in der EU28 25 % der gesamten festen Siedlungsabfälle aus, aber nur 16 % in Cluster 1 und 20 % in Cluster 2. Im Vergleich dazu liegt der Anteil in Deutschland bei 35 %. Der Anteil der getrennt gesammelten organischen Abfälle liegt bei 17 % für die EU27 bzw. 16 % für die EU28, beträgt aber nur 7 % für Cluster 1 und 12 % für Cluster 2. Für Deutschland ist ein Anteil von 23 % für die getrennt gesammelten organischen Abfälle berücksichtigt.

Der Anteil Restmüll zur Behandlung und zur Deponierung beträgt:

- EU27: 24 % Deponierung, 76 % Behandlung (davon 51 % Verbrennung)
- EU28: 25 % Deponierung, 75 % Behandlung (davon 51 % Verbrennung)
- Cluster 1: 50 % Deponierung, 50 % Behandlung (davon 9 % Verbrennung)
- Cluster 2: 29 % Deponierung, 71 % Behandlung (davon 58 % Verbrennung)

Zum Vergleich: In Deutschland werden 0 % Restmüll deponiert, 67 % des Restmülls zur Behandlung werden verbrannt.

Abbildung 1: Sankey-Diagramm Siedlungsabfall EU27 2017



Quelle: eigene Darstellung, ifeu.

Für Siedlungsabfälle werden zwei **Szenarien** für das Jahr 2030 für die EU-Bilanzräume der EU27, Cluster 1 und Cluster 2 entwickelt. Das erste Szenario für alle drei Bilanzräume wird als "Leitszenario" bezeichnet. Die Leitszenarien folgen den Zielen der Abfallrahmenrichtlinie (ARRL), d. h. sie gehen davon aus, dass alle Länder die rechtlichen Ziele einhalten und berücksichtigen wahrscheinliche Entwicklungen in der Behandlung von Siedlungsabfällen in der Zukunft. Das zweite Szenario unterscheidet sich für die EU27 und für die Cluster, alle haben jedoch das Ziel, ein niedrigeres Ambitionsniveau zu untersuchen. Für die EU27 wurde ein modell-theoretisches Szenario betrachtet, bei dem die Eigenkompostierung für die Recyclingziele berücksichtigt wurde. Für die Cluster wurden Spezialszenarien entwickelt, um die Auswirkungen der Nichteinhaltung der Recyclingquoten zu testen.

Das modell-theoretische Szenario "mit Eigenkompostierung in der RC-Rate" für die EU27 ist weniger ehrgeizig, entspricht aber immer noch dem gesetzlichen Recyclingziel. Die bewertete Menge an Eigenkompostierung für die EU27 – etwa 40,2 Mio. Tonnen (oder etwa 90 kg/E*a) – wird dem Aufkommen an Siedlungsabfällen in den Jahren 2017 und 2030 hinzugerechnet (gleiche Gesamtabfallmengen als Voraussetzung der Ökobilanzmethode für Systemvergleiche) und trägt zur Recyclingrate bei. Infolgedessen wird der Restmüll im Jahr 2030 im Szenario mit

Eigenkompostierung in der RC-Rate nur um 27 % reduziert, anstatt um 42 % im Leitszenario ohne Eigenkompostierung. Die höheren Mengen an "Restmüll zur Behandlung" werden entsprechend der gleichen Aufteilung der Behandlungstechnologien wie im Leitszenario zugewiesen, und die Einhaltung der Deponierichtlinie wird weiterhin berücksichtigt (die Menge des zu deponierenden Restmülls im Jahr 2030 ist nahezu gleich). Es ist jedoch zu beachten, dass das Szenario mit großen Datenunsicherheiten behaftet ist. Darüber hinaus war es im Rahmen der Studie nicht möglich, die potenziellen Wechselwirkungen zwischen der getrennten Sammlung von Organikabfällen und der Eigenkompostierung zu erörtern.

Zusätzlich zu den Szenarien wurde der Einfluss der regionalen Emissionsfaktoren für Strom für die beiden Cluster in Sensitivitätsanalysen untersucht.

Die **Ergebnisse der THG-Bilanz für die EU27** für das Basisjahr 2017 und für das Leitszenario 2030 zeigt Tabelle 1. Insgesamt ergeben sich in beiden Szenarien absolute Nettoentlastungspotenziale (negative Werte, Gutschriften höher als Belastungen). Das Nettoentlastungspotenzial für 2017 beträgt -3,53 Millionen Tonnen CO_2-Äq. Dieses geringe Entlastungspotenzial ist hauptsächlich auf die hohen Abfallmengen zurückzuführen, die in der EU27 immer noch deponiert werden ("Restmüll zur Deponie") und die für eine absolute Nettobelastung von 27,59 Mio. Tonnen CO_2-Äq. verantwortlich sind. Die Ergebnisse der anderen Abfallfraktionen sind mit Nettoentlastungspotenzialen verbunden, wenngleich diese bei den Organikabfällen (Lebensmittelreste, Grünabfälle, andere Bioabfälle aus dem EEA-Modell sowie Abfälle aus der Biotonne und Küchen-/Kantinenabfälle aus der deutschen Abfallstatistik) gering sind.

Die spezifischen Nettoergebnisse pro Tonne zeigen, dass vor allem das Recycling von trockenen Wertstoffen, insbesondere von Metallen, gefolgt von Leichtverpackungen (LVP, nur Deutschland), Kunststoffen, Glas und Papier, mit höheren Nettoentlastungspotenzialen verbunden ist. Das Recycling von Holz weist ein geringeres Nettoentlastungspotenzial auf, und für Organikabfälle ist es aufgrund des hohen Anteils der Kompostierung fast Null. Das spezifische Nettoentlastungspotenzial für „Restmüll zur Behandlung", zu dem die thermische Abfallbehandlung (TAB), die mechanisch-biologische Behandlung (MBA) und die mechanische Behandlung (MA) gehören (siehe rot gestrichelt umrandeter Kasten in Abbildung 1), ist ebenfalls eher gering. Das spezifische Entlastungspotenzial ist höher, wenn die erzeugten EBS anteilig auch in Zement- und Kohlekraftwerken mitverbrannt werden, wo sie fossile Brennstoffe ersetzen. Es bestehen jedoch große Datenunsicherheiten in Bezug auf den Anteil der EBS und sowohl die Zusammensetzung des Einsatzmaterials als auch Charakteristika und Qualität der erzeugten EBS. Darüber hinaus enthält dieses Ergebnis eine Korrektur für Ungarn, wo die nach dem EEA-Modell der MA zugeschriebenen Mengen laut dem nationalen Inventarbericht letztlich ohne weitere Behandlung deponiert werden (NIR HU 2019).

Im Leitszenario 2030 (2030 LS) erhöht sich das absolute Nettoentlastungspotenzial auf -29,99 Mio. Tonnen CO_2-Äq. Der auffälligste Unterschied in den Ergebnissen ist die Verringerung der Nettobelastung durch Deponierung, die auf 3,96 Mio. Tonnen CO_2-Äq. reduziert wird. Die verbleibenden THG-Belastungen resultieren aus Cluster 1 Ländern, in denen die mögliche Ausnahmeregelung gemäß Deponierichtlinie berücksichtigt ist[10]. Die absoluten Nettoentlastungspotenziale bei trockenen Wertstoffen sind vor allem durch die höhere getrennte Erfassung und Recycling gestiegen, die nötig sind, um die Recyclingrate gemäß Abfallrahmenrichtlinie zu erreichen. Eine Ausnahme bildet Papier, dessen geringeres absolutes Nettoentlastungspotenzial auf die abgeschätzten geringeren THG-Emissionen der

[10] 5 Jahre Aufschub für Mitgliedstaaten, die 2013 mehr als 60 % deponiert haben; statt nur 10 %, dürfen noch 25 % in 2035 deponiert werden.

Primärproduktion von Papier zurückzuführen ist (Strombedarf berechnet mit dem niedrigeren Stromemissionsfaktor für 2030, siehe Ergebnisse pro Tonne). Eine solche Schätzung wurde auch für die stromintensive Produktion von Aluminium durchgeführt, was der Grund für das leicht reduzierte Ergebnis pro Tonne für Metalle ist.

Tabelle 1 Absolute und spezifische Nettoergebnisse nach Abfallfraktionen - Basisvergleich Siedlungsabfälle EU27: Basisjahr 2017 und Leitszenario 2030

Abfallfraktion	Absolut		Spez. pro Kopf[1]		Spez. pro Tonne	
SiAbf	**2017**	**2030 LS**	**2017**	**2030 LS**	**2017**	**2030 LS**
	Mio. Mg CO_2-Äq		kg CO_2-Äq/E		kg CO_2-Äq/Mg	
Restmüll zur Behandlung	-2,21	2,30	-5,0	5,2	-24	35
Organikabfälle	-0,03	-0,80	-0,1	-1,8	-1	-13
Papier	-10,05	-5,39	-22,6	-12,1	-443	-169
Glas	-5,43	-7,43	-12,2	-16,7	-454	-450
Kunststoffe	-3,43	-9,03	-7,7	-20,3	-522	-695
LVP	-3,44	-3,60	-7,7	-8,1	-854	-893
Metalle	-5,95	-9,32	-13,4	-20,9	-1527	-1413
Holz	-0,59	-0,67	-1,3	-1,5	-172	-132
Restmüll zur Deponie	27,59	3,96	61,9	8,9	929	928
Summe/Durchschnitt	**-3,53**	**-29,99**	**-7,9**	**-67,3**	**-17**	**-143**

1) Berechnet mit Bevölkerungszahl von 445.529.136 in 2017 (Tabelle 27).

Das geringfügig niedrigere spezifische Nettoergebnis pro Tonne für Holzabfälle im Szenario 2030 ist ebenfalls auf Defossilisierungseffekte zurückzuführen. Die geringeren Entlastungspotenziale für die Strom- und Wärmeerzeugung werden nur teilweise durch die für 2030 angenommenen höheren Nettowirkungsgrade der Biomasseheizkraftwerke kompensiert. Die geringe Menge, für die eine Pyrolyse angenommen ist, hat kaum einen Einfluss. Das spezifische Nettoergebnis liegt in der gleichen Größenordnung wie bei der Holzverwertung. Umgekehrt sind die Effekte der Defossilisierung auch hauptsächlich für das höhere spezifische Nettoergebnis pro Tonne für Kunststoff (und Kunststoff in LVP) verantwortlich. Die geringeren THG-Belastungen für den Strombedarf führen zu geringeren spezifischen Nettobelastungen für das Kunststoffrecycling. Die Entlastungspotenziale (Gutschriften) für Kunststoffabfälle ändern sich kaum. Steigerungen dieser könnten vor allem durch bessere Qualitäten und die daraus resultierende stärkere Substitution von Neukunststoffen anstelle von Anwendungen wie Holz und Beton als Ersatzstoffe erreicht werden (siehe auch Teilbericht Deutschland).

Das Nettoentlastungspotenzial für Organikabfälle ist im Leitszenario 2030 etwas höher, was in erster Linie durch den angenommenen Anstieg der Vergärung und Biogasnutzung erreicht wird. Die aus den nationalen Inventarberichten abgeleiteten THG-Emissionen der biologischen Behandlung wurden im Leitszenario 2030 nicht verändert. Die Kompostierung führt zu einer Nettobelastung für die EU27, sowohl für 2017 als auch für 2030. Die bei den Lebensmittelresten zusätzlich berücksichtigte Behandlung mit Soldatenfliegenlarve hat bei den geringen Mengen kaum Einfluss auf das Ergebnis. Das Nettoergebnis pro Tonne Abfall ist dem der Kompostierung ähnlich. Diese Behandlungsmethode könnte eine Alternative zur Deponierung darstellen. Allerdings ist die Datenunsicherheit groß und es wurde angenommen, dass aufgrund der klimatischen Bedingungen in Südeuropa 75 % des Wärmebedarfs durch die Umgebungstemperatur gedeckt werden kann.

Das spezifische Nettoergebnis für Restmüll zur Behandlung verändert sich von einer leichten Nettogutschrift im Jahr 2017 zu einer leichten Nettobelastung im Leitszenario 2030. Dies ist zum einen auf die reduzierten Entlastungspotenziale für die Strom- und Wärmeerzeugung (Defossilisierung) aus Abfällen zurückzuführen. Andererseits ist auch der Anstieg des fossilen Kohlenstoffanteils im Restmüll von Bedeutung (insbesondere höherer Anteil an Kunststoffen)[11]. Ein weiterer Grund für geringere Gutschriften ist ebenfalls auf Klimaziele zurückzuführen und resultiert aus der Umleitung von EBS von der Mitverbrennung in Kohlekraftwerken zur Verbrennung in thermischen Behandlungsanlagen. Dies wird durch die höheren Nettowirkungsgrade, die für thermische Abfallbehandlungsanlagen im Jahr 2030 angenommen sind, leicht kompensiert.

Das modell-theoretische **Szenario mit Eigenkompostierung in der RC-Rate für die EU27** erlaubt eine Betrachtung auf einem reduzierten Ambitionsniveau für die getrennte Sammlung. Allerdings sind die Datenunsicherheiten bei der Eigenkompostierung sehr hoch, sowohl in Bezug auf die Menge als auch auf die damit verbundenen THG-Emissionen. Der Zweck dieses Szenarios ist es, die Auswirkung einer weniger ehrgeizigen Erhöhung der getrennten Sammlung zu untersuchen, und aufgrund der hohen Datenunsicherheiten wurde die Eigenkompostierung in der THG-Bilanz mit Null bewertet (obwohl tendenziell Nettobelastungen anzunehmen sind, siehe Anhang Teilbericht Deutschland).

Das Szenario mit Eigenkompostierung in der RC-Rate 2017 (SiAbf EU27 EK 2017) führt zu einem absoluten Nettoentlastungspotenzial von etwa -3,5 Mio. Tonnen CO_2-Äq. Ein Vergleich auf absoluter Ebene mit dem Basisvergleich ist aufgrund der unterschiedlichen Gesamtabfallmengen (209,4 Mio. Tonnen im Basisvergleich und 249,6 Mio. Tonnen im Szenario mit Eigenkompostierung in der RC-Rate) nicht möglich. Da jedoch die THG-Emissionen aus der Eigenkompostierung nicht berücksichtigt sind, ist das absolute Ergebnis der THG-Bilanz für 2017 identisch mit dem absoluten Ergebnis des Basisszenarios 2017 (SiAbf EU27 2017).

Für das Jahr 2030 ergibt sich für das Szenario mit Eigenkompostierung im RC-Rate (SiAbf EU27 EK 2030) ein absolutes Nettoentlastungspotenzial von -25,2 Mio. Tonnen CO_2-Äq. Auch hier gilt, dass ein Vergleich mit dem Basisvergleich (Leitszenario 2030) auf absoluter Ebene nicht möglich ist. Würde man jedoch die Eigenkompostierung als praktisch emissionsneutral betrachten, könnte man feststellen, dass das Szenario mit geringerem Ambitionsniveau für die verstärkte getrennte Sammlung zu einem geringeren Emissionseinsparungspotenzial von etwa 5 Millionen Tonnen CO_2-Äq im Vergleich zum Leitszenario 2030 führen würde. Ein qualitativer Vergleich für das Jahr 2030 zeigt, dass insbesondere das Recycling von trockenen Wertstoffen aufgrund der geringeren getrennt gesammelten Mengen geringere absolute Nettoentlastungs-potenziale erzielt. Die Ergebnisse für Restmüll weichen aufgrund unterschiedlicher Behandlungsmengen und unterschiedlicher Abfallzusammensetzungen und damit Eigenschaften leicht ab. Auf der spezifischen Ebene pro Tonne sind die Ergebnisse für die Abfallfraktionen unverändert oder leicht verändert, letzteres entweder aufgrund veränderter Behandlungssplits oder veränderter Zusammensetzungen und Eigenschaften von Restmüll. Der deutlichste Unterschied auf der spezifischen Ebene ergibt sich in Bezug auf die Gesamtabfallmengen. Das gesamte spezifische Nettoentlastungspotenzial ist deutlich geringer, da sich die Ergebnisse auf

[11] Dies ist in der separat berechneten Bilanz für Deutschland anders. Dort ist der fossile Kohlenstoffgehalt im Restmüll im Leitszenario geringer ist, was ein Grund dafür ist, dass das spezifische Nettoergebnis immer noch ein Nettoentlastungspotenzial ist (mit EU27-Emissionsfaktoren, vgl. Teilbericht Deutschland).

rund 250 Millionen Tonnen beziehen (einschließlich der 40,2 Millionen Tonnen Eigenkompostierung).

- SiAbf EU27 EK 2017: -14 kg CO_2-Äq/Mg (16 % niedriger als im Basisjahr 2017)
- Siabf EU27 EK 2030: -101 kg CO_2-Äq/Mg (30 % niedriger als im Leitszenario 2030)

Die Berechnung für **Cluster 1 und Cluster 2** wurde in der gleichen Weise durchgeführt wie für die EU27 (ohne DE). Es wurden jedoch länderspezifische Aspekte angepasst. Dies gilt neben den Abfallbehandlungsströmen auch für die aus den nationalen Inventarberichten abgeleiteten Parameter für die Deponierung, Kompostierung und Vergärung sowie für die gewichteten Nettowirkungsgrade der thermischen Abfallbehandlung. Darüber hinaus wurden die unterschiedlichen Abfallzusammensetzungen für Restmüll aus dem EEA-Modell und die daraus resultierenden Kennwerte speziell für die Ländercluster berechnet. Anders als für die EU27 (und EU28) weisen die absoluten Ergebnisse für die beiden Cluster im Basisjahr 2017 eine Nettobelastung auf, die im Wesentlichen durch die hohen Anteile von Restmüll zur Deponierung (in Cluster 1 relevanter als in Cluster 2) verursacht wird. Darüber hinaus führt in Cluster 1 die Korrektur für Ungarn (Mengen, die aus dem EEA-Modell der MA zugeschrieben sind, die aber letztlich ohne weitere Behandlung deponiert werden) zu einer spezifischen Nettobelastung für Restmüll zur Behandlung (in den anderen Bilanzräumen Nettoentlastungen).

Für **Cluster 1** sind die Nettoergebnisse für die drei Szenarien wie folgt:

- Basisjahr, 2017: +10,5 Mio. Mg CO_2-Äq (102,6 kg CO_2-Äq/E; 300 kg CO_2-Äq/Mg)
- Leitszenario 2030: -0,93 Mio. Mg CO_2-Äq (-9,1 kg CO_2-Äq/E; -27 kg CO_2-Äq/Mg)
- Spezialszenario 2030: -0,36 Mio. Mg CO_2-Äq (-3,5 kg CO_2-Äq/E; -10 kg CO_2-Äq/Mg)

Im Jahr 2017 dominiert die Restmülldeponierung eindeutig die Belastungen. Beide Szenarien 2030 zeigen eine Verschiebung des Nettoergebnisses von einer Nettobelastung zu einer leichten Nettoentlastung. In beiden Szenarien ist dies hauptsächlich auf die Abkehr von der Deponierung zurückzuführen (die auch für die korrigierte Menge für Ungarn anteilig angenommen wurde). Darüber hinaus sind die erhöhte Menge an getrennt gesammelten trockenen Wertstoffen und technische Optimierungen für die Nettoentlastung in beiden 2030-Szenarien verantwortlich. Diese Aspekte wirken den Effekten aus der Defossilisierung entgegen. Die Menge der getrennt gesammelten trockenen Wertstoffe ist im Spezialszenario 2030 geringer als im Leitszenario 2030, was vor allem das geringere Nettoentlastungspotenzial erklärt. Die Behandlung von Organikabfällen ist aufgrund des hohen Anteils der Kompostierung (94 %) im Jahr 2017 mit einer Nettobelastung verbunden. Die Nettobelastung pro Tonne Abfall ist in den Szenarien für 2030 vor allem deshalb geringer, weil von höheren Mengen an Lebensmittelresten ausgegangen wird, die durch Vergärung behandelt werden. Die Behandlung mit Soldatenfliegenlarve trägt nur geringfügig zu den spezifischen Nettobelastungen bei.

Die Sensitivitätsanalyse mit dem höheren Stromemissionsfaktor 2017 für Cluster 1 hat kaum Auswirkungen auf die Ergebnisse. Die höheren Gutschriften für die Stromerzeugung aus Abfällen (die in Cluster 1 keine hohe Relevanz haben) werden durch die höheren Belastungen für den Strombedarf insbesondere für das Recycling kompensiert.

Für **Cluster 2** sind die Nettoergebnisse für die drei Szenarien wie folgt:

- Basisjahr, 2017: +3,06 Mio. Mg CO_2-Äq (19,1 kg CO_2-Äq/E; 39 kg CO_2-Äq/Mg)
- Leitszenario 2030: -12,63 Mio. Mg CO_2-Äq (-78,8 kg CO_2-Äq/E; -163 kg CO_2-Äq/Mg)
- Spezialszenario 2030: -4,18 Mio. Mg CO_2-Äq (-26,1 kg CO_2-Äq/E; -54 kg CO_2-Äq/Mg)

Die Ergebnisse für Cluster 2 werden wiederum von den Auswirkungen der Restmülldeponierung dominiert. Die Verschiebung hin zu einer Nettoentlastung im Leitszenario in Cluster 2 ist hauptsächlich auf die angenommene vollständige Abkehr von der Deponierung zurückzuführen. Im Spezialszenario 2030 ist die Nettoentlastung um 8,4 Mio. Tonnen CO_2-Äq niedriger als im Leitszenario 2030, da angenommen wurde, dass Cluster 2 Länder die Deponierung nicht vollständig beenden, da sie gemäß der Deponierichtlinie noch weiter deponieren dürfen.

Die Behandlung von Organikabfällen führt aufgrund des hohen Anteils der Kompostierung (90 %) zu einer Nettobelastung für 2017. Für die Szenarien für 2030 kann ein leichtes Nettoentlastungspotenzial erzielt werden, da angenommen ist, dass mehr Lebensmittelreste durch Vergärung statt durch Kompostierung behandelt werden. Auch hier trägt die Behandlung mit Soldatenfliegenlarve nur geringfügig zu den spezifischen Nettobelastungen bei.

Die Sensitivitätsanalyse mit dem niedrigeren Stromemissionsfaktor 2017 für Cluster 2 führt zu einer um 33 % höheren absoluten Nettobelastung. In Cluster 2 ist im Gegensatz zu Cluster 1 der Anteil an Restmüll zur thermische Abfallbehandlung deutlich höher. Die geringeren Gutschriften für die Stromerzeugung wirken sich stärker aus und werden nicht durch die geringeren Belastungen des Strombedarfs für das Recycling kompensiert.

Sonderbilanz Lebensmittelabfälle

In Bezug auf **Lebensmittelabfälle** wendet die Studie die Definition von Lebensmittelabfällen der Abfallrahmenrichtlinie an, die besagt, dass *"Lebensmittelabfall" alle Lebensmittel gemäß Artikel 2 der Verordnung (EG) Nr. 178/2002 des Europäischen Parlaments und des Rates umfasst, die zu Abfall geworden sind.* Es wird nicht zwischen essbaren und nichtessbaren Lebensmittelabfällen unterschieden. Vom Untersuchungsumfang dieser Studie ausgenommen sind Lebensmittelabfälle, die im NACE-Abschnitt A *"Land- und Forstwirtschaft, Fischerei"* anfallen.

Die Verfügbarkeit zuverlässiger **Daten zum Aufkommen und zur Behandlung von Lebensmittelabfällen** ist unzureichend, insbesondere für Lebensmittelabfälle aus gewerblichen und industriellen Quellen. Lebensmittelabfälle sind Teil der organischen Abfälle und können in der Regel nicht separat gemessen werden. Das Gesamtaufkommen an Lebensmittelabfällen wurde auf der Grundlage von WStatR-Daten geschätzt. Lebensmittelabfälle sind größtenteils in den EAK-Stat-Schlüsseln W091 "Tierische und gemischte Nahrungsmittelabfälle", W092 "Pflanzliche Abfälle" und in W101 "Hausmüll und ähnliche Abfälle" enthalten. Die Anteile der Lebensmittelabfälle innerhalb dieser Abfallkategorien wurden anhand von Informationen aus der Literatur, nationalen statistischen Daten, Informationen aus der vom Auftragnehmer durchgeführten Validierung der WStatR-Daten und Schätzungen ermittelt. Darüber hinaus wurde die Menge der Lebensmittelabfälle aus Siedlungsabfällen im Rahmen der Analyse der Siedlungsabfalldaten mit Hilfe des EEA-Modells ermittelt. Die Menge der Lebensmittelabfälle aus gewerblichen und industriellen Quellen wurde als Differenz zwischen der WStatR-basierten Schätzung für die insgesamt anfallenden Lebensmittelabfälle und den Lebensmittelabfällen aus Siedlungsabfällen aus der Berechnung des EEA-Modells ermittelt. Die Lebensmittelabfälle wurden auf Länderebene bestimmt und die Ergebnisse dann auf Cluster- und EU27-Ebene aggregiert.

Die Gesamtmenge der Lebensmittelabfälle in der EU27 wird auf 70,1 Millionen Tonnen bzw. 157 kg/Kopf geschätzt. Rund 55 % der erzeugten Lebensmittelabfälle (38,6 Millionen Tonnen) sind in "Hausmüll und ähnlichen Abfällen" (W101) und 45 % (31,6 Millionen Tonnen) in den Abfallkategorien "Tierische und pflanzliche Abfälle" (W091, W092) enthalten.

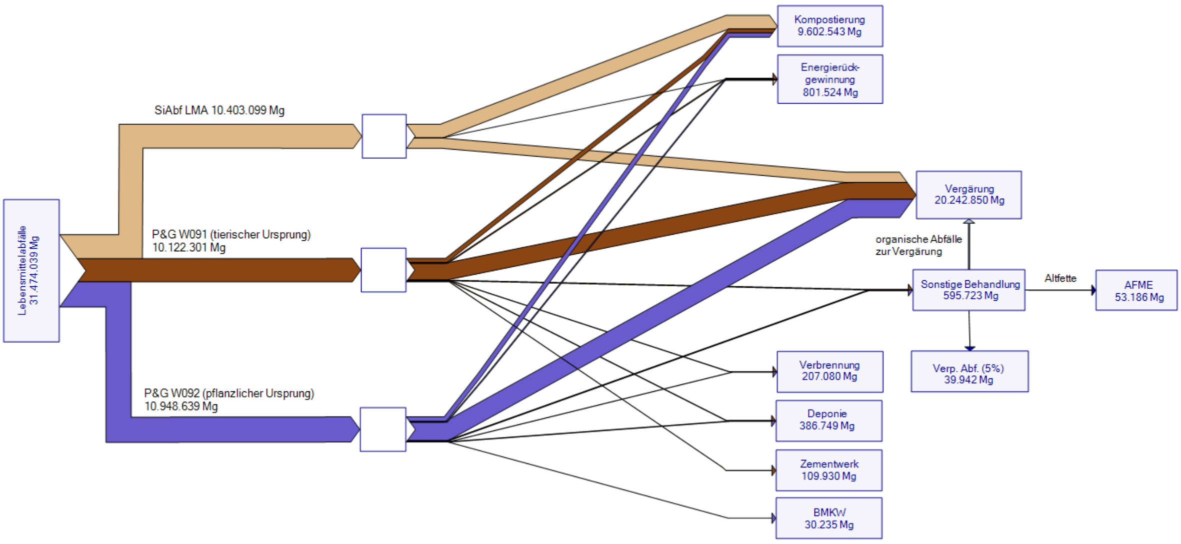
Produktionsabfälle aus der Lebensmittelindustrie machen 13,8 Millionen Tonnen oder 20 % der Lebensmittelabfälle insgesamt aus.

Die Basisdaten für die Treibhausgasbilanz sind in Abbildung 2 dargestellt. Aus methodischen Gründen wurden die in "Hausmüll und ähnlichen Abfällen" (W101) enthaltenen Lebensmittelabfälle in der THG-Bilanz nicht berücksichtigt. Die Daten in Abbildung 2 beziehen sich daher nur auf die Lebensmittelabfälle, die in den Abfallkategorien "Tierische und pflanzliche Abfälle" (W091, W092) enthalten sind.

Das Sankey-Diagramm zeigt, dass in der EU27 im Jahr 2017 etwa zwei Drittel der in den "tierischen und pflanzlichen Abfällen" (W091, W092) enthaltenen Lebensmittelabfälle aus gewerblichen und industriellen Quellen stammen, während ein Drittel kommunale Lebensmittelabfälle sind (abgeleitet aus dem EEA-Modell).

Lebensmittelabfälle werden hauptsächlich durch Vergärung behandelt, wie im Sankey-Diagramm dargestellt. Dies basiert auf der Annahme, dass der Anteil der Vergärung in der EU27 (ohne DE) ähnlich, aber niedriger als in Deutschland ist. Der Gesamtanteil der Vergärung von Lebensmittelabfällen (aus Siedlungsabfällen und P&G-Abfällen) in der EU27 beträgt 64 %. Der verbleibende Anteil wird hauptsächlich kompostiert. Andere Behandlungsoptionen wie Verbrennung (mit oder ohne Energierückgewinnung), Deponierung und sonstige Beseitigung sind von geringer Bedeutung. Die Lebensmittelabfälle aus Siedlungsabfällen werden in Deutschland hauptsächlich durch Vergärung behandelt, während in den EU-Bilanzräumen die Kompostierung dominiert.

Abbildung 2: Sankey-Diagramm Lebensmittelabfälle EU27 2017



Quelle: eigene Darstellung, ifeu.

Für jede der drei Bilanzräume (EU27, Cluster 1 und Cluster 2) wurden zwei **Szenarien für das** Jahr 2030 entwickelt. Die Leitszenarien berücksichtigen ähnliche Annahmen wie die Leitszenarien für Siedlungsabfälle und konzentrieren sich auf die Abkehr von der Deponierung und technische Optimierungen. Die zusätzlichen Szenarien berücksichtigen auch die Vermeidung von Lebensmittelabfällen, was es ermöglicht, die Klimaauswirkungen der Reduzierung gegenüber denen der Behandlung von Lebensmittelabfällen aufzuzeigen.

Die Szenarioannahmen für Lebensmittelabfälle aus Siedlungsabfällen müssen mit den Annahmen für Lebensmittelabfälle in den Leitszenarien für Siedlungsabfälle 2030 übereinstimmen:

- Die Behandlung von Lebensmittelabfällen wird von der Kompostierung auf die Vergärung umgelenkt;
- Ein kleiner Teil der Lebensmittelabfälle in den Clustern 1 und 2 wird mit Hilfe von Soldatenfliegenlarvenanlagen behandelt.

Für Lebensmittelabfälle aus industriellen und gewerblichen Quellen (P&G-Abfälle) wurden folgende Annahmen getroffen:

- Lebensmittelabfälle werden vollständig von der Kompostierung abgezweigt und hauptsächlich der Vergärung und teilweise der energetischen Verwertung zugeführt;
- Es wird davon ausgegangen, dass ein Anteil von 1,5 % der gesamten P&G-Lebensmittelabfälle Speiseöle und -fette sind, die für die Biodieselproduktion verwendet werden;
- In den Clustern 1 und 2 wird ein Anteil von 2 % der gesamten P&G-Lebensmittelabfälle in Soldatenfliegenlarvenanlagen behandelt.

Für diese Studie wurde ein methodischer Ansatz entwickelt, um die Abfallvermeidung (für Deutschland auch die Vorbereitung zur Wiederverwendung) einzubeziehen, die in der Regel, hauptsächlich aufgrund von Datenbeschränkungen, nicht Teil der Ökobilanz der Abfallwirtschaft ist. Voraussetzung für die Einbeziehung ist, dass die vermiedenen Produkte bekannt sind und dass die Auswirkungen ihrer Produktionsvermeidung quantifiziert werden können. Für Lebensmittelabfälle bedeutet dies, dass nur Verzehrprodukte berücksichtigt werden können. Für Schlämme, Schlempen, Schälreste usw. oder "zum Verzehr oder zur Verarbeitung ungeeignete Stoffe", die nach der deutschen Abfallstatistik im P&G-Abfall überwiegen, können keine ursprünglichen Produkte identifiziert werden. Dementsprechend wird die Abfallvermeidung nur für Lebensmittelabfälle aus Siedlungsabfällen berücksichtigt. Die vermiedene Menge ist für die EU27 und Cluster 2 auf 50 % und für Cluster 1 auf 30 % festgelegt.

Die Berechnung der **THG-Bilanzen** für Lebensmittelabfälle aus Siedlungsabfällen entspricht der Berechnung der Bilanz für Siedlungsabfälle. Für die Berechnung der Lebensmittelabfälle aus P&G-Abfällen waren mehr Annahmen erforderlich. Die beiden statistischen Abfallkategorien W091 und W092 bestehen aus sehr unterschiedlichen Abfallarten, die in vielen Fällen nicht weiter spezifiziert sind. Daher ist die THG-Bilanz für Lebensmittelabfälle mit erheblichen Unsicherheiten behaftet und muss als Näherung verstanden werden. Lebensmittelabfälle aus P&G-Abfällen mussten anhand der Berechnungen für Deutschland (Teilbericht Deutschland) geschätzt werden, die auf differenzierteren Daten der deutschen Abfallstatistik beruhen.

Die Ergebnisse der THG-Bilanz für die EU27 im Basisvergleich zeigt Tabelle 2. Insgesamt ergeben sich für beide Szenarien absolute Nettoentlastungspotenziale. Das Nettoentlastungspotenzial für 2017 beträgt rund -2,19 Mio. Tonnen CO_2-Äq. Zu diesem Ergebnis tragen vor allem Lebensmittelabfälle aus P&G-Abfällen bei, die auch den höchsten Anteil ausmachen. Darüber hinaus tragen insbesondere tierische und gemischte LMA (W091) zum Entlastungspotenzial bei.

Das Leitszenario 2030 weist ein absolutes Nettoentlastungspotenzial von etwa -3,79 Mio. Tonnen CO_2-Äq auf, das hauptsächlich auf die Abkehr von der Deponierung sowie von der Verbrennung ohne Energieerzeugung[12], die Umlenkung von der Kompostierung auf Vergärung und den Anteil der Verarbeitung von Speiseölen und -fetten zu Biodiesel zurückzuführen ist.

[12] In der EU-Statistik wird Verbrennung ohne Energieerzeugung (incineration) und Verbrennung mit Energieerzeugung („energy recovery“) unterschieden.

Tabelle 2: **Absolute und spezifische Nettoergebnisse nach Abfallkategorie - Basisvergleich LMA EU27: Basisjahr 2017 und Leitszenario 2030**

Abfallkategorie	Absolut	Absolut	Spez. pro Kopf[1]	Spez. pro Kopf[1]	Spez. pro Tonne	Spez. pro Tonne
LMA	**2017**	**2030 LS**	**2017**	**2030 LS**	**2017**	**2030 LS**
	1.000 t CO_2-Äq		kg CO_2-Äq/E		kg CO_2-Äq/Mg	
SiAbf LMA	-128	-392	-0,3	-0,9	-12	-38
P&G W091	-1.557	-2.315	-3,5	-5,2	-154	-229
P&G W092	-501	-1.079	-1,1	-2,4	-46	-99
Summe/Durchschn.	**-2.186**	**-3.786**	**-4,9**	**-8,5**	**-69**	**-120**

1) Berechnet mit Bevölkerungszahl von 445.529.136 in 2017 (Tabelle 27).

Die Berechnungen für das Basisjahr 2017 und das Leitszenario 2030 für **Cluster 1 und Cluster 2** werden auf die gleiche Weise durchgeführt wie für die EU27 (ohne DE). Für LMA aus Siedlungsabfällen gelten die gleichen Unterschiede wie für Lebensmittelreste in der Bilanz für Siedlungsabfälle. Geringe Unterschiede in den Ergebnissen pro Tonne für LMA aus P&G-Abfällen ergeben sich aus länderspezifischen Daten zur Energieeffizienz von thermischen Behandlungsanlagen und zu Parametern für die Deponierung (aus nationalen Inventarberichten).

Für **Cluster 1 sind** die Nettoergebnisse für die beiden Szenarien wie folgt:

- Basisjahr, 2017: -0,11 Mio. Mg CO_2-Äq (-1,1 kg CO_2-Äq/E; -37 kg CO_2-Äq/Mg)
- Leitszenario 2030: -0,36 Mio. Mg CO_2-Äq (-3,5 kg CO_2-Äq/E; -118 kg CO_2-Äq/Mg)

Für **Cluster 2** sind die Nettoergebnisse für die beiden Szenarien wie folgt:

- Basisjahr 2017: -0,48 Mio. Mg CO_2-Äq (-3,0 kg CO_2-Äq/E; -48 kg CO_2-Äq/Mg)
- Leitszenario 2030: -1,22 Mio. Mg CO_2-Äq (-7,6 kg CO_2-Äq/E; -124 kg CO_2-Äq/Mg)

Für das Szenario, das die Abfallvermeidung berücksichtigt, wird der in dieser Studie entwickelte Ansatz verfolgt (weitere Einzelheiten sind dem Teilbericht Deutschland zu entnehmen). Für die Vermeidung von Lebensmittelabfällen wird ein gewichteter durchschnittlicher Emissionswert von -1,61 kg CO_2-Äq/kg Lebensmittel angesetzt, der auf dem Anteil der verschiedenen Lebensmittelprodukte an den Lebensmittelabfällen und den abgeleiteten THG-Emissionswerten für deren Produktion basiert. Die Ergebnisse für die Szenarien, die die Abfallvermeidung berücksichtigen, zeigen deutlich höhere Nettoentlastungspotenziale. Trotz der Datenunsicherheiten zeigt sich, dass die Vermeidung von Lebensmittelabfällen einen erheblichen Beitrag zum Klimaschutz leistet.

Die absoluten Nettoentlastungspotenziale wurden zu folgenden Werten ermittelt:

- ca. -12 Mio. Mg CO_2-Äq für die EU27 (ca. 3-mal höher als beim Leitszenario)
- ca. - 0,7 Mio. Mg CO_2-Äq für Cluster 1 (ca. 2-mal höher als beim Leitszenario)
- ca. - 3,2 Mio. Mg CO_2-Äq für Cluster 2 (ca. 2,6-mal höher als beim Leitszenario)

Produktions- und Gewerbeabfälle

Für die Zwecke dieser Studie werden Produktions- und Gewerbeabfälle (P&G-Abfälle) definiert als nicht-gefährliche Abfälle aus den Wirtschaftszweigen "Verarbeitendes Gewerbe" (NACE C) und " Dienstleistungen" (NACE-Abschnitte G -U, ohne G46.77). Der Umfang der Studie umfasst darüber hinaus:

- „Hausmüll und ähnliche Abfälle“ (W101) aus allen Wirtschaftszweigen;
- „Tierische und pflanzliche Abfälle“ (W091, W092) aus allen Wirtschaftszweigen außer aus *"Land- und Forstwirtschaft, Fischerei*" (NACE A).

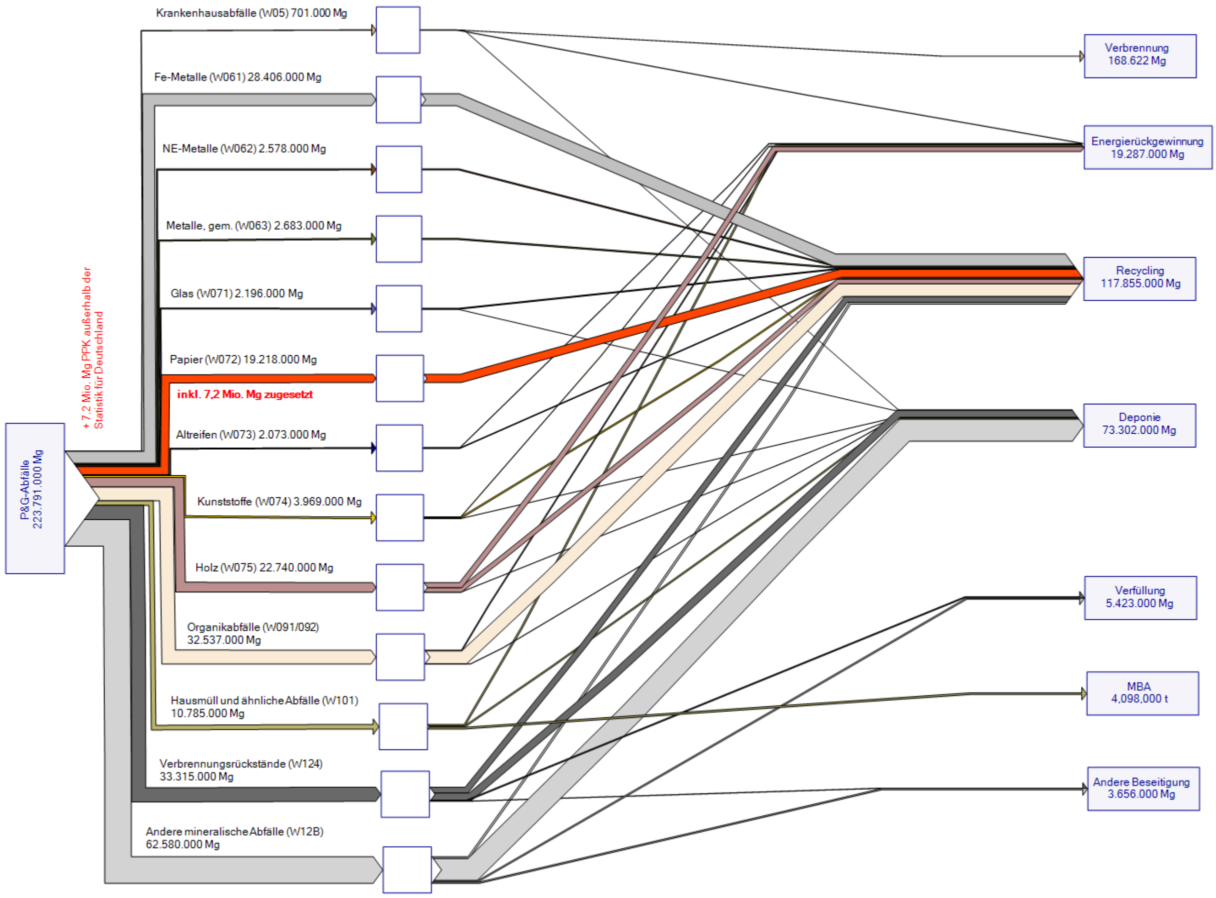
Die Studie beschränkt sich auf Primärabfälle und schließt die Abfallkategorien „Textilabfälle“ (W076), „ausrangierte Kraftfahrzeuge“ (W081), „ausrangierte Geräte“ (W08A), „Batterien und Akkumulatoren“ (W0841), „gewöhnliche Schlämme“ (W11) und „Schlämme von Industrieabwässern“ (W032) aus. Für die THG-Bilanzen wurden weitere Abfallkategorien aus methodischen Gründen ausgeschlossen.

Aufkommen und die Behandlung von Produktions- und Gewerbeabfällen wurden auf der Grundlage der WStatR-Daten ermittelt. In einem zweiten Schritt musste der Abfallstrom P&G-Abfälle von den Siedlungsabfällen abgegrenzt werden, da sich die beiden Abfallströme aufgrund der unterschiedlichen Konzepte der verwendeten Datenquellen teilweise überschneiden. Siedlungsabfälle umfassen hauptsächlich Abfälle aus Haushalten, aber auch Abfälle aus Produktion und Gewerbe, die den Haushaltsabfällen ähnlich sind. Um eine eindeutige Zuordnung der THG-Emissionen zu gewährleisten und Doppelzählungen zu vermeiden, wurde die Menge der als Siedlungsabfälle bewirtschafteten Abfälle geschätzt und von den P&G-Abfällen abgezogen. Der Umfang der Studie erlaubte nur eine grobe Datenschätzung, die weniger detailliert ist als die für Siedlungsabfälle.

Die sich daraus ergebenden Basisdaten für die Treibhausgasbilanzen sind in Abbildung 3 dargestellt. Das für die Bilanzen berücksichtigte Abfallaufkommen in der EU27 beläuft sich auf 224 Millionen Tonnen. Der wichtigste abfallerzeugende Wirtschaftszweig ist die Metallindustrie (NACE C24-C25), gefolgt von der Chemischen Industrie (NACE C20-C22), dem Dienstleistungssektor (NACE G-U) und der Nahrungsmittel- und Getränkeindustrie (NACE C10-C12).

Die Abfallkategorie "sonstige mineralische Abfälle" (W12B) ist die massemäßig wichtigste Fraktion. Diese Abfallfraktion macht 28 % der Gesamtmenge aus. Es folgen die „Verbrennungsrückstände“ (W124) und „tierische und pflanzliche Abfälle“ (W091 und W092) mit jeweils 15 % Massenanteil sowie die „Eisenmetalle“ (W061) mit 13 %. Die meisten der anderen Abfallfraktionen machen zwischen 1 % und 10 % der Gesamtmasse aus. Krankenhausabfälle, Glas und Altreifen haben Anteile unter 1 %.

Abbildung 3: Sankey-Diagramm P&G-Abfall EU27 2017



Quelle: eigene Darstellung, ifeu.

Für P&G-Abfälle wurde ein **Zukunftsszenario** für die EU27 für das Zieljahr 2030 entwickelt. Die Annahmen für die EU27 (ohne DE) wurden separat entwickelt und mit dem Szenario 2 für Deutschland zusammengeführt (siehe Teilbericht Deutschland). Für die EU27 (ohne DE) wurde angenommen, dass das Abfallaufkommen bis 2030 konstant bleibt, sowohl insgesamt (Anforderung an die LCA-Methode) als auch auf der Ebene der einzelnen Abfallkategorien.

Für die künftige Entwicklung der Abfallbehandlung wurde für jede Abfallkategorie der Mix an Behandlungsverfahren in Ländern mit weniger und mit höher entwickelten Abfallwirtschafts-systemen verglichen. Bei der Erstellung des Szenarios für 2030 wurde davon ausgegangen, dass alle EU-Mitgliedstaaten einen ähnlichen Mix an Behandlungsverfahren für P&G-Abfälle wie die EU-Länder mit weiter entwickelten Abfallwirtschaftssystemen einführen und somit bis 2030 auf dem gleichen Stand sein werden. Diese Annahmen führen zu den folgenden Entwicklungen:

- Verlagerung von „Hausmüll und ähnlichen Abfällen“ (W101) von der Deponierung hauptsächlich auf die energetische Verwertung und in geringerem Umfang auf die MBA;
- Verlagerung „tierischer und pflanzlicher Abfälle“ (W091, W092) von der Deponierung auf die energetische Verwertung und das Recycling;
- Ein Anstieg der Verwertung von „Holzabfällen“ (W075), „Kunststoffabfällen“ (W074) und „Gummiabfällen“ (W073), hauptsächlich auf Kosten der energetischen Verwertung.

Die Ergebnisse der THG-Bilanz für die EU27 zeigt Tabelle 3. Insgesamt ergeben sich für beide Szenarien absolute Nettoentlastungspotenziale. Für 2017 sind es ca. -84,1 Mio. Tonnen CO_2-Äq. Trockene Wertstoffe, darunter vor allem Metalle, tragen wesentlich zu diesem Ergebnis bei.

Verbrennungsrückstände und andere mineralische Abfälle haben trotz der hohen Masse keinen Einfluss auf das Ergebnis, da sie inert sind. Das Szenario 2030 zeigt ein reduziertes Nettoentlastungspotenzial von -76,6 Mio. Tonnen CO_2-Äq. Der Unterschied in den Ergebnissen – das insgesamt geringere Nettoentlastungspotenzial im Vergleich zum Basisjahr 2017 – ist hauptsächlich auf die Defossilisierung des Energiesystems zurückzuführen. Es sinken nicht nur die THG-Belastungen aus dem Energiebedarf, sondern auch das Substitutionspotenzial für erzeugte Energie und Primärprodukte nimmt ab (stromintensive Primärherstellung von Papier und Aluminium). Die Optimierung für 2030, insbesondere die Umlenkung von der Deponierung zur stofflichen und/oder energetischen Verwertung und die Umlenkung von der energetischen Verwertung zur stofflichen Verwertung, wirkt den oben genannten Effekten jedoch entgegen.

Tabelle 3: Absolute und spezifische Nettoergebnisse nach Abfallfraktion - P&G-Abfall EU27 2017 und 2030

Abfallfraktion	Absolut	Absolut	Spez. pro Kopf[1]	Spez. pro Kopf[1]	Spez. pro Tonne	Spez. pro Tonne
P&G-Abfall	**2017**	**2030**	**2017**	**2030**	**2017**	**2030**
	Mio. Mg CO_2-Äq		kg CO_2-Äq/E		kg CO_2-Äq/Mg	
Krankenhausabfälle	0,18	0,22	0,4	0,5	257	319
Fe-Metalle	-43,70	-43,70	-98,1	-98,1	-1,538	-1,538
NE-Metalle	-13,01	-8,79	-29,2	-19,7	-5,029	-3,398
Metalle	-4,91	-4,54	-11,0	-10,2	-1,830	-1,694
Glas	-1,01	-1,01	-2,3	-2,3	-461	-459
Papier	-8,85	-3,47	-19,9	-7,8	-461	-180
Altreifen	-2,77	-2,89	-6,2	-6,5	-1,338	-1,392
Kunststoffe	-2,18	-3,09	-4,9	-6,9	-550	-779
Holz	-5,76	-4,97	-12,9	-11,2	-253	-219
Organikabfälle	-3,18	-5,24	-7,1	-11,8	-98	-161
Verbrennungsrückstände	0,22	0,23	0,5	0,5	7	7
Sonstige mineralische Abfälle	0,38	0,38	0,9	0,9	6	6
Hausmüll & hausmüllähnl. Abfälle	0,54	0,27	1,2	0,6	50	25
Summe/Durchschnitt	**-84,06**	**-76,60**	**-188,7**	**-171,9**	**-376**	**-342**

1) Berechnet mit Bevölkerungszahl von 445.529.136 in 2017 (Tabelle 27)

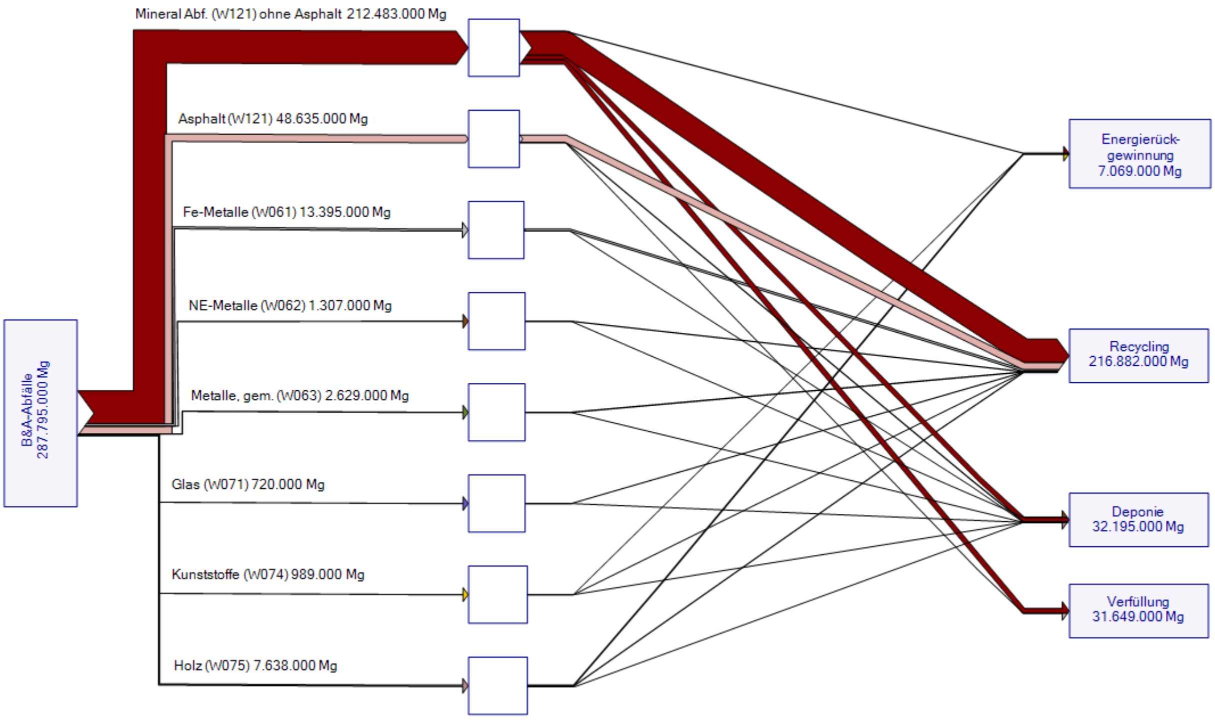
Bau- und Abbruchabfälle

Für die Zwecke dieser Studie werden Bau- und Abbruchabfälle (B&A-Abfälle) definiert als alle nicht-gefährlichen Abfälle, die in Kapitel 17 des Abfallverzeichnisses aufgeführt sind, mit Ausnahme von "Boden und Steine" (EAV-Schlüssel 17 05 04) und "Baggergut" (17 05 06).

Im Rahmen dieser Studie wurde nur eine grobe Bestimmung des **Aufkommens und der Behandlung von Bau- und Abbruchabfällen** durchgeführt. Die Ermittlung des Aufkommens und der Behandlung von B&A-Abfällen basiert auf WStatR-Daten. Das Aufkommen an B&A-Abfällen umfasst „mineralische Bau- und Abbruchabfälle“ (W121) aus allen Wirtschaftszweigen und Haushalten sowie „Metallabfälle“ (W06), „Glasabfälle“ (W071), „Kunststoffabfälle“ (W074) und „Holzabfälle“ (W075), die von Unternehmen des NACE-Abschnitts F (Baugewerbe) erzeugt werden. Darüber hinaus wurde eine Schätzung des Aufkommens und der Behandlung von Ausbauasphalt auf der Grundlage der Jahresstatistiken der European Asphalt Pavement Association (EAPA) erstellt.

Die für die Treibhausgasbilanzierung abgeleiteten Basisdaten sind in Abbildung 4 dargestellt. Für Bau- und Abbruchabfälle in der EU27 im Jahr 2017 wurde ein Gesamtaufkommen von 288 Millionen Tonnen ermittelt. Deutschland hat mit 90 Millionen Tonnen einen Anteil von fast einem Drittel am EU27-Gesamtaufkommen. Mineralische Bau- und Abbruchabfälle (ohne Asphalt) machen rund 212 Millionen Tonnen bzw. 74 % der Gesamtmenge aus. Der Anteil des Ausbauasphalts wird auf 49 Millionen Tonnen oder 17 % des gesamten B&A-Abfalls geschätzt. Metallabfälle (W06) und Holzabfälle (W075) machen 6 % bzw. 3 % aus. Auf Kunststoff- und Glasabfälle entfallen jeweils 0,3 % des erzeugten B&A-Abfalls.

Abbildung 4: Sankey-Diagramm B&A-Abfälle EU27 2017



Die im Sankey-Diagramm angegebenen Beträge sind gerundete Werte.
Quelle: eigene Darstellung, ifeu.

Für B&A-Abfälle wurde ein **Szenario** für die EU27 für das Zieljahr 2030 entwickelt. Die Annahmen für die EU27 (ohne DE) wurden separat entwickelt und mit Szenario 2 für Deutschland zusammengeführt (siehe Teilbericht Deutschland). Für die EU27 (ohne DE) wurde angenommen, dass das Aufkommen an B&A-Abfällen in der EU27 bis 2030 konstant bleibt.

Für die künftige Entwicklung der Abfallbehandlung wurde der Mix an Behandlungsverfahren in Ländern mit weniger und mit höher entwickelten Abfallwirtschaftssystemen verglichen. Der Vergleich zeigt, dass die Länder mit fortschrittlicheren Abfallwirtschaftssystemen in der Regel einen höheren Anteil an Metallen, Holz und Glas in den Bauabfällen aufweisen. Es wird angenommen, dass die bessere Trennung von Wertstoffen am Ort der Abfallentstehung der

Grund dafür ist. Für das Szenario 2030 wurde angenommen, dass die Trennung dieser Wertstoffe in der EU27 (ohne DE) auf dem Niveau liegen wird, das die EU-Länder mit fortschrittlicheren Abfallwirtschaftssystemen bereits im Jahr 2017 erreicht haben.

Für das Szenario wird Folgendes angenommen:

- eine Steigerung des Recyclings für alle B&A-Abfallkategorien;
- eine Steigerung der energetischen Verwertung von Holzabfällen (W075).

Die Ergebnisse der THG-Bilanz für die EU27 zeigt Tabelle 4. Insgesamt ergeben sich für beide Szenarien absolute Nettoentlastungspotenziale. Für 2017 sind es ca. -30,3 Mio. Tonnen CO_2-Äq. Vor allem Metalle tragen erheblich zu diesem Ergebnis bei. Die Behandlung der inerten Abfallfraktionen, die den Hauptmassenstrom darstellen, ist nicht mit relevanten THG-Emissionen verbunden. Das Szenario 2030 weist insgesamt ein etwas höheres Nettoentlastungspotenzial von -30,7 Mio. Tonnen CO_2-Äq. auf. Der Unterschied zwischen den Szenarien ist kaum signifikant, was darauf zurückzuführen ist, dass Fe-Metalle den Haupteinfluss auf das Ergebnis haben und deren Recycling kaum durch die Defossilisierung beeinflusst wird. Der Anstieg des Nettoentlastungspotenzials ist hauptsächlich auf die angenommene Abtrennung von Fe-Metallen aus den mineralischen Abfällen im Szenario 2030 zurückzuführen.

Tabelle 4: Absolute und spezifische Nettoergebnisse nach Abfallfraktion - B&A-Abfall EU27 2017 und 2030

Abfallfraktion	Absolut	Absolut	Spez. pro Kopf[1]	Spez. pro Kopf[1]	Spez. pro Tonne	Spez. pro Tonne
B&A-Abfall	**2017**	**2030**	**2017**	**2030**	**2017**	**2030**
	Mio. Mg CO_2-Äq		kg CO_2-Äq/E		kg CO_2-Äq/Mg	
Mineralische Abf. (ohne Asphalt)	1,46	2,01	3,3	4,5	7	10
Asphalt	-0,43	-0,46	-1,0	-1,0	-9	-9
Fe-Metalle	-18,62	-20,43	-41,8	-45,9	-1.390	-1.406
NE-Metalle	-4,78	-3,89	-10,7	-8,7	-3.657	-2.678
Metalle	-4,26	-4,02	-9,6	-9,0	-1.623	-1.534
Glas	-0,31	-0,36	-0,7	-0,8	-430	-433
Kunststoffe	-0,47	-0,65	-1,0	-1,4	-471	-650
Holz	-2,87	-2,88	-6,4	-6,5	-376	-323
Summe/Durchschn.	**-30,28**	**-30,68**	**-68,0**	**-68,9**	**-105**	**-107**

1) Berechnet mit Bevölkerungszahl von 445.529.136 in 2017 (Tabelle 27)

Überblick Ergebnisse EU

Die absoluten und spezifischen Nettoergebnisse pro Kopf und pro Tonne für die Bilanzen – Siedlungsabfälle, P&G-Abfälle und B&A-Abfälle – sind in Tabelle 5 zusammengefasst. Die für Siedlungsabfälle dargestellten Ergebnisse stammen aus dem Basisvergleich (Basisjahr 2017 und Leitszenario 2030). Die Gesamt-THG-Bilanz der Abfallbehandlung für die drei Herkunftsbereiche ergibt für die EU27 für das Bilanzjahr 2017 ein absolutes

Nettoentlastungspotenzial von insgesamt -117,9 Mio. Tonnen CO_2-Äq. Für die 2030-Szenarien ist das gesamte absolute Nettoentlastungspotenzial auf etwa -137,3 Mio. Tonnen CO_2-Äq berechnet, was eine Verbesserung um etwa 19,4 Mio. Tonnen CO_2-Äq an potenzieller Nettoentlastung für die EU27 bedeutet.

Bei den gesamten Nettoentlastungen im Jahr 2017 unterscheiden sich die drei Herkunftsbereiche deutlich, wobei die P&G-Abfälle bei weitem den höchsten Beitrag leisten. Die Emissionsbeiträge aus der Deponierung von Siedlungsabfällen überwiegen fast vollständig das Entlastungspotenzial durch Recycling und Verwertung der Siedlungsabfälle. Folglich ist für die EU27 eine wichtige Optimierungsmaßnahme die Abkehr von der Deponierung von Siedlungsabfällen. In Kombination damit sollten die Anstrengungen zur getrennten Erfassung von trockenen und organischen Wertstoffen erhöht und insbesondere die Behandlung organischer Wertstoffe optimiert werden. Auf diese Weise steigt das gesamte Nettoentlastungspotenzial von -3,5 Mio. Tonnen CO_2-Äq auf etwa -30 Mio. Tonnen CO_2-Äq im Jahr 2030. Im Leitszenario werden jedoch immer noch etwa 4,3 Mio. Tonnen Restmüll deponiert. Wenn die Abkehr von der Deponierung bis 2030 in der EU27 vollständig umgesetzt würde, könnten weitere etwa 4 Mio. Tonnen CO_2-Äq vermieden werden.

Die bei weitem höchsten Nettoeinsparpotenziale ergeben sich bei den P&G-Abfällen, bei denen Metalle mit 15 % der Masse (33,7 Mio. Mg) dominieren. Auch die Ergebnisse für B&A-Abfälle werden von Metallen dominiert. Allerdings ist der Anteil der Metalle bei B&A-Abfällen nur halb so hoch wie bei den P&G-Abfällen, was zu entsprechend niedrigeren Ergebnissen führt.

Tabelle 5: Abfall EU27 - Mengen und absolute sowie spezifische Nettoergebnisse nach Herkunftsgebiet

Bilanzraum	Aufkommen	THG absolut	THG absolut	Spez. pro Kopf[1]	Spez. pro Kopf[1]	Spez. pro Tonne	Spez. pro Tonne
		2017	2030	2017	2030	2017	2030
	Mio. Mg	Mio. Mg CO_2-Äq		kg CO2-Äq/ E		kg CO2-Äq/t	
SiAbf	209,4	-3,5	-30,0	-8	-67	-17	-143
P&G-Abfall	223,8	-84,1	-76,6	-189	-172	-376	-342
B&A-Abfall	287,8	-30,3	-30,7	-68	-69	-105	-107
Insgesamt	**720,9**	**-117,9**	**-137,3**	**-265**	**-308**	**-163**	**-190**

1) Berechnet mit Bevölkerungszahl von 445.529.136 in 2017 (Tabelle 27)

Schlussfolgerungen und Empfehlungen

Die Studie ist eine umfassende Untersuchung sowohl hinsichtlich der Abfallströme als auch der THG-Bilanzierung. Es wurden etwa 25 Szenarien und Sensitivitäten für die EU berechnet. Die Daten zum Abfallaufkommen und zur Abfallbehandlung wurden auf Ebene der Mitgliedstaaten ermittelt. Die THG-Bilanzierung wurde für die einzelnen Abfallfraktionen für jede der vier Abfallarten (Siedlungsabfälle, LMA, P&G, B&A) durchgeführt. Für die verschiedenen Bilanzräume wurden so weit möglich länderspezifische Daten einbezogen. Für Deutschland wurde eine eigene detaillierte Studie durchgeführt. Es ist jedoch anzumerken, dass eine relevante Datenunsicherheit verbleibt und die Ergebnisse insbesondere für LMA, P&G-Abfälle und B&A-Abfälle als orientierend zu verstehen sind. Ungeachtet dessen konnten wichtige Erkenntnisse gewonnen und die komplexen Zusammenhänge und gegenläufigen Einflüsse auf die THG-Bilanz analysiert werden.

Die wichtigsten Erkenntnisse in Bezug auf das THG-Minderungspotenzial sind:

- Die Studie zeigt, dass Siedlungsabfälle in der EU27 bei weitem das größte THG-Minderungspotenzial haben. Das geringe Nettoentlastungspotenzial von -3,5 Mio. Tonnen CO_2-Äq im Jahr 2017 kann um den Faktor 8 auf etwa -30 Mio. Tonnen CO_2-Äq im Leitszenario 2030 erhöht werden, vor allem durch die Abkehr von der Deponierung von Siedlungsabfällen und die verstärkte getrennte Sammlung für das Recycling. Für das Jahr 2017 belaufen sich die gesamten THG-Emissionen aus der Deponierung von Restmüll auf etwa 13,5 Mio. Tonnen CO_2-Äq in Cluster 1 und 13 Mio. Tonnen CO_2-Äq in Cluster 2. Im Leitszenario werden diese Emissionen in Cluster 2 auf Null und in Cluster 1 auf etwa 4 Mio. Tonnen CO_2-Äq reduziert, was die hohe Relevanz der Abkehr von der Deponierung zeigt und dass dies das THG-Minderungspotenzial in der EU27 für Siedlungsabfälle erheblich bestimmt. Darüber hinaus zeigt dies, dass weitere 4 Mio. Tonnen CO_2-Äq gemindert werden könnten, wenn die Deponierung von Siedlungsabfällen in Cluster 1 bis 2030 vollständig eingestellt würde. Um das THG-Minderungspotenzial zu erreichen, sollten die folgenden Aspekte berücksichtigt werden:
  - Unterstützung für die EU-Mitgliedstaaten, die noch immer Restmüll deponieren. Die Deponierung von unbehandelten Siedlungsabfällen sollte so schnell wie möglich und vollständig eingestellt werden. Aufschub durch Ausnahmeregelungen sollte vermieden werden.
  - Finanzielle Maßnahmen wie eine Deponiegebühr oder eine Finanzierung scheinen die vielversprechendsten Optionen zu sein, um die Abkehr von der Deponierung zu fördern.
- Das modell-theoretische Szenario mit Eigenkompostierung in der RC-Rate zeigt, wie ein geringeres Anspruchsniveau bei der Getrenntsammlung und Verwertung die Emissionseinsparpotenziale verringert. Aus Sicht des Klimaschutzes ist es wichtig, sich nicht mit einem niedrigen Ambitionsniveau zufrieden zu geben.
- Das in dieser Studie berechnete Leitszenario 2030 geht von einem hohen Ambitionsniveau hinsichtlich der Umsetzung der Getrenntsammlung und der erforderlichen alternativen Behandlungskapazitäten aus. Hier ist die Politik gefordert, gemeinsam mit den abfallwirtschaftlichen Akteurinnen und Akteuren unterstützende Maßnahmen zu identifizieren und umzusetzen. Die Abfallwirtschaftsverbände schlugen im Interview einen ordnungsrechtlichen Rahmen vor für den Bedarf an Absatzmöglichkeiten für getrennt erfasste trockene Wertstoffe, öffentliche (finanzielle) Unterstützung der getrennten Sammlung und Behandlungsmöglichkeiten für Sortierreste. Aus Sicht der Autorinnen und Autoren dieser Studie sind die wichtigsten Aspekte und Ideen für Verbesserungen:
  - Unterstützung für die Organisation und Infrastruktur zur getrennten Erfassung und des Ausbaus der Behandlungskapazitäten insbesondere für Organikabfälle. Die Vergärung, die kombinierte stoffliche und energetische Verwertung, sollte bei gegebener Eignung bevorzugt werden. Unterstützung, insbesondere für Cluster 1 Länder, bei der Analyse der Zusammensetzung des Restmülls und der Identifizierung geeigneter Optionen für die Behandlung von Organikabfällen.
  - Anreize für Bürgerinnen und Bürger, die getrennte Erfassung von Organikabfällen zu steigern und dabei geringe Verunreinigungen aufrechtzuerhalten, wie beispielsweise ein kostenloses Sammelsystem und angemessene Sammelhäufigkeit, begleitet von Kampagnen zur Öffentlichkeitsarbeit.
  - Eine ehrgeizige Ausweitung der getrennten Sammlung von trockenen Wertstoffen aus Siedlungsabfällen erfordert auch flankierende Maßnahmen zur Verbesserung der

Wissensgrundlagen. Da Basisdaten der Schlüssel zu einer angemessenen Planung sind, sind die wichtigsten ersten Maßnahmen die Analyse der aktuellen Situation, Untersuchungen zur Optimierung der Sammelsysteme und Pilotprojekte.

- Für P&G- und B&A-Abfälle zeigen die orientierenden THG-Ergebnisse, dass aus Sicht des Klimaschutzes hauptsächlich Metalle (und davon Fe-Metalle) das Nettoentlastungspotenzial bestimmen. Bei den P&G-Abfällen bieten darüber hinaus auch weitere trockene Wertstoffe, Holz und Organikabfälle Nettoentlastungspotenziale. Die Hauptmasse, mineralische und andere inerte Abfallarten, haben nur geringe THG-Effekte. Grundsätzlich ist die Datenbasis unzureichend, insbesondere bei den P&G-Abfällen mit der großen Vielfalt an Abfallarten und den Datenlücken bezüglich der Behandlung. Um die Klimaschutzpotenziale von P&G- und B&A-Abfällen zu ermitteln, wird empfohlen, sich in künftigen Studien auf die THG-relevanten Abfallarten, vor allem die Metalle, zu konzentrieren. Für die P&G-Abfälle werden Informationen über Art und Qualität der Metalle benötigt, für die B&A-Abfälle Informationen zum Potenzial der Metalle in den mineralischen Abfällen. Darüber hinaus sollten bei den P&G-Abfällen auch die Abfallströme berücksichtigt werden, die auch thermisch behandelt werden (insbesondere Kunststoffe).

- Die thermische Abfallbehandlung ist von entscheidender Bedeutung für ein funktionierendes Abfallwirtschaftssystem, da sie die nicht recyclebaren und verunreinigten Teile von Siedlungsabfällen, P&G- und B&A-Abfällen auschleust. In dieser Funktion ist sie wesentlich für eine Kreislaufwirtschaft. Der Beitrag zum Klimaschutz durch die in dieser Studie für 2030 angenommene Steigerung der Nettowirkungsgrade ist kein sich selbst erfüllendes Szenario. Sowohl für thermische Behandlungsanlagen als auch für Biomassekraftwerke müssten Möglichkeiten zur Steigerung der Nettowirkungsgrade weiter geprüft und deren Umsetzung unterstützt werden. So kann z. B. der Auf- bzw. Ausbau von Nah- und Fernwärmenetzen zu einer höheren Wärmenutzung beitragen. Die Mitverbrennung von Ersatzbrennstoffen in Zementwerken bietet einen relevanten – und im Vergleich zur thermischen Behandlung höheren – Beitrag zum Klimaschutz, solange noch Kohle als Regelbrennstoff eingesetzt werden darf, die durch Ersatzbrennstoffe substituiert werden kann. In diesem Zusammenhang ist es auch wichtig, MBAs in Optimierungsbemühungen zu unterstützen, z. B. bei der Minderung von THG-Emissionen aus der biologischen Behandlung oder der Steigerung der Effizienz.

- Die Abfallvermeidung, wie sie für Lebensmittelabfälle gezeigt wurde, ist von großer Bedeutung und kann erheblich zum Klimaschutz beitragen. Durch die Vermeidung der Abfälle wird die Primärproduktion von Lebensmitteln vermieden, die mit wesentlich höheren THG-Emissionen verbunden ist als die Einsparpotenziale, die sich aus der Behandlung von Lebensmittelabfällen erreichen lassen. Für die EU27 führt die angenommene Vermeidung von 50 % bzw. etwa 5,2 Mio. Tonnen Lebensmittelabfälle aus Siedlungsabfällen zu einem Nettoentlastungspotenzial, das um den Faktor 3 höher ist als im Leitszenario 2030. Im Falle von Cluster 1, wo eine 30 %ige Reduktion von LMA aus Siedlungsabfällen angenommen ist (etwa 200.000 Tonnen), wäre das Nettoentlastungspotenzial doppelt so hoch wie im Leitszenario. Das für die Vermeidung von Lebensmittelabfällen berechnete THG-Entlastungspotenzial ist ausreichend valide für Deutschland, wo Daten sowohl für die Zusammensetzung von Lebensmittelabfällen als auch für die THG-Belastungen aus ihrer Produktion vorliegen. Für die EU-Länder sind ähnliche Studien über die Zusammensetzung von Lebensmittelabfällen zu empfehlen, auf deren Grundlage ein Vermeidungsfaktor wie für Deutschland abgeleitet werden kann.

Die wichtigsten Ergebnisse und Empfehlungen der Studie zu den Daten über Abfälle auf EU-Ebene sind:

- ► Die Datenerhebung im Rahmen des WStatR sollte konzeptionell weiterentwickelt werden, insbesondere im Hinblick auf eine bessere Verknüpfung der Daten zum Aufkommen und zur Behandlung und eine vollständigere Darstellung der Abfallbehandlung, z. B. die Einbeziehung von Vorbehandlungsverfahren in die Datenerhebung.
- ► Sortieranalysen des Restmülls sind in der Regel die Voraussetzung, um das Potenzial für eine verstärkte getrennte Sammlung und Verwertung ermitteln zu können. Dies gilt für alle EU-Mitgliedstaaten. Repräsentative Abfallanalysen auf nationaler Ebene sind notwendig, um nicht nur das Recycling und die Sammlung, sondern vor allem auch die Klimaschutzpotenziale besser zu verstehen. Selbst in Deutschland, wo eine umfassende Hausmüllanalyse durchgeführt wurde, die die Datenbasis zu Siedlungsabfällen erheblich verbessert hat, fehlen noch Informationen über die Zusammensetzung von gewerblichen Siedlungsabfällen und Sperrmüll.

Abschließend wird für künftige Untersuchungen empfohlen, neben den Klimaschutzpotenzialen auch die Ressourcenschonung zu berücksichtigen. Die Klimaschutzpotenziale in der Kreislaufwirtschaft sinken notwendigerweise mit zunehmender Umsetzung der Klimaschutzziele, die erreicht werden müssen, um die Klimakatastrophe abzuwenden. THG-Nettoentlastungspotenziale müssen für eine Klimaneutralität Null werden. Allerdings geht das Ziel der Klimaneutralität mit einem Rohstoffbedarf einher, insbesondere für Anlagen zur Erzeugung von Erneuerbaren Energien, den es im Blick zu behalten gilt. Der Aspekt der Ressourcenschonung ist wesentlich mit dem Beitrag der Kreislaufwirtschaft verbunden. In künftigen Vorhaben sollte zunächst ermittelt werden, welche Bereiche bzw. Ressourcen für eine Untersuchung der Ressourcenschonung relevant sind und wie diese zu bewerten sind.

1 Introduction and scope

This partial report on the project "Climate Protection Potentials in the Circular Economy - Germany, EU"[13] documents the work and results for the EU. It describes the methodological procedure for the data collection, the basis for the balancing as well as the results and recommendations from the study. The results for Germany are published in a separate partial report ("partial report Germany").

Both partial reports examine the situation of waste management by the following types of waste:

- Municipal solid waste (MSW)
- Food waste (special balance)
- Commercial and industrial waste (C&I)
- Construction and demolition (C&D)

A separate quantity survey and greenhouse gas (GHG) balancing was carried out for each waste type. Methodologically, the balancing areas for municipal solid waste, commercial and industrial waste, and construction and demolition waste were complementary areas, while food waste was investigated as a special balancing area. This includes food waste from the MSW sector as well as from the C&I waste sector.

For the MSW and food waste, detailed GHG balances are presented, whereas rough assessments were made for the C&I and the C&D waste. For the MSW and food waste, the actual situation in the base year 2017 is analysed for Germany, for the current EU27, the previous EU28 (including the UK) and for two clusters defined from the EU member states. For the C&I and the C&D waste, the analysis is limited to Germany and the EU27. The future GHG reduction potentials for the target year 2030 are also analysed more comprehensively for the MSW and the food waste with two scenarios for each: Germany, the EU27 and the two EU clusters. For the C&I and the C&D waste, there are two scenarios for Germany and one scenario for the EU27.

For the waste originating from C&I, C&D and the special balance area of food waste, there are some considerable data uncertainties. In many cases, the statistics – also the LoW-code in the German statistics – show waste types where the designation provides only vague clues about the type of waste. The assessment is particularly difficult in the case of C&I waste derived from Eurostat, as the European Waste Classification for Statistics code (EWC-Stat code) sometimes include a large number of codes according to the European List of Waste[14] (LoW-codes). Despite narrowing down and interpreting the German statistics on the basis of LoW-codes, there are still waste fractions that can only be estimated very roughly. Nevertheless, assumptions had to be made also for yields of source segregated waste fractions, such as metals and plastics. Also, for food waste, which is mainly fed to anaerobic digestion, data can sometimes only be roughly estimated. Therefore, the GHG results of C&I, C&D waste and the special balance of food waste (from C&I waste) should be regarded as orienting results.

13 Long title: Determining climate protection potentials in the circular economy for Germany and the EU as a contribution to achieving the goals of national and international climate protection commitments

14 Commission Decision 2014/98/EC amending Decision 2000/532/EC on the list of waste.

2 Background and objectives

Climate protection is one of the greatest global challenges of the 21st century. With the Paris Agreement of December 2015, following the Kyoto Protocol, member states have again committed to reducing anthropogenic GHG emissions and limiting the global warming well below 2°C compared to pre-industrial levels. This requires extensive efforts across all the climate relevant sectors and source groups, including waste sector.

The waste sector is limited to direct and non-energy GHG emissions under the general reporting requirements of the Kyoto Protocol to avoid double reporting. As a result, the contribution of the waste sector is mainly represented by the diversion from landfilling. However, this does not include future GHG emissions from landfilling, nor the additional GHG reduction potentials triggered by waste management that result from material recycling and energy recovery. The entirety of the contribution to climate protection that is achieved and achievable this way can be demonstrated with the help of the life cycle assessment (LCA) method of waste management, as has already been shown in previous studies (Dehoust et al. 2010; Vogt et al. 2015).

In this study, the waste management situation in 2017 is examined and the potential climate protection contribution of the circular economy for the target year 2030 is shown against the background of the further developed political and legal framework conditions. Additionally, possibilities of including preparation for re-use and waste prevention are considered.

The objective of the study is to demonstrate the potential contributions to climate protection by the waste sector and, in particular, to show how waste policy can further promote climate protection in the future. The project is intended to contribute to the fulfilment of the national and international climate protection commitments of Germany and the European Union.

3 Procedure for collecting data

3.1 Scope of the data collection

For this study the waste streams are defined as follows:

For **municipal solid waste**, the study follows the OECD/Eurostat definition, which builds the basis for the annual Eurostat data collection on the generation and treatment of municipal solid waste (MSW). MSW is understood as waste from households as well as similar waste from other sources. (For the detailed definition please refer to Annex A.2.1). While reporting to Eurostat, this definition is understood by most of the countries to include Waste electrical and electronic equipment (WEEE), batteries and accumulators and hazardous waste, as far as they belong to chapter 20 of the LoW (municipal wastes). The EEA-model (see Chapter 3.2.2), which is also used as a data basis, includes these streams, too. However, for the overall project and the GHG balances, the considered waste streams correspond in principle to the waste streams included in the previous studies (Dehoust et al. 2010; Vogt et al. 2015). In general, hazardous waste is excluded. WEEE and batteries and accumulators were not considered in the previous studies and are also excluded from this study due to methodological reasons (WEEE is a complex waste stream, which is not well documented), and as they are of lower mass relevance.

As a further aspect, quantitative data on home composting are collected as far as possible and addressed separately in the GHG balances.

For **food waste**, the scope of the study follows the food waste definition of the revised Waste Framework Directive which stipulates that „*'food waste' means all food as defined in Article 2 of Regulation (EC) No 178/2002 of the European Parliament and of the Council that has become waste*. No distinction is made between edible and non-edible food waste. Excluded from the scope of this study is food waste that arises in NACE section A *'Agriculture, forestry and fishing.'* In addition, to avoid double accounting, food waste which is part of MSW or production and commercial waste is delimited (see Chapter 3.4).

Construction and demolition waste is defined as all non-hazardous waste types of chapter 17 of the List of Wastes (2000/532/EC) excluding:

- 17 05 04 soil and stones other than those mentioned in 17 05 03
- 17 05 06 dredging spoil other than those mentioned in 17 05 05

The LoW entries 17 05 04 and 17 05 06 mainly cover excavation waste that usually accounts for a high share of the generated waste total on one hand but is of limited relevance regarding GHG emissions due to their inert characteristics and low organic content. Furthermore, the data coverage on non-hazardous excavation waste in the EU Member States is assumed to be rather different. Thus, the exclusion of excavation waste increases the comparability of data across countries and focuses the analysis on the climate-relevant fractions of the C&D waste.

Industrial and commercial waste covers non-hazardous waste from the economic sectors 'manufacturing' (NACE C) and 'service activities' (NACE sectors G –U excl. G46.77). Considering that for industrial and commercial waste, only a rough GHG balance shall be conducted, it was agreed to limit the scope to the most important sources of C&I waste and to exclude other economic sectors from the investigation. The investigation is furthermore limited to primary waste, i.e. it excludes waste from waste treatment (so-called secondary waste). Similarly, to the stream of MSW, it was agreed with the German Environment Agency (Umweltbundesamt) to exclude further streams from the scope of C&I waste, such as the waste categories discarded vehicles (W081), discarded equipment (W08A), batteries and accumulators (W0841) and wastes from wastewater treatment like common sludges (W11) and industrial effluents sludges (W032), except for sludges from the paper industry.

3.2 Data sources

The aim of the study is to use the latest available data to build as far as possible, a consistent data set for all four waste flows that refer to the same reference year. This request was challenging, mainly due to two reasons:

- the two main sources for statistical waste data at EU level, i.e. the MSW data set and the Waste Statistics Regulation[15] (WStatR) data, are based on different concepts that are difficult to reconcile (see explanations in the following chapters);
- the frequency of data collection for both data sets differs; whereas MSW data are collected on an annual basis, the WStatR data are reported biannually for even years only. For MSW, data for the agreed reference year 2017 were available already at the beginning of the study, whereas the latest WStatR data refer to 2016.

It was agreed to use the latest MSW data for the reference year 2017 and to extrapolate the WStatR data for the other waste streams to 2017 in order to achieve a consistent data set for the GHG balances. The extrapolation of WStatR data is described in Chapter 3.3.

In addition to the MSW and WStatR data reported to Eurostat, further data sets were used for the compilation of the base data. This includes particularly the European Reference Model on Municipal Waste Generation and Management (hereafter referred to as the EEA-model[16])

The respective data are described in more detail in Chapter 3.2.2.

Table 6 gives an overview of the main data sources used for each of the four waste streams. Further information used is specified in the chapters on the different waste streams.

Table 6: Overview of waste streams and main data sources

Waste stream	Data source and latest reference year available
Municipal solid waste	• MSW data on generation and treatment, Eurostat (mun_was), (2017) • EEA-model data on generation and treatment of MSW, (2015)
Food waste	• WStatR data on waste generation and waste treatment (env_wasgen, env_wastrt), Eurostat, (2016)
Construction & demolition waste	• WStatR data on waste generation and waste treatment (env_wasgen, env_wastrt), Eurostat (2016)
Industrial & commercial waste	• WStatR data on waste generation and waste treatment (env_wasgen, env_wastrt), Eurostat, 2016

The data sets listed in the table are explained in more detail in the following chapters.

15 Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 November 2002 on waste statistics (OJ L 332, 9.12.2002, p. 1, last amended by OJ L 253, 28.9.2010, p. 2).

16 European Reference Model on Municipal Solid Waste Management, 2018 version, produced by the European Union, The EEA was so kind as to provide the model to the contractor already in March 2019, prior to the official publication. It is now available at Eionet, European Environment Information and Observation Network: https://www.eionet.europa.eu/etcs/etc-wmge/etc-wmge-files/eurm_mswm.zip.

3.2.1 Municipal solid waste data reported to Eurostat

Since the beginning of the 1990s, Eurostat has conducted surveys on European waste data using the OECD/Eurostat-Joint Questionnaire as the main source. Starting from 2004 as the first reference year, Regulation (EC) No 2150/2002 on waste statistics replaced in principle the data collection based on the Joint Questionnaire. To maintain the time series and to offer consistent data in an international context outside the EU (OECD, UN), the following set of variables (EUROSTAT / OECD 2018) on MSW is still collected annually based on a subset of the OECD/Eurostat Joint Questionnaire.

- **Municipal waste generated**
  - *(a) by source*
    - *Waste generated by households*
    - *Waste generated by other sources*
  - *(b) by type of waste*
    - *Generation of household and similar waste*
    - *Generation of bulky waste*
    - *Generation of WEEE*
- **Total municipal waste treated**
  - *Recovery*
    - **Material recycling (R2 – R11, excluding part of R3)**
    - **Composting and digestion (part of R3)**
    - **Incineration / energy recovery (R1)**
    - *Other recovery*
  - *Disposal*
    - **Incineration / disposal (D10)**
    - **Landfill / disposal (D1-D7, D12)**
    - *Other disposal*
- **Total Incineration (R1 + D10)**
- **Coverage of the municipal waste collection system**

The main variables collected by the EU Member States are marked in **bold** and cover municipal waste generated and municipal waste treated by landfill, incineration (with or without energy recovery), recycling and composting (incl. anaerobic digestion). In addition to the data on waste amounts, the countries report the percentage of their population served by a municipal waste collection system. For areas not covered by a municipal waste collection scheme, the amount of waste generated is estimated[17].

The variables marked in *italics* are OECD-variables. The EU Member States are not required to report them, but many countries report these voluntarily.

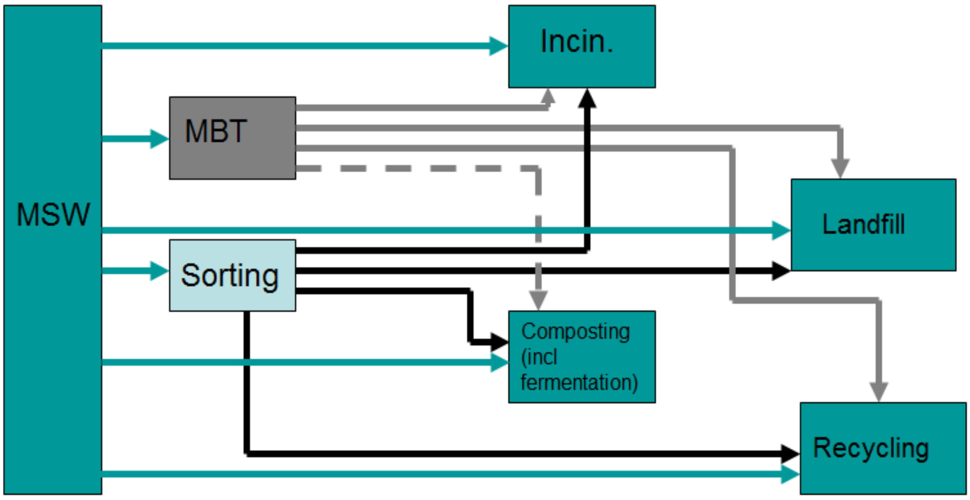
The municipal waste generation is still based on the definitions for the section on Waste in the OECD/Eurostat Joint Questionnaire, although many countries use a material-based coverage LoW-codes of chapter 20 (Municipal waste) and 1501 (Packaging waste). The definition and coverage by waste codes, as published in the Eurostat guidance document for municipal waste reporting are presented in Annex A.2.1.

It can be seen from the list of variables, that no further breakdown by the covered waste materials (organic, glass, paper, plastic metals, etc.) is reported.

It is important to note that the approach to reporting on waste treatment aims at capturing data on the 'final treatment' of MSW. This approach is illustrated in the following Figure 5.

17 This affects 5 countries of the EU28: Romania (88%), Estonia (95%), Lithuania and Croatia (both 99%) and Ireland (not specified).

Figure 5: Municipal solid waste treatment options



Source: (EUROSTAT / OECD 2018).

Figure 5 shows the elements of an MSW management system and illustrates the coverage of reporting by the dark green shaded boxes, i.e. the boxes MBT (mechanical-biological treatment) and sorting are not to be reported to Eurostat. Instead, the outputs of these operations shall be reported together with the amounts directly managed by the four operations incineration (Incin.), landfill, recycling, and composting/anaerobic digestion.

This approach has its limitations in practice since it is difficult to implement in countries with a high number of treatment plants and an MSW management system with complex treatment chains. Consequently, the data reported to Eurostat are often a mixture of the final treatment approach and the reporting on the first treatment. In addition, some countries do not follow the guidance document and report amounts treated by the organic unit of MBTs under composting.

Consequently, the data reported to Eurostat, while being the best available source for the amounts of MSW generated, cannot be used directly for the GHG balances. This concerns the way, MSW treatment is reported as well as the lack of a breakdown of the waste materials mentioned above.

3.2.2 Municipal solid waste data from the EEA-model

The European Reference Model on Municipal Waste Generation and Management (EEA 2018a) aims to support the assessment of the performance of Member States' municipal solid waste management systems, and how they are likely to perform in the future. The model can serve as a tool to compare different future policy scenarios from a broad perspective, including both financial and environmental aspects. Moreover, it is intended to be used as a tool for the early warning system proposed by the European Commission within its 2015 Circular Economy Package, aimed at identifying countries that are at risk of missing the European Union targets on recycling municipal solid waste and packaging waste, and the targets on the diversion of waste from landfill. The history of the development of the model and the main functionalities are described in more detail in Annex A.2.3.

The EEA-model is an Excel tool developed by Eunomia Research & Consulting Ltd, in cooperation with Copenhagen Resource Institute. Both companies were also mainly involved in the data collected for the model. Two major data collection rounds were conducted, covering the data for 2010 and 2015.

The part of the model used as a data source for this study is the mass flow model which is briefly described here. The data collected from the countries for the mass flow model cover the following parameters:

- Waste generation 2010, 2015 and prognosis of 2020, 2025, 2030 and 2035,
- Total MSW composition 2010 and 2015 (the compositions for 2017 in the model are equal to those of 2015),
- Breakdown in % for direct treatment of residual waste by landfilling, incineration and MBT, and prognosis of this breakdown for 2020, 2025, 2030 and 2035,
- Separately collected amounts of dry recyclables and organic waste 2010 and 2015, and
- Breakdown of different treatment technologies for 2010, 2015, and prognosis of 2020, 2025, 2030, and 2035 for MBT (5 types), incineration (4 types), aerobic treatment (2 types), anaerobic treatment (5 types).

Three major reports cover the data collected from the countries to serve as a basis for the scenarios available by the model.

- The baseline report by Eunomia /CRI from the first data collection and the set-up of the model of February 2014 (Gibbs et al. 2014a)
- The baseline report by Eunomia/CRI in the context of the further development of the model of May 2015 (Hogg et al. 2015), and
- The report of the update of the baseline data in April 2018 (Hogg et al. 2018).

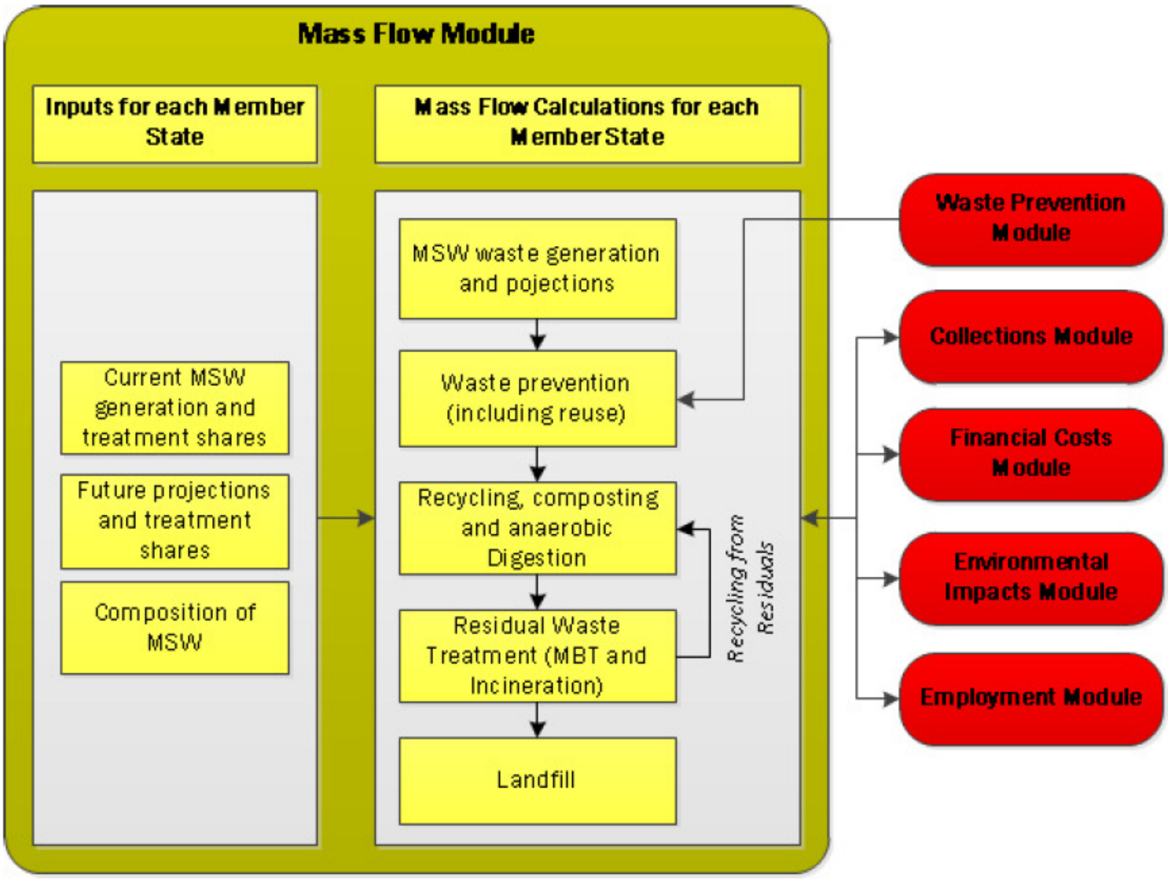
The baseline scenario is defined as follows (EEA 2018b):

The baseline scenario represents an expert opinion for future generation and management of municipal solid waste in each Member State. This scenario presents a critical view of the effects of known policy measures and planned waste treatment capacity as reported by the Member States as part of this project. Thus, the scenario presents a possible future development which is inevitably uncertain. It is used as one of several possible factors, helping to identify a potential risk of not meeting the target for recycling, thus forming a basis for dialogue.

It was decided that the baseline scenario is the most useful to be used for this study and combine the information retrieved from the model with the actual data reported to Eurostat (together with the vast amount of available metadata, including quality reports, collected throughout the years during the validation of the data).

In order to combine the two sources, the differences in the approaches must be considered. The main difference is the way, the MSW treatment is covered. The EEA-model follows the mass flow approach shown in Figure 6.

Figure 6: Concept of mass flow model from the EEA-model on MSW



Source: (Gibbs et al 2014b)

The approach can be briefly summarized as follows:

1. The amount generated (projected until 2035) in 1,000 tons for each country and year is multiplied with the overall composition by materials in % (also laid down in the model until 2035), resulting in the **amounts generated in 1,000 tons for each material**, country and year;
2. From the amounts separately collected (dry recyclables and organic waste), as provided by the countries up to 2015 (or projected for 2016 and later based on the forecast by the country), **capture rates in %** for each material are calculated and held in the model for the whole series 2010 to 2035 for each country;
3. For each material, year and country, the capture rates for separate collection are then multiplied with the amounts from step 1, resulting in the **separate collected amounts of dry recyclables and organic waste by materials in 1,000 tons**;
4. The separately collected amounts by material from step 3 are then subtracted from the amounts calculated in step 1 (generation by material), which results in the **amounts by materials in 1,000 tons contained in residual waste** which is defined as being collected in a mixed way for a direct treatment by MBT, incineration or landfill;
5. Then the model goes on and calculates the **amounts in 1,000 tons of the first treatment** by
   a. Multiplication of the amounts in 1,000 tons of the materials in residual waste with the treatment split in % of direct MBT (5 types), incineration (4 types) or landfill, resulting in the respective **amounts in 1,000 tons for each material and treatment type**; and

   b. Multiplication of the separately collected amounts of organic waste from step 3 with the treatment splits in % for aerobic (2 types)/anaerobic (5 types) treatment plants, resulting in the respective **amounts in 1,000 tons for each organic material and treatment type**.

After these five steps, the **first treatment** of the whole amount generated is calculated by materials. The next steps then refer to the determination of the amounts of **final treatment** (output calculation) as follows:

1. Multiplication of all separately collected materials from the above step 3 with material and country-specific reject rates (also available until 2035), resulting in the **amounts recycled (including bio-treatment) in 1,000 tons** and the **amounts of rejects in 1,000 tons**;
2. Multiplication of the rejects from step 1 with the treatment split in % of incineration and landfill to arrive at the amounts of rejects by material in 1,000 tons landfilled or incinerated (4 types);[18]
3. Multiplication of material- and MBT-type-specific splits in % concerning the final treatment of MBT-Input in 1,000 tons, resulting in the amounts in 1,000 tons by material and treatment types (landfill, energy recovery, recycling, land treatment, and losses);
4. Calculation of the final treatments for landfill, incineration, and recycling by adding up the results of the first treatment and the whereabouts of the outputs.

The model has a large breakdown of materials, but most of the detailed fractions have no data. When all fractions are disregarded where there are no data for any of the 28 countries, the following 16 major fractions remain:

Food, Garden, Other biowastes, Wood, Paper / Cardboard, Textiles, Glass, Metals, Plastics, *WEEE*, *Rubble and soil, Batteries and accumulators, Hazardous Waste (excl. WEEE)*, Fines, Inerts, Other

The two major waste streams **residual waste** and **separately collected** fractions are both split into these materials. The stream other biowaste was used in the model when it was not clear during the data collection to which position the organic material belongs (similar to the EWC-Stat W063 – metal waste, ferrous and non-ferrous). This stream occurs in 11 countries and it was therefore decided to keep it separated in the calculations.

From the model concept, it can easily be concluded that certain waste streams, such as mixed municipal waste (LoW 20 03 01) or bulky waste (LoW 20 03 07), cannot be clearly identified anymore. Therefore, a breakdown by these waste categories is not possible. In the model, bulky waste collected for bulky waste sorting would appear in the fraction separately collected for recycling, while bulky waste solely collected for incineration or landfill will appear under residual waste. Thus, the model differentiates the waste streams mainly by destination.

It is clear from the descriptions of the model and the Eurostat data, that the results from the model for the year 2017 cannot fit the values reported to Eurostat on account of the following effects:

- All major values (waste generation, capture rates, treatment splits) are projected from 2015 to 2017;
- The treatment data reported to Eurostat are supposed to be based on final treatment, but this requirement is often not fulfilled (e.g. first treatment reported by Germany);

18 The model assumes that no further MBT-treatment occurs for the rejects and calculates the split into landfill and incineration from the overall split from step 5 a. Example: 10% landfill, 40% incineration and 50% MBT (for direct treatment of residues) will result in 20% landfill (10%/(10%+40%)) and 80% incineration (40%/(10%+40%)).

- The Eurostat data contain many exceptions where fractions are ‘hidden’ in certain treatment variables, which are difficult to quantify (or were quantified in the past by requesting the countries); examples include:
  - MBT-amounts included in composting or recycling,
  - Recovery on landfills included in recycling,
  - Rejects from sorting/organic treatment included in recycling/composting,
  - Home-composted amounts included in composting.[19]

For this reason, a method needed to be developed which attempts to get the most out of each data source and to combine these in the best way possible and feasible. This method is described in Chapter 5.1.

3.2.3 Data collected based on the Waste Statistics Regulation (WStatR)

The legal basis for EU waste statistics is the *Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 November 2002 on waste statistics*[20], usually referred to as Waste Statistics Regulation (WStatR).

WStatR data cover generation and treatment of all waste in the EU Member States, i.e. the data include:

- all waste under the scope of the Waste Framework Directive, and
- waste from all sources, i.e. waste from all economic operators (incl. waste from waste treatment) and waste from households.

Therefore, the WStatR data reflects the total waste generation and treatment in the EU and is used as a frame of the database.

WStatR data are collected every second year on:

- waste generation (env_wasgen[21])
- waste treatment (env_wastrt)
- number and capacity of waste treatment facilities (env_wasfac)

<u>Waste classification:</u>

The waste data are collected according to the **European Waste Classification for Statistics (EWC-Stat version 4)**. The EWC-Stat is based on the European List of Wastes (LoW) and represents a material-related aggregation of the six-digit LoW entries. Each EWC-Stat category is thus defined by the assigned LoW entries. Each LoW entry is assigned to exactly one EWC-Stat category so that data collected according to the LoW can be easily converted into EWC-Stat categories (but not vice versa). The assignment of the LoW entries to the EWC-Stat is defined in the table of equivalence in Annex III of the Waste Statistics Regulation.

Waste generation and treatment are broken down in 51 EWC-Stat categories of which 30 categories are non-hazardous and 21 categories are hazardous wastes.

19 Four countries indicated that they include home-composting in the data reported to Eurostat (Finland, Italy, Greece and Romania). Finland and Greece report the amounts under ‘composting/digestion’ and provided amounts. Italy reports the figure under other recovery and Romania did not provide clear information. For further information on home-composting, see chapter 5.2.3.1

20 OJ L 332, 9.12.2002, p. 1, last amended by OJ L 253, 28.9.2010, p.2

21 The term in brackets gives the name of the data set in the Eurostat dissemination database

Waste generation and origin

Data on waste generation are broken down into 19 sectors of origin (18 economic activities covering all economic activities according to NACE Rev.2 and households). The generation data cover primary and secondary waste, thus reflecting the gross amounts. A simplified version of the WStatR reporting format is displayed in Table 153 in Annex A.8.

Waste treatment

Data on waste treatment are divided into 6 treatment categories defined by the R and D operations listed in Annex I and II of the Waste Framework Directive (except for backfilling, for which no specific R operation exists).

The pre-treatment operations D8, D9, D13, D14, D15, R12, and R13 are excluded from the WStatR survey. Thus, the data collection focuses on the final treatment of waste. The WStatR reporting format for data on waste treatment is displayed in Table 154 in Annex A.8.

In the context of this project, the WStatR statistics for waste generation and waste treatment build the basis for the three waste streams C&I waste, C&D waste and food waste from commercial and industrial sources. In a stepwise approach data on the three waste streams are isolated from this statistic (see Chapter 3.4).

3.3 Extrapolation of WStatR data to reference the year 2017

As described above, the WStatR data are used as the main data sources for the waste streams food waste, C&D waste, and the C&I waste. WStatR data are available since the reference year 2004 up to 2016 for every second (even) year.

The extrapolation of the waste generation to 2017 was carried out based on the four reference years 2010 to 2016[22] through linear regression.

The extrapolation was done in two steps as follows:

- 1. step: Extrapolation of the total amount generated (TOTAL_HH), separately for each EWC-Stat-category
- 2. step: Distribution of the extrapolated total for each EWC-Stat category by sectors according to the sectoral breakdown of the respective category in the reference year 2016.

This approach results in a complete data set on the estimated waste generation for 2017, with data that are consistent in both dimensions of the matrix (by sector, by EWC-Stat categories).

The plausibility of the extrapolated values was checked for all relevant sectors and EWC-Stat categories, by looking at the relative change from 2016 to 2017 (extrapolation) and by a visual check of the time series. In case of significant deviations of the extrapolated value from the value in 2016, the reasons for this deviation were analysed. Frequent reasons for such deviations were outliers in previous years. In case the extrapolated value was implausible (e.g. negative extrapolation value) or considered to not reflect the development trend in the country correctly, the data were adjusted, either by excluding outliers in previous years from the extrapolation or by using the value for 2016 as the best estimate for 2017.

22 The data from 2004 to 2008 were not considered because the WStatR revision carried out in 2008 results in structural changes and breaks in the time series of data for some waste categories.

3.4 Delimitation of quantities of MSW from commercial & industrial waste, balances

The waste streams under investigation are partly overlapping, either because of the chosen scope of the waste streams (food waste) or because of the different concepts of the data sources used (MSW versus C&I waste). Therefore, it is important to clearly delineate the waste streams in order to provide for a clear allocation of GHG emissions and to avoid double-counting.

3.4.1 Delimitation of municipal solid waste and commercial & industrial waste

Municipal solid waste comprises mainly waste from households but also waste from other sources that are similar to household waste in nature and composition (see Annex A.2.1). Thus, the column households in the WStatR waste generation matrix can be regarded as exclusively covering MSW for the materials covered in this study. MSW from other sources arises mainly in small enterprises, restaurants, office buildings, and public institutions, which are mostly assigned to the service sector (NACE G-U). MSW may also include waste further economic sectors. This may include for instance 'biodegradable kitchen and canteen waste' (LoW 20 01 08) or 'mixed municipal waste' (20 03 01) that arise in industrial companies of all sectors.

As a result, there is a (significant) overlap between MSW and waste from the service sector (NACE G-U) (and other economic activities) with regard to the several waste categories, including in particular separately collected packaging waste and other recyclables, organic waste and mixed MSW (LoW 20 03 01). MSW reported in the WStatR matrix under households and from the service sector (or under other economic activities), need to be subtracted from the C&I waste stream to avoid double-counting of these amounts.

The approach to the delimitation is described in more detail in Annex A.6.2

3.4.2 Food waste: Delimitation of municipal and non-municipal food waste

Food waste arises at all stages of the food supply chain considered in this study, i.e. in the food and drinks industry, in the wholesale and retail sector, in food services (restaurants, canteen, etc.) and in households. Food waste is therefore part of the MSW as well as of the C&I waste stream. In the GHG balances, food waste shall be accounted for as a separate waste stream on the one hand but also as part of the MSW and the C&I waste. Thus, a proper delimitation between MSW and non-MSW food waste is necessary.

The following approach was taken. In the first step, the municipal food waste is determined based on the Eurostat MSW data in combination with the EEA-model (see Chapter 5.1). The calculation delivers the quantities of separately collected food waste and the quantities of food waste contained in residual MSW.

In the second step, these results are compared for each country with the results of the WStatR-based food waste estimation by sectors (see Chapter 6.1.2) and checked for plausibility. The comparison is based on the following assumption:

Food waste from households ≤ municipal food waste ≤ (total food waste – food waste from processing)

In the cases where this validation rule is violated, the reasons are analysed, and adjustments are made.

The result is a consistent data set where for each country the food waste total is assigned to either the MSW or the C&I waste.

In order to achieve a proper delimitation between MSW and C&I waste and to reconcile the MSW and WStatR data the following approach was taken:

- The MSW amount is determined in the first place based on the Eurostat/OECD MSW data and broken down into waste categories by data/information from the EEA-model (for details please refer to the description of the MSW data compilation in Chapter 5.1).
- The MSW data are then compared to the WStatR data at the level of EWC-Stat categories. The relevant waste categories are listed in Table 113 (Annex A.2.2). In principle the following rule should apply for each EWC-Stat category:
  MSW ≥ waste from households (WStatR).
  For each EWC-Stat category, the share of waste that exceeds the amount generated by households is proportionally subtracted from the commercial and industrial waste (NACE sectors C and G-U).

3.5 Determination of two EU Clusters

For the GHG emissions accounting of the waste streams 'municipal waste' and 'food waste', two country clusters were defined. The two clusters shall cover countries with a backlog/catch-up demand in view of a climate-friendly waste management and in view of the EU's waste management targets with a high potential for reducing GHG emissions related to waste management.

The clustering aims to group countries with similar starting positions in view of the status of their waste management, and / or further structural or geographical conditions. The clustering shall allow for the development of specific recommendations with regard to the reduction of GHG emissions through the improvement of their waste management systems for (each of) the two country groups.

<u>Criteria for clustering</u>

Different indicators and country characteristics were investigated to identify suitable criteria for the clustering. The indicators include:

- the treatment rates for municipal waste achieved by the Member States in 2017;
- the Member States' legal situation with regard the compliance with the recycling and landfill targets of the WFD and the respective deadline (see box 1);
- the EU's assessment of countries that are at risk of non-compliance with the 2020 target for MSW recycling (see box 2);
- indicators like population density, MSW generation per capita, prosperity indicators (GDP, household expenditure) and tourism….

The considered information is summarised in Table 8.

Box 1: Deadlines for the achievement of the MSW recycling targets acc. to the revised WFD

In article 11(2)(c), (d) and (e), the amended Waste Framework Directive sets new recycling targets for the preparing for re-use and the recycling of municipal waste for the years 2025 (55%), 2030 (60%) and for 2035 (65%).

According to article 11(3), a Member State may postpone the deadlines for attaining the targets above by up to five years provided that that Member State prepared for re-use and recycled less than 20% or landfilled more than 60% of its municipal waste generated in 2013 as reported under the Joint Questionnaire of the OECD and Eurostat.

Box 2: Countries at risk to miss the 2020 recycling target for municipal waste

On 24 September 2018, the European Commission published an assessment of how well EU waste rules are applied in the EU Member States, presenting challenges and ways forward. The report gives an overview of progress and implementation challenges for several waste streams, including **municipal waste**, construction and demolition waste, hazardous waste, waste electrical and electronic equipment, and packaging waste.

For municipal waste, 14 Member States have been identified as at risk of missing the 2020 target of 50% preparation for re-use/recycling. For each of these countries, the Commission presented early warning reports including possible actions to improve their waste management and ensure compliance with EU waste legislation, taking into account best practices from other countries, but also local circumstances. These actions include more effective separate collection to ensure high quality recycling, efficient extended producer responsibility schemes, economic instruments such as landfill and incineration taxes, and improved data quality.

Based on the analysis, the two clusters were defined as follows:

- **Cluster 1** comprises all countries that are entitled to postpone the deadline for the WFD re-use/recycling targets for 2025, 2030 and 2035 period by five years, on account of their low recycling rate in 2013 and/or their high landfill rate in 2013 respectively. The cluster includes **12 countries** (see Table 7, column 1).
- **Cluster 2** comprises all countries that reported an MSW recycling rate for 2017 below or equal to the recycling rate of the EU27 (w/o UK) and that are not included in Cluster 1. Cluster 2 includes **8 countries** (see Table 7, column 2).

Table 7: Country clusters for the balancing of GHG emissions from MSW and food waste management

Cluster 1		Cluster 2	
Bulgaria	BG	Czech Republic	CZ
Estonia	EE	Denmark	DK
Greece	EL	Ireland	IE
Croatia	HR	Spain	ES
Cyprus	CY	France	FR
Latvia	LV	Portugal	PT
Lithuania	LT	Finland	FI
Hungary	HU	Sweden	SE
Malta	MT		
Poland	PL		
Romania	RO		
Slovakia	SK		

Not covered by the two clusters are the countries that reported for 2017 a recycling rate above the EU27 rate of 47% and the UK. UK is not included in Cluster 2 (although it falls below the EU27 recycling rate) as the UK left the EU and therefore is not subject to the development of recommendations.

Except for Slovenia and the Czech Republic, **Cluster 1** comprises all countries that joined the EU only in 2004 or afterwards (2007 and 2013 respectively). Accordingly, those countries had less time to implement EU waste policies than the "old" Member State. The only "old" Member State that belongs to Cluster 1 is Greece. According to the EU's 'early warning' assessment, all countries of Cluster 1 (except Lithuania) are considered at risk to miss the re-use / recycling target of 50% for 2020.

Different from Cluster 1, **Cluster 2** consists mostly of 'old' Member States (only exception: Czech Republic). Some of these countries (CZ, ES, PT) still reported very high landfill rates of 47% or above. On the other hand, the cluster comprises the Nordic countries (FI, DK, SE) that rely very much on waste incineration and have reduced the landfill rate to less than 1%. According to the EU's early warning assessment three of the 8 countries in Cluster 2 are considered at high risk to miss the 2020 targets.

Table 8: Indicators considered for clustering Member States

Cluster	Country	MSW generation (kg/cap)	Treatment rates for reference year 2017				MS is entitled to postpone deadline for recycling rate	MS at high risk of missing 2020 recycling target	Population density (cap/km²)	Final consumption expenditure of households (EUR/cap)
			Recycling rate	Landfill rate	Incineration rate	Other recovery / disposal				
1	Bulgaria	435	35%	62%	3%	0%	X	X	64	4,386
1	Estonia	390	28%	19%	42%	6%	X	X	30	8,690
1	Greece	504	19%	80%	1%	0%	X	X	82	11,051
1	Croatia	416	24%	72%	0%	0%	X	X	74	6,666
1	Cyprus	637	16%	76%	0%	0%	X	X	93	15,285
1	Latvia	438	25%	65%	3%	0%	X	X	31	8,156
1	Lithuania	455	48%	33%	18%	0%	X		45	9,358
1	Hungary	385	35%	48%	16%	0%	X	X	107	6,041
1	Malta	604	6%	86%	0%	0%	X	X	1,495	10,381
1	Poland	315	34%	42%	24%	0%	X	X	124	7,084
1	Romania	272	14%	71%	4%	11%	X	X	84	5,962
1	Slovakia	378	30%	61%	10%	0%	X	X	112	8,407
2	Czech Republic	344	34%	48%	17%	0%			137	8,466
2	Denmark	781	46%	1%	53%	0%			137	22,969
2	Ireland	575	41%	26%	29%	3%			70	19,177
2	Spain	462	33%	54%	13%	0%		X	93	14,133
2	France	514	43%	22%	36%	0%			106	17,819
2	Portugal	487	28%	47%	20%	0%		X	113	11,875
2	Finland	510	41%	1%	59%	0%		X	18	20,971
2	Sweden	452	47%	0%	53%	0%			25	20,408
remaining non-clustered EU countries	Belgium	410	54%	1%	43%	2%			374	19,208
remaining non-clustered EU countries	Germany	633	68%	1%	32%	1%			234	20,284
remaining non-clustered EU countries	Italy	489	48%	23%	19%	1%			203	17,178
remaining non-clustered EU countries	Luxembourg	607	48%	7%	45%	0%			231	26,812
remaining non-clustered EU countries	Netherlands	513	54%	1%	44%	0%			501	18,773
remaining non-clustered EU countries	Austria	570	58%	2%	39%	0%			107	20,974
remaining non-clustered EU countries	Slovenia	471	58%	10%	11%	0%			103	10,629
remaining non-clustered EU countries	United Kingdom	468	44%	17%	39%	3%			272	22,258
	EU28	**486**	**46%**	**23%**	**28%**	**0%**			**118**	**16,210**
	EU27	**488**	**47%**	**24%**	**27%**	**0%**			**109**	**15,314**

4 Background for the GHG balances

4.1 Methodology

The climate protection potentials of the circular economy are determined using the Life Cycle Assessment (LCA) method of waste management based on ISO 14040/44 44, which has already been applied and described in detail in many studies (e.g. Dehoust et al. (2010) and Vogt et al. (2015)). It permits a holistic approach, since it includes not only the direct emissions from waste treatment but also the potentially avoided emissions through the substitution of primary products and conventionally generated energy.

This type of sectoral approach differs from the consideration of the waste sector under the general reporting obligations of the Kyoto Protocol. In the National Inventory Reports (NIR), the waste sector is limited to direct and non-energy GHG emissions in order to avoid double reporting. According to these reports, the contribution of the waste management sector is mainly reflected in the diversion from landfill. The GHG reduction potentials that can be further identified by the LCA method of waste management are to be understood in the context of the reporting obligations as potentially avoided emissions in the industrial or energy sectors.

Another relevant difference between the LCA method and the NIR is the time horizon. In the NIR, the emissions occurring in one year are reported, whereas in the LCA the considered functional unit is the waste quantity. This means that all the current and the future debits and credits triggered by the disposal of a ton of waste are allocated to the considered waste quantity. This is particularly relevant in the case of landfilling, where methane emissions from the biological conversion of the deposited organic waste fraction are only released over decades. The LCA includes all the future emissions from the considered deposited waste, while the NIR reports the emissions caused by previously deposited waste.

The main rules to be considered for the balance method and methodological conventions are described in the following chapters.

4.1.1 LCA in waste management

The LCA method of the waste management is a sectoral approach and differs from the product LCA in the following points:

- Instead of "from cradle to grave", the system boundary begins with the waste generation (free of burdens) and ends with the waste disposal or the products of waste treatment (energy, secondary raw materials).
- The main benefit is the treatment of a certain total amount of waste, which must be the same for all the compared systems (requirement of equality of benefit).
- In order to meet the requirement of equality of benefits between the compared systems, additional benefits generated (substitution potential, secondary raw materials) are taken into account in the form of credits (negative values).

The requirement of equal total waste quantities also means that their composition must be the same. This means that material flow diversions within the total quantity - for example through increased separate collection of a waste fraction - can be examined, but not changes in waste quantities (e.g. increase due to more consumption). The comparison of systems with different amounts of waste requires the inclusion of the previous life of the waste, its production (product LCA). The consideration of reusable systems also requires the examination of the total life cycle of products and thus a product LCA. In contrast, a simple life-cycle extension can be included in the waste management LCA under certain circumstances. A methodological approach to include preparation for re-use and waste prevention into the LCA of waste management is presented in this project for Germany for MSW (see partial report Germany). Furthermore, waste prevention is also considered in one scenario of the special balance area of food waste (see Chapter 6.3.2).

Another relevant aspect for LCA of waste management is that the technical substitution potential is taken into account for material recycling, not the substitution potential according to the market mix. From a waste management perspective, it does not matter how high the share of secondary raw materials or products already on the market is. Since there are no other sources of origin for the secondary materials produced, it can be assumed that the use of secondary materials avoids the production of functionally equivalent primary materials. Conversely, accounting according to market mix would lead to false statements for the waste management sector; more recycling with increasing secondary shares would lead to lower relief potentials.

In the case of co-incineration of waste in cement kilns or coal power plants, there is also a physical connection between fuel from waste and substituted standard fuel, as there are no other sources of origin here either. Accordingly, it is assumed for the co-incineration of waste in coal and cement plants that the use of coal as a standard fossil fuel is avoided in terms of calorific value equivalent.

In the case of waste used in thermal treatment plants a differentiated consideration is necessary against the background of the energy transition. The main task of incineration is disposing of waste without causing damage and, additionally, these plants can generate energy, which is used the form of electricity, steam and/or heat. In the previous study (Dehoust et al. 2010) it was assumed, that the energy generated from waste will marginally displace fossil fuels from the energy generation system. Now that the share of renewable energies in the electricity mix has increased further, this marginal interpretation is no longer appropriate. The substitution by energy from waste can only take up a share alongside substitution by electricity from renewable energy sources (biomass, wind power, photovoltaics), which also accounts for a much higher share. If every alternative electricity generation were to claim the marginal approach for itself, the actual substitution potential would be overestimated. In addition, the marginal approach ignores the transformation of the energy system. Future scenarios can thus not show how the contributions to climate protection develop against the background of the decarbonisation of the electricity grid and the heat grid. For this reason, the generation of electricity and heat from waste is credited by substituting the average electricity and heat generation.

One exception is the possibility of flexible power generation. With increasing decarbonisation, the loadable power generation in which power plants can be flexibly ramped up and shut down to stabilize the power grid also decreases. This function can only be partially taken over by electricity from biogas and biomass. Fossil-fuelled power plants will continue to be necessary for flexible electricity generation. This means that flexible electricity generation will have a special status in the future energy system. If electricity can be generated flexibly from waste, the substitution of flexible electricity generation from conventional fossil reserve power plants is credited for this.

4.1.2 Other methodological boundary conditions, conventions

Emission factors electricity and heat

Average values are generally used for the energy demand and the credit for substituting conventional energy. For the base year 2017, these are values for electricity according to the ifeu electricity generation/power plant model[23]. For heat, the emission factor was derived from information for household heat from (TU Wien 2017).

The following emission factors are generally used for both debits and credits with the EU balances for reasons of consistency:

- Electricity mix EU27 2017: 429 g CO_2eq/kWh
- Heat mix EU27 2017: 265 g CO_2eq/kWh

This also accounts for the balance results for Germany which are added to the results of the EU27 (w/o DE). In the partial report for Germany the balances are calculated both with the national grid mix and the average values for the EU27.

The emission factors for electricity and heat used in this study are shown in Table 9. For the scenarios with a time horizon of 2030, the factors are adjusted to a changed energy source mix. In addition, the corresponding credit according to Dehoust et al. (2014) is applied for a proportionate flexible electricity generation in 2030. The possible share of flexible electricity generation at thermal waste treatment plants is set at 10%.

Table 9: Emission factors electricity, heat in CO_2eq/kWh end energy

	2017	2030
Electricity mix EU27	**429**	**179**
Heat mix EU27	**265**	**186**
Credit flexible electricity generation (Dehoust et al. 2014)		832
Electricity mix EU Cluster 1	748	
Electricity mix EU Cluster 2	243	

The Table also shows the emission factors for electricity for the EU Clusters 1 and 2 which are quite different from the EU27 mix. A high value here means that there is still a high share of fossil-based fuels in the electricity generation mix. In case of Cluster 1 countries the fossil fuel share in 2017 is 64%. The value for Cluster 2 countries is dominated by nuclear power (45%), the share of fossil fuels is 25%. In case of a higher electricity emission factor waste to energy options provide much better results on climate protection. However, the direct emissions from electricity demand are also higher. To show the influence of this boundary conditions of the energy system sensitivity analysis are done in the MSW balance for Cluster 1 and 2.

Harmonised emission factors

The approach to the use of uniform harmonised emission factors as established in Vogt et al. (2015) is also pursued in this study. Differences that arise for different waste origins are documented in each case. Results are more transparent and comparable when emission factors are harmonised. Regionally different assessments of replaced primary processes are standardised and the influence of the frequently given data uncertainties on the mapping of the substituted primary processes is reduced. This procedure is advantageous for the given objective of this study, which is to show the climate protection potentials of the circular economy of different country units. In contrast, the procedure would not be suitable for concrete

[23] https://www.ifeu.de/projekt/stromerzeugungkraftwerkspark-modell/

planning decisions that are to be based on a climate protection contribution. This requires realistic emission factors.

In the present study, harmonised emission factors were updated and used in the same way as Vogt et al. (2015), especially for recycling as far as possible (Chapter 4.2.6). The harmonised factors are also largely used for the scenarios with a time horizon of 2030. An exception is the primary production of materials, which is characterised by electricity demand. This is the case for the production of pulp and aluminium, for which GHG emissions are estimated using the 2030 electricity emission factor. For other materials such as pig iron, glass and plastics, a significant change in GHG emissions from primary production will only occur in later years with technology changes (direct iron reduction instead of oxygen steel route, electric furnaces, PtX-based plastics). The factors used are explained in the partial report for Germany.

Dealing with waste imports and exports

In this study, waste imports are not considered but waste exports are included. This corresponds to the systematic of reporting for Eurostat. For exported waste this approach means it is assumed that the treatment of the exported wastes corresponds to the national treatment. This is consistent with the procedure of the German balance areas. However, for Germany only exports which are subject to notification could be included as other waste (waste exported to recycling) are not reported in the waste statistics (see partial report Germany).

Potential carbon sink (C sink)

A carbon (C) sink (long-term C storage, 100-year horizon) may be given by landfilling of biogenic waste, in the application of compost (humus C) or in the storage in very durable products (antique furniture, books). However, there are considerable uncertainties regarding the actual long-term storage of biogenic carbon. In previous studies, the C sink was reported as an information variable. In this study, there is no further interest in the findings, therefore a C sink is not evaluated. A possible C enrichment through wood conservation is also not considered, like it was in Dehoust et al. (2010). In the study of Vogt et al. (2015) this was already refrained from due to the high uncertainties.

4.1.3 Impact assessment global warming potential

To evaluate the greenhouse effect, the individual greenhouse gases of the life cycle inventory are combined according to their effect equivalent to CO_2. The most important greenhouse gases and their Global Warming Potentials (GWP) according to IPCC (2013) for the 100-year horizon (GWP100) used in this study are listed in Table 10.

Table 10: Greenhouse gas potential of the main greenhouse gases

Greenhouse gas	CO_2-equivalent (GWP100) in kg CO_2eq/kg
Carbon dioxide (CO_2), fossil	1
Methane (CH_4), fossil	30
Methane (CH_4), regenerative	28
Nitrous oxide (N_2O)	265

Source: (IPCC 2013), Appendix 8.A

This differentiates between methane emissions according to their origin. Regenerative methane (from the conversion of organic matter) has a slightly lower GWP than fossil methane (from the conversion of fossil energy sources); since the regenerative carbon dioxide produced from methane over time by oxidation is considered to be climate neutral.

4.2 Procedure balancing

The procedure for the calculation of the various balance areas is largely uniform with regard to the aspects described below. Specifics for individual waste types or differing assumptions for the balance areas MSW, C&I waste or C&D waste are explained in the respective chapters. For the special balance food waste, MSW food waste and C&I food waste (W091, W092) is shown separately. The calculation of food waste is the same as for food/organic waste from MSW or C&I waste even if the food components are not 100%, as there is no meaningful way of distinguishing food components from the non-food components.

The balances for MSW and for food waste are calculated separately for Germany in more detail and are described in the partial report for Germany. The following explanations for MSW and food waste account for the EU27 without Germany, and for MSW also for the EU28 without Germany. However, the results are shown in total (with final results of Germany added) for the EU27 and the EU28.

4.2.1 Classification compared to previous studies

The balance area EU was last examined more comprehensively for the balance year 2007 exclusively for municipal waste in Dehoust et al. (2010). A rough calculation for the EU28 was last done in Vogt et al. (2015) for the year 2012. The results for MSW of this study are compared as detailed as possible with those of the previous studies (see Appendix B.1).

4.2.2 Collection and transport

In principle, the GHG impacts resulting from waste collection and transport are of minor importance in the overall life cycle of waste disposal (see e.g. results in Dehoust et al. (2010)).

In the context of this study, the GHG impacts from **collection** are not considered, as no information is available for the various Member States on collection routes and collection efforts. Additionally, the information could not be collected in a representative manner within the scope of this study. Collection related emissions are not considered in the partial report of Germany either due to consistency. In the previous studies collection was considered. For the comparison with the results for MSW, the corresponding expenses were deducted from the results at that time.

Expenditure on **transport** from the first treatment plant is taken into account in the GHG balances. Although no representative individual data are available for this either, these transports may be the only relevant source of GHG emissions, especially for mineral waste. Based on (Dehoust et al. 2010), uniform transport distances were derived for all balance areas. Table 11 shows the estimated transport distances for MSW for the various output fractions from first treatment plants. For the rough balances for C&I and C&D waste, a further simplified assumption was made for transport distances (Table 12). Food waste in the special balance food waste are mainly sent for anaerobic digestion or composting as first treatment. For impurities and secondary products separated out of these wastes, the transport distances derived for MSW were used. For fats and oils from other treatment plants for which transesterification into biodiesel is assumed, a transport distance of 200 km is assumed, thus being analogous to transports to a recycling facility.

The transport distances used for Germany are used uniformly for the EU balance areas. There are no indications for justified deviations.

Table 11: Transport distances MSW

Waste stream after first treatment plant	Distance in km
Slag for processing	50
Contaminants, sorting and processing residues to thermal treatment plants	100
Refuse derived fuels (RDF) to thermal treatment plants	100
RDF, treatment residues to co-incineration	200
Wood to biomass combined heat and power plant (CHP)	100
MBT residue to landfill	10
Minerals to landfill, other recovery	20
Metals to material recycling	200
Wood, prepared to material recycling	200
Glass, sorted to material recycling	200
Paper, cardboard, sorted to material recycling	200
Plastics sorted, to material recycling	200
Beverage cartons, other composites to recycling	500

Table 12: Transport distances C&I and C&D waste

Waste stream after first treatment plant	Distance in km
to backfilling	200
to landfill	50
to thermal treatment	100
Mineral waste to recycling	50
Recyclables to recycling	200

4.2.3 Landfill

The calculations for depositing of waste are based in principle on IPCC (2006). Key parameters for the calculation are:

- DOC: the degradable organic carbon in the deposited waste
- DOCf: the fraction of DOC that is dissimilated over time
- F CH_4: the methane content of the landfill gas (or the fraction of the degraded carbon that is converted to methane)
- MCF: the methane correction factor to take account of the type of waste disposal site
- OX: the oxidation factor
- R: the recovery rate, or the gas collection efficiency
- The type of gas use

The parameters for calculation are derived from the National Inventory Reports from each of the member states as submitted to the UNFCCC for the year 2017[24]. For the calculations weighted values are derived based on the MSW amounts landfilled for each member state (Table 135). The resulting weighted values are shown in Table 13 for the four balance areas that are calculated for MSW. The weighted recovery rates are derived from the data given in the European NIR (NIR EU 2019, Figure 7.9). The weighing for the EU27 and the EU28 was done without Germany (w/o DE) because the German GHG balance was calculated separately.

Table 13: Weighted parameters landfill

	DOC MSW	DOCf	F (CH_4-fraction)	MCF	OX	Recovery rate
Cluster 1	15%	51%	0.50	0.99	8%	19%
Cluster 2	18%	50%	0.51	1.00	10%	34%
EU27 (w/o DE)	17%	51%	0.50	0.99	9%	28%
EU28 (w/o DE)	18%	51%	0.50	1.00	9%	33%

Source: NIR Reports member states and EU27

Most of the member states use the IPCC (2006) default values for the DOCf (50%) and the F CH_4 fraction (0.5). Therefore, the weighted values do not differ much from those default values. The weighted MCF is mostly 1 or near 1, which means that the majority of landfills in the EU are managed waste disposal sites. The weighted oxidation factor is near the default value of 10% for well-managed disposal sites. Here most of the member states use this value although in the reports it is often not explicitly documented that the respective disposal sites are 'well-managed' instead of only 'managed'.

For the calculations, the recovery rate was taken directly as reported in the NIR EU (2019). This also for UK and Ireland which are the only two countries that report recovery rates above 50% (62% and 60% respectively). In the previous study (Dehoust et al. 2010) instead of a member state analysis the 20% effective gas collection efficiency (default value) was used in the standard case for the EU27 and 40% was used in the sensitivity analysis. In Vogt et al. (2015) the recovery rates reported in the NIR EU for 2012 were not adopted 1:1. The recovery rate in the NIR accounts for the yearly methane emissions, whereas the effective gas collection efficiency over the 100 year time horizon of potential methane generation is needed for the LCA in waste management. Therefore, in Vogt et al. (2015) the maximum technically feasible effective gas collection efficiency was assumed to be 50%, and this value was set as a maximum cap. However, only two member states exceeded the cap in 2017, whereas in 2012 four members states did it and also with higher rates of up to 75%.

The ways in which gas is used can range from venting and flaring to energy generation, e.g. in CHP. In general, the type of gas use was not reported in the NIRs of the EU member states. The gas use for this study was estimated based on Figure 7.8 in the NIR EU (2019). The share of methane used for energy recovery is approximately 30%, and the share of methane flared approximately 9%. The remaining methane is emitted. From this, the share of energy use was calculated to 77%, and the share of methane flared to 23%. This relation was commonly used for all balance areas.

[24] https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2019

4.2.4 Thermal treatment

The EEA-model, from which the mass balances for MSW were derived, separately considers the performance of four types of incineration plants (Gibbs et al. 2014):

- Electricity generation only
- Generation of electricity and heat for external use
- Exporting only heat
- Incineration plants without energy recovery

Co-incineration in cement kilns or coal power plants is not considered as an option for thermal treatment of collected waste. In contrast, the separate balance for Germany is based on the national statistical data (Destatis 2019) which reports thermal treatment both in incineration plants (mainly waste-to-energy (WtE) plants) and in power plants (e.g. coal power plant) or plants for other production purposes (e.g. co-incineration in cement plant). To follow the national reporting and thus be more precise was the main reason for the separate calculation of the German GHG balance. However, co-incineration is also taking place in the EU with regard to refuse derived fuel (RDF).

When considering the waste sector using the LCA method, the important distinction is whether the plants are waste management plants (main purpose: waste treatment) or production or energy generation plants. In the latter case, waste is co-incinerated instead of regular fuels like coal. This means that differences result exclusively from differences in the fuels, process-related emissions are unaffected.

Fossil CO_2 emissions from waste combustion occur independently of the process and are determined by the fossil carbon content of the waste. In general, complete incineration in this study is assumed[25]. Further pollution and thus direct emissions arise in thermal treatment plants through the use of auxiliary and operating materials such as heating oil for auxiliary firing and substances such as hydrated lime, quicklime, stove coke, ammonia for flue gas cleaning. In general, the value of 30 kg CO_2eq/t waste input from Dehoust et al. (2010) is used for the expenditure for auxiliary and operating materials for thermal treatment plants, since the influence compared to the direct CO_2 emissions is small and no relevant changes in the use of operating resources are assumed. In the case of co-incineration of waste, it can be assumed that auxiliary and operating materials are used independently of the fuel, i.e. that they would also be used in the event of operation with standard fuel.

The substitution potential of energy recovery also differs between co-incineration and thermal treatment (see Chapter 4.1.1). In the case of co-incineration, regular fuel is substituted equivalent to the energy content. In the case of thermal treatment plants, the substitution potential is determined by the generated, externally usable energy (degree of utilization or net efficiency) as well as by the substituted average energy generation (emission factors, see Chapter 4.1.2).

The relevant waste characteristics for thermal treatment, the calorific value and the fossil carbon content of the waste are described in the chapters for the various waste balance areas. Energy generation efficiencies, gross electricity generation efficiency and external heat use, are also given in Gibbs et al. (2014). To derive the externally used energy the own use of electricity, which is assumed to be 3%, was subtracted from the given gross electricity generation efficiency. The final values are shown in Table 14.

[25] Usually an almost complete combustion is technically achieved. The simplification takes into account the later atmospheric oxidation of CO or VOC to CO_2.

This distinction can only be used for MSW that was determined using the EEA-model. Eurostat data differentiate only between thermal treatment with energy recovery (Recovery – energy recovery, (R1)) and combustion without energy generation (Disposal – Incineration (D10)). In a first approach weighted efficiencies were calculated based on the MSW mass flows derived from the EEA-model. However, this led to implausible results as for example for France and for Spain incineration is only given with "electricity only" (INC 1, see Table 135), which results in a heat efficiency of zero. This does not correspond to the current status.

Alternatively, weighted values were derived based on information on country specific capacities for thermal treatment plants in Scarlat et al. (2019). The resulting values for each of the balance areas – the EU28 (without Germany), the EU27 (without Germany), the Cluster 1 and 2 – are shown in Table 15. For Germany, the weighting results in slightly higher values than the ones used for the calculation of the German balances based on information in Flamme et al. (2018). However, the weighting results for the EU27 including Germany (electrical 12.3%, thermal 36.4%) are plausible and correspond to the more recent net efficiencies of 15% for electricity and 32% for heat for 2019 communicated by CEWEP (2021).

The weighted values in Table 15 are used for residual MSW, RDF, sorting or processing residues being incinerated, and in general for energy recovery in the GHG balances for C&I- and C&D waste and also in the special balance food waste.

Table 14: Net efficiencies for MSWI plants

Thermal treatment	Net electricity generation efficiency	Net efficiency, external heat use
Electricity only	22%	-
CHP	11%	42%
Heat only	-	80%

Source: own calculations based on Gibbs et al. (2014)

Table 15: Weighted net efficiencies for energy recovery

Balance area	Electrical	Thermal
EU27 (w/o DE)	12.6%	35.1%
EU28 (w/o DE)	13.3%	32.5%
Cluster 1	11.1%	41.7%
Cluster 2	12.3%	36.2%
Germany[1]	11.6%	39.0%

1) For the GHG balance German specific values are used based on Flamme et al. (2018): 11.3% electricity efficiency, 34% heat efficiency.

Source: own calculations based on Scarlat et al.(2019) and Gibbs et al. (2014)

The energy recovery from wood is calculated with efficiencies for biomass CHP with 21.3% electrical and 15% thermal (see also partial report Germany).

Another component of the GHG balance is the processing of the resulting slag and the metal recovery from it. Here the data derived for Germany are used (see partial report Germany), as deviating EU-specific information is not available. In general, it can be assumed that the slag is being processed. In the BREF (2019, Section 3.4.3), the slag processing and separation of Fe metals is specified for all the plants, while the separation of non-ferrous metals for some plants. The amount of slag produced is not named in it. According to information for individual plants in Germany, about 20-30% processed slag is produced based on the amount of waste incinerated. In CEWEP (2019) the amount of slag in relation to the incinerated waste is given as around 20%. The calculation in this study assumes 20% processed slag and based on this, the amount of fresh slag was recalculated (i.e. plus separated metals). The values used in this study for metal recovery from slag are shown in Table 16.

Table 16: Metal recovery from slag

Fraction	Unit	Value
Share of slag processing	% slag	100%
Fresh slag	% waste incinerated	22%
Fe metals from slag	% slag	7.14%
of which pure metals	% Fe metal fraction	93%
Non-ferrous metals from slag	% slag	2.73%
of which pure metals	% non-ferrous metal fraction	66%

Source: BREF (2019), CEWEP (2019), IGAM and ITAD (2019)

4.2.5 Mechanical biological treatment

Treatment in mechanical-biological treatment plants (MBT) is only relevant for MSW. For the rough accounting of C&I waste and C&D waste, only the final destination can be evaluated. It is not known to what extent MBT plays a role in these areas of origin. However, MBT is not involved in the treatment of food waste.

The mass balance for MSW treated via MBT is taken from the EEA-model (see Chapter 3.2.2), which distinguishes the five types:

- MBT 1 – sorting, mixed waste composting, no RDF production
- MBT 2 – sorting, RDF production, biodrying mixed waste
- MBT 3 – like MBT 2, but also separating plastics
- MBT 4 – sorting, anaerobic digestion (AD), no RDF production
- MBT 5 – basic sorting, RDF production

These types correspond quite well to the MBT types reported for Germany (see partial report Germany). For the calculations the MBT 2 and MBT 3 were summarised under the German term "MBS" (mechanical-biological stabilisation), which corresponds to the biodrying treatment and main objective of RDF production. MBT 1 and MBT 4 both produce stabilised material for landfill, which corresponds to the German "aerobic MBT" and "anaerobic MBT", which both produce a stabilised MBT residue for disposal. The German aerobic and anaerobic MBT also produce RDF but to a smaller extent than MBS. The MBT 5, the basic sorting to produce RDF without any biological treatment corresponds to the German "mixed waste sorting", which is described separately in the report for Germany.

The mass balances resulting from the EEA-model for the four EU balance areas are shown as ranges in Table 17. Special attention must be paid to MBT 5 regarding the range to landfill and the RDF fraction. Here corrections had to be done. In two cases (Latvia and Hungary) the EEA-model assigned waste to the MBT 5 instead of to landfill (EEA-model result to landfill was 0), although this waste was disposed of 100% according to the NIR reports of the two countries. In the case of Latvia, no real pre-treatment takes places. The MSW is "stored in bioreactor" and "disposed in polygons" (NIR LV 2019). In this case, the respective amount was subtracted from the MBT 5 input and added to the landfill input. In the other case of Hungary, no MBT is reported in the NIR (NIR HU 2019). However, some kind of pre-treatment may take place before disposal but surely no production of RDF. The MBT 5 output for Hungary was manually corrected. Instead of 92.2% production of RDF, the total amount for Hungary was assigned to landfill. This correction explains the lower end of the range for RDF production which stands for Cluster 1. In the EU27 and EU28 balances, this effect is also visible; Cluster 2 is unaffected and shows the typical outputs for MBT 5 from the EEA-model.

The corrected output for Hungary was systematically calculated as landfilling, since biological stabilisation from the possible pre-treatment is not likely. For MBT 1 to 4, the output to landfill was assumed to be either inert material or stabilised organic material. Remaining emissions from landfilling of the MBT residue are calculated in the same way as for Germany (see partial report Germany). The residual gas formation potential was determined as in Knappe et al. (2012, Section 4.3.3). Characterised by the GWP according to IPCC (2013), this results in a GHG emission value of 62.4 kg CO_2eq/t MBT residue.

Table 17: Output MBT from EEA-model

	MBT 1	MBT 2+3	MBT 4 (AD)	MBT 5 (MT)
Metals	1.4%-2.1%	1.1%-1.5%	1.4%-2.0%	1.4%-1.6%
Plastics	0.9%-1.4%	0.4%-1%	1.1%-1.3%	1.5%
Paper	0%	0%	0%	2.5%-3.2%
Losses	25.2%-36.2%	15.7%-20.1%	28.3%-31.7%	0%
Land recovery	17.1%-20.8%	0%	21.9%-22.8%	0%
Landfill	39.9%-54.9%	6.1%-8.3%	42.3%-47.1%	1.7%-44.6%
of which inert material	0%-6.3%	0%	0.7%-5.9%	1.7%-4.6%
RDF	0%	71.3%-73.9%	0%	49.8%-92.2%

Source: Results gained from EEA-model (Chapter 3.2.2)

Data and technical parameters for the calculations are basically taken from Gibbs et al. (2014), and supplemented by data for Germany. The energy demand used for the calculations of the EU27 (without Germany), the EU28 (without Germany), Cluster 1 and 2 is shown in Table 18.

Table 18: Energy demand MBT

	Unit	MBT 1, 2, 3	MBT 4	MBT 5
Electricity	kWh/t Input	40	35	30
Diesel	kWh/t Input	1	1	0.7
Gas	kWh/t Input	0	0	0

Source: Gibbs et al. (2014)

For Germany national data was used. In average the energy demand for MBT 1 to 4 is higher than for the EU as taken from Gibbs et al. (2014) (see partial report Germany).

The output fractions from the EEA-model do not further differentiate the type of metals, and neither the fate of RDF. Data for metals were taken from Germany, and also the characteristics for produced RDF:

- 85% Fe-metals, of which 73% are pure metals
- 15% non-ferrous metals, of which 34% are pure metals (calculated as aluminium)
- RDF calorific value 13 MJ/kg, fossil carbon content 15%

The fate of RDF was derived from ERFO-Cembureau (2015). For “others” co-incineration in coal power plants was assumed. The resulting distribution for RDF is:

- 52% thermal treatment (energy efficiency, see Table 15)
- 37% co-incineration in cement kilns
- 11% co-incineration in coal power plants

For co-incineration in coal-fired power plants and cement plants, the equivalent calorific value is taken into account for the substitution of lignite. However, the provision of hard coal and lignite is associated with similarly high specific GHG emissions in terms of energy content, which are a little over 400 g CO_2eq/kWh. For the EU countries, the substitution of lignite is also set, because no EU-specific information is available and in principle, there is less co-incineration in hard coal power plants, also because these are increasingly specialized in dust injection.

Emissions from MBT are calculated in the same way as for Germany (see partial report Germany). Gibbs et al. (2014) refer to a comparatively old study from 2003 with regard to CH_4 and N_2O emissions. The values correspond very well for CH_4 (around 20 g/t input), but are lower for N_2O (10 compared to 14 g/t input).

Energy generation from biogas is reported as end energy (electricity, heat produced) per waste fraction in Gibbs et al. (2014), and not for the total mixed waste. Counting back to the gas yield for residual MSW and energy efficiencies of the biogas CHP cannot be easily done. Therefore, the German data for AD MBT was uniformly used for biogas:

- Biogas yield: 40.6 m^3/t input
- Methane content: 60 Vol%
- Gross electricity generation efficiency: 37.5%
- Heat generation: 43%

4.2.6 Recycling dry recyclables

The waste fractions paper, glass, metals and plastics belong to the dry recyclables. For MSW in Germany, this also includes the waste fraction lightweight packaging waste and non-packaging waste of the same material (in this study short LWP). The balancing for the latter is described in the partial report for Germany. In other EU member states, LWP are not recorded separately or are not shown separately in the Eurostat data.

In general, a harmonized approach was followed for the calculation of the dry recyclables (Chapter 4.1.2). The German conditions have been largely used to calculate sorting and processing per fraction (see partial report Germany). In the following the aspects are described for which there are separate approaches in the EU balances.

The sorting yields for Germany widely correspond to the sorting yields resulting for MSW from the EEA-model. Exceptions are paper and glass with rather high shares of sorting residues in the EEA-model (e.g. 15% for paper compared to 1% for Germany). Here the share of sorting residues was adjusted to 5% for the EU. For C&I and C&D waste the higher German yields were retained for glass in the EU balances. Paper is not relevant for C&D waste and for C&I waste no sorting losses are calculated for the production waste. Table 19 shows the sorting yields for the dry recyclable materials, which are used for balancing. Exceptions for C&I and C&D waste are listed accordingly in the table.

For the rough calculation for C&I and C&D waste, for which only the final treatment is given, the sorting expenses are based on the recalculated input quantities. For plastic waste, on the other hand, processing residues are calculated based on the reported amount for recycling, as it is assumed that these amounts are not recorded in the statistical data of the final treatment. For plastic waste, a higher yield is assumed for C&I waste than for the other areas of origin, because it is not post-consumer waste, but waste from production and is therefore assumed to be less mixed with contaminants by collection. In the case of metals, too, higher yields are set for C&I waste. It is mostly metal shavings. In the case of ferrous metals, there is only contamination from cooling liquid amounting to a maximum of 3%, because the waste must be "dry". In the case of the non-ferrous metals from C&I waste, the yield was estimated based on the ferrous metals.

The contaminants separated during the sorting go to the waste incineration plant (paper sorting residues, glass labels and closures), to the landfill or to other disposal (from glass, metal fractions). For sorting residues, the characteristics (calorific value and fossil carbon content) for residual MSW has been used in a simplified manner as in the previous study (Dehoust et al. 2010). For the processing residues from plastic waste, the characteristics for processing residues from LWP have been adopted (calorific value 16 MJ/kg, fossil carbon content 26%, see partial report Germany). A moisture loss of 20% is assumed for the residues from plastic processing. The whereabouts of the residues is assumed to be analogous to the whereabouts of the processing residues from LWP waste (98% cement plant, 2% MSWI). The applied substitution factor of 0.8 for secondary plastics produced is also based on the values for LWP for Germany as given in Dehoust et al. (2016) (see also partial report Germany).

Table 19: Yields processing for dry recyclables

Waste fraction	EU
Paper, MSW	95%[1]
Glass, MSW	95%[1]
Glass, C&I and C&D waste	97%
Fe-metals	90%
Fe-metals, C&I waste	97%
Non-ferrous metals	70%
Non-ferrous metals, C&I waste	90%
Plastics	70%
Plastics, C&I waste	80%

1) Values in the German balance: 99% for paper and 97% for glass.

The EEA-model does not distinguish between dry recyclables and packing waste at all. However, for some materials the balance is quite different for packaging waste. This accounts for paper and beverage cartons and for metals and tinplate or aluminium packagings. To address these differences the share of packaging waste was estimated for the two fractions. The share of beverage carton in paper waste was estimated based on information from the association[26]. In 2018 around 450,000 tons of beverage cartons were recycled which represents a recycling rate of 49%. With a total of about 22.7 million tons paper waste from MSW in the EU27 (see Table 33), this results in a share of beverage cartons in paper waste of about 2%. For metals data on the share of packaging waste is not available. As an approximation data on packaging waste for Germany was used (GVM 2019), which distinguishes waste amounts from private households and from commercial sources. With the assumption that the waste from private households is packaging waste, the share of tinplate and alumimum packagings in metal waste was calculated to 58%.

Paper packaging waste consists of beverage cartons and other paper composites. The share between these two was taken from data in Dehoust et al. (2016) for Germany (72% beverage carton, 28% other paper composites). The share of tinplate and aluminium packagings was also taken from data in Dehoust et al. (2016) for Germany and results in 82% for tinplate and 18% for aluminium. The procedure of calculation for the packaging waste (beverage carton, other paper composites, tinplate, aluminium packaging) is described in the partial report Germany.

Metal waste is not further specified in the EEA-model. For MSW the German statistic neither provides differentiated data. The distribution into ferrous and non-ferrous metals was estimated based on the corresponding proportions of metals from slag, metals from MBT and metals in LWP, and used for the EU also. For C&I and C&D waste, metals are shown in the statistics as mixed metals (EWC-Stat Code W063), and separately as ferrous metals (W061) and non-ferrous metals (W062). Here the division for mixed metals was derived from the ratio of the pure fractions. The respective breakdown for the various areas of origin is shown in Table 20.

Table 20: Distribution of mixed metals in ferrous and non-ferrous metals

Waste fraction	MSW	C&I waste	C&D waste
Ferrous metals	85%	92%	91%
Non-ferrous metals	15%	8%	9%

Information about the composition of plastic wastes are not available from the statistics. Therefore, market mixes for Germany (Heinrich-Böll-Stiftung 2019)) and the EU (PlasticsEurope 2018) were used in a simplified way for the calculation of substitution mixes, whereby only the different types of plastic specified were taken into account ("Others" cannot be classified). The resulting mixes for both are shown in Table 21.

Table 21: Substitution mix for recycled plastics

Plastics type	Mix Germany	Mix EU
Polypropylene (PP)	25%	26%
Polyethylene (50% LDPE and 50% LLDPE)	22%	24%
Polyethylene (HDPE)	19%	17%
PVC (88% S-PVC and 12% E-PVC)	19%	14%
PET	9%	10%
PS/EPS	7%	9%

[26] https://www.beveragecarton.eu/policy-areas/recycling/ (15.09.2021)

On the basis of emission values for primary plastics (eco-profiles according to PlasticsEurope[27]), weighted specific emission values were calculated for primary production. Since the market mix for recyclable plastic waste differs only slightly for Germany and the EU, almost identical weighted specific emission values result for primary production for the substitution mix:

- Germany substitution mix: 1,894 kg CO_2eq/t primary plastic
- EU substitution mix: 1,892 kg CO_2eq/t primary plastic

4.2.7 Recycling organic recyclables

The EEA-model for MSW distinguishes “food waste”, “garden waste” and “other biowaste”. The term “other biowaste” is not explained. It is assumed to be used for mixed organic waste, which corresponds to the German bio bin in which both food and garden waste are collected. This fraction was calculated in the same way as the German “waste from the bio bin” (LoW 20 03 01 04). In order to avoid mix-ups with the “special balance food waste”, the fraction there is named “MSW food waste” and corresponds to “food waste” from the EEA-model. For Germany the waste fractions “kitchen/canteen waste” (LoW 20 01 08) and the share of food waste from the bio bin are included. The calculation of the latter corresponds to that for “waste from the bio bin”, even if only the food content of the waste is considered in the special balance (for kitchen/canteen waste, the food content is 100%). For the food content in the bio bin, there is no sensible way of distinguishing it from the total quantities collected. Food waste from C&I waste is calculated and reported separately as far as possible. For Germany it was possible to carry out an evaluation based on the LoW Codes, while for the EU this was not possible. Only the EWC-Stat codes W091 and W092 could be differentiated based on assumptions. The results of the special balance food waste are used for the C&I waste balance for the item "animal and vegetable waste (W091, W092)" reported there. There are no organic recyclables in the case of C&D waste.

The basic procedure for the calculation of the biological treatment of organic recyclables from MSW is described below. For organic waste from C&I waste, there are differences and additional processes that are described in more detail in the chapter for the special balance food waste (Chapter 6).

4.2.7.1 Composting and anaerobic digestion of organic waste

In general, the calculation for the biological treatment of organic waste from MSW is uniform for all EU balance areas. The data used is similar to the data used for Germany as far as no EU-specific data was available. This is the case for the composition and characteristics of impurities, the calculation of biogas generation and use, and for compost products and use. EU-specific data were used for the energy demand as reported in Gibbs et al. (2014). The share of open and closed composting is derived from the EEA-model and also the type of biogas use (see Chapter A.1.2). The parameters used commonly for all EU balance areas are shown in Table 22.

The characteristics for biogas generation, which are commonly used for all balance areas, have been derived from KTBL (2013) for waste from the bio bin and kitchen/canteen waste. For garden waste the value for "grass, fresh" from KTBL (2007) was used as approximation. The characteristics and calculated biogas and methane yield per ton of input are shown in Table 23.

[27] Reports and LCI data published on PlasticsEurope Website (free registration required).

Table 22: Common parameters biological treatment

Parameters	Unit	Values	Source
Impurities			
Share impurities		5%	Gibbs et al. (2014)
Characteristics impurities	calorific value 12 MJ/kg; C_{fossil} 21%		Calculated (see partial report Germany)
Composting			
Diesel demand open composting	l Diesel/t Input	1	Gibbs et al. (2014)
Electricity demand open composting	kWh/t Input	0	Gibbs et al. (2014)
Electricity demand closed composting	kWh/t Input	30	Gibbs et al. (2014)
Anaerobic digestion (AD)			
Average electricity demand AD	kWh/t Input	45	Derived from Vogt et al. (2008)
Gross efficiency of CHP	37.5% electrical, 43% thermal		Knappe et al. (2012)
Excess heat utilisation rate		20%	Knappe et al. (2012)
Average electricity demand CO_2 separation	kWh/m³ raw gas	0.3	Derived from Vogt et al. (2008)
Average methane slip CO_2 separation[1]		2%	Derived from Vogt et al. (2008)

[1] Loss, but no emissions to air; assumption like Germany with regenerative thermal oxidation

Table 23: Characteristics biogas generation

Parameters	Unit	Waste from the bio bin	Garden waste	Kitchen/canteen waste
Dry matter	% wet weight	40	18	16
Organic substance (OS)	% dry weight	50	91	87
Biogas	l/kg OS	615	600	680
Methane content	Vol%	60	54	60
Biogas yield, calculated	m³/t input	123	98	95
Methane yield, calculated	m³/t input	74	53	57

Table 24 shows the share of open composting and of the type of biogas use for the different EU balance areas as derived from the EEA-model. The types “gas cleaned and injected to the gas distribution network” and “gas cleaned and compressed for use as vehicle fuel” from the EEA-model are combined under “CO_2 separation” in this study as also the fuel for vehicle use is usually distributed via the gas distribution network.

Table 24: Share of open composting and type of biogas use derived from EEA-model

Parameters	EU27 (w/o DE)	EU28 (w/o DE)	Cluster 1	Cluster 2
Share open composting				
Other biowaste	45%	34%	96%	24%
Garden waste	44%	52%	84%	18%
Food waste	24%	23%	80%	25%
Type of biogas use for other biowaste				
Generation of electricity only	82%	75%	6%	31%
Generation of electricity & heat	14%	21%	94%	48%
CO_2 separation	4%	4%	0%	17%
Flaring	0%	0%	0%	4%
Type of biogas use for garden waste				
Generation of electricity only	45%	40%	1%	75%
Generation of electricity & heat	50%	56%	99%	20%
CO_2 separation	4%	4%	0%	5%
Flaring	1%	0%	0%	1%
Type of biogas use for food waste				
Generation of electricity only	56%	48%	1%	9%
Generation of electricity & heat	27%	37%	99%	49%
CO_2 separation	17%	14%	0%	39%
Flaring	1%	1%	0%	2%

For CH_4- and N_2O-emissions the emission factors from the National Inventory Reports from each of the member states as submitted to the UNFCCC for the year 2017 were used. For the calculations weighted values were derived based on the amounts composted or anaerobically digested (see Table 122). The resulting values are shown in Table 25 for the EU balance areas. For comparison also the values for Germany and the IPCC (2006) default values are given.

The results show that the EU member states under Cluster 1 use the IPCC (2006) default values. This also accounts for most of the EU member states under the Cluster 2, exceptions are France and Denmark. Especially for anaerobic digestion, many member states do not report emission factors. In case amounts for anaerobic digestion have been derived from the EEA-model, the IPCC (2006) default values were taken for calculation. The comparison with Germany shows that the factors for composting are lower than the IPCC (2006) default values, and thus also lower than for all of the EU balance areas, while the factors for anaerobic digestion are higher.

Table 25: Weighted emissions for composting and aerobic digestion

	Methane kg CH_4/t waste	Nitrous oxide kg N_2O/t waste	GHG emissions kg CO_2eq/t waste
Composting			
Cluster 1	4.00	0.240	176
Cluster 2	2.53	0.299	150
EU27 (w/o DE)	2.13	0.233	121
EU28 (w/o DE)	2.44	0.235	130
Germany	1.40	0.074	59
IPCC (2006) default	4.00	0.240	176
Anaerobic digestion			
Cluster 1	0.80	0	22
Cluster 2	1.43	0	40
EU27 (w/o DE)	1.10	0.004	32
EU28 (w/o DE)	1.09	0.003	31
Germany	2.80	0.067	96
IPCC (2006) default	0.80	assumed negligible	22

Source: NIR Reports member states

4.2.7.2 Compost products and application

The calculation of the application and the substitution potential for compost products corresponds to the calculation for Germany. The compost production and use was evaluated based on the results in Knappe et al. (2012). The proportion of fresh compost from composting of waste from the bio bin is according to Knappe et al. (2019) set at 39%. Garden waste compost is analogous to Knappe et al. (2012) assumed with 100%. Composted digestate was also generally assumed for anaerobic digestion.

According to Knappe et al. (2012), the following product quantities are generated per ton of waste input for mixtures of organic and garden waste in the biological treatment:

- Fresh compost: 0.421 kg/kg input
- Finished compost: 0.442 kg/kg input
- Composted digestate: 0.388 kg/kg input

The values were also used for food waste (kitchen/canteen waste). This should be approximately valid for composting. For anaerobic digestion no corresponding data are available. Here, however, it is assumed that the digestate is usually not post-composted, but used directly in agriculture, which would result in a lower substitution potential. Nevertheless, the calculation for composted digestate from kitchen/canteen waste is not changed from the general calculation. This is due to data gaps, and that the NIR emission factors for anaerobic digestion are uniformly used, which are relevantly higher than the specific values for anaerobic digestion without after-composting. Thus, the error deviation goes in both directions.

For composted digestate, the proportion used in agriculture is as in Knappe et al. (2012) assumed with 46%. According to IPCC (2006), N_2O-N emissions of 1% based on the nitrogen applied are calculated for use in agriculture. The credits for agricultural use result from the nutrient content and the humus reproduction potential as in Knappe et al. (2012). For the use of composted digestate in horticulture, half of the substitution of peat and bark humus is taken into account, analogous to aerobic compost.

4.2.8 Wood waste

In the absence of EU specific data, the calculation for wood waste is largely carried out in the same way as for Germany. The only difference assumed for the EU is a different percentage of impurities than for Germany (5% instead of 1.6%).

For the material recycling of wood waste, the emission factors according to Prognos et al. (2008) for chipboard recycling in a damp environment are used. The corresponding specific emission factors are:

- Debit: 366 kg CO_2eq/t waste wood
- Credit: 431 kg CO_2eq/t waste wood

The energy recovery of wood waste is calculated in the same way as energy recovery in general as described in Chapter 4.2.4. The key data – calorific value and fossil carbon content – are uniformly taken for all balance areas from Flamme et al. (2018):

- Calorific value: 16 MJ/kg
- Fossil carbon content: 2.3%

5 Municipal Solid Waste

The MSW data are based on the amounts reported to Eurostat and the mass flow data from the EEA-model.

5.1 Methodology

From the specifics described about the data sources EEA-model (Chapter 3.2.2) and MSW data reported to Eurostat (Chapter 3.2.1), the approach was taken as described in the following.

It was decided to start with the data compilation with the following activities:

- Calculate the model baseline scenario as most likely development for all 28 countries,
- Use the Eurostat data 2017 (actually reported by the member states) to adjust the major streams calculated by the model,
- Take the breakdowns by major waste streams in the EEA-model and the treatment split reported by the countries to Eurostat as a means to adjust the major streams (Table 26) of the EEA-model data with the reported trends, and
- Use the breakdowns of materials and the detailed treatment splits in % (e.g. 5 MBT-types and related outputs) to apply them on the adjusted major streams.

To proceed like this, similarities between the Eurostat data and those of the EEA-model were identified, which were helpful to adjust the EEA-model data (prognosis) with the real developments reflected in the Eurostat data (exception: major methodological changes occurred which caused the 'trend').

Table 26: Comparable and *adjustable* waste streams of EEA-model- and Eurostat data on MSW

EEA-model	Eurostat
MSW Generation, of which	*MSW Generation*
Organic wastes collected,	*Composting/digestion*
Dry recyclables collected	*Recycling*
Mixed (residual) waste collected[1]	Landfill Total incineration Other recovery Other disposal

1. Cannot be adjusted directly, but calculated as the difference between waste (fractions) collected and source segregated dry recyclables and organic wastes

The adjustment with Eurostat data is based on the following assumptions:

1. MSW generation in both data sets has the same coverage;
2. Concerning the major waste streams (Mixed (residual) waste collected / *Dry recyclables collected / Organic wastes collected)*, there is a comparability between the Eurostat data and the EEA-model data as shown in Table 26;
3. It is assumed that apart from the stream *MSW generation*, the following two streams are suitable for adjustment

a. *Dry recyclables collected* (EEA-model) vs. *Recycling* (Eurostat)
b. *Organic wastes collected* (EEA-model) vs. *Composting/digestion* (Eurostat)

These two streams are likely to have a closer (and with a specific factor for 2015[28]) relation between EEA-model and Eurostat data (streams marked in italics in Table 26). The stream mixed (residual) waste is less comparable, since this stream represents the sum of all other treatment parameters covered in the Eurostat data, and the comparison of the differentiated mixed residual waste fractions going to landfill, to incineration and the outputs of MBT would require a more comprehensive calculation with the EEA-model.

Based on the above assumptions, the following approach was taken for the adjustment, using the Eurostat values for the three streams generation, dry recyclables, organic waste:

1. Adjust the value for waste generation 2017 of the EEA-model by setting it to the value reported to Eurostat;
2. Adjust the trend 2015 to 2017, calculated by the EEA-model for dry recyclables and organic waste with the Eurostat trend as follows:
   a. Use the ratio 2017 to 2015 of these two streams of the EEA, to 'remove' the trend 2015 to 2017 reflected in the EEA-model data,
   b. Use the ratio 2017 to 2015 of the two corresponding Eurostat streams, to 'force' the trend 2015 to 2017 reflected in the Eurostat data, i.e. the data reflecting the real trend.
3. Check the Eurostat metadata for breaks, outliers etc. and make manual corrections to the trend factor or the results of the adjusted figures.
4. When the streams dry recyclables and organic waste are adjusted, calculate the **mixed (residual) waste** as **Generation$_{\text{adjusted}}$ - dry recyclables$_{\text{adjusted}}$ - organic waste$_{\text{adjusted}}$**

Following the approach described above, the waste generation and the three major streams of the EEA-model data describing the first treatment are adjusted to the reported magnitude and the trends over the two years reflected by the Eurostat reporting.

The further proceeding consists in the validation of the calculations. This validation was planned to be performed only for the larger countries which cover 80% or more of the 2 defined EU-clusters and also for the remaining EU countries not represented in a cluster which are marked in bold in Table 27 below. The validation covered the following:

1. Quick check of Eurostat metadata for methodological changes and of the adjustment factors; corrections of obvious inconsistencies (e.g. extreme different trends caused by methodological breaks such as the exclusion of MBT amounts from composting/digestion in the Eurostat data in 2017 compared to 2015)
2. Comparison of all relevant breakdowns in % used in the model 2017 and 2015 and adjustment of major inconsistencies (documented in the mentioned tables of Annex A.1)
   a. Total MSW composition by materials (Table 104),
   b. Breakdown of residual waste treatment (landfill, incineration and MBT), including further breakdowns of MBT (5 types) and incineration (4 types) (Table 107),

28 Considering the fact that the Eurostat data do not exactly fit the EEA-values for the waste streams shown in Table 1, but considering also, that country visits were conducted that shed light into exactly these differences, one can assume, that the values for 2015 have a certain relation to the Eurostat values. In the data sheets for each country, the Eurostat data for the streams presented in Table 1 are compared with the EEA-model data for the year 2010 to 2017 and the ratios are calculated. Of particular interest are the ratios for 2015, since these reflect the latest available actual data from the data gathering for the EEA-model.

   c. Breakdown of organic waste treatment (aerobic treatment and anaerobic digestion), including further breakdowns of aerobic treatment (2 types) and anaerobic digestion (5 types) (Table 108 and Table 109)
   d. Capture rates for dry recyclables and organic wastes (Table 105)
   e. Loss rates to calculate the rejects for dry recyclables and organic wastes (Table 106),
3. Compare the calculated residual waste composition with the composition data from literature research (e.g. from national waste management plans) (Table 110),
4. When the reporting to Eurostat is known to be close to the concept of final treatment: Comparison of the amounts calculated by the model for final treatment with the Eurostat data.

During the work on points number 1 and 2 above for the larger countries, it turned out, that some major breaks in the Eurostat data or some obvious mistakes occurred in the model (breakdowns larger 100%, capture rates larger than 100%), which require correction in any case. For this reason, the validations 1 and 2 needed to be performed for all countries, while the remaining validations were only applied to the 12 larger countries shown in **bold** in Table 27 (except for the composition data, which were only available for the 14 countries marked in the right column).

The shares shown for the EU-groups at the bottom of the table illustrate the extent, to which the respective EU-group was covered by the validation based on the population of the covered countries (81% to 84%, the second column to the right). This means that the 12 countries marked in Table 27 in bold cover more than 80% of the respective cluster/group by population. These 12 countries also cover more than 80% of the two EU-aggregates (81% of EU28, 84% of EU27). Since the availability of composition data was different from the selected larger countries, the shares at the bottom of the right column illustrate the corresponding shares for the check of the available composition data (45% to 91%). It can be seen that the availability of composition data was low in Cluster 1 (45%), but on account of Cluster 1 representing only one-fifth of the total EU-population, the shares of composition data checked for the EU-aggregates still amount to 78%.

Table 27: Countries covering larger 80% of the 2 EU clusters and from the remaining non-clustered countries (marked in bold), to be considered for the validation; and countries with available composition data checked

Cluster	Country	Country-Code	Population 2017	Share within Group	Common share of **large**/small countries	Composition data used (**x = yes**)
1	Malta	MT	460,297	0%	17%	
	Cyprus	CY	854,802	1%		
	Estonia	EE	1,315,635	1%		X
	Latvia	LV	1,950,116	2%		
	Lithuania	LT	2,847,904	3%		
	Croatia	HR	4,154,213	4%		X
	Slovakia	SK	5,435,343	5%		
	Bulgaria	**BG**	**7,101,859**	**7%**	**83%**	
	Hungary	**HU**	**9,797,561**	**10%**		X
	Greece	**EL**	**10,768,193**	**11%**		X
	Romania	**RO**	**19,644,350**	**19%**		X
	Poland	**PL**	**37,972,964**	**37%**		
2	Ireland	IE	4,784,383	3%	16%	X
	Finland	FI	5,503,297	3%		
	Denmark	DK	5,748,769	4%		
	Sweden	SE	9,995,153	6%		
	Portugal	**PT**	**10,309,573**	**6%**	**84%**	
	Czech Republic	**CZ**	**10,578,820**	**7%**		X
	Spain	**ES**	**46,528,024**	**29%**		X
	France	**FR**	**66,804,121**	**42%**		X
remaining non-clustered EU countries	Luxembourg	LU	590,667	0%	16%	X
	Slovenia	SI	2,065,895	1%		
	Austria	AT	8,772,865	4%		
	Belgium	BE	11,351,727	5%		
	Netherlands	NL	17,081,507	7%		X
	Italy	**IT**	**60,589,445**	**24%**	**84%**	X
	United Kingdom	**UK**	**65,844,142**	**26%**		X
	Germany	**DE**	**82,521,653**	**33%**		X
	Cluster 1		102,303,237	100%	**83%** / 17%	**45%** / 55%
	Cluster 2		160,252,140	100%	**84%** / 16%	**80%** / 20%
	Remaining non-clustered countries		248,817,901	100%	**84%** / 16%	**91%** / 9%
	EU27		445,529,136		**81%** / 19%	**78%** / 22%
	EU28		511,373,278		**84%** / 16%	**78%** / 22%

1) Eurostat: Population on 1 January 2017 (demo_gind), extracted on 08.08.2019

The material streams *WEEE*, *batteries and accumulators, hazardous waste (excl. WEEE), rubble and soil* and, within dry recyclables, *textiles*, are not in the scope of this study but needed to be kept in the calculations in order to be coherent with the Eurostat data, which also contain these streams. If the streams were taken out of the calculations, wrong adjustment factors would have resulted. Therefore, these streams are used in the overall calculations of the MSW data but are disregarded in the finally presented amounts and the GHG balances.

The presented amounts (see Chapter 5.2.1 to 5.2.4) represent the aggregates of the figures of the covered materials, compiled on the basis of the explained methodology (EEA-model and MSW statistics reported to Eurostat, see Annex A.3, see column “total within scope) for all Member States except Germany. The values from Germany were taken from the separate data collection of the German data (see partial report Germany). Since the structure of the German data is different from the breakdowns of the MSW data derived at the European level, the German data are not presented in Annex A.3 but are only shown in the next chapters at the aggregate level.

5.2 Waste generation and treatment

5.2.1 MSW generated

This chapter provides an overview of the amounts of MSW generated. In Table 28, the amounts are presented by the main streams covered in the following chapters in more detail (first treatment and its outputs):

- (mixed) residual waste (5.2.2),
- separately collected fractions
  - dry recyclables (Chapter 5.2.4)
  - organic waste (Chapter 5.2.3)

The uncollected amounts are shown in a separate column and refer to amounts generated in areas without a MSW collection system. These amounts were estimated and reported by four countries to a low extent and were regarded as landfilled.

All presented tables cover the Clusters 1 and 2, the EU27-aggregate without Germany, Germany (DE), the EU27 and the EU28 aggregates. This aggregate EU27 (w/o DE) was created and presented to make the calculation transparent to calculate the EU27 and the EU28 aggregates by adding the German data. The EU27 (w/o DE)-aggregate is also presented in Annex A.3 in order to be coherent with the data presented below. All parameters are presented in the units of 1,000 tons, kg per capita and percent (related to the total amounts in bold). All tables are based on the tables of the detailed data presented in Annex A.3.

It can be seen, that the overall MSW generated in the EU28 is 241 million tons for the covered materials or 471 kg per capita. In Cluster 1, the generation per capita is the lowest (353 kg/cap.), while Germany has the highest generation with 597 kg per capita.

The degree of the mixed and separate collection shows the expected pattern. While in Cluster 1, 73% of the generated waste is residual waste, this share is increasingly lower for Cluster 2 and the EU-aggregates and lowest in Germany with 42%. This observation is also reflected in the amounts per capita of collected dry recyclables and organic waste which are lowest in Cluster 1 and highest in Germany.

The amounts per capita for residual waste collected are in a similar order for all clusters except Cluster 2 (252 to 278 kg/cap.). This indicates that many countries with large shares of separate collection have a higher waste generation per capita. Uncollected amounts mostly occur in Cluster 1 and to a lower extent in Cluster 2, but in overall minor amounts.

Table 28: MSW generation, 2017

Cluster	Residual Waste		Dry Recyclables[3]	Organic waste[4]	Total generation
	Collected[1]	Uncollected[2]			
1,000 tons					
Cluster 1	26,406	455	6,863	2,388	**36,112**
Cluster 2	52,176	44	16,380	9,639	**78,240**
EU27 (w/o DE)	100,781	499	37,767	23,526	**162,573**
DE	20,821	0	17,269	11,143	**49,232**
EU27	121,602	499	55,035	34,669	**211,805**
EU28	138,844	499	62,456	39,150	**240,949**
kg/cap					
Cluster 1	258	4	67	23	**353**
Cluster 2	326	0	102	60	**488**
EU27 (w/o DE)	278	1	104	65	**448**
DE	252	0	209	135	**597**
EU27	273	1	124	78	**475**
EU28	272	1	122	77	**471**
%					
Cluster 1	73%	1%	19%	7%	**100%**
Cluster 2	67%	0%	21%	12%	**100%**
EU27 (w/o DE)	62%	0%	23%	14%	**100%**
DE	42%	0%	35%	23%	**100%**
EU27	57%	0%	26%	16%	**100%**
EU28	58%	0%	26%	16%	**100%**

Source tables:

1) Table 114 and Table 115.

2) Table 116 and Table 117.

3) Table 129 and Table 130.

4) Table 122 and Table 123.

5.2.2 Residual waste collected

This chapter presents the results of the calculations for residual waste collection and treatment. Residual waste in the scope of this study covers the following streams:

- Household and business waste (collected together)
- Household-type commercial waste (collected separately)
- Bulky waste collected for incineration, landfill of MBT
- Street sweepings

These streams are covered by concept of the EEA-model, but the EEA-model does not differentiate between these streams. In fact, the data reflect the mixture of the mixed (residual) waste streams by the 16 materials covered by the data of the model.

Table 29 displays the first treatment of the total collected residual waste, broken down into the main treatment categories as follows:

- Mechanical biological treatment (MBT)
- Incineration (INC)
- Landfill (LF)

It can be seen that the data reflect well the different residual waste management approaches applied by the clusters of member states, with landfilling being the least ambitious way of treatment and incineration the most advanced and costly.

Cluster 1 relies very much on landfilling (49%) as residual waste management in comparison to the other clusters. Also, treatment in MBT has increased a lot in Cluster 1 in recent years and is almost at the same level as landfilling, while incineration plays a minor role (5%). Remarkable is the strategy of Cluster 2, where incineration is the most important treatment option (41%), followed by equal shares of 29% for MBT and landfilling.

For the EU27 (w/o DE)-aggregate, landfilling is at the same level as for Cluster 2 (29%), but the most important treatment is MBT with a share of 38%. For the EU27 and EU28, incineration (39%) is the most important treatment of residual waste, followed by MBT (37%) and landfill (24%). The higher incineration rates and lower landfill rates compared to EU27 (w/o DE) are caused by the inclusion of Germany, where incineration is most important (67%) and landfilling is zero.

Table 29: Residual Waste treatment, 2017

Cluster	MBT	Incineration	Landfill	Residual Waste treated total
		1,000 tons		
Cluster 1	12,145	1,220	13,040	**26,406**
Cluster 2	15,357	21,491	15,329	**52,176**
EU27 (w/o DE)	38,420	33,163	29,199	**100,781**
DE	6,856	13,960	5	**20,821**
EU27	45,275	47,123	29,204	**121,602**
EU28	51,042	53,832	33,970	**138,844**
		kg/cap		
Cluster 1	119	12	127	**258**
Cluster 2	96	134	96	**326**
EU27 (w/o DE)	106	91	80	**278**
DE	83	169	0	**252**
EU27	102	106	66	**273**
EU28	100	105	66	**272**

Cluster	MBT	Incineration	Landfill	Residual Waste treated total
		%		
Cluster 1	46%	5%	49%	**100%**
Cluster 2	29%	41%	29%	**100%**
EU27 (w/o DE)	38%	33%	29%	**100%**
DE	33%	67%	0%	**100%**
EU27	37%	39%	24%	**100%**
EU28	37%	39%	24%	**100%**

Source tables: Table 118 and Table 119.

In the source tables (see Annex A.1.4), the amounts treated by incineration and MBT are further broken down by 4 types and 5 types, respectively. The following incineration-types are covered by their way of energy recovery:

- INC 1: Incineration - Electricity Only
- INC 2: Incineration – combined heat and power (CHP): Heat and electricity used.
- INC 3: Incineration - Heat Only
- INC 4: Incineration Only (no energy recovery)

The following MBT-types are covered:

- MBT 1 – Biostabilization: Mechanical separation of metal and plastics, subsequent biological stabilization (mixed waste composting) with subsequent landfilling or land recovery,
- MBT 2 - Biodrying no plastics recycling: Mechanical separation of metals only, the remainder is biodryed for production of refused derived fuel (RDF) and landfilling of residues,
- MBT 3 - Biodrying with plastics recycling: as MBT 2, but also a separation of plastics,
- MBT 4 - AD based: Mechanical separation of metal and plastics, subsequent anaerobic digestion and landfilling of digestate, no RDF production,
- MBT 5 - basic sorting + energy generation: Mechanical separation of metal and plastics, Residues landfilled (inerts) or incinerated (high calorific fractions).

For landfills, no further characterization is available from the model.

Table 30 shows the output data from MBTs. The outputs are calculated in the EEA-model for the following categories:

- Landfill
- Energy recovery (by co-incineration or as refuse-derived-fuel)
- Land recovery (for landscaping purposes or usage as landfill cover)
- Recycling
- Mass loss (from biological degradation and water evaporation)

The total amounts shown in Table 30 correspond to the input to MBT shown in Table 29, since the mass losses are also estimated by the model. The distribution of the output-amounts to the various final treatments is a result of the cluster-specific mixes of MBT-types laid down in the model, since the mass flow assumptions vary between the MBT-types and are calculated in the same way for all countries (see Table 112). The assumptions consider no energy recovery for MBT 1 and MBT 4, which focus on biostabilisation, while the other MBT types, particularly

MBT 5, are assumed to have an increasing focus on the separation of high calorific materials for energy recovery. The German data are, as already mentioned, taken from a different data pool and not from the EEA-model.

Except for Germany, where energy recovery dominates the treatment of MBT outputs (78%), landfilling is the most important treatment option of outputs from MBT, ranging from 37% for Cluster 2 to 44% for Cluster 1 and EU27 (w/o DE). The German data for the share of MBT outputs landfilled (9%) reduces the landfill shares of outputs from the EU27 (39%) and EU28 (37%). The same applies to the mass loss and land recovery, where the low German values decrease the EU27 and EU28 shares compared to the EU27 (w/o DE). The rates of recycling are with 3% generally low and equal for all clusters, with Germany (4%) in a similar order of magnitude despite the different data sources.

Table 30: MBT-Outputs, 2017

Cluster	Landfill	Energy Recovery	Land Recovery	Recycling	Mass loss	Total
			1,000 tons			
Cluster 1	5,290	2,958	1,336	410	2,151	**12,145**
Cluster 2	5,644	1,327	2,939	474	4,974	**15,357**
EU27 (w/o DE)	16,955	4,648	6,020	1,274	9,524	**38,420**
DE	639	5,317	0	262	638	**6,856**
EU27	17,594	9,964	6,020	1,535	10,162	**45,275**
EU28	18,716	13,099	6,404	1,738	11,084	**51,042**
			kg/cap			
Cluster 1	52	29	13	4	21	**119**
Cluster 2	35	8	18	3	31	**96**
EU27 (w/o DE)	47	13	17	4	26	**106**
DE	8	64	0	3	8	**83**
EU27	39	22	14	3	23	**102**
EU28	37	26	13	3	22	**100**
			%			
Cluster 1	44%	24%	11%	3%	18%	**100%**
Cluster 2	37%	9%	19%	3%	32%	**100%**
EU27 (w/o DE)	44%	12%	16%	3%	25%	**100%**
DE	9%	78%	0%	4%	9%	**100%**
EU27	39%	22%	13%	3%	22%	**100%**
EU28	37%	26%	13%	3%	22%	**100%**

Source tables: Table , Table 120 and Table 121.

In the following chapter, the treatment of organic waste is presented.

5.2.3 Organic waste

This chapter presents the results of the calculations for the generation and treatment of separately collected organic waste. Organic waste as available from the EEA-model covers the following streams:

- Food waste
- Garden waste
- Other biowastes (no clear allocation to food or garden possible)

Table 31 shows the treatment and residues of the amounts of separately collected organic waste. It is broken down by the main treatment categories as follows:

- Open Air Windrow
- In-Vessel Composting
- Anaerobic Digestion (AD)

The residues from organic waste treatment are assumed in the EEA-model to be landfilled or incinerated. They are subjected to reject rates (see Table 106) applied to the amounts of organic waste **collected,** which are assumed in the model to be **equal to the inputs** to the above mentioned three types of organic waste treatment (columns 2 to 4 below). Thus, the amounts are shown in Table 31 in the column "Input total", which refers to the amounts of organic waste collected. The percentages of residues subject to landfilling or incineration are then again related to the total input and do therefore not add up to 100%. In the logic of the model, the differences of rejects to 100% represent the recycling rates for organic waste.

The data presentation is limited to the total incineration. The data presented in the source tables also contains the breakdown by the 4 types of incineration as described under residual waste in Chapter 5.2.2.

The total amount of organic waste collected in the EU28 is 39 million tons, which corresponds to 77 kg per capita for the EU28 and 78 kg per capita for the EU27. As can be expected, the organic waste collected in Clusters 1 and 2 is lower on the per capita-level than the EU-average. In Cluster 1 much less organic waste is collected (23 kg/cap) than in Cluster 2 (60 kg/cap).

Despite the differences in the per-capita-amounts across the different clusters, the distribution among the different organic waste treatment types is also different. In Cluster 1, the open-air windrow technology dominates with 78%, while in Cluster 2, 72% of the inputs refer to in-vessel treatment. The share of anaerobic digestion is lowest in Cluster 1 (6%), followed by Cluster 2 (10%) and is highest in Germany (32%). The latter causes the difference of the shares of AD between the EU27 (w/o DE) (16%) and the EU27 (21%) as well as the EU28 (20%).

The total reject rates (sum of presented shares of residues landfilled and incinerated) of all EU-clusters without Germany (5%), resulting solely from the EEA-model, are lower than that of Germany from national data sources (8%). The rates from EU27 and EU28 (both 6%) are again a result of the influence of Germany´s higher rate. The distribution of reject treatment among the categories landfilling and incineration is a result of the model assumptions and reflects in principle the treatment strategies for residual waste except for MBTs, which are assumed in the model not to receive any rejects.

Table 31: Organic waste treatment and residues, 2017

Cluster	Open air windrow	In-vessel composting	Anaerobic digestion	Input total	Residues to	
					Incineration[1]	Landfill
1,000 tons						
Cluster 1	1,870	375	143	**2,388**	31	92
Cluster 2	1,661	6,978	1,001	**9,639**	327	190
EU27 (w/o DE)	7,629	12,143	3,753	**23,526**	943	345
DE	4,266	2,960	3,594	**11,143**	863	0
EU27	11,895	15,104	7,348	**34,699**	1,806	345
EU28	14,800	16,113	7,916	**39,150**	1,958	453
kg/cap						
Cluster 1	18	4	1	**23**	0	1
Cluster 2	10	44	6	**60**	2	1
EU27 (w/o DE)	21	33	10	**65**	3	1
DE	52	36	44	**135**	10	0
EU27	27	34	16	**78**	4	1
EU28	29	32	15	**77**	4	1
%						
Cluster 1	78%	16%	6%	**100%**	1%	4%
Cluster 2	17%	72%	10%	**100%**	3%	2%
EU27 (w/o DE)	32%	52%	16%	**100%**	4%	1%
DE	38%	27%	32%	**100%**	8%	0%
EU27	34%	44%	21%	**100%**	5%	1%
EU28	38%	41%	20%	**100%**	5%	1%

1) For Germany, 322 000 tons of organic waste were directly treated by biomass power stations. These amounts were allocated to incineration of residues and are included in the total amount collected. For this reason, the sum of the three organic waste treatments (Open Air Windrow, In-Vessel Composting, Anaerobic Digestion) is lower than the total amount collected for DE, EU27 and EU28.

Source tables: Treatment: Table 124 and Table 128; residues: Table 133 and Table 134.

In the source tables (see Annex A.3.2), the amounts treated by AD are further broken down into5 types according to the use of the biogas as follows:

- AD 1 - Electricity Only
- AD 2 – combined heat and power (CHP): Heat and electricity used.
- AD 3 - Gas to Grid
- AD 4 - Gas to Vehicle Fuel
- AD 5 - Gas to Flaring Only (no energy recovery)

The following section summarises the results of the research on home composting in the EU.

5.2.3.1 Home composting

Home composting of organic waste is widespread in many EU Member States but reliable data on the respective quantities are scarce. Several countries are encouraging and/or actively promoting home composting of bio-waste through a variety of measures. Among these countries are Belgium (Flemish region), Bulgaria, Croatia, Finland, Greece, Hungary, Lithuania, Poland, Romania, Slovenia, Slovakia and the UK.

However, most EU countries do not include home-composted quantities for the calculation and reporting of the amounts of MSW generation and recycling. Home composting is therefore not regularly measured. Furthermore, measuring of home composting is methodologically challenging. Among the few countries that include home composting in their MSW data are Finland, Sweden, and Italy.

The available data vary considerably in terms of quantity and probably also in terms of quality. The respective information is summarised in the following:

- In Austria, home and community composting play an important role, especially in rural areas. In 2018, it is estimated that 1.5 million tons of biogenic materials were recovered across the country through home and community composting. Hence, an annual volume of 169 kg/cap per person can be assumed. The volume was determined based on a study from the "Environmental protection" specialist department in the province of Upper Austria, in collaboration with the provincial statistical service, and was adapted to regional circumstances. The estimate indicates that the amount of home-composted material is higher than the amount of organic waste collected separately from households and similar establishments of 1,035 million tons. (BMK AT 2020).
- Denmark reports in its National Inventory Report that in 2017 23,000 tons of garden and vegetal food waste were composted which corresponds to 4 kg/cap (NIR DK 2019). This figure is an update of study results for reference years 2001. (Petersen & Kielland 2003) According to the study from 2003, the determined amount refers to vegetal food waste only and not to garden waste which would explain the comparably low per-capita amount.
- In the Flemish waste policy, the encouragement of home composting for vegetable, fruit, and garden waste is a key element that is actively promoted e.g. through courses, campaigns, and information materials. As a result, about 52% of all the population compost at home – up from 5% in 1991 – and an estimated 106,000 tons (16 kg/cap) of organic wastes are treated this way. (EEA(a) 2016).
- As mentioned above, Finland is one of the EU countries that includes home-composted amounts in its data on MSW generation and recycling. A home composting target of 6% of the MSW generated was part of the national waste plan that was running until 2016. The annual amount of home-composted organic waste is reported with 54,000 tons or 9.8 kg/cap respectively. It seems that Finland uses the same estimate for home composting already since the reference year 2000. (EEA(b) 2016).
- In Sweden, home composting figures are also included in the municipal waste generated. “In the case of composting household waste such as food waste, registration of home composting is required from households and, in case of lacking data, standard values of 180 kilograms per household per year in detached houses and 100 kilograms per household per year in apartment houses can be used for estimation.” (EEA(c) 2016).

- France has launched a national promotion plan for home composting in 2006 and carried out an interview-based survey on home composting in 2008. Based on this survey France estimates that around 4.1 million tons or 65 kg/cap of organic waste are managed by home composting (3.5 million t of garden waste; 0.6 million t of kitchen waste), which corresponds approximately to the amount of organic waste that separately collected and composted by public services. (ADEME 2009).

The cited figures indicate that the data on home composting are scarce, and their quality seems often limited as they mostly are based on one-off studies which are rather old in some cases. However, data availability will most likely improve in the coming years due to the recast of Directive 2008/98/EC. The Directive sets out that EU Member States may count home composting of municipal organic waste towards the MSW recycling rates set out in Art 11(2). A methodology for calculating municipal organic waste separated and recycled at source referred to in Art 4(3) is laid down in Annex II of decision 2019/1004/EU, which was published in June 2019. Considering the ambitious future recycling targets, it seems likely that several countries will make use of including the amounts of home composted organic waste in the calculation of their recycling rates.

5.2.4 Dry recyclables waste

Table 32 shows the recycled amounts and residues of the amounts of separately collected dry recyclables. Since the model assumes all dry recyclables being subjected to mechanical separation (e.g. sorting), the amounts collected in column Dry 'recyclables collection' can be regarded as the input to mechanical separation categories.

Table 32: Dry recyclables and residues, 2017

Cluster	Recycled	Residues to		Dry recyclables collection
		Incineration	Landfill	
1,000 tons				
Cluster 1	5,815	238	811	**6,863**
Cluster 2	14,341	1,159	879	**16,380**
EU27 (w/o DE)	32,668	3,159	1,940	**37,767**
DE	13,784	3,482	3	**17,269**
EU27	46,451	6,641	1,943	**55,035**
EU28	52,959	7,175	2,322	**62,456**
kg/cap				
Cluster 1	57	2	8	**67**
Cluster 2	89	7	5	**102**
EU27 (w/o DE)	*90*	*9*	*5*	***104***
DE	167	42	0	**209**
EU27	104	15	4	**124**
EU28	*104*	*14*	*5*	***122***

Cluster	Recycled	Residues to		Dry recyclables collection
		Incineration	Landfill	
%				
Cluster 1	85%	3%	12%	**100%**
Cluster 2	88%	7%	5%	**100%**
EU27 (w/o DE)	86%	8%	5%	**100%**
DE	80%	20%	0%	**100%**
EU27	84%	12%	4%	**100%**
EU28	*85%*	*11%*	*4%*	***100%***

Source tables: Recycling: Table 124 and Table 128; residues treatment: Table 133 and Table 134.

The data presentation is limited to the total incineration. The data presented in the source tables also contain the breakdown by the 4 types of incineration as described under residual waste in Chapter 5.2.2.

The total amount of dry recyclables collected in the EU28 is 62 million tons or 122 kg per capita, while in the clusters the values are much lower (Cluster 1: 67 kg/cap.; Cluster 2: 102 kg/cap.) and almost the same value for the EU27 (w/o DE) (104 kg/cap.). The largest value of dry recyclables collected has Germany (209 kg/cap.), which is responsible for the higher rates in EU27 (124 kg/cap.) and to some extent in the EU28 (122 kg/cap.) when compared to the EU27 (w/o DE).

Although the shares of residues vary between 12% and 20% for all clusters and Germany, the differences in the per capita values recycled between the clusters follow the trend described above for the amount of dry recyclables separately collected. The differences in the shares of residues are a result of the fact that the reject rates are different for the materials (e.g. low for glass, high for plastics, see Table 106), and that each cluster has a specific composition of dry recyclables by materials.

The following chapter summarizes the amounts presented in the previous chapter to a presentation of the resulting base data for GHG balancing.

5.2.5 Base data for GHG balancing

Table 33 shows the data on the generation and treatment of MSW as used for the GHG balancing. Compared to the data presented the previous chapter several adjustments were made as explained in the following.

- Some waste categories were completely excluded from the GHG balancing for the following reasons: The waste categories 'fines' 'inerts' and 'other' were excluded from separate collection of dry recyclables, because no suitable data records for the GHG balancing are given. This reduces the amounts of dry recyclables compared to Table 32 and the totals of MSW generated compared to Table 28[29], respectively.

29 These amounts are shown in Table 129 and amount to 1,126 kt for Cluster 1, 528 kt for Cluster 2, zero for DE, 2,444 kt for EU27 (w/o DE) and EU27, and 2,945 kt for EU28.

Table 33: Base data for the GHG balancing of MSW for Cluster 1, Cluster 2, EU27 and EU28, 2017, in 1,000 tons

Waste fraction	Cluster 1	Cluster 2	EU27 (w/o DE)	DE	EU27	EU28
			1,000 tons			
Residual waste	**26,861**	**52,220**	**101,280**	**20,821**	**122,101**	**139,343**
thereof residual waste landfill	13,495	15,373	29,698	5	29,703	34,469
thereof residual waste INC	1,220	21,491	33,163	13,960	47,123	53,832
thereof residual waste MBTs	8,905	14,986	34,701	2,970	37,671	41,765
thereof "mixed waste" sorting	3,240	371	3,719	3,885	7,604	9,277
Other biowaste	**69**	**32**	**1,578**	**4,479**	**6,057**	**6,754**
thereof composting	68	22	1,034	2,498	3,531	4,179
thereof anaerobic digestion	2	10	544	1,981	2,526	2,575
Garden waste	**1,660**	**7,088**	**14,062**	**5,682**	**19,743**	**22,949**
thereof composting	1,590	6,922	13,704	4,673	18,378	21,533
thereof anaerobic digestion	70	166	357	686	1,043	1,094
thereof biomass power plant	0	0	0	322	322	322
Food waste	**659**	**2,519**	**7,886**	**982**	**8,868**	**9,447**
thereof composting	587	1,694	5,034	55	5,090	5,200
thereof anaerobic digestion	71	825	2,851	927	3,778	4,247
Dry Recyclables	**5,737**	**15,852**	**35,323**	**17,269**	**52,592**	**59,511**
thereof paper	2,711	5,654	14,906	7,790	22,695	26,001
thereof glass	1,245	5,293	9,391	2,575	11,966	13,377
thereof plastics	1,081	2,377	5,440	1,137	6,577	7,324
thereof LWP	0	0	0	4,030	4,030	4,030
thereof metals	605	2,136	3,523	372	3,895	4,575
thereof wood	96	392	2,063	1,366	3,429	4,205
Total	**34,986**	**77,712**	**160,129**	**49,232**	**209,362**	**238,004**

► The breakdown of dry recyclables collected by materials presented in Table 33 is based on the values in Table 129.

- The minor amounts of uncollected residual waste[30] were regarded as residual waste landfilled and result in slightly larger amounts landfilled compared to Table 29.
- The amounts of organic waste presented in Table 31 were further broken down into the categories 'food', 'garden' and 'other biowaste' and are based on the detailed figures in Table 124 to Table 126.
- The German data for organic waste collection via bio bins was assigned to the category other biowaste (the EEA-model mostly uses disaggregated figures for these 'mixed organic waste' collections by assigning them to 'food' and 'garden').
- The category 'biomass power plant' does not exist in the EEA-model, but only in the German data, and is included in Table 33 to calculate the EU27 and EU28 aggregates.
- The figures for 'residual waste MBTs' in Table 33 are lower than those presented in Table 29, since they only contain the amounts treated in MBT 1 to MBT 4 according to the EEA-model, while MBT 5 was presented separately as "mixed waste" sorting. This was done for the reason that, in contrast to MBT 1 to MBT 4 (see Chapter 5.2.2), MBT 5 does not involve any biological treatment component and, therefore, requires separate consideration for the GHG-balancing; detailed data on the breakdown of MBT-treatment from the EEA-model are presented in Table 118.

As a result of the adjustments, the amount of MSW considered for the GHG balance are lower than the MSW considered in the previous chapters for all clusters and the EU.

The results of the basic data collection on the generation and the destination of MSW for EU27, EU28, Cluster 1 and Cluster 2 are shown as Sankey diagrams from Figure 7 to Figure 10. It should be noted that incineration, MBT (MBT 1 to 4 in the EEA-model) and MT (mechanical treatment, MBT 5 in the EEA-model) within the red dashed-border box, are considered together in the results of the GHG balance. Therefore, the term "residual MSW for treatment" will refer to these three treatment routes of residual waste in the following chapters. The results for landfilling of MSW will be presented separately under the term "residual MSW to landfill" as landfilling is of major relevance with regard to GHG emissions. Figure 11 shows the volumes of first treatment as a bar chart by waste type for the EU areas. Here the amounts of residual waste treatment via incineration, MBT, MT are summarised ("Res. MSW for treatment") and also the amounts for source segregated organic waste (garden waste, food waste and other biowaste), which are mainly treated via composting or anaerobic digestion due to their similar waste characteristic.

Both graphical representations, the Sankey diagrams and the bar chart, show that the majority of waste in the EU is still residual MSW. The shares are 58% for the EU27, 59% for the EU28, 77% for Cluster 1 and 67% for Cluster 2 (for comparison, the value for Germany is 42%). The separately collected dry recyclable materials (including wood) account for 25% both for the EU27 and EU28, 16% for Cluster 1 and 20% for Cluster 2 (Germany 35%). The share of the separate collected organic waste is 17% for the EU27, 16% for the EU28, 7% for Cluster 1 and 12% for Cluster 2 (Germany 23%).

The share of residual MSW for treatment and to landfill differs for the balance areas:

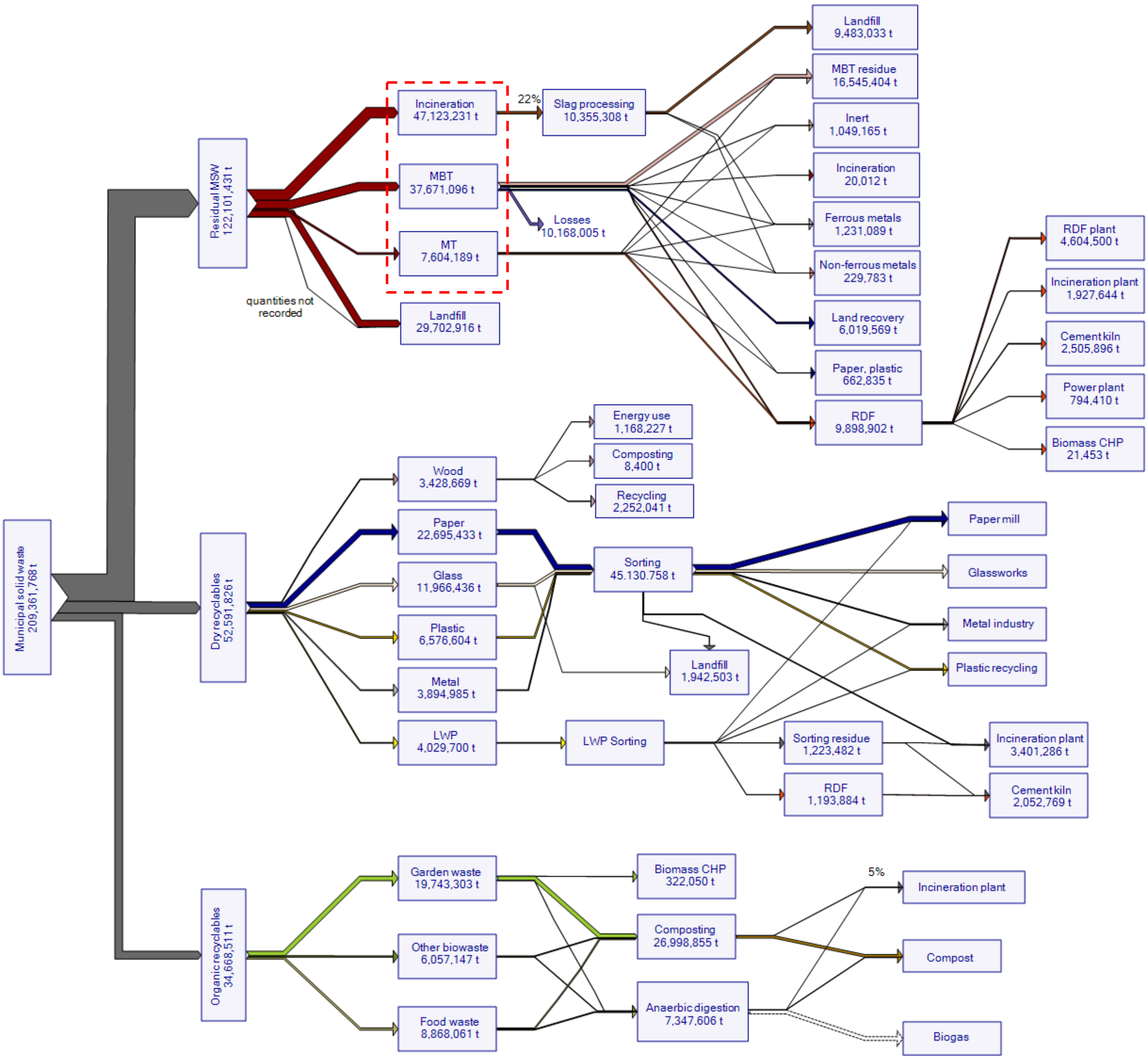
- EU27: 24% to landfill, 76% for treatment (thereof 51% incineration)
- EU28: 25% landfill, 75% for treatment (thereof 51% incineration)

30 Uncollected residual waste according to Table 28 are 455 kt in Cluster 1, 44 kt in Cluster 2 and 499 kt in EU27 (w/o DE), EU27 and EU28). Detailed country data on this issue can be found in Table 116.

- Cluster 1: 50% landfill, 50% for treatment (thereof 9% incineration)
- Cluster 2: 29% landfill, 71% for treatment (thereof 58% incineration)

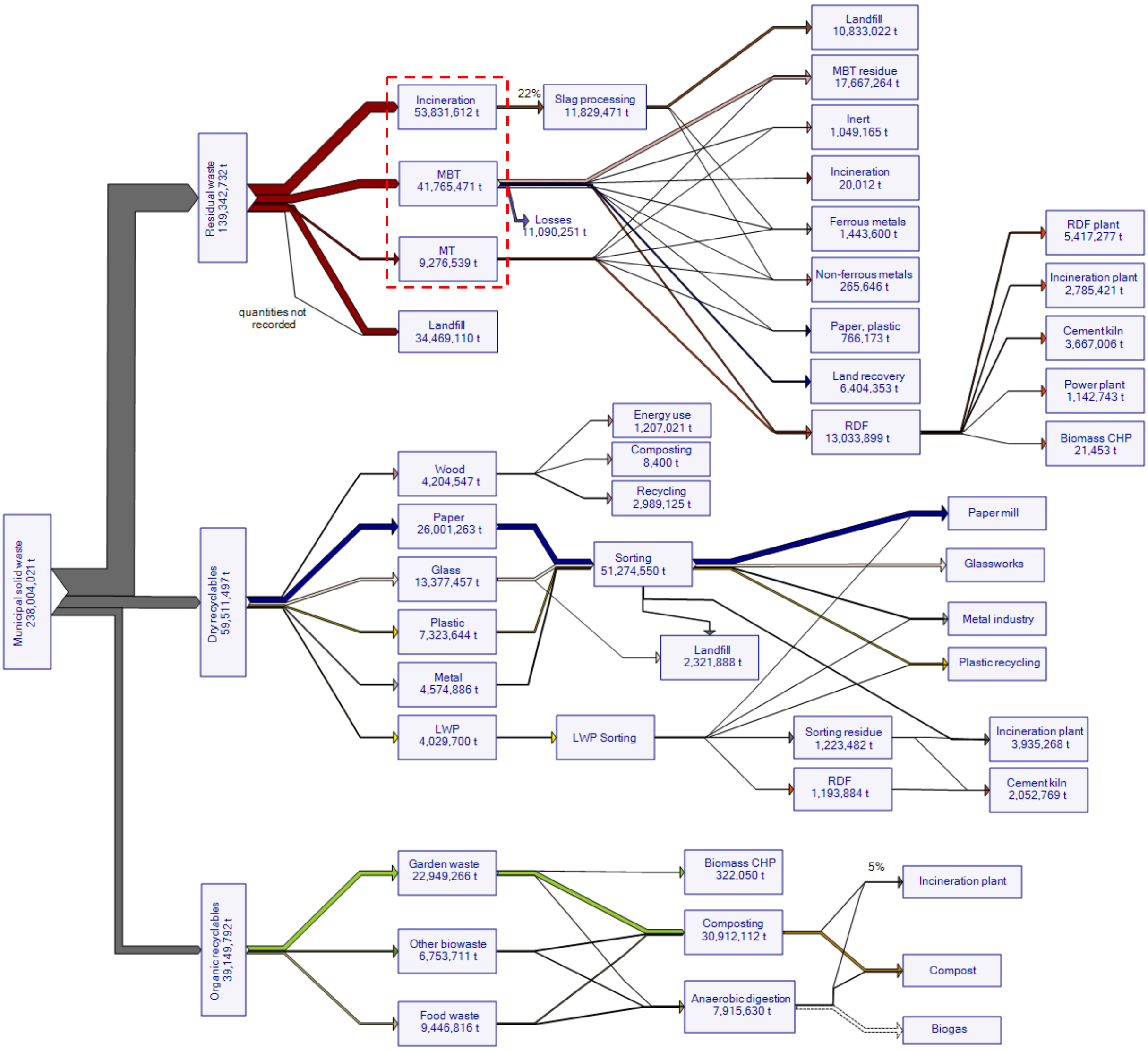
For comparison, in Germany 0% is landfilled, residual MSW for treatment is incinerated to 67%.

Figure 7: Sankey diagram MSW EU27 2017



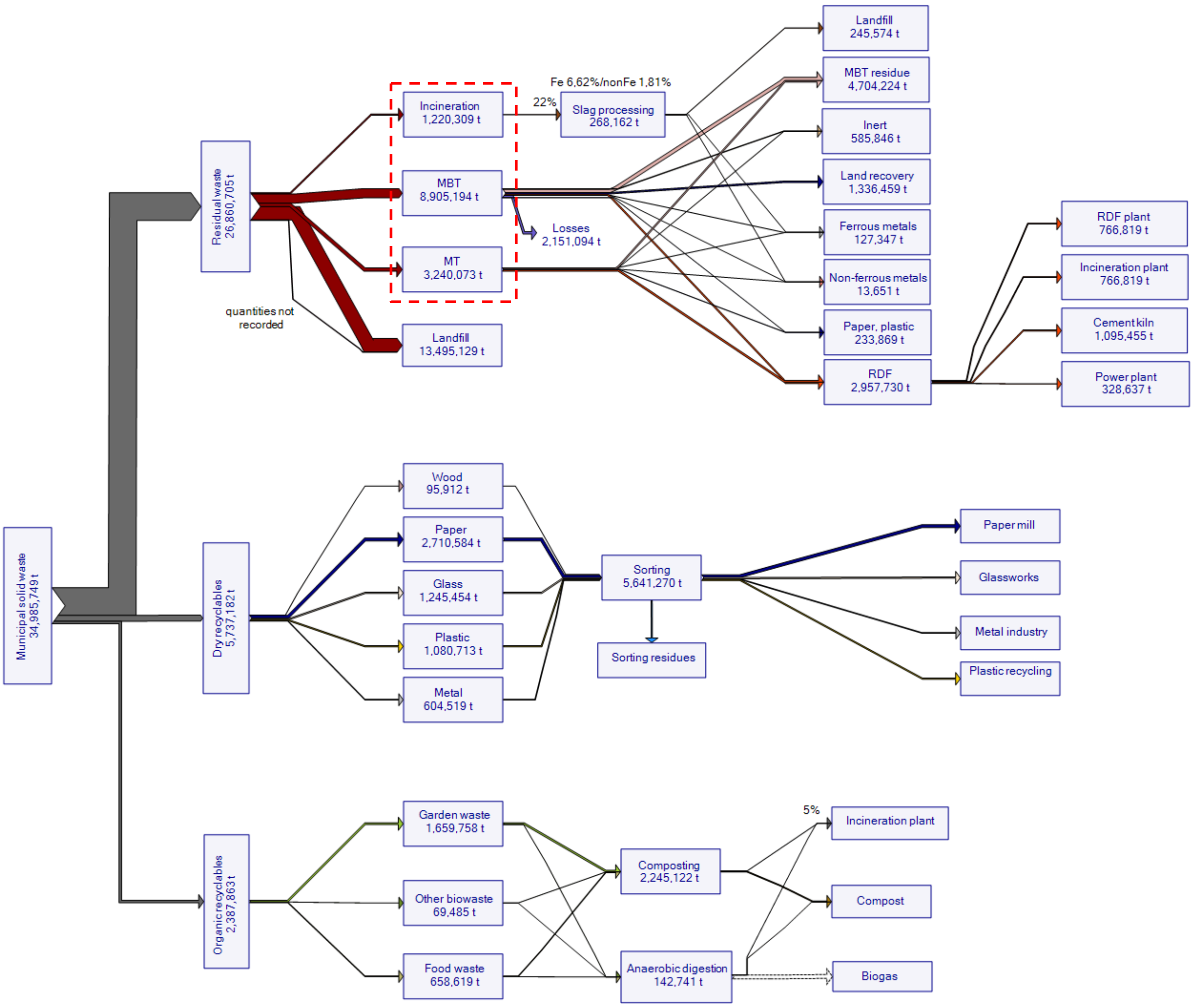
Source: own illustration, ifeu.

Figure 8: Sankey diagram MSW EU28 2017



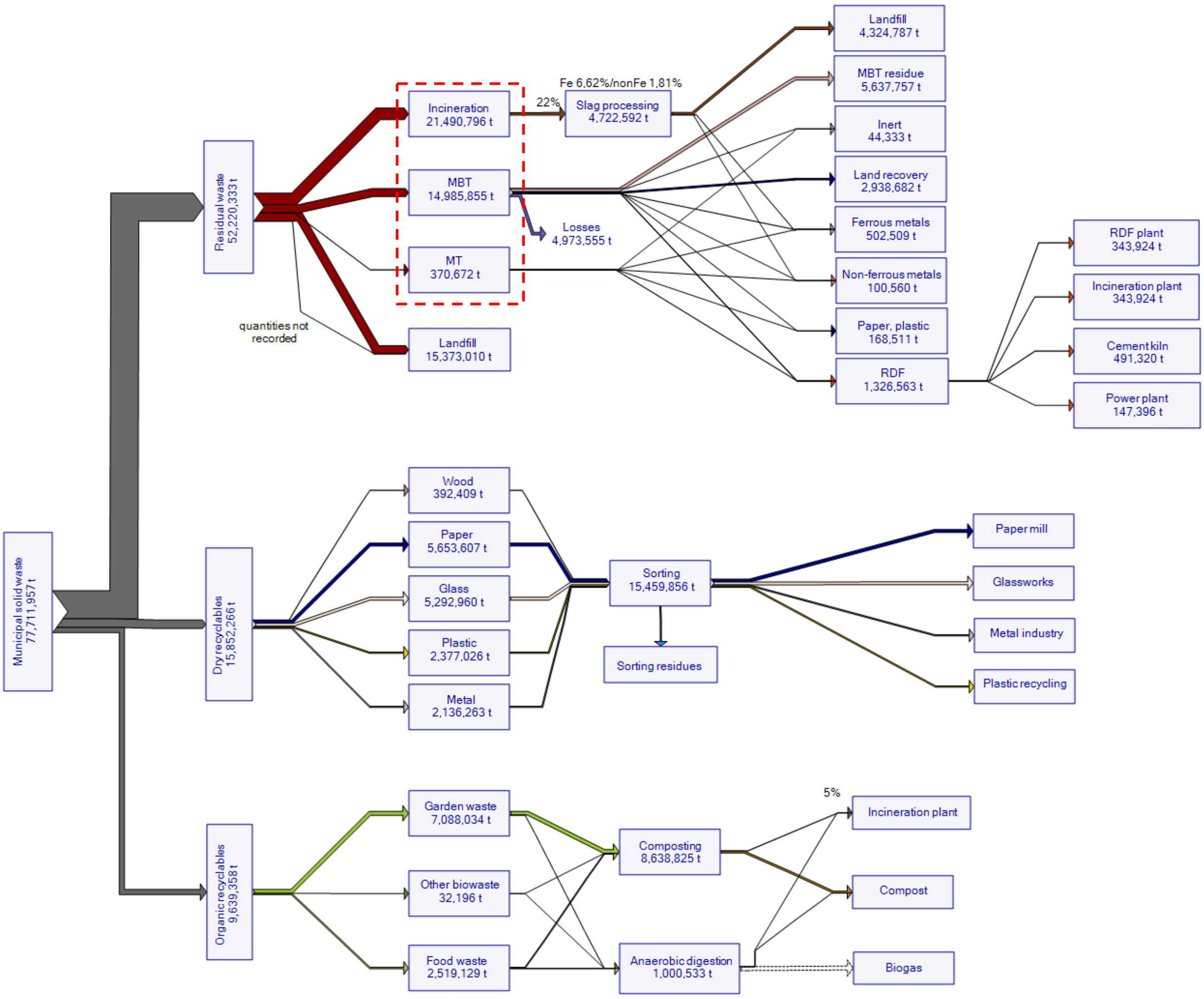
Source: own illustration, ifeu.

Figure 9: Sankey diagram MSW Cluster 1 2017



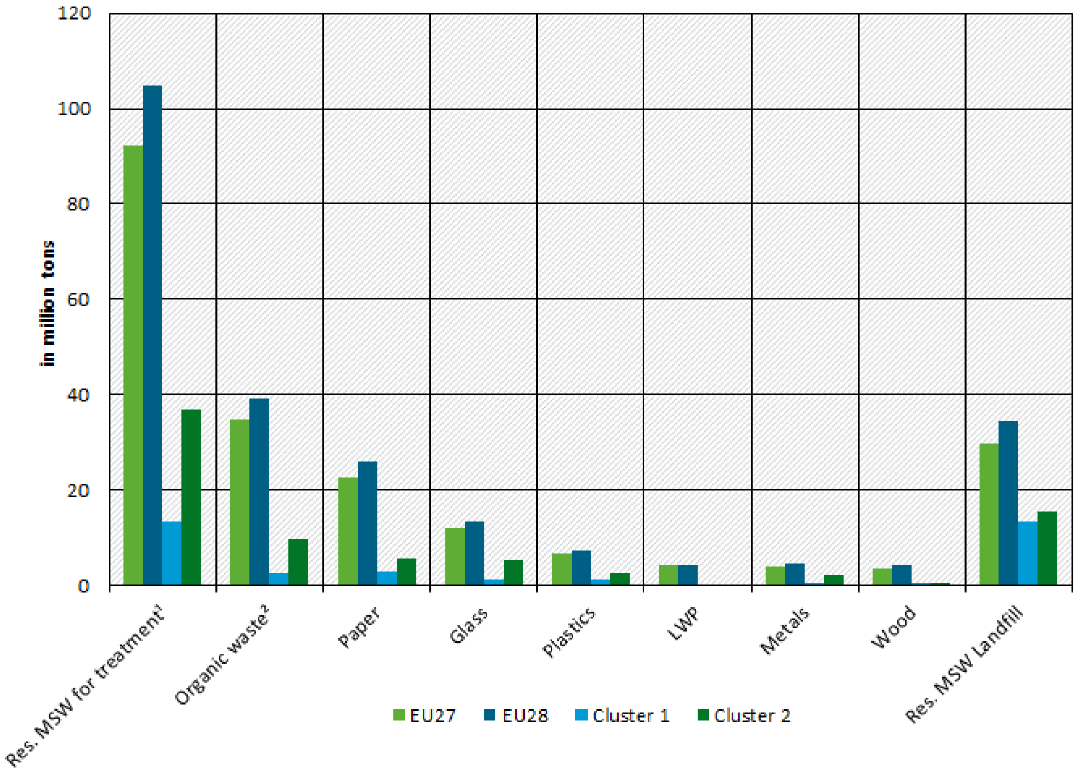
Source: own illustration, ifeu.

Figure 10: Sankey diagram MSW Cluster 2 2017



Source: own illustration, ifeu.

Figure 11: MSW generation in the EU



1) Total of residual waste treatment via incineration, MBT, MT

2) Total of food waste, garden waste and other biowaste

Source: own illustration, ifeu.

5.2.6 New treatment methods

As a part of the collection of material flow data for balancing, framework conditions for waste treatment processes, which have not yet been represented in the GHG balance models, were to be researched and compiled. For this purpose, three processes - pyrolysis, hydrothermal carbonisation (HTC) and conversion of waste with the soldier fly larva - were selected in the course of the project. They are suitable for the utilisation of organic residues. The three selected treatment processes are described in detail in the partial report Germany. For all three processes data from the UBA project "Determining criteria for high-quality alternatives for recycling of organic waste" (Bulach et al. 2021) were used. The debits were recalculated with the emission factors for energy demand and the waste characteristics of this study. This was also done for the EU balance areas using the energy emission factors for the EU27. For the EU balance areas two of the three processes were selected to be included in the 2030 scenarios: the pyrolysis for wood waste and the soldier fly larva for food waste.

5.2.6.1 Pyrolysis of organic waste materials

Pyrolysis is a process in which organic material, in this study limited to wood, is thermo-chemically converted to so-called biochar and one or more liquid phases (pyrolysis oils, tars). The process takes place anaerobically and usually at temperatures between 200 and 600 °C. Possible substrates for pyrolysis are often woody biomasses as well as organic waste materials; other wastes such as used tyres have also been used (Lechleitner et al. 2019; Quicker et al. 2017). The proportions and types of products depend significantly on the process duration and temperature as well as the input used.

For the GHG balances, the average pyrolysis yield of 126 kg of biochar per ton of woody biomass, determined in Bulach et al. (2021), is used. For the biochar, it is assumed that 20% is used as stable bedding (replacement of wood chips, as well as use as a soil conditioner), 30% as activated carbon (replacement of charcoal) and 50% (plus 20% from the subsequent use of stable bedding) as a soil conditioner (replacement of peat) (Bulach et al. 2021). The use of biochar as a food supplement for animals has also been described, but no verifiable data exist. In addition, heat is extracted from the process, which can be credited for productive use. However, pyrolysis oils were not considered as a product.

With the adjustments for this study (energy emission factors, waste characteristic) the specific net results are very similar for Germany and for the EU balance areas:

- Germany 2030: -73 kg CO_2eq/t
- EU 2030: -75 kg CO_2eq/t

5.2.6.2 Soldier fly larvae for the treatment of organic recyclables

The soldier fly larva is a tropical feeding insect that can be used to treat organic residues and waste. Kitchen waste, food scraps or residual materials from agriculture or industry are used as substrate after crushing and adjusting the water content. The young larvae are placed on the biomass and, under aerobic conditions, they transform it into a special compost, so-called "larval fertiliser", within about 12 days. During this time, the larvae grow up to the pre-pupa stage. They are then separated from the rest of the substrate and can either be used directly as live food or further processed into meal and oil. The protein-rich larvae meal can replace e.g. fishmeal for feeding. If necessary, after post-composting the larval fertiliser can be used in agriculture due to the improved availability of nutrients through enzymatic digestion by the larvae.

With regard to the marketing of products for animal feed, the European feed law, which was influenced by the BSE scandal, does not yet allow the economic breeding of soldier fly larvae for waste treatment. Today, only small-scale plants exist that sell the larvae regionally or offer larvae-based animal feed for pets. In South Africa and Canada, there is one company each that uses soldier fly larvae on an industrial scale for a capacity of 36,000 t and 91,000 t of substrate annually, respectively. However, the data base is still uncertain.

Despite the feed law restrictions, it was assumed in the GHG balance of the benefits according to Bulach et al. (2021) that the 126 kg of larvae meal resulting from the use of 1 ton of organic residue replace protein feed. In addition, 667 kg of larvae fertiliser is produced, which substitutes fertiliser and soil conditioner in the same way as compost.

For growth the soldier fly larvae need an average temperature of at least 20 °C. For German conditions, this means a relatively high heat demand which is the main reason why the treatment process results in a net debit (debits higher than credits). For the EU balance areas, it was assumed that the treatment process is especially suitable for southern European member states where the heat demand can be partly covered by the ambient temperature. It was assumed that only 25% of the original heat demand needs to be provided from conventional sources. With this assumption the specific net result is still positive (net debit) but much lower than for German conditions and also much lower than GHG emissions from landfilling of organic waste.

With the adjustments for this study (energy emission factors, waste characteristic and especially energy demand) the specific net results for Germany and for the EU balance areas are:

- Germany 2030: 550 kg CO_2eq/t
- EU 2030: 62 kg CO_2eq/t

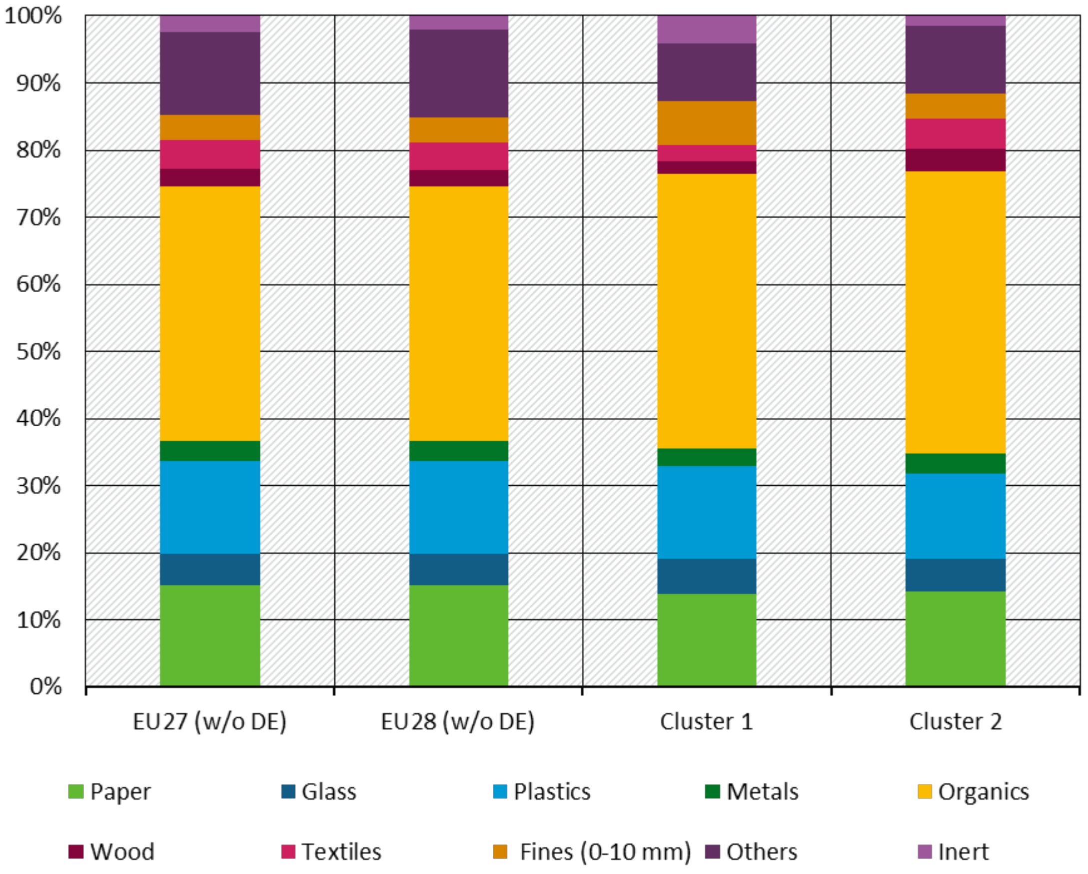
5.3 Waste composition residual MSW and parameters

The GHG balance is done for each of the waste fractions shown in Figure 11. For the EU this is possible because the EEA-model could be used. (Eurostat WStatR data report the final treatment, the losses through treatment are not known from the statistics). To calculate the treatment for residual MSW the characteristics calorific value and fossil carbon content (C_{fossil}) are needed. As no representative data is available, the characteristics were calculated based on the waste composition which results from the EEA-model and with aid of the standard values per waste fraction given in Table 34.

The waste composition in Figure 12 is shown for the EU27 and EU28 without Germany (w/o DE), because the calculation for Germany was done separately (partial report Germany). However, the GHG results shown in Chapter 5.5 are the final results with the separately calculated results for Germany added.

The composition for the different EU balance areas in Figure 12 is quite similar. The main fractions are organics with about 38% to 42%. Further relevant fractions in the residual MSW are paper and plastics, with about 15% to 14% and 14% to 13%, respectively. The fraction "others" accounts for about 8% (Cluster 1) to 13% (EU28 w/o DE). The remaining fractions each have a share of 6% or less. The calculated characteristics are presented in Table 35.

Figure 12: Residual MSW compositions EU based on EEA-model



Source: own illustration, ifeu.

Table 34: Standard values for waste fractions

	C total in % fresh matter	C biogenic in % C total	Calorific value in kJ/kg waste
Paper	37%	100%	13,020
Glass	0%	0%	0
Plastics	68%	0%	30,481
Metals	0%	0%	0
Bio- and green waste	16%	100%	4,620
Wood	38%	100%	13,250
Textiles, leather, rubber	39%	56%	15,020
Composites	43%	49%	18,017
Fines < 8 mm	13%	65%	5,133
Other waste	21%	53%	7,800
Inerts	0%	0%	0
Nappies	18%	75%	4,447

Source: Dehoust et al. (2010)

Table 35: Characteristics residual MSW EU

	Calorific value in MJ/kg	Fossil C content in % waste	Biogenic C content in % waste
EU27 (w/o DE)	10.1	11.5%	15.1%
EU28 (w/o DE)	10.1	11.6%	15.1%
Cluster 1	9.5	10.9%	14.2%
Cluster 2	9.8	10.6%	15.5%
Germany	9.2	9.4%	15.7%

The calorific value and fossil carbon content are used for the calculation of incineration. Due to consistency reasons, also the calculated biogenic carbon content is used as DOC to calculate methane emissions from landfilling instead of the DOC MSW reported in the NIR of the EU member states (see Table 13). The results for Germany are also shown for comparison (data base see partial report Germany).

5.4 Description GHG balance scenarios 2030

For the EU balance areas EU27, Cluster 1 and Cluster 2, two scenarios are developed for the year 2030, respectively. The first scenario for all three balance areas is named “lead scenario”. The second scenario differs for the EU27 and for the Clusters. The lead scenarios for all the three balance areas follow the goals of the Waste Framework Directive (WFD), i.e., they assume that all countries comply with the legislative targets and consider likely developments in MSW treatment in the future. For the EU balance areas Cluster 1 and Cluster 2, special scenarios were developed to test the effect of non-compliance with the recycling rates, while for the EU27, a scenario including home composting is considered. The latter follows the approach for the separately calculated balance for Germany where findings for the lead scenario – with the main goal "achieving the recycling target of 60% for MSW in 2030" – showed that this target is very ambitious assuming that the most important lever for achieving it lies in increasing source segregation and subsequent recycling. Both the feasibility and the achievable qualities of recyclable separately collected fractions are in question. In order to investigate a less ambitious scenario still in compliance with the legal recycling target it was decided to assess a model-theoretical scenario with home composting in the recycling rate (RC rate). For this scenario both the base year 2017 and the future scenario 2030 were added by an assessed amount for home composting (equal total waste quantities as prerequisite of the LCA method for system comparisons).

According to the Waste Framework Directive, the amount of home composting can be counted towards the legal recycling target. However, based on the current state of knowledge, the actual amounts of home composting are not known and could only be roughly estimated. Another disadvantage of including home composting is that no robust GHG assessment is possible for it. Neither the benefit of home composting nor the methane and nitrous oxide emissions resulting from the treatment can be validly stated. A net debit tends to be expected (see partial report Germany, appendix, Chapter A.4). In this study, home composting is given a zero rating in order to keep the impact on the GHG balance as neutral as possible and thus to influence the actual issue of the scenario as little as possible. The purpose of the scenario with "home composting in the RC rate" is to show and discuss the range of different levels of ambition for increased separate collection. A direct comparison between the lead scenario and the scenario with home composting is not possible due to the different total amounts of waste. The results of the scenarios are discussed comparatively at the level of specific values.

Note: recycling target – recycling rate

Not all statistically reported MSW is considered in this study. In addition, model assumptions were done to derive data for 2017 (see Chapter 3.2.2), and the material flow balance (amount and whereabouts of the output) is based on the analysis of further data and on expert knowledge. As a result, the recycling quantities determined in this study and the recycling percentages calculated from them should not be confused with the legal recycling target. To differentiate, the percentage recycled is referred to in this study as the "recycling rate" (RC rate).

The interfaces used in this study to determine the RC rate basically correspond to the calculation points specified at European level according to (EU 2019). In the case of source segregated organic waste, the quantities actually fed into the aerobic or anaerobic treatment are included. For dry recyclables, the included quantities are not subjected to any further processing before being fed for example, into a glass furnace, melting furnace, pulper or an extrusion process. In this respect, the RC rate determined in this study provides an orientation in relation to the legal recycling target.

In addition to the scenarios described, two sensitivities are considered in order to examine the influence of the regional electricity emission factor: one for Cluster 1 with a comparably high electricity emission factor and one for Cluster 2 with a much lower electricity emission factor than for the EU27 (see Chapter 4.1.2).

In the following chapters, the approaches for the development of the scenarios and sensitivities are described.

5.4.1 Lead scenarios (2030 WFD)

For this study it is proposed to use the WFD scenario presented in the EEA-model. On the basis of the mass flows determined for 2017, the WFD scenario presents a situation where each EU member state meets the targets set by the revised Waste Framework Directive and the revised Landfill Directive. The respective targets are shown in Table 36. Since the model covers only the breakdown by main waste fractions (metals, paper, glass etc.) and does not distinguish packaging, the packaging targets of the revised Packaging and Packaging Waste Directive were not considered.

Table 36: Targets regulations EU

Targets	by 2025	by 2030	by 2035
MSW recycling target	55%	60%	65%
with derogation[1]	50%	55%	60%
Landfill reduction target			10%
with derogation[2]			25%
Packaging waste total (not only from MSW)[3]	65%	70%	

1. Member States that recycled less than 20% or landfilled more than 60% in 2013 can obtain a 5-year derogation.
2. 5-year derogation is possible for Member States that landfilled more than 60% in 2013
3. no postponement possible

The WFD scenario assumes that all member states that have the right for a derogation will make use of the full derogation periods. Thus, the WFD scenario assumes, that the MSW recycling target and the landfill reduction target are met. In the WFD scenario is also assumed that technical aspects are further optimized, such as likely future developments in MSW treatment. These aspects were discussed in interviews with European stakeholders such as CEWEP, ECN and FEAD.

For the scenarios 2030, the development of waste generation was tested with the EEA-model based on the forecasts of the countries during the data collection for the model. This resulted only in a low increase. Like for Germany, this low increase is not considered but the waste amount of the current situation is used also for the 2030 scenarios. Same waste amounts are needed for scenario comparison to comply with the LCA in waste management method.

The development of the scenarios for the three EU balance areas sets the recycling target as the first requirement. For Cluster 1, with member states that can obtain the 5-year derogation, the 2030 recycling target is set to 55%. For Cluster 2 the regular recycling target for 2030 is set (60%). For the EU27 the recycling target is calculated from the targets of Cluster 1 and Cluster 2, and a recycling target of 60% also for the non-clustered EU member states, resulting in the overall recycling target of 59%.

To achieve the set recycling targets, only an increase of source segregation for the dry and organic recyclables is assumed. The assumptions address the EU27 without Germany. The assumptions for Germany are described in the partial report Germany. For the EU27 (w/o DE) unspecific waste fractions (from EEA-model) like other biowaste are not changed for the scenarios, while the waste fractions of fines, inerts and others were not considered at all for the separate collection and recycling. The increase of source segregation and recycling of the dry and organic recyclables depends on the potential in the residual MSW. Here the residual waste content 2017 for organic waste (food waste, garden waste) and dry recyclables (paper, glass, metals, plastic, and wood) was taken as a basis. Textiles are excluded from this study.

The calculation covered all current EU countries except Germany, i.e., 26 countries. The results were calculated for the two clusters and the EU27 without Germany. In the presented results for the waste generation and the first treatment, the data for the EU27 are merged with those of Germany to cover the whole EU27, thus acting as the basis for the GHG calculations. In the intermediate tables showing additional separate collection and the residual waste composition, the German data are not included. In the following, the main assumptions and the calculation steps are described.

Assumptions to increase the separate collection of dry recyclables and organic waste

The assumptions to increase the separate collection of dry recyclables and organic waste are based on the residual waste composition 2017. The potential for increased separate collection was considered for food waste, garden waste, paper, glass, metals, plastics and wood. For each country, the following steps of calculation were done:

1. Based on the recycling rate 2017 (calculated for each country from the figures in Table 135) and the target to be achieved in 2030 (55% for Cluster 1, 60% for all other countries), the additional amounts were calculated which need to be recycled to fulfil the targets.
2. Depending on the potentials of organic waste and dry recyclables in the residual waste 2017, the additional amounts to be recycled in 2030 were distributed among organic waste and dry recyclables.
3. The amounts distributed in step 2 were then further distributed among the covered materials, again depending on the shares in residual waste 2017. For example, organic waste was split according to the shares of food and garden waste within the organic waste potential, whereas the dry recyclables were distributed according to the shares of paper, glass, plastic, metal, and wood.

To account for rejects from the processing of separate collected waste prior to recycling, the higher amounts of separate collection required to achieve the recycled amounts were calculated based on the average loss rates presented at the bottom of Table 106.

As a result, the amounts of additional materials for separate collection 2030 were deducted from the residual waste amounts 2017 and added to the separate collected amounts 2017 to arrive at the corresponding figures for 2030. The values were then aggregated for the two clusters and the EU27 without Germany and were then adjusted on aggregate level to account for the differences in the usable potential of the materials. It was assumed that metals and glass have a larger usable potential than plastics. The same applies to garden waste compared to food waste[31]. Table 37 to Table 39 present the additional amounts for separate collection 2030 and Table 40 to Table 42 show the resulting compositions of residual waste 2030 in comparison to those 2017.

It can be seen for each balance area that significant amounts of additional separate collection are required to fulfil the recycling targets. In Cluster 1, these correspond to 160% of the separately collected amounts in 2017, in Cluster 2 this value is 101%, in the EU27 without Germany it is 77%, while in the merged data for EU27 it is 59%.

In Cluster 1, this has the effect of a reduction of residual waste by 48% (Table 138). The corresponding value is 49% for Cluster 2 (Table 139), and 45% for the EU27 without Germany

[31] Glass and metals: 85%, Garden waste: 80%.

(Table 140). When the data are merged with Germany, the residual waste in the EU27 is reduced by 42% (calculated from Table 49).

Table 37: Amounts separate collection 2017, additional and total separate collection 2030, and increase rates compared to 2017, Cluster 1, lead scenario (MSW CL1 2030 WFD)

Waste fraction	Separate collection 2017 (1,000 t)	Additional separate collection 2030 (1,000 t)	Separate collection 2030 (1,000 t)	Increase rates [%]
Organic waste	**2,388**	**7,210**	**9,598**	**302%**
Food	659	5,115	5,773	777%
Garden	1,660	2,095	3,755	126%
other	69	0	69	0%
Dry Recyclables	**5,737**	**5,802**	**11,539**	**101%**
Paper	2,711	2,113	4,824	78%
Glass	1,245	1,215	2,461	98%
Wood	96	255	351	266%
Metal	605	599	1,204	99%
Plastic	1,081	1,619	2,699	150%
Total[1]	**8,125**	**13,011**	**21,137**	**160%**

Table 38: Amounts separate collection 2017, additional and total separate collection 2030, and increase rates compared to 2017, Cluster 2, lead scenario (MSW CL2 2030 WFD)

Waste fraction	Separate collection 2017 (1,000 t)	Additional separate collection 2030 (1,000 t)	Separate collection 2030 (1,000 t)	Increase rates [%]
Organic waste	**9,639**	**13,941**	**23,581**	**145%**
Food	2,519	11,281	13,800	448%
Garden	7,088	2,660	9,748	38%
other	32	0	32	0%
Dry Recyclables	**15,852**	**11,896**	**27,749**	**75%**
Paper	5,654	4,435	10,089	78%
Glass	5,293	2,139	7,432	40%
Wood	392	925	1,318	236%
Metal	2,136	1,339	3,475	63%
Plastic	2,377	3,058	5,435	129%
Total[1]	**25,492**	**25,838**	**51,329**	**101%**

Table 39: Amounts separate collection 2017, additional and total separate collection 2030, and increase rates compared to 2017, EU27 (w/o DE), lead scenario (MSW EU27 (w/o DE) 2030 WFD)

Waste fraction	Separate collection 2017 (1,000 t)	Additional separate collection 2030 (1,000 t)	Separate collection 2030 (1,000 t)	Increase rates [%]
Organic waste	**23,526**	**23,497**	**47,023**	**100%**
Food	7,886	17,603	25,489	223%
Garden	14,062	5,893	19,955	42%
other	1,578	0	1,578	0%
Dry Recyclables	**35,323**	**21,612**	**56,935**	**61%**
Paper	14,906	8,284	23,190	56%
Glass	9,391	4,003	13,394	43%
Wood	2,063	1,367	3,430	66%
Metal	3,523	2,469	5,992	70%
Plastic	5,440	5,489	10,929	101%
Total	**58,849**	**45,109**	**103,958**	**77%**

Table 40: Residual MSW compositions, Cluster 1, lead scenario (MSW CL1 2030 WFD)

Waste fraction	2017		2030	
	1,000 t	%	1,000 t	%
Food	8,355	31%	3,240	23%
Garden	2,619	10%	524	4%
other biowaste	110	0%	110	1%
Paper	3,707	14%	1,594	12%
Glass	1,430	5%	215	2%
Wood	481	2%	225	2%
Metal	705	3%	105	1%
Plastic	3,707	14%	2,089	15%
Textiles	680	3%	680	5%
Fines	1,725	6%	1,725	12%
Inerts	1,104	4%	1,104	8%
other	2,238	8%	2,238	16%
Total	**26,861**	**100%**	**13,849**	**100%**

Table 41: Residual MSW compositions, Cluster 2, lead scenario (MSW CL2 2030 WFD)

Waste fraction	2017		2030	
	1,000 t	%	1,000 t	%
Food	18,335	35%	7,054	27%
Garden	3,325	6%	665	3%
other biowaste	282	1%	282	1%
Paper	7,455	14%	3,020	11%
Glass	2,516	5%	377	1%
Wood	1,766	3%	840	3%
Metal	1,575	3%	237	1%
Plastic	6,649	13%	3,591	14%
Textiles	2,263	4%	2,263	9%
Fines	2,045	4%	2,045	8%
Inerts	829	2%	829	3%
other	5,179	10%	5,179	20%
Total	**52,220**	**100%**	**26,383**	**100%**

Table 42: Residual MSW compositions 2017 and 2030, EU27 (w/o DE), lead scenario (MSW EU27 (w/o DE) 2030 WFD)

Waste fraction	2017		2030	
	1,000 t	%	1,000 t	%
Food	30,307	30%	12,704	23%
Garden	7,462	7%	1,569	3%
other biowaste	833	1%	833	1%
Paper	15,412	15%	7,128	13%
Glass	4,757	5%	754	1%
Wood	2,683	3%	1,317	2%
Metal	2,944	3%	475	1%
Plastic	13,948	14%	8,459	15%
Textiles	4,206	4%	4,206	7%
Fines	3,927	4%	3,927	7%
Inerts	2,395	2%	2,395	4%
other	12,405	12%	12,405	22%
Total	**101,280**	**100%**	**56,171**	**100%**

The waste characteristics for the residual waste compositions in the lead scenario 2030 are again calculated in the same way as for the base year (see Chapter 5.3). Table 43 shows the resulting values. The values for Germany are included again for comparison.[32] Compared to the base year 2017 (Table 35) the assumptions in the lead scenarios result in higher calorific values and higher fossil carbon contents in the residual waste for the EU27 (w/o DE), Cluster 1 and Cluster 2, and to lower biogenic carbon contents respectively. This is different in the lead scenario for Germany where the shares of fossil-based recyclables like plastics remaining in the residual waste are lower.

Table 43: Characteristics residual MSW, lead scenarios 2030 (MSW 2030 WFD)

	Calorific value in MJ/kg	Fossil C content in % waste	Biogenic C content in % waste
EU27 (w/o DE)	11.0	14.0%	14.4%
Cluster 1	10.2	13.2%	13.1%
Cluster 2	10.7	13.0%	14.8%
Germany	9.1	8.9%	15.9%

Based on the amounts of additional separate collection and the amounts and composition of residual waste, further assumptions for the first treatment are required.

Assumptions on the first treatment for the lead scenario 2030

Based on the calculation described above, the first treatment 2030 was determined in two steps:

- Distribute the largely reduced amounts of residual waste treated 2030 among landfill, incineration and MBT.
- Distribute the amounts treated in MBT among the 5 facility types and distribute the organic waste treated among composting, digestion and soldier fly larvae.

Residual MSW treatment 2030

The residual MSW treatment 2030 was calculated for each country as follows:

1. The amounts of additional separate collection were deducted from the landfill-value 2017,
2. Then it was checked whether the resulting amounts landfilled are larger or smaller than zero
   a. Landfilled amounts smaller than zero were always adjusted to zero and the amounts added to landfill were subtracted from the other two treatments (MBT and INC, see step 3 below),
   b. Landfilled amounts larger than zero were reduced to zero for Cluster 2 and the non-clustered countries[33],

[32] An overall overview for residual waste characteristics for the different MSW balance areas and scenarios is given in Table 156.

[33] For Cluster 2 and the remaining non-clustered countries, the amount landfilled was smaller than zero in 12 out of 14 countries, i.e., the amounts landfilled in 2017 were already smaller than the additional amounts to be collected separately in 2030. For the two countries (Czechia and Ireland, both in Cluster 2) with remaining landfill amounts 2030 larger zero, the landfill amounts were set to zero and added equally to MBT and incineration.

   c. For Cluster 1, the landfilled amounts were checked against the LF target 2035, i.e., whether the value 2030 was low enough to realistically achieve the landfill target (28% was seen reasonable to achieve the target of 25% five years later[34]).
      i) For three countries (Croatia, Romania, Slovakia), the landfilling needed to be reduced to achieve a rate of 28%, with the amounts solely added to MBT or incineration.
      ii) For the remaining countries, no changes were required except for three countries (Croatia, Romania, Slovakia), where it was known from the stakeholder interviews that incineration capacity is planned: Here the capacity assumed for MSW direct incineration was added to incineration and deducted from landfill.
3. For the 12 countries with landfilled amounts lower than zero from step 1 above, the following country groups were distinguished:
   a. Deduct amounts solely from the MBT, which dominated the split MBT/incineration 2017,
   b. Deduct amounts solely from the incineration, which dominated the split MBT/incineration 2017,
   c. Deduct amounts proportionally from MBT and incineration according to the split MBT/incineration 2017.

Concerning the groups a) to c), a decision was made on the basis of the individual country, taking into account also aspects, such as the treatment infrastructure and likely changes (e.g., closure of old facilities).

Table 137 summarizes for all countries in detail, what adjustments were done for each country, which assumptions were made, and shows the first treatment of residual waste 2030 for all 26 countries covered.

MBT treatment and organic waste treatment 2030

The assumptions for the distribution of MBT and organic waste treatment were done at the level of Cluster 1, Cluster 2, and the non-clustered country group, but also considering likely developments in single countries, when the affected amounts were relevant for the whole geographical area (e.g., MBT in Italy and Spain). Under the condition that the recycling targets are met, there are two main drivers for the future of the treatment infrastructure of MBTs and organic waste treatment facilities in Europe.

On the one hand, the residual waste amounts will be extremely reduced, while the amounts of separate collected organic waste requiring treatment will increase significantly. The reduction of MBT capacities will mostly affect MBT1 (biostabilisation) facilities which will either be closed or refurbished to MBT4 (anaerobic digestion based). Considering the large future demand of organic waste treatment facilities, a refurbishment of MBT1 to composting or digestion plants without mechanical sorting component is also likely. In addition, the reduced organic content in residual waste will be a driver for more facilities with only mechanical sorting (MBT5) without biological treatment.

Since the separately collected organic waste in 2030 will have a much higher content of food waste, large capacities of anaerobic digestion will be required. For composting, there will be a shift from open air windrow to in-vessel composting.

This led to the assumptions described in the right column of Table 44 to Table 46 for the Cluster 1, Cluster 2 and the group of non-clustered countries. Assumptions in blue font mean that the reduction or increase was done proportionally to the distribution 2017. For organic waste, the

[34] The landfill target of the Landfill Directive is given for 2035 and therefore not directly usable for the 2030 scenarios. Simplifying, the amount to landfill is manually set for Cluster 1 by interpolating the share landfilled in 2030 with the share landfilled in 2017 (37%) and the target 2035 (25%), resulting in 28% in 2030 required to achieve the target.

calculations were done stepwise by following the expected developments described above and then adjusting the food waste share in composting processes to maximum of 20% for open air windrow and 33% for in-vessel composting. For Cluster 1, 50% was accepted since anaerobic digestion could not be further increased compared to 2017. Concerning the new treatment methods, 2% of food waste is assumed to be treated with soldier fly larvae in both clusters, as they include southern countries with warm climates. Additionally, in Cluster 2 and the non-clustered countries with more advanced waste management systems, 5% of the separately collected wood will be subject to pyrolysis.

Table 44: Treatment in MBTs and organic waste treatment 2017 and 2030 and assumptions made, Cluster 1, lead scenario (MSW CL1 2030 WFD)

Waste stream	2017	2030	Difference	Assumption
	1,000 t	1,000 t	%	
MBTs	**12,145**	**7,729**	**-36%**	
MBT 1 - Biostabilisation	4,537	454	-90%	Will be largely closed down or converted to composting plants
MBT 2 - Biodrying no plastics recycling	965	965	0%	Unchanged
MBT 3 - Biodrying with plastics recycling	851	851	0%	Unchanged
MBT 4 - AD based	2,552	2,219	-13%	Slightly reduced
MBT 5 - basic sorting + energy generation	3,240	3,240	0%	Unchanged
Organic waste	**2,388**	**9,598**	**302%**	
Food - soldier fly larvae		115	-	Assumed to be 2% of food waste due to Cyprus, Greece and Malta
Food - composting open air windrow	473	366	-23%	Slight decrease
Food - in-vessel composting	115	2,140	1768%	Same value as corresponding value for garden (max. 50% food)
Food - anaerobic digestion	71	3,152	4310%	New plants due to limitation of food waste in composting
Garden - composting open air windrow	1,332	1,464	10%	Slight increase
Garden - in-vessel composting	258	2,140	730%	New plants important here
Garden - anaerobic digestion	70	150	116%	Slight increase
Other - composting open air windrow	65	65	0%	Unchanged
Other - in-vessel composting	3	3	0%	Unchanged
Other - anaerobic digestion	2	2	0%	Unchanged

Table 45: Treatment in MBTs and organic waste treatment2017 and 2030 and assumptions made, Cluster 2, lead scenario (MSW CL2 2030 WFD)

Waste stream	2017	2030	Difference	Assumption
	1,000 t	1,000 t	%	
MBTs	**15,357**	**8,367**	**-46%**	
MBT 1 - Biostabilisation	8,501	0	-100%	Will be closed down or converted to composting plants (e.g., Spain)
MBT 2 - Biodrying no plastics recycling	0	0	-	Unchanged
MBT 3 - Biodrying with plastics recycling	1,374	1,677	22%	Increase proportionally to 2017
MBT 4 - AD based	5,111	6,238	22%	Increase proportionally to 2017
MBT 5 - basic sorting + energy generation	371	452	22%	Increase proportionally to 2017
Organic waste	**9,639**	**23,581**	**145%**	
Food - soldier fly larvae	0	276	-	Assumed to be 2% of food waste, due to Spain and Portugal
Food - composting open air windrow	430	276	-36%	Slight decrease
Food - in-vessel composting	1,264	3,864	206%	Increased to achieve max. share of food waste in this type (20%)
Food - anaerobic digestion	825	9,384	1038%	Increased to achieve max. share of food waste in this type (33%)
Garden - composting open air windrow	1,225	1,684	38%	Increase proportionally to 2017
Garden - in-vessel composting	5,697	7,836	38%	Increase proportionally to 2017
Garden - anaerobic digestion	166	228	38%	Increase proportionally to 2017
Other - composting open air windrow	5	5	0%	Unchanged
Other - in-vessel composting	17	17	0%	Unchanged
Other - anaerobic digestion	10	10	0%	Unchanged

Table 46: Treatment in MBTs and organic waste treatment 2017 and 2030 and assumptions made, non-clustered countries, lead scenario (non-clustered 2030 WFD)

Waste stream	2017	2030	Difference	Assumption
	1,000 t	1,000 t	%	
MBTs	**10,918**	**6,893**	**-37%**	
MBT 1 - Biostabilisation	9,976	2,007	-80%	Will be largely closed down or converted to composting plants (e.g., Italy)
MBT 2 - Biodrying no plastics recycling	318	318	0%	Unchanged
MBT 3 - Biodrying with plastics recycling	0	0		Unchanged
MBT 4 - AD based	516	3,777	632%	Increase proportionally to 2017
MBT 5 - basic sorting + energy generation	108	792	632%	Increase proportionally to 2017
Organic waste	**11,499**	**13,844**	**20%**	
Food - soldier fly larvae	0	0	-	Not applied
Food - composting open air windrow	292	177	-39%	Slight decrease
Food - in-vessel composting	2,461	2,721	11%	Required for amounts of mixed organic waste collected (Belgium, Austria etc.)
Food - anaerobic digestion	1,955	3,017	54%	Required for additional food waste in countries like Italy
Garden - composting open air windrow	3,417	1,807	-47%	Decrease on account of increased closed composting
Garden - in-vessel composting	1,775	4,517	154%	Required for high food waste shares in mixed collection
Garden - anaerobic digestion	122	129	6%	Unchanged
Other - composting open air windrow	390	390	0%	Unchanged
Other - in-vessel composting	554	554	0%	Unchanged
Other - anaerobic digestion	533	533	0%	Unchanged

For Cluster 1 and Cluster 2, the summary tables generation and first treatment of MSW 2030 were directly calculated from tables presented above, whereby MBT 1 to MBT 4 are aggregated to MBT, MBT 5 is presented, similar to the German data, as "Mixed waste" sorting, and the two composting types are aggregated as well (Table 47 and Table 48). The detailed results without aggregates are shown in Table 138 and Table 139.

Table 47: Generation and first treatment 2017 and 2030, Cluster 1, lead scenario (MSW CL1 2030 WFD)

Waste fraction	2017	2030	Difference
	1,000 t	1,000 t	%
Residual waste landfill	13,495	4,268	-68%
Residual waste INC	1,220	1,853	52%
Residual waste MBTs	8,905	4,489	-50%
"Mixed waste" sorting	3,240	3,240	0%
Other Biowaste	69	69	0%
thereof composting	68	68	0%
thereof anaerobic digestion	2	2	0%
thereof HTC	-	-	-
thereof soldier fly larvae	-	-	-
Garden waste	1,660	3,755	126%
thereof composting	1,590	3,605	127%
thereof anaerobic digestion	70	150	116%
thereof biomass power plant	-	-	-
Food waste	659	5,773	777%
thereof composting	587	2,506	327%
thereof anaerobic digestion	71	3,152	4310%
thereof soldier fly larvae	0	115	-
Paper	2,711	4,824	78%
Glass	1,245	2,461	98%
Plastics	1,081	2,699	150%
LWP			
Metals	605	1,204	99%
Wood	96	351	266%
thereof pyrolysis	-	-	
Total	**34,986**	**34,986**	**0%**

Table 48: Generation and first treatment 2017 and 2030, Cluster 2, lead scenario (MSW CL2 2030 WFD)

Waste fraction	2017	2030	Difference
	1,000 t	1,000 t	%
Residual waste landfill	15,373	0	-100%
Residual waste INC	21,491	18,015	-16%
Residual waste MBTs	14,986	7,915	-47%
"Mixed waste" sorting	371	452	22%
Other Biowaste	32	32	0%
thereof composting	22	22	0%
thereof anaerobic digestion	10	10	0%
thereof HTC	-	-	-
thereof soldier fly larvae	-	-	-
Garden waste	7,088	9,748	38%
thereof composting	6,922	9,520	38%
thereof anaerobic digestion	166	228	38%
thereof biomass power plant	-	-	-
Food waste	2,519	13,800	448%
thereof composting	1,694	4,140	144%
thereof anaerobic digestion	825	9,384	1038%
thereof soldier fly larvae	-	276	-
Paper	5,654	10,089	78%
Glass	5,293	7,432	40%
Plastics	2,377	5,435	129%
LWP	-	-	-
Metals	2,136	3,475	63%
Wood	392	1,318	236%
thereof pyrolysis	-	66	-
Total	**77,712**	**77,712**	0%

For the EU27, the amounts calculated for Cluster 1, Cluster 2 and the non-clustered countries were aggregated to arrive at the detailed results for the EU27 without Germany presented in Table 140. These were then merged with the German data (Table 141) to arrive to the values presented in Table 49.

Table 49: Generation and first treatment 2017 and 2030, EU27, lead scenario (MSW EU27 2030 WFD)

Waste fraction	2017	2030	Difference
	1,000 t	1,000 t	%
Residual waste landfill	29,703	4,268	-86%
Residual waste INC	47,123	38,819	-18%
Residual waste MBTs	37,671	20,612	-45%
"Mixed waste" sorting	7,604	7,241	-5%
Other Biowaste	6,057	9,256	53%
thereof composting	3,531	3,531	0%
thereof anaerobic digestion	2,526	5,649	124%
thereof HTC	-	25	-
thereof soldier fly larvae	-	50	-
Garden waste	19,743	25,637	30%
thereof composting	18,378	23,654	29%
thereof anaerobic digestion	1,043	1,661	59%
thereof biomass power plant	322	322	
Food waste	8,868	26,472	199%
thereof composting	5,090	9,545	88%
thereof anaerobic digestion	3,778	16,535	338%
thereof soldier fly larvae	-	391	-
Paper	22,695	31,832	40%
Glass	11,966	16,516	38%
Plastics	6,577	12,994	98%
LWP	4,030	4,030	0%
Metals	3,895	6,598	69%
Wood	3,429	5,089	48%
thereof pyrolysis	-	254	-
Total	**209,362**	**209,362**	**0%**

Note: Merged from Table 140 and Table 141

Assumptions of technical optimisations

In addition to the mass flow diversions, technical optimisations are assumed in the lead scenarios 2030:

- Increase of the efficiency of thermal treatment plants and biomass CHP,

- increase in metal yields from residual MSW for treatment,
- increase in the share of biomethane generation.

The assumptions are largely the same as for Germany (partial report Germany), and are used uniformly for all EU balance areas. An exception is the increase of the yield from sorting and processing of dry recyclables which was generally not assumed for the EU balance areas without Germany. The increase of the efficiency for thermal treatment plants and biomass CHP is shown in Table 50. For the metals yield from residual MSW for treatment a 20% increase is assumed equally for all treatment routes (incineration, MBT, MT). The share of the generation of biomethane from anaerobic digestion of source segregated organic waste (see "CO_2 separation" Table 24) is assumed to increase by 10%.

Table 50: Net efficiencies for energy recovery in the lead scenario

	Electrical	Thermal
Thermal treatment plants	16%	46%
biomass CHP	18%	40%

In addition, also the assumption for RDF, sorting residues or rejects was adopted from Germany that no more co-incineration in coal power plants will take place in 2030. The co-incinerated amounts in 2017 are treated via thermal treatment plants in the scenarios for 2030.

5.4.2 Scenario with home composting in the RC rate for the EU27

The purpose of the scenario with home composting in the RC rate is – like for the separately calculated German balance area – to contrast the high level of ambition for achieving the RC rate in the lead scenario 2030. This is done with a model variant that enables a less ambitious increase in separate collection by including the volume of home composting within the RC rate. For this purpose, the home composting volume is set in such a way that a relevant lower ambition level for the increased separate collection results, thus enabling the discussion of the range of different ambition levels. This approach is a model variant, the data uncertainties are high (Chapter 5.2.3.1). In addition, within the scope of this study, it is neither intended nor possible to discuss potential interactions between separate collection of native-organic waste and home composting.

The scenario with home composting in the RC rate builds entirely on the lead scenario for the EU27 above. The main assumptions concerning the scenario with home composting are:

- In Cluster 1 and non-clustered countries, 100 kg/cap will be home composted, in Cluster 2, this value is 75 kg/cap. Using the population figures for 2017, this results in 32.3 million tons home composted in the EU27 without Germany.

- For Germany the amount of home composting was set at 7.9 million tons (about 95 kg/cap) (see partial report Germany). In total the amount for home composting considered in the scenario for the EU27 results in 40.2 million tons.

- The amounts home composted are added to the MSW generation in 2017 and in 2030 (equal total waste quantities as prerequisite of the LCA method for system comparisons), and are counted as recycling. This results in increased amount of residual waste, as well as, in decreased amount of separate collection (compared to the lead scenario), which is required to achieve the recycling targets.

- All treatment splits (residual waste, MBTs, organic waste) from the lead scenario were kept and applied to the changed amounts.

The value per capita assumed above for home composting in Cluster 1 and non-clustered countries is similar to that assumed for Germany. The reason for the different value for Cluster 2 is the assumption that Cluster 2 has a lower home composting rate due to its higher degree of urbanization mentioned in the stakeholder interviews.

In the scenario with home composting in the RC rate a lower separate collection is required to fulfill the recycling target than in the lead scenario, since the amounts of home composting can be accounted for the compliance with the recycling target. In the EU27 (w/o DE) the amount of residual waste only needs to be reduced by 30%[35] compared to 45% in the lead scenario. For Germany the share of residual waste which needs to be additionally source segregated in the scenario with home composting in the RC rate is 13%(see Table 145), while in the lead scenario it is about twice as high at 29% (see Table 141). In the merged data for the EU27 the residual waste is reduced by 27% in the scenario with home composting in the RC rate (calculated from Table 54, value for the lead scenario 2030: 42%, calculated from Table 49).

In the EU27 without Germany the total increase rate of separate collection for recycling in 2030 is 52% (see Table 51; for comparison lead scenario 77%, see Table 40). In the merged data for the EU27 the increase rate of separate collection for recycling is 38% (lead scenario 2030: 59%).

Table 51: Amounts for separate collection 2017, additional and total separate collection 2030, and increase rates compared to 2017, EU27 (w/o DE), scenario with home composting in the RC rate (MSW EU27 (w/o DE) 2030 HC)

Waste stream	Separate collection 2017 (1,000 t)	Additional separate collection 2030 (1,000 t)	Separate collection 2030 (1,000 t)	Increase rates [%]
Organic waste	**23,526**	**16,829**	**40,355**	**72%**
Food	7,886	13,864	21,749	176%
Garden	14,062	2,966	17,027	21%
other	1,578	0	1,578	0%
Dry Recyclables	**35,323**	**13,539**	**48,862**	**38%**
Paper	14,906	4,996	19,902	34%
Glass	9,391	2,104	11,495	22%
Wood	2,063	880	2,943	43%
Metal	3,523	1,619	5,142	46%
Plastic	5,440	3,939	9,379	72%
Total	**58,849**	**30,368**	**89,217**	**52%**

The changed composition of residual waste in the scenario with home composting in the RC rate 2030 for the EU27 (w/o DE) is shown in Table 52. The composition in the base year 2017 is the same as in the comparison in the lead scenario. For the waste composition in the scenario with home composting in the RC rate 2030, the characteristic data of calorific value and fossil as well

[35] 30,368 kt additional separate collection 2030 in Table 51 divided by 101,280 kt residual waste in 2017.

as biogenic carbon content are again calculated according to the procedure described in Chapter 5.3. The resulting values for the EU27 (w/o DE) and for the separately calculated balance for Germany are shown in Table 53. Compared to the values for the lead scenario (Table 43) the heating value and especially the fossil carbon content are lower for the EU27 (w/o DE), the biogenic carbon content a little higher. Again, for Germany it is the other way around, but the difference to the base year 2017 (Table 35) is smaller than with the lead scenario.

Table 52: Residual MSW compositions 2017 and 2030, EU27 (w/o DE), scenario with home composting in the RC rate (MSW EU27 (w/o DE) HC 2030)

Waste stream	2017[1]		2030	
	1,000 t	%	1,000 t	%
Food	30,307	30%	16,443	23%
Garden	7,462	7%	4,497	6%
other biowaste	833	1%	833	1%
Paper	15,412	15%	10,416	15%
Glass	4,757	5%	2,653	4%
Wood	2,683	3%	1,803	3%
Metal	2,944	3%	1,325	2%
Plastic	13,948	14%	10,009	14%
Textiles	4,206	4%	4,206	6%
Fines	3,927	4%	3,927	6%
Inerts	2,395	2%	2,395	3%
other	12,405	12%	12,405	17%
Total	**101,280**	**100%**	**70,912**	**100%**

1) Corresponds to the residual waste composition of the base scenario 2017.

Table 53: Characteristics residual MSW, scenario with home composting in the RC rate 2030

	Calorific value in MJ/kg	Fossil C content in % waste	Biogenic C content in % waste
EU27 (w/o DE)	10.5	12.6%	14.8%
Germany	9.2	9.2%	15.8%

The merged data for waste generation and the first treatment for the EU27 are shown in Table 54. For the year 2017, the only difference compared to the base scenario 2017 is that the defined home composting volume is added, which is also set unchanged for 2030. Compared to the lead scenario (Table 49) the reduced amount of residual waste to landfill in 2030 is nearly the same. The less required separate collection and thus higher amount of residual waste in the scenario with home composting in the RC rate is treated via incineration, MBTs and as mixed waste. The minimum required diversion from landfill results in a little higher amount of residual waste to incineration than in 2017 in this scenario with home composting in the RC rate.

A further significant difference in the 2030 scenario with home composting in the RC rate can be seen in the organic waste. Here, only about 18.3 million tons of organic waste needs to be additionally separately collected (instead of about 26.7 million t in the lead scenario). However, this quantity still requires a significant expansion of the existing treatment capacities.

Table 54: Generation and first treatment 2017 and 2030, EU27, scenario with home composting in the RC rate (MSW EU27 2030 HC)

Waste fraction	2017	2030	Difference
	1,000 t	1,000 t	%
Residual waste landfill	29,703	5,388	-82%
Residual waste INC	47,123	48,631	3%
Residual waste MBTs	37,671	25,942	-31%
"Mixed waste" sorting	7,604	9,037	19%
Other Biowaste	6,057	7,569	25%
thereof composting	3,531	3,531	0%
thereof anaerobic digestion	2,526	3,962	57%
thereof HTC (Germany only)		25	-
thereof soldier fly larvae		50	-
Garden waste	19,743	22,709	15%
thereof composting	18,378	20,800	13%
thereof anaerobic digestion	1,043	1,586	52%
thereof biomass power plant	322	322	0%
Food waste	8,868	22,732	156%
thereof composting	5,090	8,145	60%
thereof anaerobic digestion	3,778	14,253	277%
thereof soldier fly larvae		334	-
Paper	22,695	28,068	24%
Glass	11,966	14,320	20%
Plastics	6,577	10,935	66%
LWP	4,030	4,030	0%
Metals	3,895	5,621	44%
Wood	3,429	4,382	28%
thereof pyrolysis		232	-
Home composting	40,194	40,194	0%
Total	**249,556**	**249,556**	**0%**

Note: Merged from Table 144 and Table 145

5.4.3 Special scenarios for Cluster 1 and Cluster 2

For the EU balance areas Cluster 1 and Cluster 2, special scenarios were developed to test the effect that some member states are not fully compliant with the recycling rates. The scenarios build entirely on the lead scenarios in Chapter 5.4.1. The following changes were applied:

- Cluster 1:
  - 10% less separate collection than in lead scenario (recycling target not met): The affected amounts (not separately collected) are entirely incinerated.
  - 70% of ash is removed from residual waste fractions "inerts" and "fines" and instead separately collected for landfilling. The amounts removed from residual waste are proportionally subtracted from landfill, incineration and MBTs, based on the residual waste treatment splits in the lead scenario.
  - All other treatment splits (MBTs, organic waste) from the lead scenarios were kept and applied to the changed amounts.
- Cluster 2:
  - Landfilling will not be zero, but it is assumed that the countries will landfill as much residual waste as to likely fulfil the landfill target (13% was seen reasonable to achieve the target of 10% five years later[36]). For countries with landfill rates in 2017 less than 13%, this level was kept, while for the others, the amounts to landfill were reduced to 13%.
  - 10% less separate collection than in lead scenario (recycling target not met): The affected amounts (not separately collected).
  - The increased amount of residual waste is assigned to landfill to the maximum amount allowed (8.8 million t) and the remaining amounts of residual waste are proportionally assigned to incineration and MBT, based on the split between these two treatment types in the lead scenario.
  - All the other treatment splits (MBTs, organic waste) from the lead scenarios were kept and applied to the changed amounts.

The idea behind the special scenarios for Cluster 1 and Cluster 2 is to test the effects of less recycling. For Cluster 1, the removal of a waste fraction (ash) without heat value is tested in addition, while for Cluster 2, the effect of substantial amounts still landfilled shall be assessed. Because of the assumptions above, the amounts of additional separate collection are lower for each balance area compared to the lead scenarios. This is, because the recycling targets are not required to be fulfilled in the special scenarios (Cluster 1 and 2).

In Cluster 1, the additional amounts of separate collection for recycling correspond to 134% of the separately collected amounts 2017 (WFD 2030: 160%), in Cluster 2 this value is 81% (WFD 2030: 101%). In Cluster 1, this reduces the residual waste in 2030 by 48% (Table 142, value for WFD 2030: 48%), compared to 2017. The corresponding value is 40% for Cluster 2 (Table 143, value for WFD 2030: 49%). The reason, why the residual waste in Cluster 1 has not decreased, is the removal of ash from residual waste in a similar order (2 million tons.) than the increase through a decrease in separate collection (2.1 million tons).

[36] The landfill target of the Landfill Directive is given for 2035 and therefore not directly usable for the 2030 scenarios. Simplifying the amount to landfill is manually set for Cluster 2 by interpolating the share landfilled 2030 with the share landfilled in 2017 (20%) and the target 2035 (10%), resulting in 13% in 2030 required to achieve the target.

Table 55: Amounts separate collection 2017, additional and total separate collection 2030, and increase rates compared to 2017, Cluster 1, special scenario (MSW CL1 2030 SS)

Waste stream	Separate collection 2017 (1,000 t)	Additional separate collection 2030 (1,000 t)	Separate collection 2030 (1,000 t)	Increase rates [%]
Organic waste	**2,388**	**6,257**	**8,645**	**262%**
Food	659	4,537	5,196	689%
Garden	1,660	1,720	3,379	104%
other	69	0	69	0%
Dry Recyclables	**5,737**	**4,648**	**10,385**	**81%**
Paper	2,711	1,631	4,341	60%
Glass	1,245	969	2,215	78%
Wood	96	220	316	229%
Metal	605	479	1,084	79%
Plastic	1,081	1,349	2,429	125%
Total (separate collection for Recycling)	**8,125**	**10,905**	**19,030**	**134%**
Ash from residual waste - landfill		**1,980**		

Table 56: Amounts separate collection 2017, additional and total separate collection 2030, and increase rates compared to 2017, Cluster 2, special scenario (MSW CL2 2030 SS)

Waste stream	Separate collection 2017 (1,000 t)	Additional separate collection 2030 (1,000 t)	Separate collection 2030 (1,000 t)	Increase rates [%]
Organic waste	**9,639**	**11,587**	**21,226**	**120%**
Food	2,519	9,901	12,420	393%
Garden	7,088	1,685	8,773	24%
other	32	0	32	0%
Dry Recyclables	**15,852**	**9,122**	**24,974**	**58%**
Paper	5,654	3,427	9,080	61%
Glass	5,293	1,396	6,689	26%
Wood	392	794	1,186	202%
Metal	2,136	991	3,127	46%
Plastic	2,377	2,514	4,892	106%
Total	**25,492**	**20,708**	**46,200**	**81%**

Table 57: Residual MSW compositions, Cluster 1, special scenario (MSW CL1 2030 SS)

Waste stream	2017		2030	
	1,000 t	%	1,000 t	%
Food	8,355	31%	3,818	27%
Garden	2,619	10%	900	6%
other biowaste	110	0%	110	1%
Paper	3,707	14%	2,076	15%
Glass	1,430	5%	461	3%
Wood	481	2%	261	2%
Metal	705	3%	226	2%
Plastic	3,707	14%	2,359	17%
Textiles	680	3%	680	5%
Fines	1,725	6%	517	4%
Inerts	1,104	4%	331	2%
other	2,238	8%	2,238	16%
Total	**26,861**	**100%**	**13,976**	**100%**

Table 58: Residual MSW compositions, Cluster 2, special scenario (MSW CL2 2030 SS)

Waste stream	2017		2030	
	1,000 t	%	1,000 t	%
Food	18,335	35%	8,425	27%
Garden	3,325	6%	794	3%
other biowaste	282	1%	337	1%
Paper	7,455	14%	3,607	11%
Glass	2,516	5%	451	1%
Wood	1,766	3%	1,004	3%
Metal	1,575	3%	283	1%
Plastic	6,649	13%	4,289	14%
Textiles	2,263	4%	2,704	9%
Fines	2,045	4%	2,443	8%
Inerts	829	2%	990	3%
other	5,179	10%	6,186	20%
Total	**52,220**	**100%**	**31,512**	**100%**

Compared to the lead scenarios, no further assumptions for MBTs and organic waste treatment were applied since all splits were taken from the lead scenarios.

Table 59: Generation and first treatment 2017 and 2030, Cluster 1, special scenario (MSW CL1 2030 SS)

Waste fraction	2017	2030	Difference
	1,000 t	1,000 t	%
Residual waste landfill	13,495	3,657	-73%
Residual waste INC	1,220	3,695	203%
Residual waste MBTs	8,905	3,847	-57%
"Mixed waste" sorting	3,240	2,777	-14%
Other Biowaste	69	69	0%
thereof composting	68	68	0%
thereof anaerobic digestion	2	2	0%
thereof soldier fly larvae			
Garden waste	1,660	3,379	104%
thereof composting	1,590	3,244	104%
thereof anaerobic digestion	70	135	94%
thereof biomass power plant			
Food waste	659	5,196	689%
thereof composting	587	2,256	284%
thereof anaerobic digestion	71	2,836	3869%
thereof soldier fly larvae		104	-
Paper	2,711	4,341	60%
Glass	1,245	2,215	78%
Plastics	1,081	2,429	125%
LWP			
Metals	605	1,084	79%
Wood	96	316	229%
thereof pyrolysis		0	
Ash from residual waste - landfill		1,980	-
Total	**34,986**	**34,986**	0%

Note: Based on Table 142

Table 60: Generation and first treatment 2017 and 2030, Cluster 2, special scenario (MSW CL2 2030 SS)

Waste fraction	2017	2030	Difference
	1,000 t	1,000 t	%
Residual waste landfill	15,373	8,817	-43%
Residual waste INC	21,491	15,497	-28%
Residual waste MBTs	14,986	6,809	-55%
"Mixed waste" sorting	371	389	5%
Other Biowaste	32	32	0%
thereof composting	22	22	0%
thereof anaerobic digestion	10	10	0%
thereof soldier fly larvae			
Garden waste	7,088	8,773	24%
thereof composting	6,922	8,568	24%
thereof anaerobic digestion	166	205	24%
thereof biomass power plant			
Food waste	2,519	12,420	393%
thereof composting	1,694	3,726	120%
thereof anaerobic digestion	825	8,446	924%
thereof soldier fly larvae		248	-
Paper	5,654	9,080	61%
Glass	5,293	6,689	26%
Plastics	2,377	4,892	106%
LWP			
Metals	2,136	3,127	46%
Wood	392	1,186	202%
thereof pyrolysis		59	-
Total	**77,712**	**77,712**	**0%**

Note: Based on Table 143

The waste characteristics for the residual waste compositions in the special scenarios 2030 are again calculated in the same way as for the base year and the lead scenario (see Chapter 5.3). A difference is given only for the special scenario for Cluster 1. For Cluster 2 the proportional composition is not affected by the assumptions in the special scenario, and are the same as in the lead scenario (Table 43). For Cluster 1, the removal of ash leads to a higher calorific value and also to higher carbon contents:

- Calorific value: 11.1 MJ/kg
- fossil C content: 14.1%
- biogenic C content: 14.7%

An overall overview for residual waste characteristics for the different MSW balance areas and scenarios is given in Table 156.

5.4.4 Sensitivity emission factor electricity for Cluster 1 and Cluster 2

Originally, it was planned for this study, in which both Germany and the EU are considered, to use the EU27 emission factors for electricity and heat uniformly for all balancing areas[37]. This is to avoid that different energy systems in the different balancing areas influence the results. This applies above all to the substitution potential through energy from waste. In countries or country clusters with a high GHG emission factor, especially for electricity, the energy recovery of one and the same type of waste achieves higher GHG reduction potentials than in countries with a low GHG emission factor. The reason for this is not measures in the circular economy, but in the energy sector. Since the climate protection potentials of the circular economy of the EU balance areas are to be examined comparatively, a uniform emission factor is indispensable in order to be able to recognise the differences as well as the advantages and disadvantages of the waste management measures. The emission factors for electricity vary considerably depending on whether the EU27, or Clusters 1 or 2 are considered (see Chapter 4.1.2).

On the other hand, considered individually, the national electricity mix is certainly relevant for the consideration of the circular economy sector from a climate protection perspective. Particularly, in countries still having difficulties establishing higher recycling shares and have a long way to go to defossilise their electricity generation, energy recovery can make a relevant contribution to climate protection. In addition, it was critically noted in the workshops for Germany that national emission factors should be used for Germany as a separately considered balance area. To acknowledge the latter, national emission factors for electricity and heat are used uniformly for the GHG balances for Germany in the partial report Germany. Conversely, in order to avoid generating a bias for the EU balances, the GHG balances for Germany are also calculated with the EU27 emission factors for electricity and heat. Only the results from this are included in the GHG balances for the EU. The differences that result for Germany from the balances with national and EU27 emission factors are described in the partial report Germany.

For the EU balances for MSW, sensitivities are calculated for the base year 2017 with the regional electricity emission factors for Cluster 1 and for Cluster 2 (Table 9).

5.5 Results GHG balances

In the following, the results of base year 2017 are presented for EU27, Cluster 1 and Cluster 2. In addition, only for the base year 2017 results for the EU28 are presented, and the specific results are also compared to the results for Germany. Task of this study was also to maintain or show the connectivity to previous studies. Climate protection potentials of MSW management have been investigated in two previous studies. The EU27 (with UK, without Croatia) was last examined more comprehensively for the balance year 2007 for MSW in Dehoust et al. (2010). A rough calculation was done for the EU28 for the year 2012 by Vogt et al. (2015). The comparison in the time series is – for methodological reasons – only possible to a limited extent. In order to

[37] For the separate balance for Germany, the national values were ultimately used and, in addition, the EU emission factors were used for the EU balances.

understand the development, a comparison can be found, especially at the specific level of waste types, in the Appendix B.1.

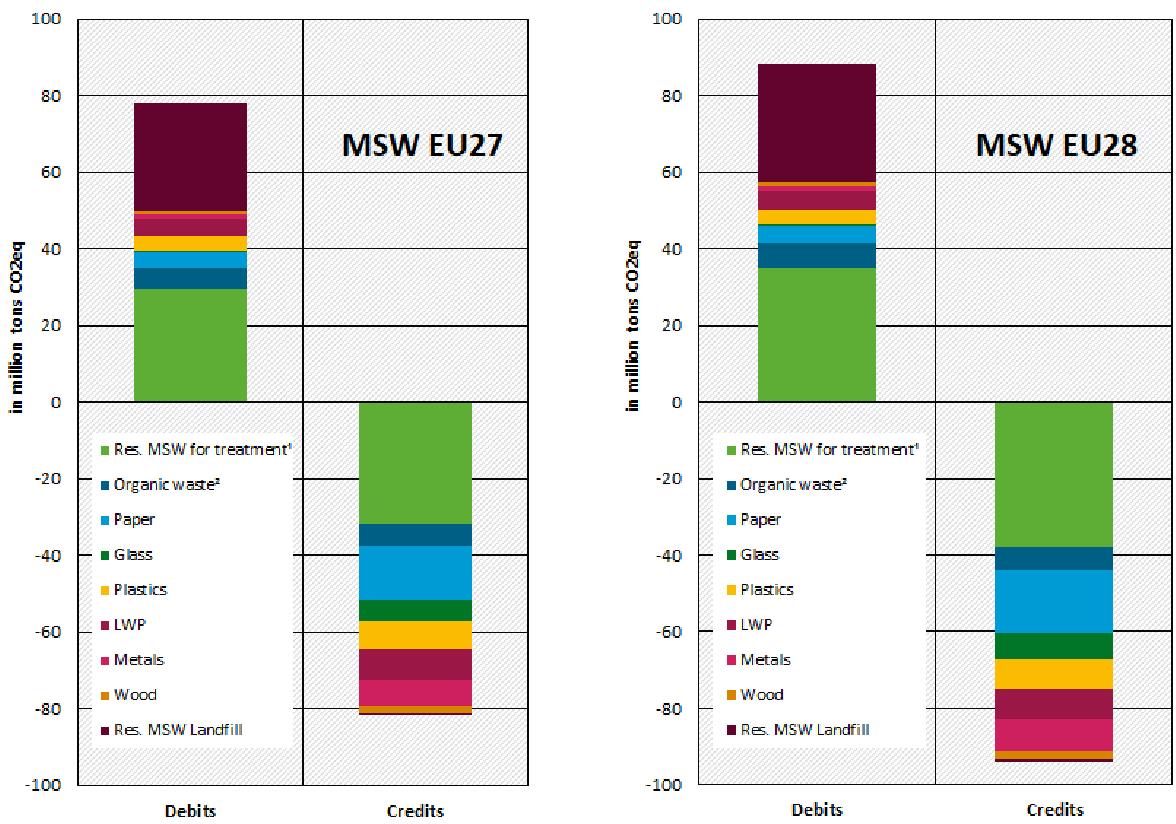
Chapter 5.5.2 presents the result of the GHG balance for the base comparison for the EU27 – the actual situation in 2017 (MSW EU27 2017) compared to the lead scenario 2030 (MSW EU27 2030 WFD). The following Chapter 5.5.3 describes the results for the scenario with home composting in the RC rate for the EU27. Chapters 5.5.4 and 5.5.5 present the results for Cluster 1 and Cluster 2, both the lead scenario and the special scenario compared to the base year 2017. The sensitivities with the regional electricity mix are shown in Chapter 5.5.1.1.

5.5.1 Base year 2017

The absolute GHG results for MSW per waste fraction in the base year 2017 for the four balance areas EU27, EU28, Cluster 2 and Cluster 1 are shown in Figure 13 and Figure 14. The results cannot be compared directly as they refer to different waste amounts. Nevertheless, it is evident from the results that for all balance areas the main contributions come from residual MSW, which is the main fraction and determines the results.

For the EU27 and the EU28, the debits from residual MSW for treatment are approximately in the same range as the debits from residual MSW to landfill. This also accounts for the results for Cluster 2. For Cluster 1 the debits from MSW to landfill are dominating. Landfill gas collection is considered (see Chapter 4.2.3) but gives no relevant saving potentials in the GHG results. The relevant credits are derived from recycling and also from residual MSW for treatment.

Figure 13: Absolute GHG results MSW EU27 2017 (left) and MSW EU28 2017 (right)



1) Includes treatment via incineration, MBT and MT

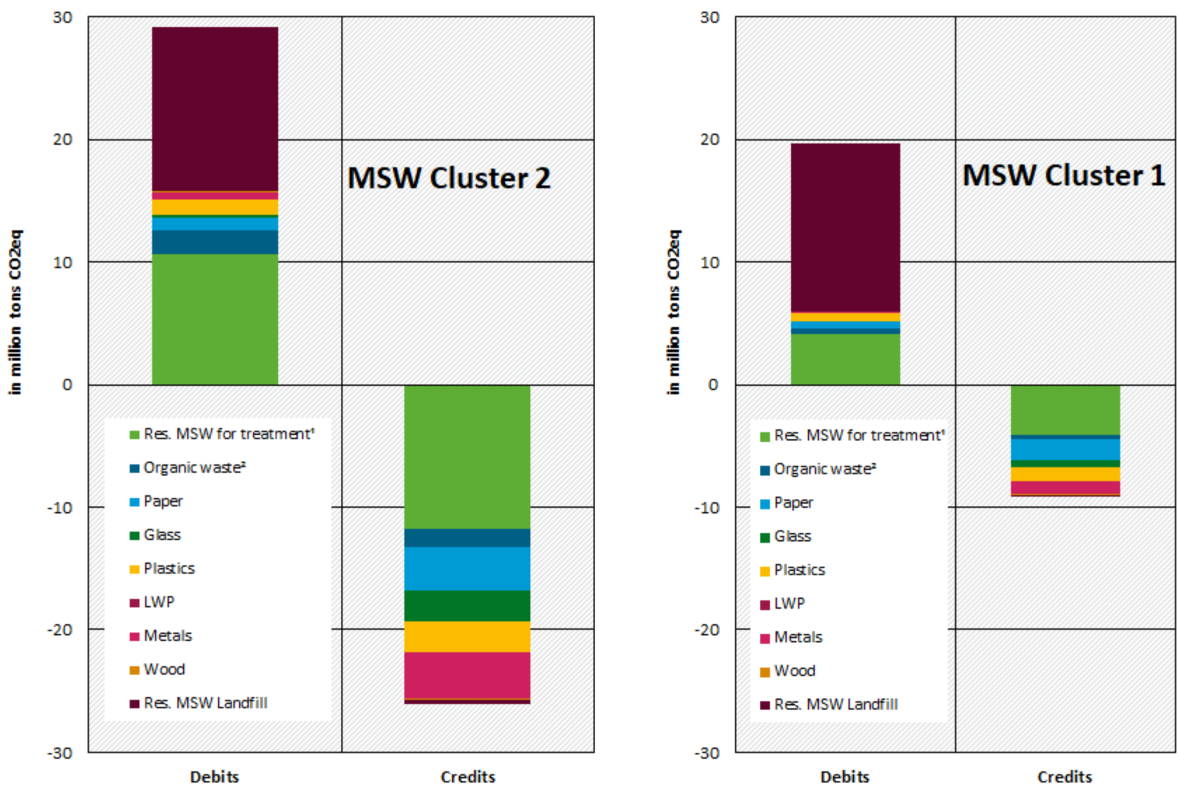
2) Organic waste includes food waste, garden waste, other biowaste

Source: own illustration, ifeu.

For the EU27, residual MSW for treatment and residual MSW to landfill together comprise 74% of the debits. The debit share of landfilling alone is 36%. The main contributions for the credits, with the share of 39%, come from residual MSW for treatment. The results for the EU28 are similar to those of the EU27 with nearly the same contributions of the waste fractions as described for the EU27.

The results for Cluster 1 are dominated residual MSW to landfill with 70% share of the debits. Also, for Cluster 2 residual MSW to landfill plays a more important role compared to the EU27 with 46% contribution to the debits. Main contributions for the credits come from the treatment of residual MSW, while recycling of dry recyclables also play an important role.

Figure 14: Absolute GHG results MSW 2017 Cluster 2 (left) and Cluster 1 (right)



1) Includes treatment via incineration, MBT and MT
2) Organic waste includes food waste, garden waste, other biowaste
Source: own illustration, ifeu.

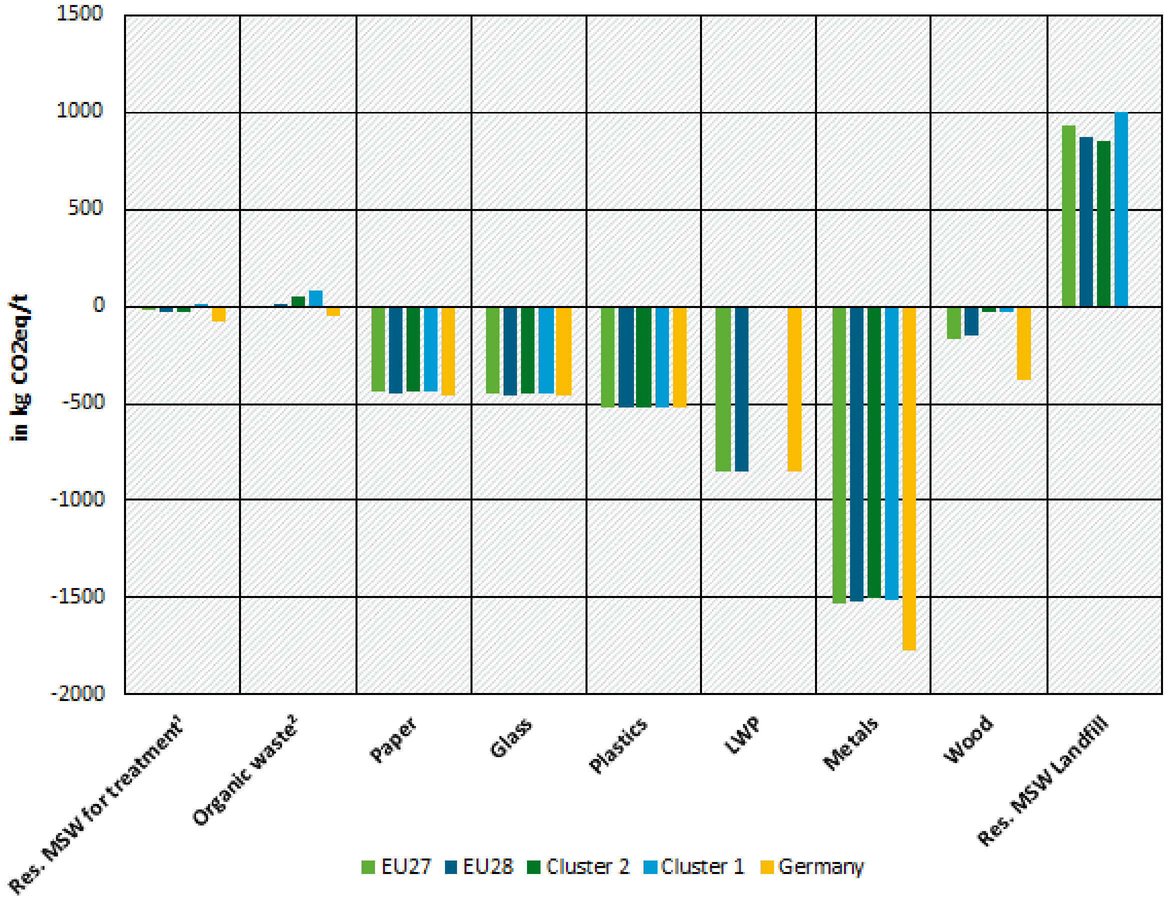
The absolute GHG net results (debits minus credits) for the four balance areas are:

- EU27: -3.5 million tons CO_2eq
- EU28: -5.4 million tons CO_2eq
- Cluster 2: 3.1 million tons CO_2eq
- Cluster 1: 10.5 million tons CO_2eq

While the EU27 and EU28 achieve net credits, Cluster 1 and Cluster 2 show net debit results. This is mainly due to the comparably high share of residual MSW of the total MSW, which is landfilled or incinerated. The absolute GHG net result for Germany is -12.2 million tons CO_2eq (see partial report Germany). The rather high net credit is the result of the comparably high share of source segregated MSW for recycling, in Germany in 2017 only 42% were residual MSW (for EU balance areas see Chapter 5.2.5).

A comparison of the results is possible with the specific GHG results. Figure 15 shows the net specific GHG results by waste fraction for the EU27, EU28, Cluster 1 and Cluster 2 and, for comparison, also for Germany.

Figure 15: Specific GHG net results MSW 2017 EU balance areas



1) Includes treatment via incineration, MBT and MT

2) Organic waste includes food waste, garden waste, other biowaste

Source: own illustration, ifeu.

The specific net results for the different balance areas are not very different for most of the waste fractions as the calculations are similar. **Residual MSW to landfill** shows by far the highest net specific debits. The net results from residual MSW to landfill depend on the parameters, which differ for the four EU balance areas (see Chapter 4.2.3). For Germany, the result is zero as landfilling has been banned since 2005. The net specific results for **residual MSW for treatment** show a slight net saving potential for all the balance areas, except for Cluster 1. The net debits from Cluster 1 are mainly due to the necessary correction for Hungary where the MBT5 output from the EEA-model needed to be manually corrected. The amount was assigned to landfill instead (see Chapter 4.2.5) with respective high GHG emissions. This landfilled fraction is included in the calculations for the EU27 and EU28, which explains their lower credits compared to Cluster 2 and Germany. Somewhat higher differences are given for **wood**, where in Germany – based on the German statistic (Destatis 2019) – wood is mainly used for energy generation. In the EEA-model, the separately collected wood is assigned 100% to recycling. For the time being with the current emission factors for electricity and heat generation, the net contribution of wood recycling (see Chapter 4.2.8) is lower than the net contribution from energy use (see also partial report Germany). The specific net result for wood recycling is represented by the results for Cluster 1 and Cluster 2, which are equal. The higher net results for the EU27 and the EU28 are due to the share of Germany.

The differences for the treatment of the **organic waste** fractions are mainly due to the respective share of anaerobic digestion. The higher this share, the better the net result. Cluster 1 countries have high composting rates for organic waste fractions and the highest direct emissions for composting (Table 25), and, therefore, the highest net debit result (see Chapter 4.2.7). **Paper** recycling for the different EU balance areas differs slightly due to the sorting residues that are incinerated with different energy efficiencies (see Chapter 4.2.4). The net result for **metals** is higher for Germany, since metal packaging with a slightly lower net credit is included in the LWP. The net results for **plastics** are equal for all the balance areas even though plastic packaging is also included in the LWP for Germany. **LWP** is only calculated for Germany and therefore, equals the absolute result for the EU27 and EU28 in the specific results.

An overview of the specific GHG net results per ton per waste fraction is shown in Table 61. Table 62 presents the specific GHG net results per capita.

Table 61: Specific net results per waste fraction per ton – MSW 2017 – in kg CO_2eq/t

Waste fraction	EU27	EU28	Cluster 2	Cluster 1
Res. MSW for treatment	-24	-29	-31	2
Organic waste	-1	-7	53	79
Paper	-443	-454	-436	-439
Glass	-454	-461	-452	-452
Plastics	-522	-521	-522	-522
LWP	-854	-854	0	0
Metals	-1,527	-1,522	-1,503	-1,507
Wood	-172	-147	-32	-32
Res. MSW to landfill	929	876	847	1,002
Total	**-17**	**-23**	**39**	**300**

Table 62: Specific net results per waste fraction per capita[1] – MSW 2017 – in kg CO_2eq/cap

Waste fraction	EU27	EU28	Cluster 2	Cluster 1
Res. MSW for treatment	-5.0	-5.9	-7.2	0.2
Organic waste	-0.1	0.5	3.2	1.8
Paper	-22.6	-23.1	-15.4	-11.6
Glass	-12.2	-12.1	-14.9	-5.5
Plastics	-7.7	-7.5	-7.7	-5.5
LWP	-7.7	-6.7	-	-

Waste fraction	EU27	EU28	Cluster 2	Cluster 1
Metals	-13.4	-13.6	-20.0	-8.9
Wood	-1.3	-1.2	-0.1	0.03
Res. MSW to landfill	61.9	59.0	81.3	132.1
Total	**-7.9**	**-10.5**	**19.1**	**102.6**

1) With 445,529,136 inhabitants for EU27; 511,373,278 inhabitants for EU28; 160,252,140 inhabitants for Cluster 2 102,303,237 inhabitants for Cluster 1 (see Table 27).

5.5.1.1 Sensitivity, regional electricity emission factor 2017 for Cluster 1 and Cluster 2

In this study, the energy emission factors for the EU27 are used uniformly for all EU balance areas (Chapter 5.4.4). This is indispensable in order to be able to recognise the differences as well as the advantages and disadvantages of the waste management measures. However, for the EU balances for MSW, sensitivities are calculated for the base year 2017 with the regional electricity emission factors for Cluster 1 and Cluster 2 (Table 9). A higher emission factor as for Cluster 1 leads to higher savings potentials for electricity generation from waste but also to higher debits for electricity demand. With a lower factor as for Cluster 2 it is vice versa. Table 63 and Table 64 show the absolute net results of the sensitivities for Cluster 1 and Cluster 2.

For Cluster 1, in total the higher electricity emission factor leads to a 1% higher absolute net debit. Per waste fraction it depends whether the direct emissions from energy demand or the credits from waste to energy are more relevant. The latter leads to better results especially for residual MSW for treatment and for residual MSW to landfill (electricity from landfill gas). In case of residual MSW for treatment the higher credit for electricity from incineration leads to the shift from a net debit to a net credit. However, the net debit for Cluster 1 is only due to the correction for Hungary (see Chapter 4.2.5). The higher credits are counteracted by the higher debits for electricity demand which is especially relevant for plastics and also for paper recycling. The influence of the higher credits for electricity generation is low for Cluster 1 because most of the residual MSW is still landfilled (55% including the correction for Hungary).

Table 63: Sensitivity regional electricity emission factor Cluster 1 – absolute results in million tons CO_2eq

Waste fraction	2017 sensitivity	2017
Res. MSW for treatment	-0.18	0.02
Organic waste	0.17	0.19
Paper	-1.02	-1.19
Glass	-0.57	-0.56
Plastics	-0.33	-0.56
Metals	-0.92	-0.91
Wood	0.00	0.00
Res. MSW to landfill	13.42	13.52
Total	**10.57**	**10.50**

For Cluster 2, in total the lower electricity emission factor leads to a 33% higher absolute net debit. Again, the results per waste fraction depend weather the direct emissions from energy demand or the credits from electricity generation from waste are more relevant. For Cluster 2, in contrast to Cluster 1, the share of residual MSW for thermal treatment is much higher and therefore the reduced credit for electricity generation is more relevant. This is the reason for the shift from a net credit to a net debit for residual MSW for treatment and dominates the higher overall net debit in the sensitivity. The effect for electricity demand can also be observed. The lower electricity emission factor in the sensitivity leads to lower debits for the recycling especially of plastics and also of paper, and thus to higher net credits for these waste fractions.

Table 64: Sensitivity regional electricity emission factor Cluster 2 – absolute results in million tons CO_2eq

Waste fraction	2017 sensitivity	2017
Res. MSW for treatment	0.18	-1.15
Organic waste	0.53	0.51
Paper	-2.66	-2.47
Glass	-2,37	-2.39
Plastics	-1.54	-1.24
Metals	-3.20	-3.21
Wood	-0.01	-0.01
Res. MSW to landfill	13.15	13.03
Total	**4.07**	**3.06**

5.5.2 Base comparison EU27

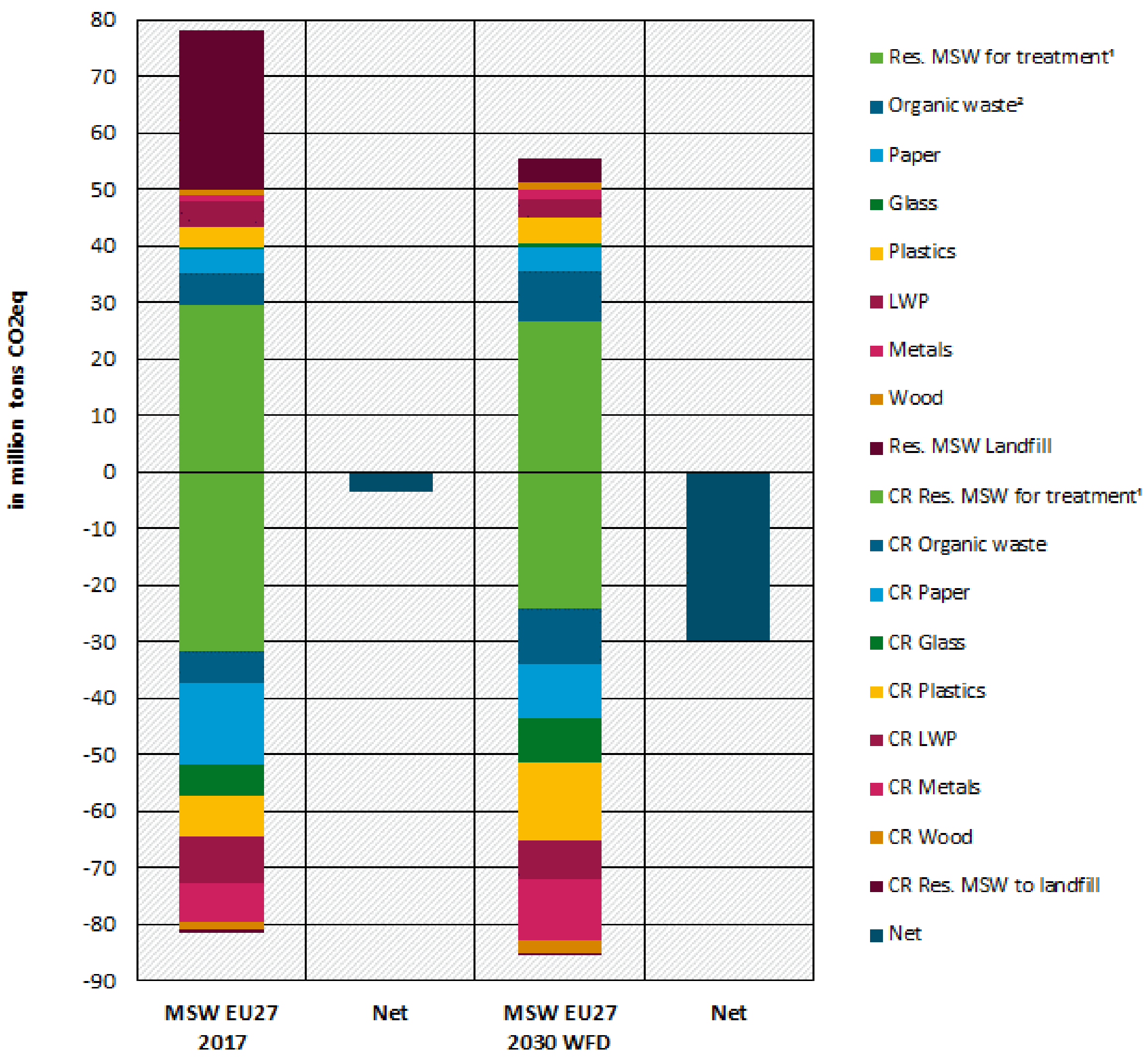
In the base comparison, the GHG results for the actual situation for EU27 in 2017 are compared with those of the lead scenario (WFD) described in Chapter 5.4.1. Following terms are used in the figures:

- Base 2017, EU27: "MSW EU27 2017"
- Lead scenario 2030, EU27: "MSW EU27 2030 WFD"

Figure 16 shows a comparison of the absolute results according to the debits and credits of the waste fractions, as well as, the total net results for both years. For the **base year 2017**, there is an **absolute net saving potential of about -3.5 million tons CO_2eq**. The underlying debits amount to about 78 million tons CO_2eq and the credits to about -81.6 million tons CO_2eq. The absolute debits are mainly caused by residual MSW for treatment and residual MSW to landfill, which together represent 74% of the debits. The saving potentials result from residual MSW for treatment, which are a little higher than the respective debits, and otherwise mainly from recycling of source segregated dry recyclables. The waste fractions of residual MSW for treatment and paper comprise 56% of the absolute credits, and represent 55% of the generated waste in 2017 in terms of mass.

The debits in the **lead scenario (WFD)** in turn are lower with about 55 million tons CO_2eq, while the credits remain on a similar level with the base scenario at -85 million tons CO_2eq. This results in an **absolute net saving potential of about -30 million tons CO_2eq**. The most distinctive difference in the share of total debits is the reduction in landfilling from 36% to 7%. In turn, residual MSW for treatment and organic waste account for about 64% of the debits. 69% of the credits consist of residual MSW for treatment and recycling of paper, plastics and metals (accounts for 60 wt%).

Figure 16: Base comparison MSW EU27 – base 2017 and lead scenario 2030



CR: credit, or emission savings potential.

1) Includes treatment via incineration, MBT and MT

Source: own illustration, ifeu.

The differences in the result – the remarkably higher net credit – is mainly due to the significant decrease in the amount of landfilling within the WFD scenario. Moreover, the increased amount of separately collected dry recyclables and technical optimisations (especially for residual MSW for treatment, see Chapter 5.4.1), are responsible for the higher net credit in the lead scenario 2030. However, the net credits are partly countered by the defossilisation of the energy system, which means that emissions from energy generation are reduced and the substitution potentials for energy and primary products with it. The latter is visible in the absolute results for paper recycling due to the electricity intensive primary production (see Chapter 5.2.4).

In the WFD scenario still about 4.3 million tons of residual MSW is landfilled (Cluster 1). If diversion from landfill could be completely implemented until 2030 in the EU27 further about 4 million tons CO_2eq would be avoided.

The following table shows the overall GHG net results for MSW by waste fraction in absolute values as well as in specific results per ton and per capita for the base year 2017 and the lead scenario (WFD) 2030.

Table 65: Absolute and specific net results by waste fraction – base comparison MSW EU27: base year 2017 and lead scenario, WFD, 2030

Waste fraction	Absolute		Specific per capita[1]		Specific per ton	
MSW	**2017**	**2030 WFD**	**2017**	**2030 WFD**	**2017**	**2030 WFD**
	Million tons CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
Res. MSW for treatment	-2.21	2.30	-5.0	5.2	-24	35
Organic waste	-0.03	-0.80	-0.1	-1.8	-1	-13
Paper	-10.05	-5.39	-22.6	-12.1	-443	-169
Glass	-5.43	-7.43	-12.2	-16.7	-454	-450
Plastics	-3.43	-9.03	-7.7	-20.3	-522	-695
LWP	-3.44	-3.60	-7.7	-8.1	-854	-893
Metals	-5.95	-9.32	-13.4	-20.9	-1,527	-1,413
Wood	-0.59	-0.67	-1.3	-1.5	-172	-132
Res. MSW to landfill	27.59	3.96	61.9	8.9	929	928
Sum/average	**-3.53**	**-29.99**	**-7.9**	**-67.3**	**-17**	**-143**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27).

Based on the specific net results by waste fraction per ton of waste, the differences in results can be explained as follows:

At the specific level per ton, **metals** show high net emission savings potentials. The production of pig iron and aluminium is associated with relatively high GHG emissions. In the lead scenario 2030, the specific net emission savings decrease, as reduced GHG impacts are estimated for the electricity intensive primary production of aluminium (see also partial report Germany).

Moreover, the treatment of **plastic waste and LWP** show relatively high specific net emission savings potentials. In the lead scenario 2030, the net savings for plastics increase more significantly than for LWP. This is due to the lower GHG debits for electricity demand (higher for pure plastics than for LWP mixed with other packaging waste). The emission savings potentials for plastic waste change little. Increases in the emission savings potentials could be achieved primarily through better qualities and the resulting greater substitution of virgin plastics instead of applications as wood and concrete as substitutes (see also partial report Germany).

The net emission savings potentials per ton for **paper and glass** are roughly similar in the base year 2017. In the lead scenario 2030, the specific net emission savings potential for paper decreases. The main reason is the reduced GHG impacts estimated for the electricity intensive primary production of wood and pulp. Reduced emission savings potentials from the energy recovery of rejects also play a role. In 2017, these went proportionately to coal-fired power plants for co-incineration. In contrast, the diversion for treatment in thermal treatment plants in 2030 is associated with lower emission savings potentials. Partly, these are compensated by the higher efficiency rates assumed for thermal treatment plants in 2030. The specific net result for glass waste is almost unchanged; as electricity demand and energy recovery from processing residues only play a minor role.

Wood also shows a net emission savings potential for 2017. Chipboard recycling of wood is associated with a comparatively low specific net credit (Chapter 4.2.8). For wood waste, the slightly reduced specific net savings potential for 2030 is partly due to the lower electricity and heat credits (defossilisation) for energy generation, which are only partly compensated by the higher net efficiencies for biomass CHP assumed for 2030. The small quantity for which pyrolysis is assumed, has hardly any influence. The specific net result is in the same range as for wood recycling.

For **organic waste**, the specific net emission savings potential is near zero in the base year 2017, which is primarily achieved through proportional anaerobic digestion and biogas utilisation. For composting GHG debits are higher than the credits. In the lead scenario 2030, the specific net emission savings potential is a little higher. This is due to the assumed increase of anaerobic digestion of food waste which overcompensates the reduced electricity and heat credits from energy generated by biogas or biomethane (defossilisation). The specific results for composting remain largely unchanged in the lead scenario 2030. The soldier fly larvae additionally considered for the food waste treatment has hardly any influence on the result due to the small quantities of waste assumed to be treated in this way. On a specific level, the net result is similar to that from composting. However, data uncertainty is high and compared to Germany it was assumed that 75% of the heat requirement can be covered from ambient temperature due to more southern country locations in the EU areas (see Chapter 5.2.6.2). Nevertheless, this option could be an alternative to landfilling.

The **residual MSW for treatment** is associated with a slight specific net emission savings potential in the base year 2017. The specific emission savings potential is higher when the produced RDF is also proportionately co-incinerated in coal power plants and cement kilns where it replaces fossil fuels. However, there are high data uncertainties about the share of RDF, and both the composition of the input material and the characteristics and quality of the RDF produced (Chapter 4.2.5). Additionally, the special case of Hungary (cf. Chapter 4.2.5) reduces the specific net results for residual MSW for treatment. In the lead scenario 2030, the specific net result of residual MSW treatment shifts to a net debit. On the one hand, the background to this lies in the reduced emission savings potentials from electricity and heat generation from waste (defossilisation, see emission factors for electricity and heat in Table 9). On the other hand, the further increase of the fossil carbon content in the residual MSW is of relevance (Table 156)[38]. A further reason for less credits is the diversion of RDF from co-incineration in coal power plants to incineration in thermal treatment plants. On average, this affects 11% of the RDF. This is counteracted by the higher net energy efficiencies assumed for thermal treatment plants in 2030 (Table 50).

The specific net results for **residual MSW to landfill** show a very high net debit both in 2017 and in 2030. Methane emissions to air from biodegradation cause significant climate impacts. The share of landfill gas recovered per ton waste disposed of is technically limited. In addition,

[38] This is different in the separately calculated balance for Germany, where the fossil carbon content in residual MSW for treatment is lower in the lead scenario, which is one reason why the specific net result is still a net savings potential (with EU27 emission factors, cf. partial report Germany).

the achievable substitution potential (credit) from landfill gas use is very low compared to the impacts from methane emissions.

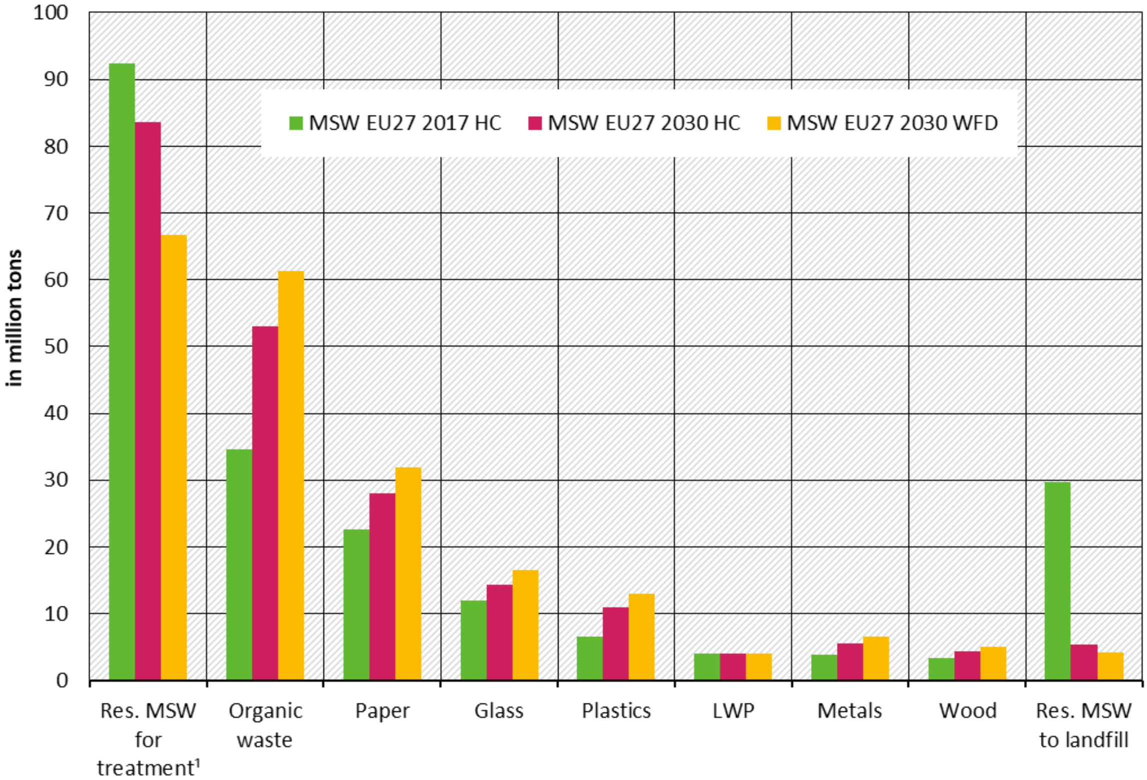
5.5.3 Scenario with home composting in the RC rate for the EU27

The scenario with home composting in the RC rate for the EU27 allows consideration at a reduced ambition level of separate collection, although there are very high data uncertainties regarding home composting. The purpose and the assumptions of the scenario with home composting in the RC rate are described in Chapter 5.4 and 5.4.2. Due to the purpose and due to high data uncertainties home composting is rated zero in the GHG balance. For the figures, the following (further[39]) designations are used in this scenario:

- Scenario with home composting in the RC rate 2017: "MSW EU27 2017 HC"
- Scenario with home composting in the RC rate 2030: "MSW EU27 2030 HC"

Figure 17 shows the differences in the waste amounts to first treatment in the scenario with home composting in the RC rate compared to the base comparison. For clarity, the amount of home composting is not shown. Without the home composting, the volume in the 2017 base year is the same as that shown in the figure for the scenario with home composting in the RC rate for 2017 and is not listed separately. The figure illustrates the reduced ambition level for increased separate collection by the defined home composting volume and its inclusion in the RC rate.

Figure 17: Scenario with home composting in the RC rate MSW EU27 – comparison MSW to first treatment with the lead scenario 2030 (WFD)



For reasons of clarity, the volume of 40.2 million tons for the home composting is not shown.
1) Includes treatment via incineration; MBT, MT
Source: own illustration, ifeu.

[39] For comparison, the lead scenario 2030 is shown "MSW EU27 2030 WFD".

The scenario with home composting in the RC rate results in an absolute net emission savings potential of around -3.5 million tons CO_2eq for the balance year 2017. A comparison at the absolute level with the baseline comparison is generally not methodologically permissible due to the different total waste quantities (209.4 million tons in the base comparison and 249.6 million tons in the scenario with home composting in the RC rate). However, since home composting itself is valued at zero in the GHG balance, there is no difference in the absolute result for 2017 compared to the result of the 2017 base scenario.

For the year 2030, the scenario with home composting in the RC rate results in an absolute net emission savings potential of -25.2 million tons CO_2eq. Again, it is true that a comparison with the base comparison (lead scenario 2030) is fundamentally methodologically not permissible at the absolute level. If it were correct that home composting was virtually neutral and thus had no influence on the GHG emissions, it could be stated that the scenario with a lower ambition level for the increased separate collection, compared to the lead scenario 2030, **would lead to a reduction of the emission savings potential by about 5 million tons CO_2eq.**

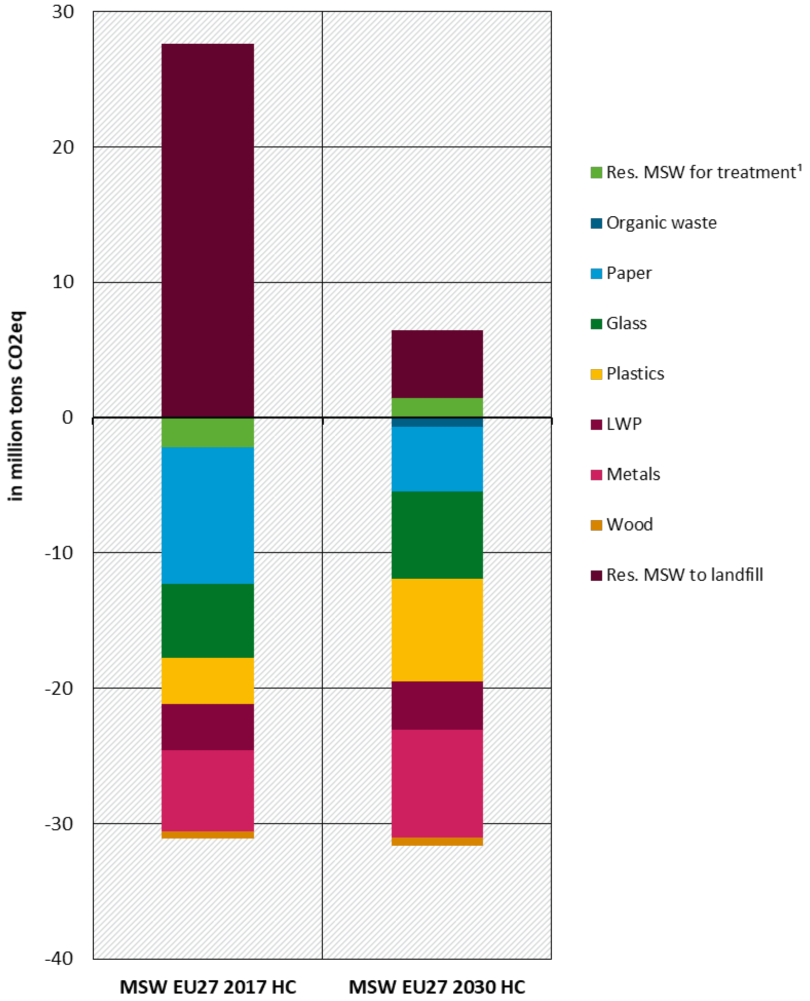
Figure 18 shows the result for the scenario with home composting in the RC rate as absolute net results by waste fraction. In contrast to the results shown in Figure 16 here the results are presented as net values per waste fraction (difference of debits and credits per waste fraction). This helps to prevent direct comparison (which should not be done) and the net contributions per waste fraction are more obvious.

In the Figure 18, the results for 2017 are the same as for the 2017 base scenario (since home composting is valued at zero). For 2030, the qualitative comparison with the lead scenario 2030 shows that the recycling of dry recyclables in particular achieves lower absolute net emission savings potentials, due to the reduced separately collected quantities. The results for residual MSW differ slightly due to different amounts treated and different waste compositions and thus characteristics (calorific value, fossil and biogenic carbon content).

The fact that the absolute net emission savings potential is not more significantly lower than in the lead scenario 2030, is due to the fact that the reduced amount of residual MSW to landfill is nearly the same as in the lead scenario (reduction by 82% in the scenario with home composting in the RC rate (Table 54) compared to a reduction by 86% in the lead scenario 2030 (Table 49)). Another aspect is that about half of the increased separate collection is in organic waste. For the year 2017, the net emission savings potential for organic waste is close to zero (Table 65). Therefore, the reduced increase for this fraction does not make a relevant difference in the scenario with home composting in the RC rate. The more significant net savings potentials result from the recycling of dry recyclables.

At the specific level per ton of waste, the results can be compared quantitatively. Differences to the base comparison in the specific result by waste type exist only for 2030 and especially for the waste fractions of residual MSW to landfill and residual MSW for treatment. The net debits from landfilling of residual waste are in the same range. Differences result from slightly different compositions and thus biogenic carbon contents. For the residual MSW for treatment, the shift from a specific net credit in 2017 to a specific net debit in 2030 is also given as in the base comparison. However, the specific net debit in 2030 is lower in the scenario with home composting in the RC rate. This is mainly due to different characteristic data for calorific value and fossil C content for thermal treatment (different composition of residual waste in 2030). In addition, the result for treatment of “mixed waste” is slightly better on a specific basis because of the necessary correction for the amount to landfill for Hungary (see Chapter 4.2.5) which is unchanged in both scenarios for 2030[40], whereas the total amount of residual MSW ("mixed waste") to mechanical treatment is higher in the scenario with home composting in the RC rate. For all other fractions, the specific net result remains unchanged or changes only slightly compared to the 2030 lead scenario.

Figure 18: Scenario with home composting in the RC rate MSW EU27 – absolute net results by waste fraction (debit minus credit per waste fraction)



1) Includes treatment via incineration, MBT, MT
Source: own illustration, ifeu.

The clearest difference at the specific level arises in relation to the total waste quantities. The total specific net savings potential is significantly lower, as the results refer to around 250 million tons (including the 40.2 million tons of home composting).

- MSW EU27 HC 2017: -14 kg CO_2eq/t MSW (16% lower than base year 2017)
- MSW EU27 HC 2030: -101 kg CO_2eq/t MSW (30% lower than lead scenario 2030)

The values apply to the assessment of home composting with zero, which is assumed here in order to keep the influence on the GHG balance as low as possible. In general, however, net debits are to be expected from home composting (cf. partial report Germany, annex A4).

[40] The corrected amount landfilled for 2017 is also reduced like landfilling in general for 2030, but is the same both in the lead scenario and in the scenario with home composting in the RC rate.

In the overall view of the scenario with home composting in the RC rate, it is to be noted that net emission savings potential is lost primarily due to the reduced separate collection of dry recyclables. With regard to organic recyclables, a lower ambition level would have less influence on the result of the GHG balance from a climate protection perspective. This applies even more if the ambitious increase in the separate collection of organic recyclables in the lead scenario 2030 of 26.7 million tons were to be associated with a significant increase in the content of impurities. With the average composition of the contaminants determined in this study (Chapter 4.2.7.1), an increase in the proportion of contaminants from 5% to 15% in the base comparison would be accompanied by a loss in the absolute net emission savings potential of around 2 million tons CO_2eq. This is due to the fossil CO_2 emissions from the incineration of the contaminants, which outweigh the emission savings potential from energy generation.

On the one hand, however, it should be noted that the observations in this study are scenario observations. They are based on average values and assumptions out of necessity. The amount of home composting itself is a determination; reliable data is still lacking. On the other hand, the increased separate collection and treatment of organic waste is an important component of a circular economy in terms of resource protection. The potential for optimising biological treatment through low-emission and efficient anaerobic digestion plants should also be investigated more closely. Currently, most EU member states use the IPCC guideline default values (IPCC 2006) (cf. Chapter 4.2.7.1). National measurement programs are recommended here. This also applies to Germany, where measured values date back several years (Cuhls et al. 2015), refer to anaerobic digestion facilities of biogenic waste from households[41] and the number of cases for concepts was 9, whereas in 2016 already about 80 anaerobic digestion plants existed in Germany. In addition, the technology of plant concepts has advanced in the meantime (see partial report Germany).

5.5.4 Scenario comparison Cluster 1

This chapter presents the GHG results of the actual situation for Cluster 1 in 2017 in comparison with those of the lead scenario 2030 and the special scenario 2030 (scenario descriptions in Chapter 5.4). Following terms are used in the figures:

- Base 2017, Cluster 1: “MSW CL1 2017”
- Lead scenario 2030, Cluster 1: “MSW CL1 2030 WFD”
- Special scenario 2030, Cluster 1: “MSW CL1 2030 SS”

Figure 19 shows a comparison of the absolute results according to the debits and credits of the waste fractions, as well as the total net results for each scenario. **The absolute net debit of the base year 2017 is 10.5 million tons CO_2eq**. The underlying debits amount to 19.6 million tons CO_2eq and the credits to -9.1 million tons CO_2eq. Landfilling of residual MSW clearly dominates the debits, with the share of 70% (with 39 wt% of total MSW). On the other hand, 88% of the credits include the credits for residual MSW for treatment and recycling of paper, plastics and metal, while comprising 51% of the total waste mass.

Both scenario 2030 show a shift in the net result from a net debit to a slight net credit. In both scenarios this is mainly due to diversion from landfill. In the lead scenario the share of MSW to landfill is cut down to 12 wt% of the total MSW, and in the special scenario to even 10 wt%.

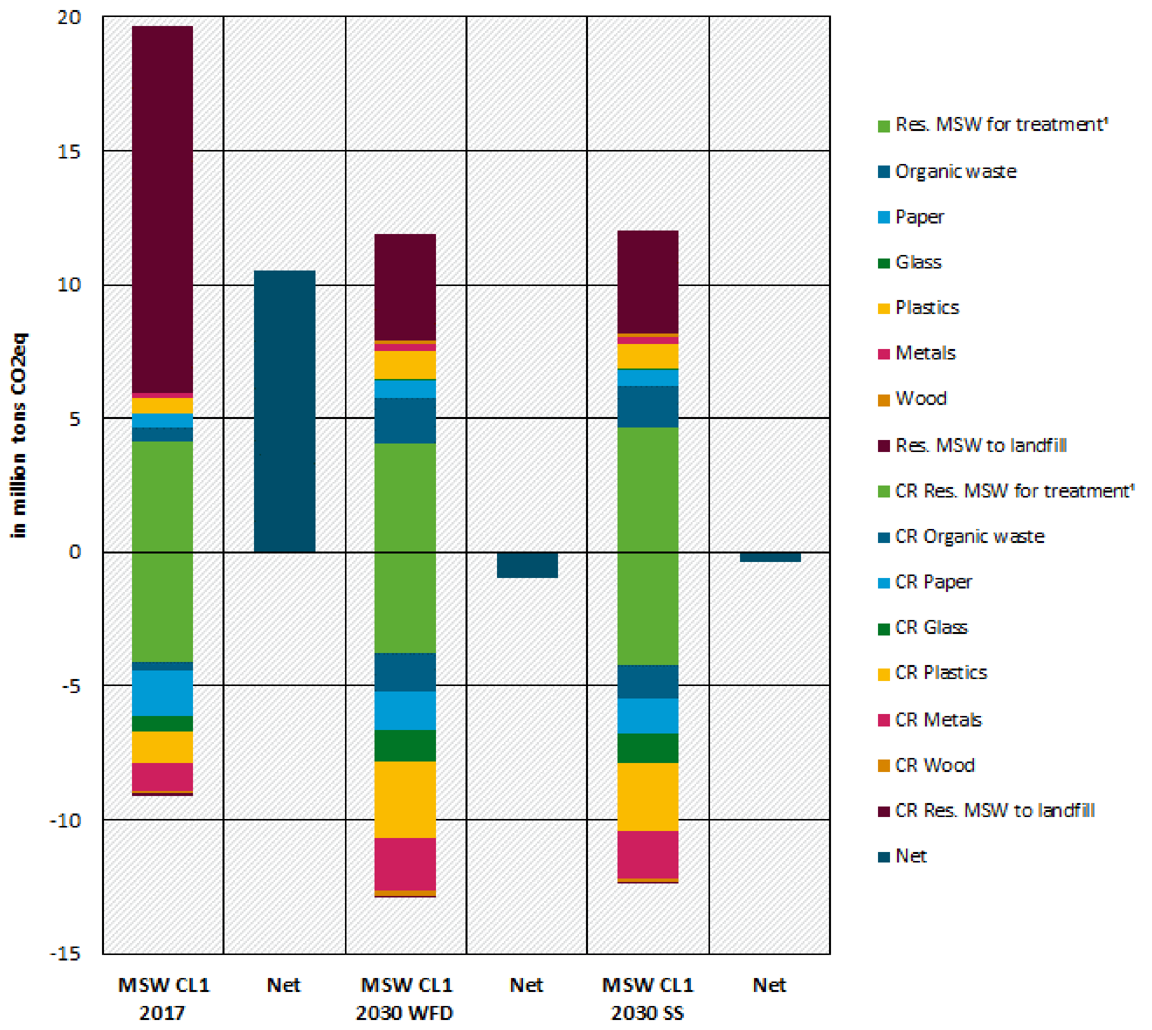
The lead scenario 2030 results in an absolute net emission savings potential of -0.9 million tons CO_2eq. The underlying debits are 11.9 million tons CO_2eq, while the credits

[41] In the NIR for Germany, the values are equally used for the anaerobic digestion of commercial food waste (stores, canteens), for which there is little public information available on the plant concepts.

are -12.8 million tons CO_2eq. The share of landfilling of residual MSW is distinctively lower in this scenario compared to the base year 2017, comprising 33% of the debits. Together with residual MSW for treatment, it accounts for 67% of the absolute debits. Simultaneously, residual MSW for treatment and recycling of plastics and metals form 67% of the credits (account for 39 wt%).

The results of **the special scenario 2030** are close to the lead scenario, with **the absolute net credit of -0.4 million tons CO_2eq.** Residual MSW to landfill and residual MSW for treatment form 71% of the total debits of 12.0 million tons CO_2eq. In turn, residual MSW for treatment and the recycling of plastics and metal comprise 69% of the total credits of -12.4 million tons CO_2eq and represent 40% of the total waste mass.

Figure 19: Scenario comparison MSW Cluster 1



CR: credit, or emission savings potential.
1) Includes treatment via incineration, MBT, MT
Source: own illustration, ifeu.

In addition to the distinctly reduced amounts of residual MSW to landfill in the lead scenario 2030 and the special scenario 2030, the increased amount of separately collected dry recyclables and technical optimisations (especially for residual MSW for treatment, see Chapter 5.4.1) are responsible for the net credit in both 2030 scenarios. These aspects counteract the effects from defossilisation of the energy system (lower credits for energy generation and lower credits for electricity intensive primary production (paper, aluminium)). The amount of separate collected dry recyclables in the special scenario 2030 is more moderate than in the lead scenario 2030, which mainly explains the lower net emission savings potential. Although, the amount landfilled is a little lower in the special scenario this effect is less relevant than the additional net debits from incineration of the recyclables which are less collected separately in the special scenario.

The following table shows the overall GHG net results for MSW of Cluster 1 by waste fraction in absolute values as well as in specific values per capita and per ton for the base year 2017, the lead scenario 2030 and the special scenario 2030.

Table 66: Absolute and specific net results by waste fraction – scenario comparison MSW Cluster 1: base year 2017, lead scenario 2030 (WFD) and special scenario 2030

Waste fraction	Absolute			Specific per capita[1]			Specific per ton		
MSW	**2017**	**2030 WFD**	**2030 SS**	**2017**	**2030 WFD**	**2030 SS**	**2017**	**2030 WFD**	**2030 SS**
	Million tons CO_2eq			kg CO_2eq/cap			kg CO_2eq/t		
Res. MSW for treatment	0.02	0.26	0.47	0.2	2.5	4.6	2	27	45
Organic waste	0.19	0.31	0.28	1.8	3.0	2.7	79	32	32
Paper	-1.19	-0.80	-0.72	-11.6	-7.8	-7.1	-439	-166	-166
Glass	-0.56	-1.10	-0.99	-5.5	-10.8	-9.7	-452	-448	-448
Plastics	-0.56	-1.87	-1.68	-5.5	-18.2	-16.4	-522	-691	-691
Metals	-0.91	-1.67	-1.51	-8.9	-16.4	-14.7	-1,507	-1,391	-1,391
Wood	0.00	-0.01	-0.01	0.0	-0.1	-0.1	-32	-37	-37
Res. MSW to landfill	13.52	3.96	3.81	132.1	38.7	37.2	1,002	928	1,040
Sum/average	**10.50**	**-0.93**	**-0.36**	**102.6**	**-9.1**	**-3.5**	**300**	**-27**	**-10**

1) Calculated with 102,303,237 inhabitants in 2017 (Table 27).

On the basis of the specific net results by waste fraction per ton of waste, the variances in the results can be explained. In general, the two scenarios, the lead scenario 2030 (WFD) and the special scenario 2030, show no differences in the specific net results for dry recyclables (paper, glass, plastics, metals), wood and organic waste. On a specific basis, the assumptions are only relevant for residual MSW and the respective shares to landfill and for treatment.

The specific net results for **dry recyclables** for the years 2017 and 2030 are equal or similar to those for the EU27 which are explained in Chapter 5.5.1.1. Small differences derive from the thermal treatment of sorting residues due to differing net efficiencies in the EU balance areas (Table 15). In addition, the results for Germany are included in the EU27 which are slightly different (see explanation Chapter 5.5.1).

The emission savings potential of **wood** is relatively low, though in 2030 it increases marginally due to the lower debits from electricity demand for the recycling process (defossilisation). Pyrolysis is not considered for Cluster 1 countries.

For the **organic waste**, there is a specific net debit in the base year 2017 because of the high share of composting (94%). In the lead scenario 2030, the specific net debits are reduced. This is primarily because of the increased quantity of food waste diverted from composting to anaerobic digestion. Furthermore, for anaerobic digestion both the debits from the process as well the emission savings potentials through biogas and biomethane decrease due to the defossilisation. The specific results for composting remain largely unchanged in both 2030 scenarios. They are a little higher than for the EU27 due to higher direct emissions for the Cluster 1 countries (see Table 25). Additionally, the treatment with solder fly larvae has a minor contribution to the specific net debits (here lower than that from composting). Even though, the heat requirement for the process is reduced by 75%, as in the case of EU27, the emissions from the energy demand are higher than the emission savings potentials from the process (see Chapter 5.2.6.2). Nevertheless, the option could be an alternative to landfilling, especially in countries where the heat demand could be covered by the ambient temperature and/or generated e.g. from solar energy.

The **residual MSW for treatment** in the base year 2017 has a specific net debit due to the necessary correction for Hungary" (see Chapter 5.5.1). The specific net results for treatment via incineration and via MBT are associated with specific net credits in 2017. Although, the share attributed to landfill for Hungary is reduced in the 2030 scenarios (like landfilling in general) a relevant specific net debit remains. In addition, as in the case of EU27, the specific net result for treatment via incineration shifts to a net debit in the 2030 scenarios. The main reasons are the same as explained for the EU27 (especially defossilisation and increase of fossil carbon content in the residual MSW). For treatment via MBT the specific net credit is increased mainly because the assumptions for the different MBT types (MBT1 to 4) result in relatively higher RDF yields for co-incineration in cement kilns. The net specific values for the different residual MSW treatments (treatment via incineration, MBT and MT) do not differ between the lead scenario 2030 and the special scenario 2030. However, in the special scenario 2030 the share of incineration is increased (see assumptions), which leads to a higher specific net debit for the aggregated result of residual MSW for treatment. The reduced ash content has no relevant influence on the specific result for thermal treatment, both calorific value and the fossil carbon content in the residual MSW increase in a similar ratio (see Table 156).

The specific net results for **residual MSW to landfill** show, as in the case of EU27, a very high net debit both in 2017 and in the 2030 scenarios. The slight differences in the specific net debits result from slightly different biogenic carbon contents in the residual waste (see Table 156).

5.5.5 Scenario comparison Cluster 2

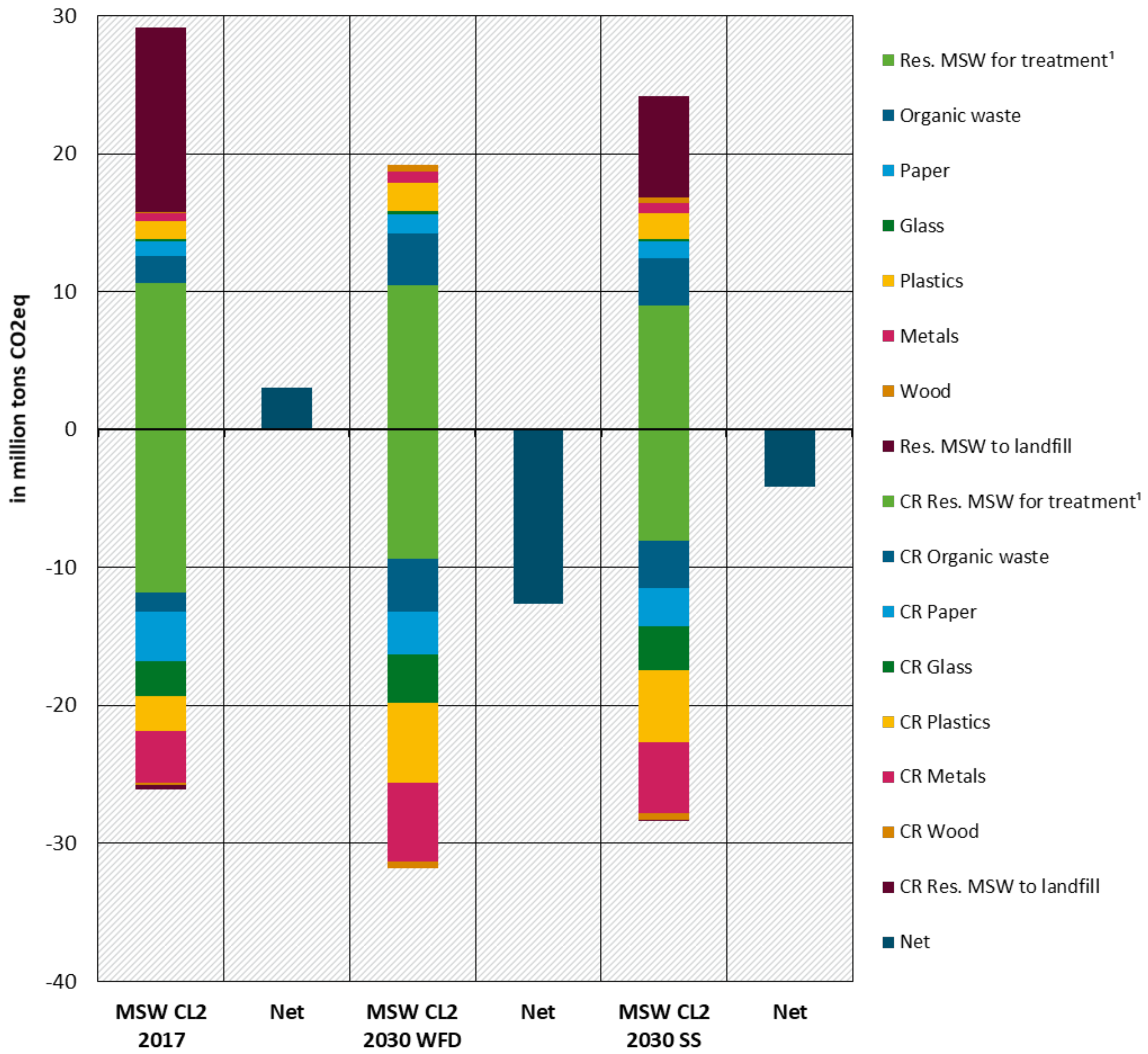
The GHG results of the base year 2017 for the Cluster 2 are presented in this chapter in comparison with those of the lead scenario 2030 and the special scenario 2030 (scenario descriptions in Chapter 5.4). Following terms are used in the figures:

- Base 2017, Cluster 2: "MSW CL2 2017"
- Lead scenario 2030, Cluster 2: "MSW CL2 2030 WFD"
- Special scenario 2030, Cluster 2: "MSW CL2 2030 SS"

Figure 20 compares the absolute results according to the debits and credits of the waste fractions, as well as the total net results for each scenario. **For the base year 2017, the absolute net debit is 3.1 million tons CO_2eq**. The underlying debits amount to about 29 million tons CO_2eq and the credits to -26 million tons CO_2eq. Landfilling of residual MSW has the highest share of debits and together with residual MSW for treatment, they form 82% of the debits. In turn, the residual MSW for treatment and the recycling of paper and metal account for 73% of the absolute credits (57 wt%).

Both scenario 2030 show a shift in the net result from a net debit to a net credit. In the lead scenario 2030 this is mainly due to the complete diversion from landfill. In the special scenario 2030 the net credit is much lower but here a relevant factor is the reduced share of MSW to landfill which is cut down to 11 wt% of the total MSW (assumption: as allowed according to landfill directive).

Figure 20: Scenario comparison MSW Cluster 2



CR: credit, or emission savings potential.

1) Includes treatment via incineration, MBT and MT

Source: own illustration, ifeu.

The lead scenario 2030 achieves an absolute net emission savings potential of -12.6 million tons CO_2eq. The underlying debits are 19.2 million tons CO_2eq, while the credits are -31.8 million tons CO_2eq. There is no landfilling of residual MSW in the lead scenario, which is the main reason for the distinct net emission savings potential. In this scenario, 55% of the debits are caused by the residual MSW for treatment. 65% of the credits come from residual MSW for treatment and the recycling of plastics and metal (45 wt%).

The absolute net emission savings potential of the special scenario 2030 is with -4.2 million tons CO_2eq somewhat lower than the one of the lead scenario. The total debits amount to 24.2 million tons CO_2eq, of which the landfilling and the residual MSW for treatment comprises 68%. On the other hand, the total absolute net emission savings potential is -28.4 million tons CO_2eq, of which the residual MSW for treatment and the recycling of plastics and metal make up 65% of the total credits (40 wt%).

As in the case of Cluster 1, in addition to the high influence of diversion from landfill, the increased amount of separately collected dry recyclables and technical optimisations (especially for residual MSW for treatment, see Chapter 5.4.1) are responsible for the net credit in both 2030 scenarios. These aspects counteract the effects from defossilisation of the energy system (lower credits for energy generation and lower credits for electricity intensive primary production (paper, aluminium)). The amount of separate collected dry recyclables in the special scenario 2030 is more moderate than in the lead scenario 2030, which further explains the lower net emission savings potential.

Table 67 shows the overall GHG net results for MSW of Cluster 2 by waste fraction in absolute values as well as in specific values per capita and per ton for the base year 2017, the lead scenario 2030 and the special scenario 2030.

Table 67: Absolute and specific net results by waste fraction – scenario comparison MSW Cluster 2: base year 2017, lead scenario 2030 (WFD) and special scenario 2030

Waste fraction	Absolute			Specific per capita[1]			Specific per ton		
MSW	**2017**	**2030 WFD**	**2030 SS**	**2017**	**2030 WFD**	**2030 SS**	**2017**	**2030 WFD**	**2030 SS**
	Million tons CO_2eq			kg CO_2eq/cap			kg CO_2eq/t		
Res. MSW for treatment	-1.15	1.10	0.95	-7.2	6.9	5.9	-31	42	42
Organic waste	0.51	-0.07	-0.06	3.2	-0.4	-0.4	53	-3	-3
Paper	-2.47	-1.69	-1.52	-15.4	-10.6	-9.5	-436	-168	-168
Glass	-2.39	-3.33	-3.00	-14.9	-20.8	-18.7	-452	-448	-448
Plastics	-1.24	-3.76	-3.38	-7.7	-23.4	-21.1	-522	-691	-691
Metals	-3.21	-4.84	-4.35	-20.0	-30.2	-27.2	-1,503	-1,392	-1,392
Wood	-0.01	-0.05	-0.05	-0.1	-0.3	-0.3	-32	-39	-39
Res. MSW to landfill	13.03	0.00	7.24	81.3	0.0	45.2	847	0	821
Sum/average	**3.06**	**-12.63**	**-4.18**	**19.1**	**-78.8**	**-26.1**	**39**	**-163**	**-54**

1) Calculated with 160,252,140 inhabitants in 2017 (Table 27).

On the basis of the specific net results by waste fraction per ton of waste, the differences in the results can be explained. In general, the two scenarios, the lead scenario 2030 (WFD) and the special scenario 2030, show no differences in the specific net results for all waste fractions but for residual MSW to landfill. In contrast to the assumptions for Cluster 1, here the proportions of the treatment options for residual MSW for treatment are unchanged.

As in the case of Cluster 1, the specific net results for **dry recyclables** for the years 2017 and 2030 are equal or similar to those for the EU27 which are explained in Chapter 5.5.1.1. Small differences derive from the thermal treatment of sorting residues due to differing net efficiencies in the EU balance areas (Table 15). In addition, the results for Germany are included in the EU27 which are slightly different (see explanation Chapter 5.5.1).

The emission savings potential of **wood** is relatively low, though in 2030 it increases marginally due to the lower debits from electricity demand for the recycling process (defossilisation). Furthermore, the new treatment method, pyrolysis, has a small effect on the increased emission savings potential.

Organic waste has a specific net debit in the base year 2017 due to the high share of composting (90%). However, compared to Cluster 1, the specific net debit is lower due to lower direct emissions for Cluster 2 countries (see Table 25). The specific net debit turns to a slight net credit in the 2030 scenarios. The increased quantity of food waste diverted from composting to anaerobic digestion is largely responsible for it (the specific results for garden waste and other biowaste change very little). The decreased emission saving potentials due to the defossilisation play a smaller role for Cluster 2 due to the share of biomethane generation and use as substitute for fossil fuel[42]. The new treatment method in 2030 scenarios, solder fly larvae, contributes to specific net debits (here a little lower than that from composting). Nevertheless, as mentioned before, the option could be an alternative to landfilling.

In the base year 2017, the **residual MSW for treatment** has a specific net emission savings potential. This accounts for all three treatment options but is higher for the proportionate co-incineration of produced RDF in coal and cement plants in order to replace fossil fuels. However, as explained for the EU27, there are high data uncertainties about the share of RDF, the composition of the input material (MSW to MT shall not have organic components), and characteristics and quality of RDF produced. In the scenarios for 2030, the specific net result of residual MSW for treatment shifts to a net debit. Again, the background to this lies in the reduced emission savings potentials from electricity and heat generation from waste (defossilisation, see Table 9). And the further reason for less credits is the diversion of RDF from co-incineration in coal-fired power plants to incineration in thermal treatment plants. In addition, the increase of the fossil carbon content in the remaining residual MSW is of relevance (Table 156).

The specific net results for **residual MSW to landfill** show a very high net debit both in 2017 and in the special scenario 2030 (as no more MSW is landfilled in the lead scenario the respective value is zero). The slightly lower specific net debit in the special scenario 2030 compared to the base year 2017 results from the slightly lower biogenic carbon content in the residual MSW (Table 156).

[42] No AD4 and 5 for Cluster 1 countries from the EEA model (chapter A.1.2).

6 Special balance food waste

The special balance sheet food waste comprises the food content in the organic waste of MSW and C&I waste. A distinction was made between the areas of origin when collecting the basic data or, in particular for the EU, an attempt was made to obtain a differentiation between food waste managed as MSW and food waste contained in C&I waste. In general, food waste is reported under the EWC-Stat categories W091+W092 “animal and mixed food waste; vegetal wastes” and under W101 “household and similar wastes”. The shares of W091 and W092 and for kitchen and organic waste could be determined based on information from literature, national statistical data, information from the validation of WStatR data carried out by the contractor and estimates (Gonser et al. 2020). For the accounting of the EU balance areas, the German statistic (Destatis 2019) was evaluated in more detail in order to be able to make plausible assumptions for the EU based on them.

6.1 Waste generation and treatment

6.1.1 Methodology

For the estimation of food waste generation two approaches were investigated:

- the FUSIONS approach;
- the WStatR-based approach.

FUSIONS approach:

The EU FP7 research programme FUSIONS investigated in the period 2012 – 2016 the available methods for the determination of food waste generation and produced an estimate of the amount of food waste generated in the EU (Stenmarck et al. 2016) for the reference year 2012. The estimate refers to the whole EU28 and consists of separate estimates for the different stages of the food supply chain, i.e. for the sectors:

- Primary production (NACE 01-03)
- Food processing (NACE C10-C11)
- Wholesale and logistics and retail markets (NACE 46 and 47)
- Food service (NACE 55-56)
- Households

The data used by FUSIONS were based on literature research, covering literature up to 2015, and on information collected from countries via questionnaires. Country data that were considered to be of sufficient quality were then used to build sector-specific estimates for the EU. The extrapolation from country to EU level was done through sector-specific base data (e.g. amount of food produced; turnover; population, ...). The sector-specific estimates are based on data from between four and eleven countries, depending on the sector.

WStatR-based approach:

The WStatR-based approach uses the WStatR data as a frame for the estimation. In the WStatR data structure, food waste is included mainly in the following EWC-Stat categories:

- W091 Animal and mixed food waste
- W092 Vegetal wastes
- W101 Household and similar wastes

These three 'food waste-containing' waste categories cover food waste together with other organic non-food waste (W091, W092) or as part of the mixed residual waste (W101). The list of LoW entries that are assigned to the three waste categories[43] above is provided in Table 146 in Annex A.5. An estimate of the food waste generation can be produced by estimating for each of the three waste categories the share of food waste contained and by multiplying the shares with the generated amounts as reported under the WStatR.

Based on the investigation and comparison of both approaches it was agreed to use the WStatR-based estimation for the present study, mainly for the following reasons:

- The WStatR-based estimation ensures the coherence of the data with the other waste streams considered in this study as the food waste estimate is embedded in the same definitional and methodological framework as applied for the other waste streams.
- The WStatR-based approach allows to produce estimates at country level and to aggregate the data according to the defined clusters.
- Whereas the FUSIONS estimate refers exclusively to food waste generation, the WStatR-based generation estimates can be related to the WStatR treatment data and thus provide some insight into the destination of the food waste, although not always in the required detail.

The estimation of food waste generation for this study is based on the extrapolated WStatR data for 2017 in combination with information from literature, national statistical data, information from the validation of WStatR data carried out by the contractor and estimates.

As described above, the estimation aims to derive for each of the three food waste-containing waste categories the percentage of food waste contained, separately for the different stages of the food supply chain.

The estimation approach is slightly different for the waste categories of ‚animal and mixed food waste‘ (W091) and ‚vegetal waste‘ (W092) on the one hand and for ‚household and similar waste‘ (W101) on the other hand.

For ,'animal and mixed food waste‘ (W091) and ‚vegetal waste‘ (W092) the estimation is based on a three-step approach as follows:

- Step 1: Estimation of an average share of food waste for each LoW entry assigned to W091 or W092 (Table 146 in Annex A.5).
- Step 2: Calculation of the share of food waste by EWC-Stat category and by sector.
- Step 3: Multiplication of the WStatR data for the respective EWC-Stat category and sector with the factors determined in step 2.

A literature research was conducted to collect information on the share of food waste by LoW entry. As the results of the research were poor, the used shares are mainly based on unpublished information and estimates. The same shares were used for all sectors and all countries.

The calculation in step 2 was based on national data at LoW level, where such data was available. From this information, average shares of food waste per EWC-Stat category were derived for all other countries for which no national LoW-based information was available.

[43] The assignment of LoW entries to EWC-Stat entries is defined in the table of equivalence in Annex III of the Waste Statistics Regulation.

The estimation of the food waste contained in ‚household and similar waste' (W101) was done differently. In order to ensure a consistent approach for the determination of food waste in MSW and total food waste, the food waste content in residual waste as resulting from the EEA-model was used. This means that for W101 country-specific shares were used.

6.1.2 Generation of food waste

Table 68 shows the estimated food waste generation for 2017 for the two country-clusters, for Germany and for the EU in 1,000 tons and in kg per capita, respectively. The data for Germany are taken from the partial report Germany. Although the conducted estimate of food waste generation is considered as a robust approximation at cluster and at EU level, data are not displayed at country level as this might lead to misinterpretations.

The total amounts of food waste are displayed in column 8 of Table 68. The columns 2 to 6 display the amount of food waste contained in the EWC-Stat categories animal and vegetal waste (W091, W092), by generating sector and in total. For the sector 'food processing', the amounts reflect predominantly production wastes that arise in the course of food processing and which are classified in chapter 02 of the LoW. The food waste from households, service activities and other sectors in W091/W092 mainly reflects separately collected organic waste like kitchen/canteen waste which are classified in LoW chapter 20.

Column 7 shows the amount of food waste not separately collected but contained in 'household and similar wastes' (mainly in 20 03 01 mixed municipal waste). Household and similar waste arises predominantly in households but also in all other economic sectors. A breakdown by the generating sector was not considered useful for this waste category.

The food waste total in the EU27 is estimated at 70.1 million tons or 157 kg/cap respectively. Around 55% of the generated food waste (38.6 million tons) are found in the 'household and similar waste' (W101) and 45% (31.6 million tons) are contained in the waste categories 'animal and vegetal waste' (W091, W092). Production waste from the food processing industry accounts for 13.8 million tons or 20% of the food waste in total.

The estimated food waste generation varies significantly across the clusters and EU-aggregates. The per-capita generation is highest in Cluster 2 with 182 kg/cap which is about a third higher than in Cluster 1 (120 kg/cap) and also clearly above the EU27 average of 157 kg/cap. The high amounts of food waste in Cluster 2 are mainly caused by the high values for food waste contained in 'household and similar waste'. The difference between the comparably low food waste amount in Germany (110 kg/cap) and the cluster- and EU-aggregates are surprisingly high. The reasons for the differences need to be further investigated.

Clear differences between the clusters are, for instance, visible regarding the amount of animal and vegetal waste collected from households, which basically reflects food waste contained in the organic waste collection from households. Collected amounts are very low in the countries of Cluster 1 with only 2 kg/cap. With 11 kg/cap, the collection of animal and vegetal waste in Cluster 2 is also clearly below the EU27 average of 23 kg/cap. This confirms the expectation that the separate collection of food waste / organic waste is the least developed in Cluster 1 countries and best developed in the non-clustered EU countries.

It has to be noted that Cluster 2 is a rather heterogeneous group of countries, comprising the Nordic countries Sweden, Finland and Denmark with well-developed separate organic waste collection systems from households and other countries where the level of separate collection of organic waste is more comparable to Cluster 1 countries.

Table 68: Food waste generation, by sectors and waste categories, 2017, in 1,000 t

(1) Cluster/ Country	(2) Food waste in 'animal and vegetal waste' (W091, W092) by sectors: Food processing (NACE 10 - 12)	(3) Services (G-U excl. G46.77)	(4) Other economic sectors	(5) Households	(6) Total food waste in 'animal & vegetal waste (W091,W092)	(7) Food waste in 'household and similar waste (W101)	(8) Food waste total (W09 + W101)
in 1,000 tons							
Cluster 1	2,212	414	150	246	3,022	9,225	12,247
Cluster 2	4,663	2,954	413	1,827	9,857	19,308	29,165
EU27 (w/o DE)	12,717	4,284	1,784	8,618	27,403	33,591	60,994
DE	1,202	1,131	283	1,533	4,149	4,966	9,115
EU27	13,919	5,416	2,067	10,151	31,552	38,557	70,109
EU28	16,117	6,206	2,610	11,409	36,342	46,619	82,961
in kg/cap							
Cluster 1	22	4	1	2	30	90	120
Cluster 2	29	18	3	11	62	120	182
EU27 (w/o DE)	35	12	5	24	75	93	168
DE	15	14	3	19	50	60	110
EU27	31	12	5	23	71	87	157
EU28	32	12	5	22	71	91	162
in %							
Cluster 1	18	3	1	2	25	75	100
Cluster 2	16	10	1	6	34	66	100
EU27 (w/o DE)	21	7	3	14	45	55	100
DE	13	12	3	17	46	54	100
EU27	20	8	3	14	45	55	100
EU28	19	7	3	14	44	56	100

In Table 69 the results of the food waste estimation are combined with the municipal waste data from Chapter 5. The table shows how much food waste is collected and reported as municipal solid waste and how much is managed outside of the MSW system as part of the commercial and industrial waste.

To determine the split between municipal food waste and other food waste, the municipal food waste, as determined in Chapter 5, is subtracted from the total food waste for each country as described in Chapter 3.4.2. For Germany, the delimitation between municipal and non-municipal waste was done differently, i.e. based on LoW-codes. 'Biodegradable kitchen and canteen waste' (LoW 20 01 08) were here assigned completely to the MSW. The comparability of the resulting split between municipal and non-municipal waste is therefore limited.

The data show that, at the EU27 (w/o DE) level, 62% of the food waste is managed as municipal solid waste (49% in mixed residual waste (W101), 13% in W091, W092). Compared to the EU-aggregate, this share is at average higher in Clusters 1 and 2, where municipal food waste accounts for 72% and 71%, respectively, of the total food waste. A possible explanation for this observation is that food waste that ends up in residual waste is mostly collected as municipal solid waste whereas separately collected food waste, e.g. from the retail trade or from canteens and restaurants, may be handled by private waste management companies. As a result, the share of non-municipal food waste increases with the separate collection of food waste because the separately collected food waste that is handled by private companies does not appear as municipal solid waste in statistics but as non-municipal waste. The high share of food waste from MSW in Germany results from the fact that the delimitation between municipal and non-municipal waste was done differently from the other EU-countries.

Table 69: Food waste generation by waste stream (MSW and C&I waste), 2017, in 1,000 t

(1) Cluster/ Country	(2) Total food waste	(3) Of which in: Commercial and industrial waste Total	(4) W091, W092	(5) W101	(6) Municipal waste Total	(7) W091, W092	(8) W101
in 1,000 tons							
Cluster 1	12,247	3,444	2,364	1,081	8,803	659	8,144
Cluster 2	29,165	8,319	7,338	981	20,845	2,519	18,326
EU27 (w/o DE)	60,994	23,021	19,517	3,504	37,973	7,886	30,087
DE	9,115	1,645	1,645	0[1)]	7,469	2,504[2)]	4,966
EU27	70,109	24,667	21,163	3,504	45,442	10,389	35,053
EU28	82,961	32,325	25,374	6,951	50,636	10,968	39,668
in %							
Cluster 1	100%	28%	19%	9%	72%	5%	66%
Cluster 2	100%	29%	25%	3%	71%	9%	63%
EU27 (w/o DE)	100%	38%	32%	6%	62%	13%	49%
DE	100%	18%	18%	0[1)]	82%	27%[2)]	54%
EU27	100%	35%	30%	5%	65%	15%	50%
EU28	100%	39%	31%	8%	61%	13%	48%

1) In Germany, all household and similar waste is counted completely as MSW.

2) The figure includes the sum of food waste collected via separate organic waste collection from households and ‘biodegradable kitchen and canteen waste’ (LoW 20 01 08)

6.1.3 Treatment of food waste

The treatment of food waste is determined separately for the food waste in the MSW stream and for food waste from industrial and commercial sources that is managed outside of the MSW system. The data presented in the following refer to the food waste contained in the waste categories ‘animal and vegetal wastes’ (W091, W092). It does not reflect the amount of food waste that is treated as a part of the ‘household and similar waste’ (W101). ‘Household and similar waste’ is either incinerated, treated in MT and MBT facilities, or directly landfilled. For balancing reasons (e.g. incineration of a pure food waste stream with a high water content is difficult to model plausibly and does not correspond to the real treatment of the waste mixture), it was decided not to consider the food waste contained in the household and similar waste.

For the food waste in MSW, the treatment is estimated by means of the EEA-model (see Chapter 5) for the whole EU excluding Germany. The data for Germany, the determination of which is described in the partial report Germany, were integrated into the EU estimate. The data shown in Table 70 reflect the input into waste treatment facilities.

Nearly all food waste is managed in biological treatment plants. Of the total of 11.0 million tons, 55% or 6.0 million tons are treated in composting plants and 45% or 4.9 million tons go to anaerobic digestion plants. With 89%, the share of composting is particularly high in countries of Cluster 1. In Germany, anaerobic digestion is the prevailing treatment with a share of 64%.

Table 70: Treatment of food waste contained in 'animal and vegetal wastes' managed as part of the MSW, 2017, in 1,000 t and weight -%

Cluster/Country	Composting	Anaerobic digestion	Energy recovery	Total input
In 1,000 tons				
Cluster 1	587	71	0	659
Cluster 2	1,694	825	0	2,519
EU27 (w/o DE)	5,034	2,851	0	7,886
DE	907	1,599	12	2,517
EU27	5,941	4,450	12	10,403
EU28	6,051	4,919	12	10,981
in weight-%				
Cluster 1	89%	11%	0%	100%
Cluster 2	67%	33%	0%	100%
EU27 (w/o DE)	64%	36%	0%	100%
DE	36%	64%	<0.5%	100%
EU27	57%	43%	<0.5%	100%
EU28	55%	45%	<0.5%	100%

The treatment of food waste from industrial and commercial sources was estimated based on the WStatR treatment data for the reference year 2016. It was assumed that the treatment has not changed from 2016 to 2017. The treatment mix for the EU27 (w/o DE), however, is not specific enough as no distinction is made between composting and anaerobic digestion. Both types of treatment are summarised under the category 'recycling' which accounted for 91% for the waste categories 'animal and vegetal wastes' in the EU27 (w/o DE) in 2016. Therefore, the split between composting and anaerobic digestion has to be estimated.

As described in the partial report Germany, it was determined that in Germany 83% of the food waste from commercial and industrial sources is treated in anaerobic digestion plants, 15% is incinerated with energy recovery and only 2% goes to composting plants (see Table 71). For the EU27 (w/o DE), it was also assumed that food waste is mainly treated by anaerobic digestion, but that the share of anaerobic digestion is lower than in Germany. Therefore, a ratio of 20 : 80 between composting and anaerobic digestion was assumed. The resulting treatment amounts are shown in Table 72.

Table 71: Treatment mix for food waste from commercial and industrial sources in the EU (2016) and in Germany (2017), in weight-%

Country	Recycling [1)]		Energy recovery (R1)	Incineration (D10)	Landfill	Other disposal	Waste treatment
	Composting	Anaerobic digestion	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
EU27 (w/o DE)	19%	74%	4%	1%	2%	0.3%	100%
DE	2%	83%	15%	0%	0%	0%	100%

1) The share of recycling for the waste categories 'animal and vegetal wastes' of 91% is split into composting and anaerobic digestion according to the ratio 20: 80.

Table 72: Treatment of food waste from industrial and commercial sources in the EU, 2017, in 1,000 t

Country	Recycling		Energy recovery (R1)	Incineration (D10)	Landfill	Other disposal	Waste treatment
	Composting	Anaerobic digestion	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
Cluster 1	440	1,759	97	13	47	8	2,364
Cluster 2	1,365	5,462	301	40	145	24	7,338
EU27 (w/o DE)	3,632	14,527	802	106	387	64	19,517
DE	30	1,294	230	0	0	0	1,554
EU27	3,661	15,822	1,031	106	387	64	21,071
EU28	4,445	18,956	1,204	128	470	78	25,282

6.1.4 Use of former foodstuffs as animal feed

Article 2(2,e) of Directive 2008/98/EC sets out that substances that are destined for use as feed materials in compliance with the requirements of EU feed legislation[44], and that do not consist of or contain animal by-products, are excluded from the scope of the Directive and shall not be considered as waste. The use of food, that is no longer intended for human consumption (in the following referred to as former foodstuffs[45]), as animal feed, is considered as waste prevention and shall be encouraged by the Member States as laid down in article 9 of Directive 98/2008/EC.

In the following, it is examined whether the quantities of former foodstuffs used as animal feed can be quantified and whether the quantities of food waste and food used as animal feed can be clearly distinguished.

[44] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety (OJ L 31, 1.2.2002, p.1)

[45] Former foodstuffs are defined as "foodstuffs, other than catering reflux (catering waste), which were manufactured for human consumption in full compliance with the Union food law but which are no longer intended for human consumption for practical or logistical reasons or due to problems of manufacturing or packaging defects or other defects and which do not present any health risks when used as feed" (see Commission Regulation (EU) No 68/2013 of January 2013 on the Catalogue of feed materials, OJ L 29, 30.1.2013, p.1

Former foodstuff that is processed into animal feed typically includes biscuits, bread, breakfast cereals, chocolate bars, pasta, savoury snacks and sweets, because of their high energy content in the form of sugars, oils and starch. (EFFPA(a) 2020)

Official statistics on the amounts of former foodstuffs used as feed do not exist. Some data are available from the European Former Foodstuff Processors Association (EFFPA) website. The EFFPA represents feed business operators that buy former foodstuffs from food business operators and produce animal feed that is mostly delivered to compound feed manufacturers but also directly to livestock farmers. According to the association, around 100 former foodstuff processors varying from very small scale to medium-size companies are active in the EU. The published data are based on the amounts processed by member companies and on industry sector estimates provided by national member associations. (EFFPA(b) 2020)

On this basis, the EFFPA estimates that, in those EU countries where EFFPA holds active membership[46], around 3.5 million tons of former foodstuffs are processed into animal feed annually, of which around 2.8 million tons are processed directly by member companies. For the entire EU (including the UK), the association estimates the amount at 5 million tons, which corresponds to 9.8 kg/cap. The association expects that with continued innovation in processing techniques and expansion to other food chain sources, the sector could grow up to 7 million tons by 2025. An expansion to other food chain sources is considered possible for instance in the distribution sector. Currently, the processed materials come mainly from food manufacturers. (EFFPA(a) 2020; EFFPA(b) 2020)

The use of further materials is in some cases hampered by legislation. This applies for instance to foodstuffs containing ruminant collagen and/or gelatine, which fall under the Regulation on animal by-products[47]. Such materials are banned from feeding to farmed animals and may only be used as feed for pets and fur animals. According to the EU Commission, an estimated 100,000 tons of foodstuffs containing ruminant collagen and/or gelatine currently go for disposal, due to the legal provisions and are thus underused in the EU. (Byrne 2019)

The data provided by the EFFPA includes packaged and non-packaged former foodstuffs. Whereas the processing of non-packaged food into feed is clearly exempt from the waste regime according to the provisions of Directive 2008/98/EC, the legal status of packaged food that is processed into animal feed is not explicitly addressed in the Directive. In Germany, packaged food is generally considered as waste and unpacking constitutes a waste treatment operation. However, it seems that the interpretation and implementation of the legal provisions are different across the EU Member States. It is therefore unclear whether these materials are handled under the waste regime in the EU Member States. Although there are no data available on the share of packaged food, it is assumed that their share is significant. As a result of the unclear handling of this issue in EU countries, it is unknown whether and to which extent packaged food is already reflected in EU waste statistics.

Due to the insufficient data availability, the reliable determination of food quantities used as feed is not possible. The use as feed is therefore only considered for information purposes in this study and not included in the base data for GHG balancing.

[46] Countries with active members include Belgium, Germany, France, Spain, Italy, the Netherlands and UK (https://www.effpa.eu/members/)

[47] Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (OJ L 300, 14.11.2009, p.1)

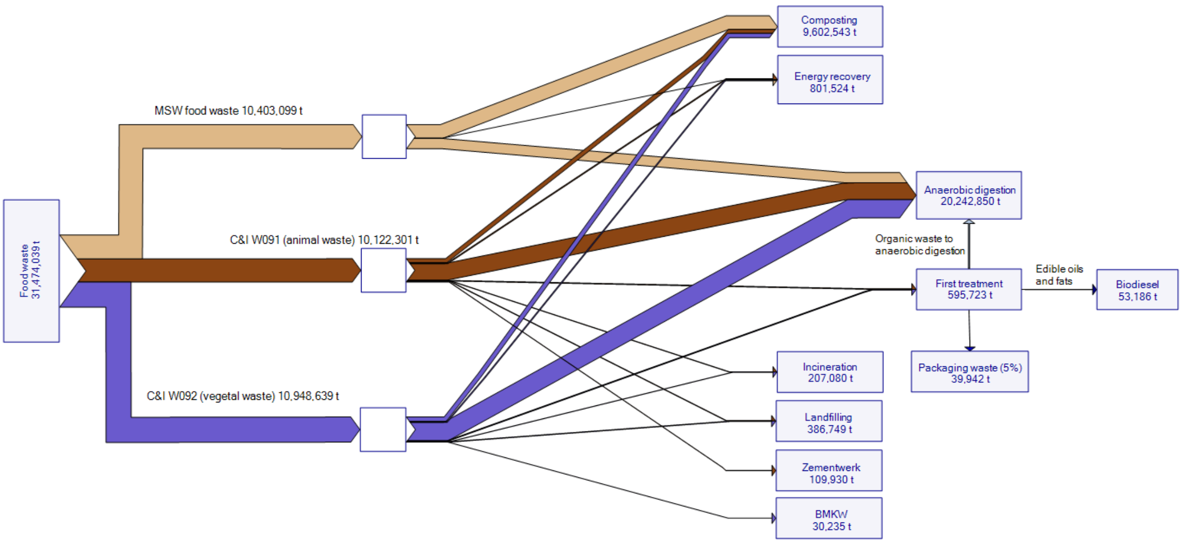
6.1.5 Base data for GHG balancing

The data presented in Table 70 for food waste managed as MSW ("MSW food waste") and in Table 72 for food waste from commercial and industrial sources (C&I W091, C&I W092) build the basis for the GHG balancing.

Figure 21 to Figure 23 show the results of the basic data collection on the generation and the destination of food waste for EU27, Cluster 1 and Cluster 2 as material flow diagrams. Figure 24 shows the amounts of food waste by the three waste categories that could be differentiated for the EU balance areas. The Sankey diagrams and the bar chart make it clear that in the EU27, Cluster 1 and Cluster 2 the food waste consists mainly of C&I waste. While the share of food waste from MSW is 62% for Germany, it is 33% for the EU27 (29% for the EU27 (w/o DE)), 26% for Cluster 2 and 22% for Cluster 1.

Nevertheless, for both Germany and EU balance areas food waste is mainly treated via anaerobic digestion (due to the corresponding assumption for the EU), as can be seen from the Sankey diagrams. The total share of anaerobic digestion of food waste (from MSW and from C&I waste) for all EU balance areas is between 61% (Cluster 1) and 64% (Cluster 2 and EU27)[48]. The remaining share is mainly composted and other treatment options, such as incineration (with or without energy recovery), landfill and other disposal are of minor importance. The food waste from MSW is mainly anaerobically digested for Germany, whereas for the EU balance areas composting dominates.

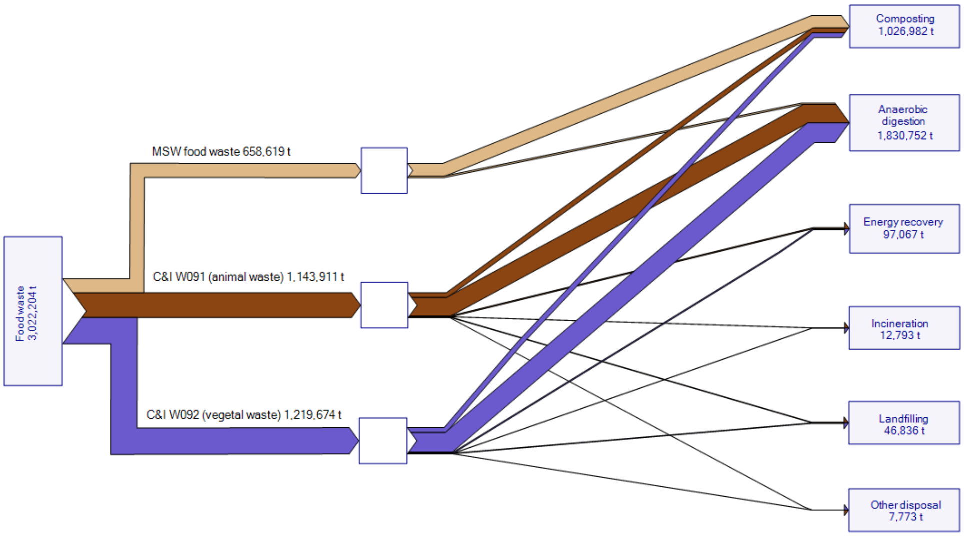
Figure 21: Sankey diagram Food waste EU27 2017



Source: own illustration, ifeu.

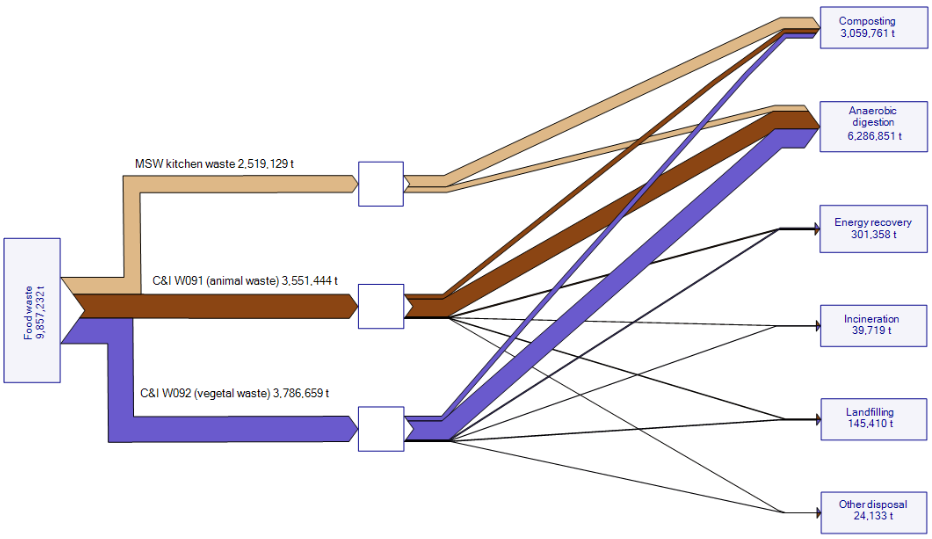
[48] The share for Germany is 71% for first treatment (including edible oil and packaging waste; the share for final treatment is 69% (partial report Germany)).

Figure 22: Sankey diagram Food waste Cluster 1 2017



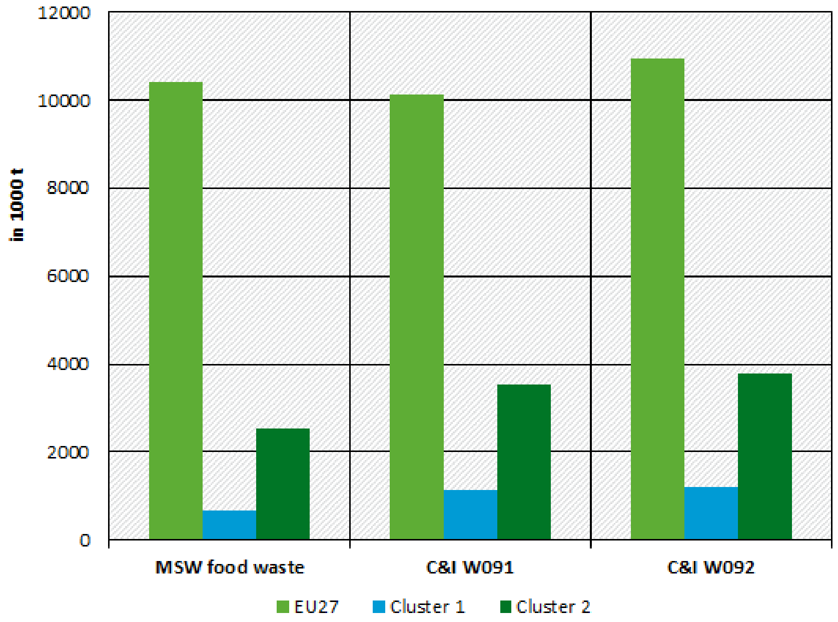
Source: own illustration, ifeu.

Figure 23: Sankey diagram Food waste Cluster 2 2017



Source: own illustration, ifeu.

Figure 24: Generation of food waste EU 2017



Source: own illustration, ifeu.

6.2 Procedure balancing and waste parameters

The procedure for the calculation of MSW food waste corresponds to the calculation for the MSW balance (see Chapter 5). For the calculation of the food waste from C&I waste, assumptions were necessary. The two differentiated waste categories W091 and W092 consist of very different waste fractions which in many cases are not further specified. Therefore, the GHG balance for food waste underlies relevant uncertainties and needs to be understood as an approximation.

The characteristics for food waste from C&I waste was estimated based on the estimations for Germany. The procedure for balancing is described in more detail in the partial report Germany. The balancing for Germany is more differentiated due to the more detailed data from the German waste statistic. The aggregated characteristics used for the calculation for anaerobic digestion for the EU are shown in Table 73.

Table 73: Estimated characteristics for anaerobic digestion food waste from C&I waste

Type of waste	Dry matter in % waste	Organic substance (OS) in % dry matter	N-content in % dry matter	Gas yield in l/kg OS	Gas yield in m^3/t	Methane content in Vol%
W091 Animal and mixed food wastes	37%	89%	3.4%	812	266	68%
W092 vegetable wastes	28%	83%	1.3%	562	132	55%

Anaerobic Digestion

The calculation of anaerobic digestion for food waste from C&I waste is done differently than for food waste from MSW. For this waste, it cannot be assumed that, after anaerobic digestion, it will be after-composted to produce mature compost. On the contrary, it is assumed that the anaerobic digestion residue (digestate) is usually applied to agriculture, possibly after a solid-liquid separation. For the German case in this respect, it was not feasible to use the emission factors from the NIR report for digestion, as these are mainly characterized by after-composting. For consistency reasons a different approach was chosen in general for food waste from C&I waste.

As no data or measurements for anaerobic digestion of food waste from C&I waste are available or known, the assessment is approximated to the knowledge of agricultural biogas plants. It is assumed that the process technology used, similar to agriculture, is primarily concrete or steel digesters with membrane covers. It was further assumed that the plants are partly equipped with a gastight post digester. Against this background, the following assumptions were made for the calculation of anaerobic digestion (see also partial report Germany):

- Diffuse methane emissions from fermenter 1% of the methane produced,
- Biogas loss from flaring 2%
- Assumption share of plants with post digester 70%, remainder open digestate storage,
- Methane emissions from storage in plants with post digesters (and subsequent open storage) 1.5%
- Methane emissions from open digestate storage facilities 2.5%

For the use of biogas, use in a CHP was assumed. The efficiencies were assumed to be the same as for MSW (see Table 22). In deviation, however, the degree of utilization for excess heat was assumed to be zero, as the systems usually are decentralised and no connection to local or district heating networks is assumed.

A mass loss of 10% due to anaerobic degradation was assumed for the digestate produced, and a loss of 10% for the nitrogen contained. For the use of the digestate in agriculture, N_2O emissions of 1% based on the nitrogen content are also uniformly set according to (IPCC 2006). The credits of the application are taken into account through mineral fertilizer substitution.

Other treatment

Due to missing information, composting of food waste from C&I waste was calculated in the same way as MSW food waste. For incineration with energy recovery a proxy calorific value was used (about 20 MJ/kg) and the fossil carbon content was set to zero for food waste (see partial report Germany). The efficiencies for energy recovery correspond to the weighted efficiencies per EU balance area in Table 15. Landfilling is calculated in the same way as described in Chapter 4.2.3. Simplifying, the DOC values given in Table 13 were used in general for the different EU balance areas. Very small amounts of other disposal are not considered further (cut-off criteria 1%).

For the EU balance areas, it is not possible to investigate to what extent animal meal may be co-incinerated as it is the case in Germany. Not even the generation of animal meal in the EU can be evaluated. The same accounts for edible oils and fats, neither the generation nor the potential share used for the production of biodiesel can be estimated. Quantities could at best be set arbitrarily.

6.3 Description GHG balance scenarios 2030

For the EU balance areas EU27, Cluster 1 and Cluster 2 each two sets of scenarios (6 scenarios in total) are developed for the year 2030. The first set of scenarios, referred to as lead scenarios, consider similar to the lead scenarios for MSW both waste flow diversions and technical optimisations. For the second set of scenarios, waste prevention is additionally taken into account. This allows legal requirements to be considered, which in the case of food waste focus on reducing food waste. Furthermore, it is assumed for both food waste from MSW and from C&I waste that in Cluster 1 and 2 a small share will be treated with solider fly larvae.

The two sets of scenarios are referred to as follows:

- "FW EU27 2030 LS", "FW CL1 2030 LS" and "FW CL2 2030 LS" for the lead scenarios which consider flow diversions and technology improvements.
- "FW EU27 2030 P", "FW CL1 2030 P " and " FW CL2 2030 P" for the scenarios that consider in addition the prevention of food waste from the MSW.

6.3.1 Lead scenarios "FW EU27 2030 LS", "FW CL1 2030 LS" and "FW CL2 2030 LS"

The changes of food waste flows within the municipal solid waste can only be carried out consistently in both areas under consideration, i.e. the MSW and the food waste. The assumptions for the treatment of food waste in the food waste scenarios therefore correspond to the assumptions for food waste in the MSW scenarios:

- There is a shift for food waste treatment from composting to anaerobic digestion;
- A small share of food waste in Cluster 1 and 2 is treated with solider fly larvae.

The data for the lead scenarios for the food waste from MSW are shown in Table 74.

Table 74: Treatment of food waste from MSW in the EU in 2030 according to the lead scenarios, in 1,000 t

Cluster/Country	Composting	Anaerobic digestion	Energy recovery	Soldier fly larvae	Total input
Cluster 1	184	360	0	115	659
Cluster 2	530	1,713	0	276	2,519
EU27 (w/o DE)	2,683	4,812	0	391	7,886
DE	523	1,982	12	0	2,517
EU27	3,206	6,794	12	391	10,403

For food waste from industrial and commercial sources (C&I waste) the following assumptions were made:

- Food waste will be completely diverted from composting, mainly towards anaerobic digestion and partly towards energy recovery;
- A share of 1.5% of the total C&I food waste is assumed to be edible oils and fats that are used for biodiesel production (included in anaerobic digestion in Table 75);
- In Cluster 1 and 2 a share of 2% of the total C&I food waste is treated with solider fly larvae.

The data for the lead scenarios for the C&I food waste are displayed in Table 75.

Table 75: Treatment of C&I food waste in the EU in 2030 according to the lead scenarios, in 1,000 t

Country	Composting	Anaerobic digestion	Energy recovery	Soldier fly larvae	Disposal (landfill, incineration, other)	Waste treatment
Cluster 1	0	2,014	302	47	0	2,364
Cluster 2	0	6,253	938	147	0	7,338
EU27 (w/o DE)	0	16,631	2,692	194	0	19,517
DE	0	1,324	230	0	0	1,554
EU27	0	17,955	2,922	194	0	21,071

6.3.2 Scenarios with waste prevention "FW EU27 2030 P", "FW CL1 2030 P" and "FW CL2 2030 P"

In general, the inclusion of waste prevention into the LCA of waste management is not well established. Usually, LCAs of waste management are restricted to the waste hierarchy levels recycling, other recovery and disposal, which correspond clearly to the typical system boundaries from “waste to secondary product or final disposal” (see Chapter 4.1.1). In this study a methodological approach to integrate waste prevention and also preparation for re-use into the LCA of waste management was developed. The problems behind and the developed approach are described in more detail in the partial report Germany.

The inclusion of waste prevention is only possible for the LCA method of waste management if the avoided products are known and their avoided production can be counted. For food waste, this means that only consumption products can be considered. No original products can be identified for sludges, slops, peeling residues, etc. or the "substances unsuitable for consumption or processing" that predominate in C&I waste according to the German waste statistic. Accordingly, for Germany waste prevention is considered only for source segregated food waste from households (waste from the bio bin) and from out-of-home consumption (kitchen/canteen waste). Based on data on avoidable food waste divided into different foods for these two areas of origin avoidable GHG emissions from food production are derived. However, for EU balance areas the consideration is not possible on the same level of accuracy and therefore waste prevention is considered for the MSW food waste fraction using the data derived for Germany.

In general, the scenarios with prevention of food waste build on the lead scenarios. The avoided amount is set to 50% for EU27 and Cluster 2 and to 30% for Cluster 1. The 50% follow the Sustainable Development Goal 12.3 of United Nations, to which EU countries have committed in order to halve the amount of food waste by 2030[49,50]. In Cluster 1 countries, the food waste generation per capita is significantly lower than in Cluster 2 countries and below the EU27 average. Therefore, for Cluster 1 the prevention scenario was calculated with a lower reduction rate of 30%.

[49] https://ec.europa.eu/food/safety/food-waste/eu-actions-against-food-waste_en (4.2.2022)

[50] For Germany this goal corresponds also to the “German National Food Waste Reduction Strategy” (partial report Germany).

With 50% prevention for MSW food waste for EU27 and Cluster 2, and 30% for Cluster 1, the **MSW food waste prevented calculates to** (50%, and 30%, respectively, of total input in Table 74):

- EU27: 5,201,549 tons MSW food waste
- Cluster 2: 1,259,564 tons MSW food waste
- Cluster 1: 197,586 tons MSW food waste

For compliancy with the LCA method of waste management it is mandatory to consider equal waste amounts for scenario comparison. Therefore, in the scenario with waste prevention the avoided amount is subtracted from the total input of MSW food waste and calculated as prevented food waste ("FW prevented"). The amount of waste avoided was deducted equally from the various treatment paths.

For the evaluation, the approach described in the partial report Germany is followed. The proportion of different food products in the food waste as well as the derived GHG emission factors for their production are assumed to be the same for the EU balance areas as for Germany. Thus, **the weighted average emission value for food waste prevention is -1.61 kg CO_2eq/kg food** for all the EU balance areas.

6.4 Results GHG balances

This chapter presents first the results for the balance year 2017 for EU27, Cluster 1 and Cluster 2, which is followed by a base comparison - the actual situation in 2017 and the base scenario in 2030. In the following chapter, the results for the scenario with waste prevention are also presented for the three EU balance areas. In general, the results are to be understood as orienting due to data uncertainties and data gaps (cf. Chapter 1).

6.4.1 Base year 2017

The results for the base year 2017 for the three balance areas EU27, Cluster 1 and Cluster 2 are shown in Table 76. The results are presented as absolute GHG emissions – debits, credits and the net result – for the three waste categories which could be differentiated for the EU. For comparison, the absolute net GHG result for Germany is -0.7 million tons CO_2eq (calculated with EU27 energy emission factors, cf. partial report Germany). All balance areas achieve a net credit.

The results cannot be compared as they are based on different total waste amounts. However, the results show that for all balance areas the main contributions come from the treatment of animal and mixed food waste (W091). This is due to the higher savings potentials from anaerobic digestion of these wastes. Further contribution to the net credit is derived from the share of vegetal waste (W092), which is mostly anaerobically digested. The higher shares of composting of MSW food waste result in net debits for Cluster 1 and Cluster 2. The net credit for the EU27 is influenced by the result for Germany where MSW food waste is mainly anaerobically digested.

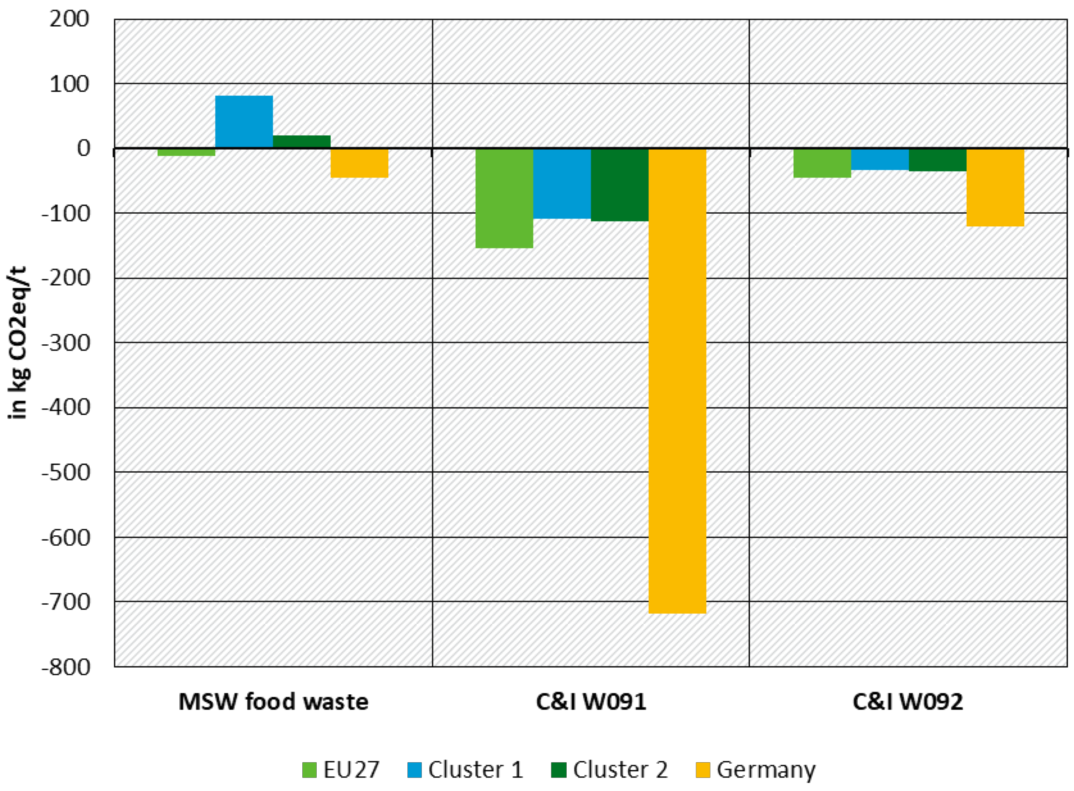
Table 76: Absolut result food waste EU 2017, in 1,000 tons CO_2eq

	Debits	Credits	Net
EU27			
MSW food waste	1,615	-1,742	-128
C&I waste W091	2,021	-3,579	-1,557
C&I waste W092	1,356	-1,857	-501
Total EU27	**4,991**	**-7,177**	**-2,186**
Cluster 1			
MSW food waste	143	-90	54
C&I waste W091	243	-366	-123
C&I waste W092	161	-202	-41
Total Cluster 1	**548**	**-658**	**-111**
Cluster 2			
MSW food waste	455	-404	51
C&I waste W091	730	-1,128	-398
C&I waste W092	487	-618	-131
Total Cluster 2	**1,672**	**-2,150**	**-478**

A comparison of the results is possible with the specific GHG results. Figure 25 shows the net specific GHG results for the three EU balance areas, and for Germany in comparison, by the three waste categories that could be differentiated for the EU.

The specific net results for Germany show net credits for all three waste categories with the highest values. In general, Germany has the highest share of anaerobic digestion for the three waste categories. In addition, the calculation for Germany could be done in more detail. Based on the German statistic altogether nine waste fractions could be differentiated. The assumptions for the EU balance areas on the average characteristics for animal and mixed food waste (W091) and vegetal wastes (W092) (Table 73) may underestimate the potential of the food waste from C&I waste for the EU balance areas. The specific net result for "C&I W091" for Germany is much higher due to the fact that co-incineration of animal meal and processing of edible oils and fats into biodiesel are included. For the EU balance areas, it was not possible to derive information on potential quantities for these two treatment options and it was refrained from setting them arbitrarily.

Figure 25: Specific GHG net results food waste EU balance areas 2017



Source: own illustration, ifeu.

The differences between the specific net results for the EU balance areas are small for “C&I W091” and “C&I W092”. They are highest for the EU27 mainly due to the results for Germany. The specific net results for MSW food waste again reflect the respective share of composting which is highest in the Cluster 1 countries, where also the GHG emissions from composting are the highest (Table 25).

An overview of the specific GHG net results in 2017 for the EU balance areas per ton per waste category is shown in Table 77. Table 78 presents the specific GHG net results per capita.

Table 77: Specific net result per ton – food waste 2017 – in kg CO_2eq/t

Waste category	EU27	Cluster 1	Cluster 2
MSW food waste	-12	81	20
C&I waste W091	-154	-108	-112
C&I waste W092	-46	-34	-35
Total	**-69**	**-37**	**-48**

Table 78: Specific net results per capita[1] – food waste 2017 – kg CO_2eq/cap

Waste category	EU27	Cluster 1	Cluster 2
MSW food waste	-0.3	0.5	0.3
C&I waste W091	-3.5	-1.2	-2.5
C&I waste W092	-1.1	-0.4	-0.8
Total	**-4.9**	**-1.1**	**-3.0**

1) With 445,529,136 inhabitants for EU27; 102,303,237 for Cluster 1; 160,252,140 for Cluster 2 (Table 27).

6.4.2 Base comparison EU27

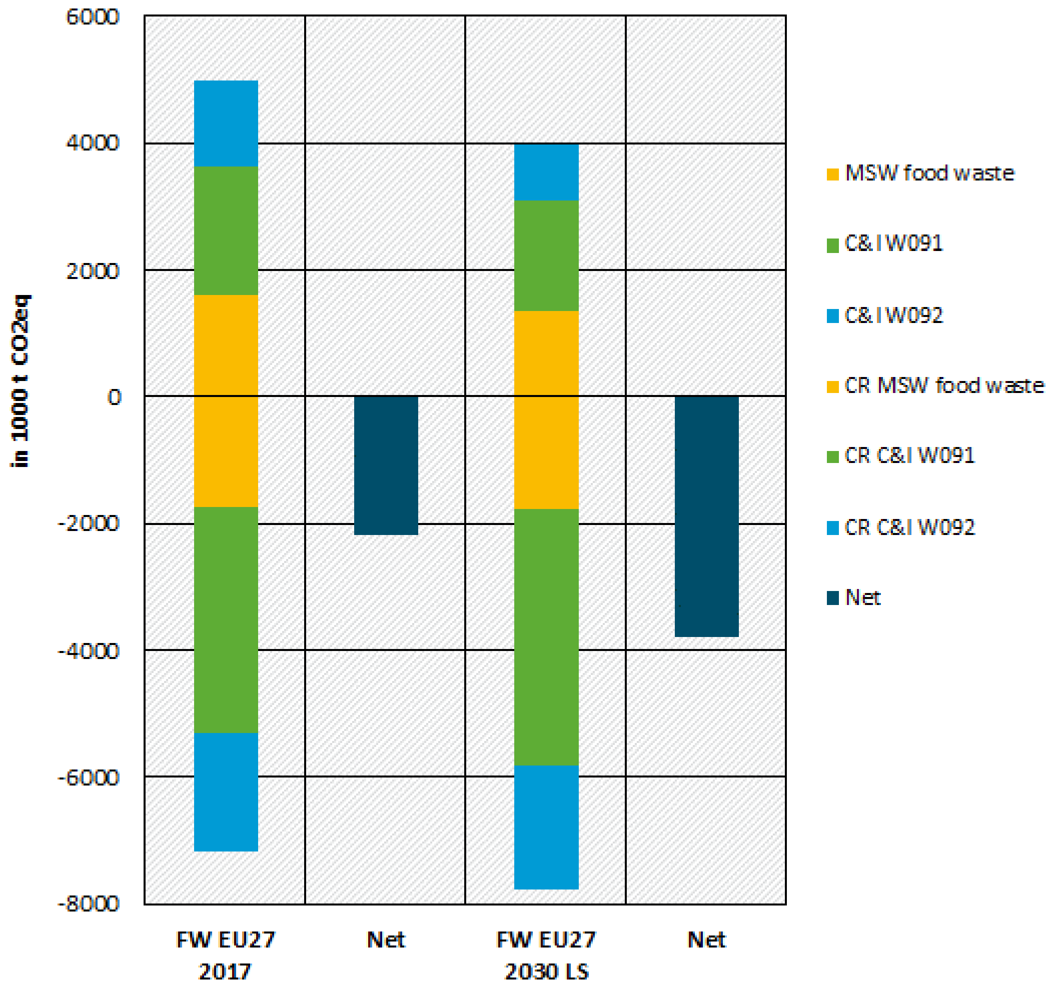
In the base comparison, the GHG results for the waste streams derived in Chapter 6.1.5 for the actual situation in EU27 in 2017 are compared with those of the lead scenario 2030 described in Chapter 6.3.1. The following terms are used in the figures:

- Base 2017, EU27: "FW EU27 2017"
- Lead scenario 2030, EU27: "FW EU27 2030 LS"

Figure 26 shows the absolute results according to the debits and credits by waste category as well as the total net results in a year-on-year comparison. **For the actual situation in 2017, there is an absolute net emission savings potential of around -2.19 million tons CO_2eq**. The underlying debits amount to 4.99 million tons CO_2eq and the emission savings potential to around -7.18 million tons CO_2eq. It is clear from the figure that food waste from commercial and industrial origins, which also account the highest share, mainly contribute to the result. In addition, especially animal and mixed food waste (W091) contribute to the emission savings potential.

For **the lead scenario 2030**, the debits are clearly lower compared to those of 2017, while emission savings potential is slightly higher in 2030. **The absolute net emission savings potential is around -3.79 million tons CO_2eq**. The debits amount to 3.98 million tons CO_2eq and the emission savings potentials to -7.76 million tons CO_2eq. The differences in the result – the overall higher emission savings potential – is mainly due to the optimisations assigned for the waste streams in the lead scenario 2030, especially the diversion of landfilling, incineration (without energy generation) and composting into anaerobic digestion and the share of processing of edible oils and fats into biodiesel.

Figure 26: Base comparison food waste EU27



CR: credit, or emission savings potential
Source: own illustration, ifeu.

Table 79 shows the overall GHG net results for food waste by waste fraction in absolute values as well as the specific per capita and per ton values for the actual situation in 2017 and in the lead scenario 2030 (2030 LS).

Table 79: Absolute and specific net results by waste category – base comparison FW EU27: base year 2017 and lead scenario 2030

Waste category	Absolute	Absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
FW	**2017**	**2030 LS**	**2017**	**2030 LS**	**2017**	**2030 LS**
	1,000 t CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
MSW food waste	-128	-392	-0.3	-0.9	-12	-38
C&I W091	-1,557	-2,315	-3.5	-5.2	-154	-229
C&I W092	-501	-1,079	-1.1	-2.4	-46	-99
Sum/average	**-2,186**	**-3,786**	**-4.9**	**-8.5**	**-69**	**-120**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27).

Based on the specific net results by waste category per ton of waste, the differences in results can be explained:

The high specific net emission savings potential of animal and mixed food waste (W091) from C&I waste in 2017 is mainly due to the high share of anaerobic digestion. Also, the share of energy recovery shows a high specific net emission savings potential. However, this is only representative, if the comparatively high calorific value of 20.4 MJ/kg with a simultaneous fossil carbon content of 0% applies in practice. Vegetal waste (W092) from C&I waste also has distinct emission savings potential due to similar treatment methods as animal and mixed food waste. Nevertheless, the lower specific net emission savings potential of vegetal waste (W092) is mainly caused by the lower methane yield for the biogas production compared to animal and mixed food waste (W091).

In the lead scenario 2030, the share of animal and mixed food waste expected to be edible oils and fats is directed to biodiesel production, which is mainly responsible for the increased specific net emission savings potential. The optimised energy efficiencies of incineration counteract the effects of defossilisation, so that the specific net emission savings potential drops only slightly. In contrast, no change is assumed for the efficiencies of biogas utilization in CHP plants. Furthermore, the specific net emission savings potential of MSW food waste increases slightly mainly due to the increased anaerobic digestion. The effect of solder fly larvae is insignificant to the result because of the small quantities considered to be treated like this. The specific net debit is in the same range as for composting (cf. Chapter 5.5.2).

6.4.3 Base comparison Cluster 1

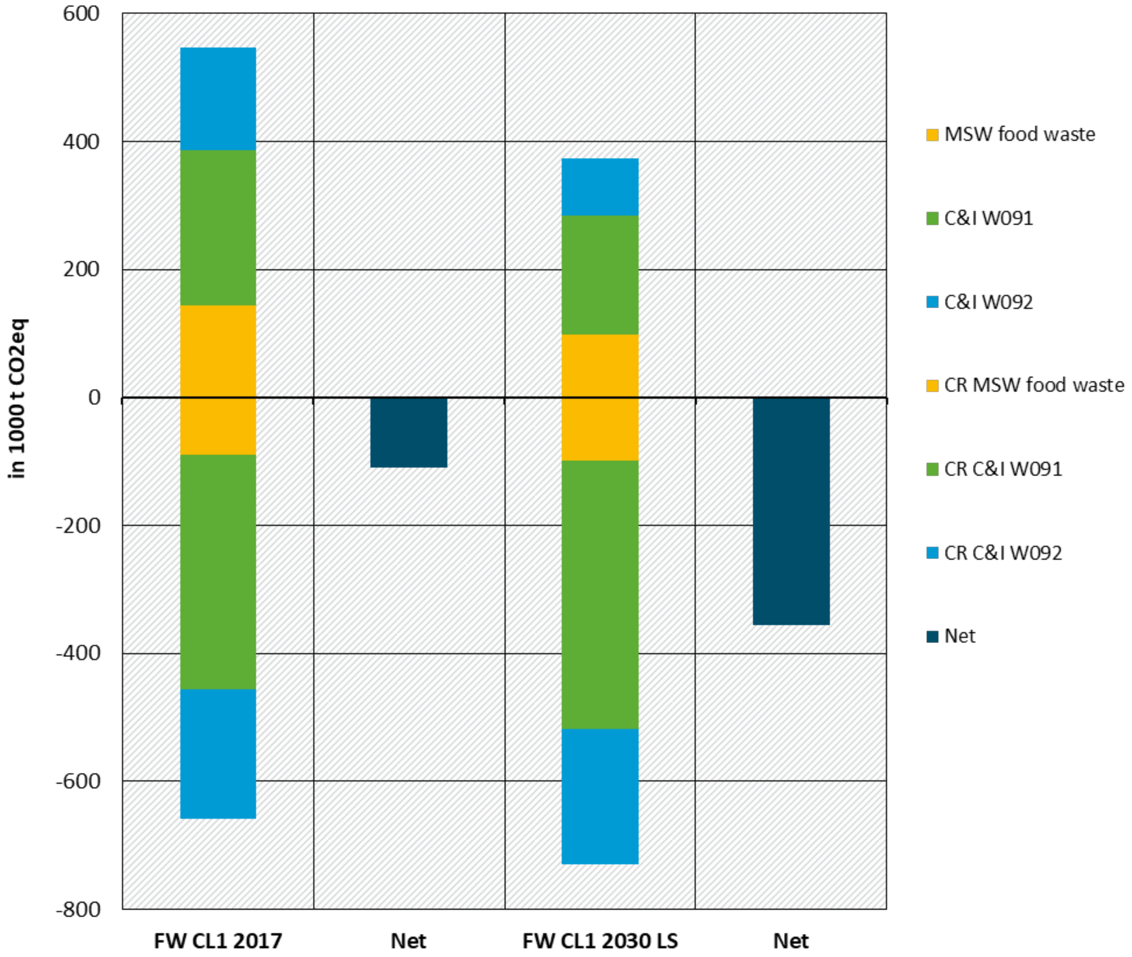
In this chapter, the GHG results of the actual situation for Cluster 1 in 2017 in comparison with those of the lead scenario 2030 are presented. Following terms are used in the figures:

- Base 2017, Cluster 1: "FW CL1 2017"
- Lead scenario 2030, Cluster 1: "FW CL1 2030 LS"

The absolute GHG debits and credits by waste category as well as the total net results are shown in Figure 27 as a comparison of these two scenarios. **The actual situation in 2017 has an absolute emission savings potential of around -0.11 million tons CO_2eq**. The debits amount to 0.55 million tons CO_2eq, while the emission savings potential is -0.66 million tons CO_2eq. As for the EU27, also for Cluster 1, food waste from C&I waste forms the major part and this reflects to the GHG results accordingly. Furthermore, animal and mixed food waste (W091) influences the emission savings potential significantly.

The debits are significantly lower in **the lead scenario 2030**, whereas the emission savings potential is slightly higher**. The absolute net emission savings potential is around - 0.36 million tons CO_2eq,** with debits of 0.37 million tons CO_2eq and credits of -0.73 million tons CO_2eq. The remarkably higher absolute net emission savings potential in the lead scenario 2030 is mainly result of diverting the waste streams from landfilling, incineration and composting to anaerobic digestion and energy recovery. Additionally, the newly introduced treatment of edible fats and oils (in W091) to biodiesel production plays a role.

Figure 27: Base comparison food waste Cluster 1



CR: credit, or emission savings potential
Source: own illustration, ifeu.

In Table 80 the overall GHG net results for food waste by waste category in absolute values as well as the specific per capita and per ton values are shown for the actual situation in 2017 and in the lead scenario 2030 (2030 LS).

Table 80: Absolute and specific net results by waste category – base comparison FW Cluster 1: base year 2017 and lead scenario 2030

Waste category	Absolute	Absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
FW	**2017**	**2030 LS**	**2017**	**2030 LS**	**2017**	**2030 LS**
	1,000 t CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
MSW food waste	54	-2	0.5	-0.0	81	-2
C&I W091	-123	-231	-1.2	-2.3	-108	-202
C&I W092	-41	-123	-0.4	-1.2	-34	-101
Sum/average	**-111**	**-356**	**-1.1**	**-3.5**	**-37**	**-118**

1) Calculated with 102,303,237 inhabitants in 2017 (Table 27).

The differences in the specific net results by waste category per ton of waste can be explained as follows:

In 2017, the specific net emission savings potential is the highest for the animal and mixed waste (W091) from C&I waste. This is because of the high share of anaerobic digestion which allows the energy generation from biogas. Although the share of anaerobic digestion is high for the vegetal waste (W092) from C&I waste as well, the yield of biogas for the energy generation is lower with this waste type, thus resulting to lower specific net emission savings potential. Furthermore, energy recovery shows comparatively high specific net emission savings potential for these two waste fractions. Nevertheless, this applies in practice only if the relatively high calorific value of 20.4 MJ/kg comes with a simultaneous fossil carbon content of 0%. MSW food waste has a relatively high specific net debit in 2017 because of the high share of composting (89%) in Cluster 1 countries.

In the lead scenario 2030, the specific net emission savings potentials of W091 and W092 increase distinctly. This is largely depending on the share of edible oils and fats from animal and mixed waste, that is designated to biodiesel production, having a high specific net emission savings potential. The increase of specific net emission savings potentials is hindered by the effects of defossilisation, even though the optimised energy efficiencies for incineration counteract this effect slightly. In contrast, no change is assumed for the efficiencies of biogas utilization in CHP plants.

Furthermore, for MSW food waste, the specific net result shifts from a net debit to specific net emission savings potential in the lead scenario 2030. This is mainly due to the diversion of waste from composting to anaerobic digestion. The effect of solder fly larvae is insignificant to the result because of the small quantities. The specific net debit is lower than that for composting (cf. Chapter 5.5.4).

6.4.4 Base comparison Cluster 2

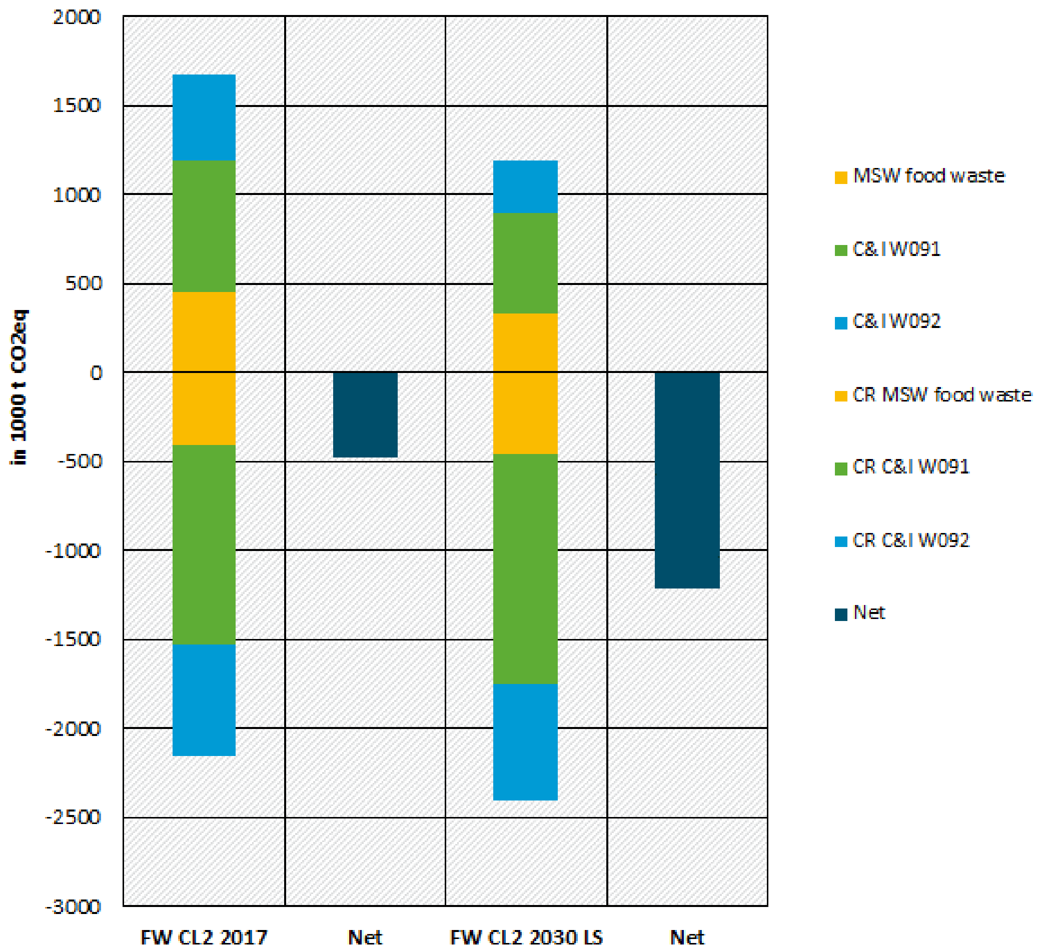
The GHG results of the actual situation for Cluster 2 in 2017 in comparison with those of the lead scenario 2030 are presented in this chapter. Following terms are used in the figures:

- Base 2017, Cluster 2: "FW CL2 2017"
- Lead scenario 2030, Cluster 2: "FW CL2 2030 LS"

Figure 28 presents a comparison of the above-mentioned scenarios as the absolute GHG results by waste category and as total net results. **The actual situation in 2017 shows an absolute emission savings potential of around -0.48 million tons CO_2eq**. The underlying debits amounts to 1.67 million tons CO_2eq and the emission savings potential to -2.15 million tons CO_2eq. As for the previous EU balance areas, also for Cluster 2, food waste from C&I waste forms the major part and this reflects to the GHG results accordingly. Furthermore, animal and mixed food waste (W091) contributes the most to the emission savings potential.

In the lead scenario 2030, the absolute net emission savings potential is remarkably higher with -1.22 million tons CO_2eq. The difference is largely due to the lower debits, which amount to 1.19 million tons CO_2eq. Simultaneously, the emission savings potential of -2.41 million tons CO_2eq is higher, though with a lower magnitude. The absolute net emission savings potential is significantly higher in 2030 largely due to the diversion of waste streams from landfilling, incineration and composting to anaerobic digestion and energy recovery. Additionally, the newly introduced treatment of edible fats and oils (in W091) to biodiesel production plays a role.

Figure 28: Base comparison food waste Cluster 2



CR: credit, or emission savings potential
Source: own illustration, ifeu.

In Table 81 the overall GHG net results for food waste by waste category in absolute values as well as the specific per capita and per ton values are shown for the actual situation in 2017 and in the lead scenario 2030 (2030 LS).

Table 81: Absolute and specific net results by waste category – base comparison FW Cluster 2: base year 2017 and lead scenario 2030

Waste category	Absolute	Absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
FW	**2017**	**2030 LS**	**2017**	**2030 LS**	**2017**	**2030 LS**
	1,000 t CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
MSW food waste	51	-127	0.3	-0.8	20	-50
C&I W091	-398	-731	-2.5	-4.6	-112	-206
C&I W092	-131	-362	-0.8	-2.3	-35	-96
Sum/average	**-478**	**-1,220**	**-3.0**	**-7.6**	**-48**	**-124**

1) Calculated with 160,252,140 inhabitants in 2017 (Table 27).

The differences in the specific net results by waste category per ton of waste can be explained as follows:

The specific net emission savings potential is the highest for the animal and mixed waste (W091) from C&I waste. The main contribution to this comes from the high share of anaerobic digestion with the recovery of biogas. The lower specific net emission savings potential of vegetal waste (W092) is due to the lower yield of biogas for the energy generation. In addition, the energy recovery of these two waste fractions contributes to the specific emission savings potential of these two waste fractions. However, in order to this to apply in practice, relatively high calorific value of 20.4 MJ/kg and a simultaneous carbon fossil content of 0% are needed. MSW food waste has a specific net burden in 2017 due to the high share of composting (67%).

In the lead scenario 2030, the specific net emission savings potential of W091 is roughly doubled from 2017. The main reason for this is the newly introduced biodiesel production of the edible fats and oils from animal and mixed waste (W091). However, due to the effects of defossilisation, the increase of the specific net emission savings potential is hindered, though optimised energy efficiencies of incineration counteract the effect slightly. In contrast, no change is assumed for the efficiencies of biogas utilization in CHP plants.

Furthermore, the specific net result of MSW food waste shifts from net debits to emission savings potentials in the lead scenario 2030. The main reason for this is the diverted waste stream from composting to anaerobic digestion. The effect of solder fly larvae is insignificant to the result because of the small quantities. The specific net debit is a little lower than for composting (cf. Chapter 5.5.5).

6.4.5 Scenarios with waste prevention

The scenario with waste prevention shows a methodical approach to integrating this aspect into the LCA of waste management. A description of the problems, which make it difficult to integrate this aspect and why it has not or has hardly been done so far, can be found in Chapter 6.3.2, and in more detail in the partial report Germany.

As is generally required, the total amount of waste must be the same for a comparison of the results at the absolute level. The scenario with waste prevention ("FW 2030 P") corresponds to the lead scenario 2030 ("FW 2030 LS") except that, additionally, it is assumed that in the EU27 and Cluster 2 areas 50% of the MSW food waste can be prevented, whereas the corresponding amount for Cluster 1 is assumed to be 30%.

In total, for EU27 this amounts to around 5.2 million tons of food waste or around 17% of the total waste volume considered[51]. For Cluster 1 and Cluster 2, this amounts to 0.20 and 1.26 million tons of food waste, or around 7% and 13% of the total volume, respectively.

Figure 29 shows the volume by waste category from the base comparison compared to the scenario with waste prevention on the example for the EU27. The prevented waste quantity is shown in the figure as dotted bars and reduced accordingly for the waste from MSW food waste. This is done accordingly in the scenarios with waste prevention for Cluster 1 and Cluster 2.

Figure 30 to Figure 32 show the results for the scenario with waste prevention “FW 2030 P” compared to the results from the base comparison as absolute net results by waste category. In contrast to the results shown before for the base comparison here the results are presented as net values per waste category (difference of debits and credits per waste category).

[51] For Germany, also 50% waste prevention is considered which corresponds to 31% of the total amount of food waste due to the higher share of MSW food waste for Germany (see also partial report Germany).

Figure 29: Scenario with waste prevention – waste generation EU27

Source: own illustration, ifeu.

The results for the scenarios with waste prevention show significantly higher net emission savings potentials than in the base comparison. Despite data uncertainties, it is clear that waste prevention makes a very large contribution to climate protection. With food waste prevention the primary production of foods is avoided which is combined with much higher GHG emissions than the savings potentials which can be derived from treatment of food waste. With food waste prevention the original primary product can be avoided, while in biological treatment it is not the actual product that is replaced, but rather other products such as energy and compost, with losses always occurring.

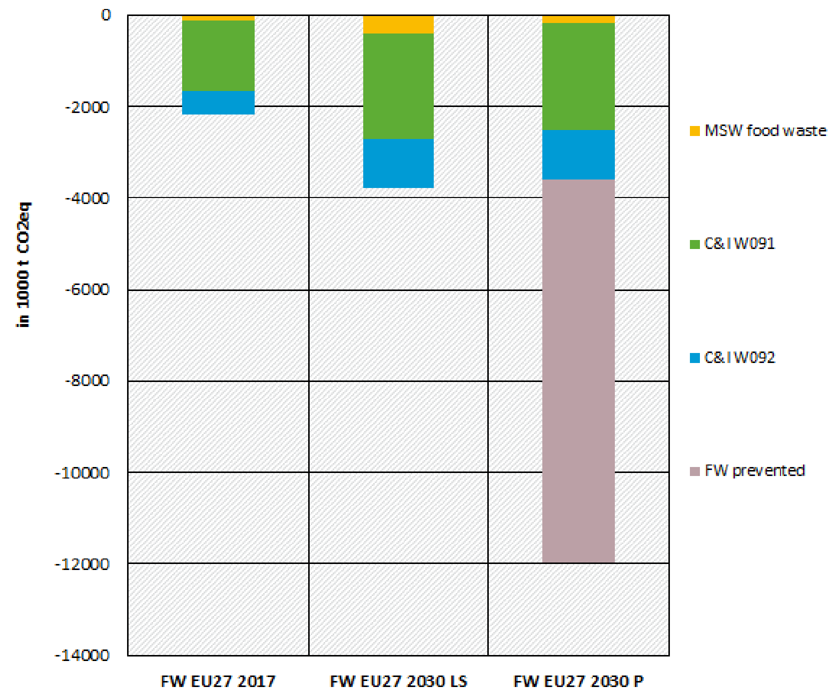
The **absolute net emission savings potentials are**:

- around **-12 million tons CO_2eq** for the EU27
- around **-0.7 million tons CO_2eq** for Cluster 1
- around **-3.2 million tons CO_2eq** for Cluster 2

In case of the EU27 the net emission savings potential is ca. a factor of 3 higher compared to the lead scenario “FW EU27 2030 LS”. For Cluster 1 the net emission savings potential is roughly doubled with the waste prevention, and for Cluster 2 it is ca. a factor of 2.6 higher than in the respective lead scenario.

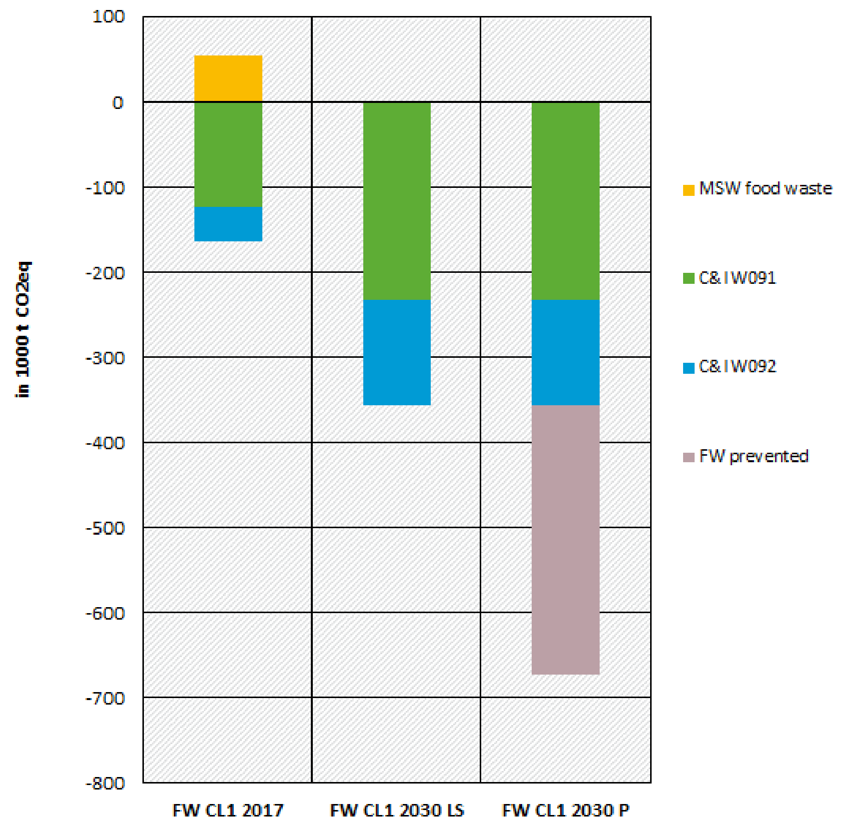
The significantly higher net emission savings potentials result from the relevance of food waste prevention. On the one hand, these are set for 7%, 13% and 17% of the total food waste for Cluster 1, Cluster 2 and EU27, respectively. On the other hand, the specific net reduction potential for food waste prevention of -1.61 kg CO_2eq/kg FW is comparatively high.

Figure 30: Scenario with waste prevention FW EU27 – absolute net results by waste category



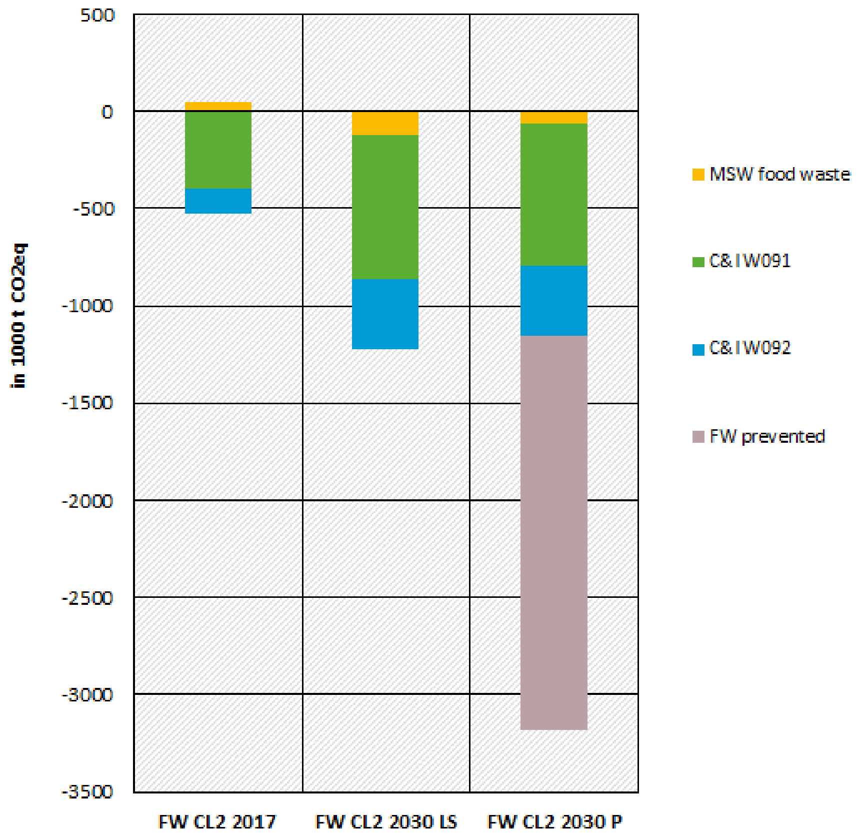
Source: own illustration, ifeu.

Figure 31: Scenario with waste prevention FW Cluster 1 – absolute net results by waste category



Source: own illustration, ifeu.

Figure 32: Scenario with waste prevention FW Cluster 2 – absolute net results by waste category



Source: own illustration, ifeu.

7 Commercial and industrial waste

C&I waste is roughly calculated in this study. The procedure for collecting the basic data is described in the following. The waste quantities are derived for the final treatment. Insofar as sorting expenses from the initial treatment are relevant and can be mapped, as with dry recyclable materials, input quantities are recalculated based on sorting losses.

7.1 Waste generation and treatment

7.1.1 Methodology

Generation of C&I waste

As described in Chapter 3.1, the waste stream **commercial and industrial (C&I) waste,** as defined for this study, covers non-hazardous waste from 'manufacturing' (NACE C) and from 'service activities' (NACE sectors G –U excl. G46.77).

It includes in addition:

- Household and similar wastes (W101) from all economic activities;
- Animal and vegetal wastes (W091, W092) from all economic activities except from *'Agriculture, forestry and fishing'* (NACE A).

The study is limited to primary waste and excludes the waste categories textile wastes (W076), discarded vehicles (W081), discarded equipment (W08A), batteries and accumulators (W0841) and common sludges (W11). Furthermore, excluded are industrial effluent sludges (W032), except for the sludges from the paper industry covered by this waste category.

The total generation of C&I waste is determined on the basis of the extrapolated WStatR data for the reference year 2017 by summing up the amounts for the waste categories and NACE sectors covered according to the defined scope. The scope of the C&I waste stream is illustrated in Table 147 in the Annex.

In a further step, the determined C&I waste generation is adjusted for the overlap with the waste stream municipal solid waste to avoid double-counting. MSW includes waste from commercial activities, institutions and other sources that is similar to waste from households and therefore collected and managed together with the waste from households. For the purposes of this study, this waste is assigned to the MSW and accordingly deducted from the C&I waste.

This adjustment is done at the level of the EU27 (w/o DE) for those EWC-Stat categories that contain MSW. For this purpose, the material fractions of MSW were grouped according to the EWC-Stat-categories (see Annex A.2.2) and then compared to the WStatR data of the respective categories. The details and results of the delimitation are described in Annex A.6.2. For Germany the adjustment is done separately as described in the partial report Germany.

Treatment of C&I waste

The estimation of the C&I waste treatment is based on the WStatR treatment data for the reference year 2016. It is assumed that the treatment has not changed from 2016 to 2017, meaning that the share of the treatment operations for each EWC-Stat category remained the same.

The treatment mix was determined at the level of the EU27 (w/o DE) aggregate. The treatment data for Germany were added to build the EU27 aggregate. The use of the WStatR data for accurately determining the treatment of the waste generated in the EU is hampered by the following characteristics of the WStatR data:

- The treatment data cannot be linked to the economic activities that produce the waste. This means that the treatment mix for a specific EWC-Stat category reflects the treatment of the respective waste category from all economic activities. It is not possible to retrieve specific treatment data for the C&I waste. Therefore, the assumption is made that the treatment mix for each EWC-Stat category is the same, irrespective of the origin of the waste (for more detail see Chapter 7.1.3).
- The treated waste quantities do not equal the generated amounts, neither at the level of EWC-Stat categories nor at the level of the waste total. The reasons for the imbalances and the related quality issues are described in more detail together with the results in Chapter 7.1.3.

Gaps in the WStatR treatment data resulting from data confidentiality were closed through estimates. As the data gaps were mostly small, the impact of the estimates on data accuracy is neglectable.

7.1.2 Generation of C&I waste

Table 82 shows the estimated generation of C&I waste for the EU27 (w/o DE) by economic activity and by EWC-Stat category. The data for Germany are shown in Table 83. The EU27 aggregate, i.e. the sum of both data sets, is displayed in Table 84.

The total C&I waste for the EU27 is estimated to be 245 million tons, of which 47.1 million tons come from Germany, corresponding to a share of 19.2%.

The main waste generating sector is the metal industry (NACE C24-C25) which accounts for 24% of the generated waste, followed by the chemical industry (NACE C20-C22) with 18%, the service sector with 14% and the food and drinks industry (NACE C10-C12) with a share of 12% (see Figure 34).

The waste category with the highest amount is EWC-Stat category W12B with the rather unspecific name ‘other mineral waste’ (see Figure 33). This waste category accounts for 62.8 million tons or 26% of the total C&I waste generated. The waste category covers a variety of mineral wastes (48 non-hazardous LoW entries) which include extractive wastes, wastes from manufacture of glass, ceramic goods and cement, casting cores and moulds from the casting of ferrous and non-ferrous pieces, as well as linings and refractories from thermal processes. Although the mining sector is not a part of the economic sectors considered for the C&I waste stream, extractive wastes may nevertheless contribute significant amounts when companies of the manufacturing industries are also active in mining activities.

Further important waste categories are metal waste (W06) and combustion waste (W124), each with a share of 14%, and animal and vegetal waste (W091, W092), which account for 13% of C&I waste generation.

The share of the waste generated in Germany is particularly high in the chemical industry where the waste from Germany accounts for about 61% of the EU total, and for the waste category ‘other mineral wastes’ (12B) with a share of 43% of the EU total. The data indicate that both observations are related and result from very high amounts of wastes from mineral non-metalliferous excavation (LoW 01 01 02) that are generated by companies of the chemical industries.

Table 82: Generation of C&I waste by waste category and economic sector in the EU27 (w/o DE), 2017, in 1,000 t

EWC-Stat category Code	Description	C10-C12 Manufacture of food products; beverages and tobacco products	C13-C15 Manufacture of textiles, wearing apparel, leather and related products	C16 Manufacture of wood and of products of wood and cork, except furniture …	C17_C18 Manufacture of paper and paper products; printing and reproduction of recorded media	C19 Manufacture of coke and refined petroleum products	C20-C22 Manufacture of chemical, pharmaceutical, rubber and plastic products	C23 Manufacture of other non-metallic mineral products	C24_C25 Manufacture of basic metals and fabricated metal products, except machinery and equipment	C26-C30 Manufacture of computer, electronic & optical products, electrical equipment, motor vehicles …	C31-C33 Manufacture of furniture; musical instruments, toys; repair/installation of machinery and equipment	G-U (excl. 46.77) Services (except wholesale of waste and scrap)	A, B, D, E, G46.77 Other sectors	C&I total Commercial and industrial waste
W012	Acid, alkaline or saline wastes	4	1	0	513	535	969	12	350	9	2	12	:	2,407
W02A	Chemical wastes	56	262	44	748	62	1,795	14	175	103	41	80	:	3,380
W032	Industrial effluent sludges	:	:	:	1,037	:	:	:	:	:	:	:	:	1,037
W05	Health care and biological wastes	2	0	0	0	0	5	0	0	0	0	340	:	348
W061	Metal wastes, ferrous	127	40	106	86	54	265	317	11,225	6,058	367	7,428	:	26,071
W062	Metal wastes, non-ferrous	9	3	9	27	4	36	6	1,375	553	27	149	:	2,199
W063	Metal wastes, mixed ferrous and non-ferrous	112	14	30	75	27	131	61	1,177	652	108	253	:	2,640
W071	Glass wastes	352	14	25	1	0	53	1,291	22	31	10	0	:	1,800
W072	Paper and cardboard wastes	1,034	213	46	4,557	6	541	100	257	813	258	4,323	:	12,149
W073	Rubber wastes	9	5	1	0	1	129	2	3	5	5	1,365	:	1,524
W074	Plastic wastes	594	150	40	282	9	1,588	77	145	488	119	0	:	3,492
W075	Wood wastes	210	51	10,761	2,651	10	386	183	296	648	1,885	2,172	:	19,254
W091, W092	Animal and vegetal waste (excl. slurry and manure)	18,980	21	115	64	18	743	10	10	29	22	4,069	5,163	29,245
W101	Household and similar wastes	572	75	69	120	10	323	88	216	266	188	6,232	2,624	10,785
W102	Mixed and undifferentiated materials	2,350	238	153	3,269	42	1,987	740	2,996	811	312	3,353	:	16,249
W124	Combustion wastes	368	6	1,003	831	55	1,173	319	24,343	195	120	1,053	:	29,466
W12B	Other mineral wastes	2,831	7	26	172	4,721	6,686	10,226	8,556	649	119	1,734	:	35,726
Total		**27,612**	**1,101**	**12,427**	**14,434**	**5,553**	**16,808**	**13,447**	**51,145**	**11,309**	**3,582**	**32,563**	**7,788**	**197,770**

":" no applicable because waste is not considered as C&I waste (see definition of survey scope)

1) excludes waste from NACE A

Table 83: Generation of C&I waste by waste category and economic sector in Germany, 2017, in 1,000 t

EWC-Stat category Code	Description	C10-C12 Manufacture of food products; beverages and tobacco products	C13-C15 Manufacture of textiles, wearing apparel, leather and related products	C16 Manufacture of wood and of products of wood and cork, except furniture …	C17_C18 Manufacture of paper and paper products; printing and reproduction of recorded media	C19 Manufacture of coke and refined petroleum products	C20-C22 Manufacture of chemical, pharmaceutical, rubber and plastic products	C23 Manufacture of other non-metallic mineral products	C24_C25 Manufacture of basic metals and fabricated metal products, except machinery and equipment	C26-C30 Manufacture of computer, electronic & optical products, electrical equipment, motor vehicles …	C31-C33 Manufacture of furniture; musical instruments, toys; repair/installation of machinery and equipment	G-U (excl. 46.77) Services (except wholesale of waste and scrap)	A, B, D, E, G46.77 Other sectors	C&I total Commercial and industrial waste
W012	Acid, alkaline or saline wastes	18	0	0	10	1	177	18	21	22	0	5	:	272
W02A	Chemical wastes	11	4	5	38	11	94	5	82	33	11	53	:	348
W032	Industrial effluent sludges	:	:	:	730	:	:	:	:	:	:	:	:	730
W05	Health care and biological wastes	0	0	0	0	0	3	0	0	0	0	358	:	360
W061	Metal wastes, ferrous	2	3	9	18	0	12	27	1,247	747	102	217	:	2,384
W062	Metal wastes, non-ferrous	0	0	0	1	0	5	2	144	153	12	72	:	391
W063	Metal wastes, mixed ferrous and non-ferrous	7	1	1	4	0	6	0	9	2	1	19	:	48
W071	Glass wastes	183	0	6	3	0	23	153	20	5	14	0	:	407
W072	Paper and cardboard wastes	0	0	0	0	0	0	0	0	0	0	0	:	0
W073	Rubber wastes	0	0	0	1	0	142	2	73	8	11	332	:	570
W074	Plastic wastes	93	12	7	44	5	172	57	40	75	24	0	:	529
W075	Wood wastes	20	4	2,619	270	0	66	75	91	220	262	0	:	3,627
W091, W092	Animal and vegetal waste (excl. slurry and manure)	1,720	2	42	7	0	437	2	7	20	79	804	428	3,548
W101	Household and similar wastes	0	0	0	0	0	0	0	0	0	0	0	0	0
W102	Mixed and undifferentiated materials	525	17	68	1,529	1	271	29	143	169	57	49	:	2,858
W124	Combustion wastes	46	0	64	203	38	146	136	3,105	31	8	193	:	3,971
W12B	Other mineral wastes	11	1	0	9	1	24,212	237	2,102	166	37	257	:	27,033
Total		**2,637**	**43**	**2,823**	**2,867**	**59**	**25,766**	**742**	**7,085**	**1,650**	**618**	**2,360**	**428**	**47,078**

":" no applicable because waste is not considered as C&I waste (see definition of survey scope)

1) excludes waste from NACE A

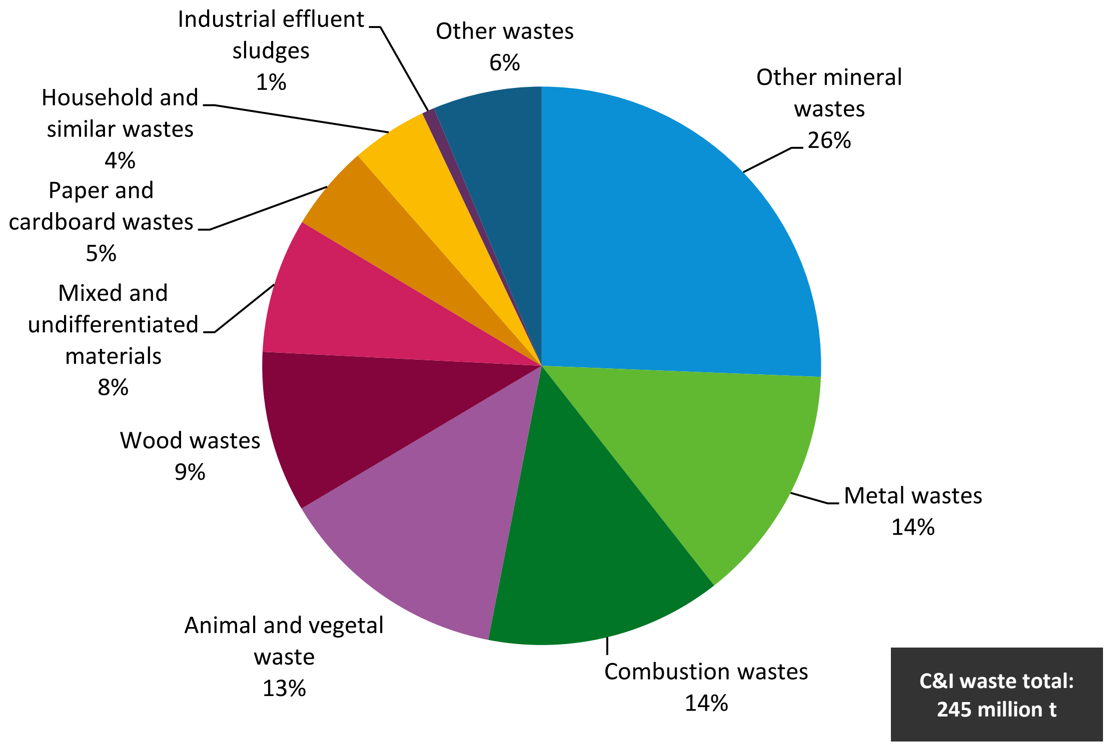
Table 84: Generation of C&I waste by waste category and economic sector in the EU27, 2017, in 1,000 t

EWC-Stat category Code	Description	C10-C12 Manufacture of food products; beverages and tobacco products	C13-C15 Manufacture of textiles, wearing apparel, leather and related products	C16 Manufacture of wood and of products of wood and cork, except furniture …	C17_C18 Manufacture of paper and paper products; printing and reproduction of recorded media	C19 Manufacture of coke and refined petroleum products	C20-C22 Manufacture of chemical, pharmaceutical, rubber and plastic products	C23 Manufacture of other non-metallic mineral products	C24_C25 Manufacture of basic metals and fabricated metal products, except machinery and equipment	C26-C30 Manufacture of computer, electronic & optical products, electrical equipment, motor vehicles …	C31-C33 Manufacture of furniture; musical instruments, toys; repair/installation of machinery and equipment	G-U (excl. 46.77) Services (except wholesale of waste and scrap)	A, B, D, E, G46.77 Other sectors	C&I total Commercial and industrial waste
W012	Acid, alkaline or saline wastes	23	1	0	523	536	1,145	30	371	31	2	17	:	2,679
W02A	Chemical wastes	67	266	49	787	73	1,889	20	257	135	52	133	:	3,728
W032	Industrial effluent sludges	:	:	:	1,767	:	:	:	:	:	:	:	:	1,767
W05	Health care and biological wastes	2	0	0	0	0	8	0	0	0	0	698	:	708
W061	Metal wastes, ferrous	130	43	114	104	54	277	343	12,473	6,805	469	7,645	:	28,456
W062	Metal wastes, non-ferrous	9	3	9	28	4	41	8	1,519	706	39	222	:	2,589
W063	Metal wastes, mixed ferrous and non-ferrous	118	15	31	78	27	137	61	1,186	654	109	271	:	2,688
W071	Glass wastes	535	14	31	4	0	76	1,444	42	36	24	0	:	2,207
W072	Paper and cardboard wastes	1,034	213	46	4,557	6	541	100	257	813	258	4,323	:	12,149
W073	Rubber wastes	10	5	1	1	1	271	4	76	13	16	1,697	:	2,094
W074	Plastic wastes	687	162	47	326	14	1,760	134	185	563	143	0	:	4,022
W075	Wood wastes	229	55	13,380	2,922	10	452	258	387	868	2,147	2,172	:	22,881
W091, W092	Animal and vegetal waste (excl. slurry and manure)	20,700	23	158	71	18	1,179	12	16	49	102	4,874	5,591	32,793
W101	Household and similar wastes	572	75	69	120	10	323	88	216	266	188	6,232	2,624	10,785
W102	Mixed and undifferentiated materials	2,875	254	220	4,798	44	2,258	769	3,139	979	369	3,402	:	19,108
W124	Combustion wastes	414	7	1,068	1,034	93	1,319	456	27,448	226	128	1,245	:	33,436
W12B	Other mineral wastes	2,842	8	26	181	4,722	30,898	10,463	10,658	814	156	1,991	:	62,759
Total		**30,248**	**1,144**	**15,250**	**17,302**	**5,612**	**42,574**	**14,189**	**58,230**	**12,959**	**4,200**	**34,923**	**8,216**	**244,848**

":" no applicable because waste is not considered as C&I waste (see definition of survey scope)

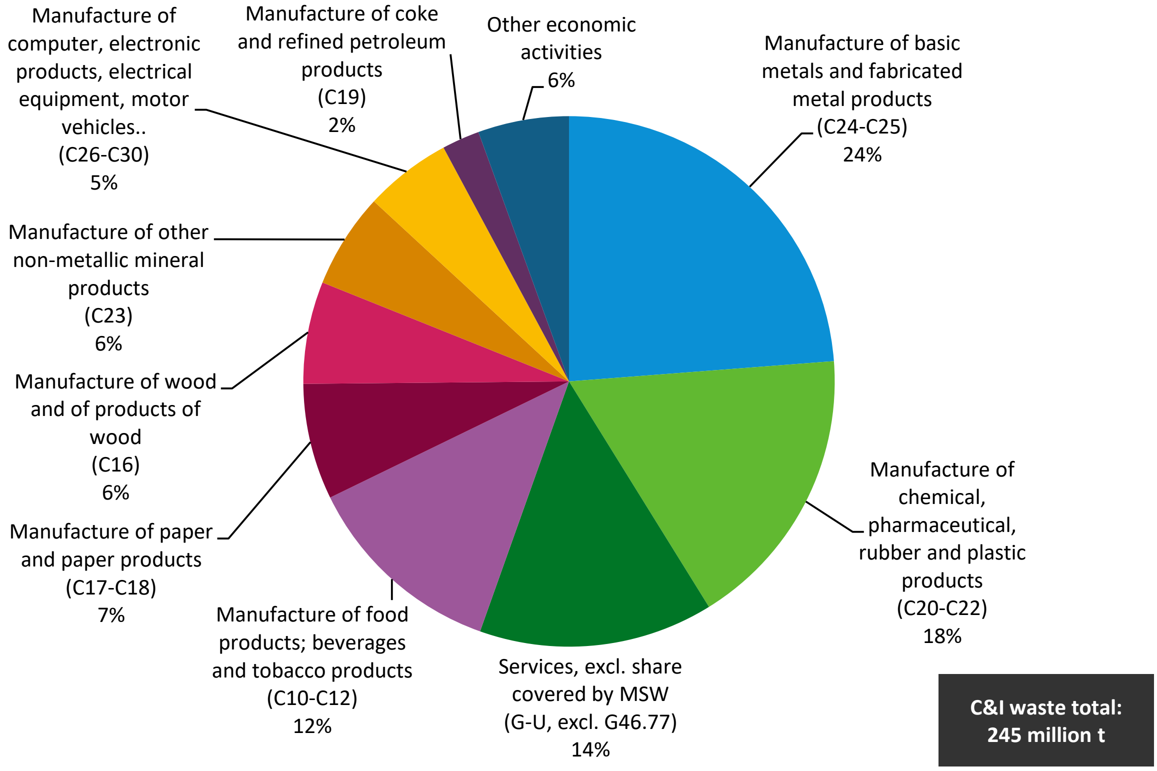
1) excludes waste from NACE A

Figure 33: Breakdown of C&I waste generated by waste category, EU27, 2017



Source: own illustration, Argus.

Figure 34: Breakdown of C&I waste generated by economic activity, EU27, 2017



Source: own illustration, Argus.

7.1.3 Treatment of C&I waste

As outlined in Chapter 7.1.1, the estimation of the C&I waste treatment for EU27 (w/o DE) is based on the WStatR treatment data for the reference year 2016. The treatment mix per EWC-Stat category from 2016 is used as an estimate for the treatment in 2017. The treated amounts for 2017 are then estimated by multiplying the generated amount as determined in the previous chapter (see Table 82) for each EWC-Stat category with the respective treatment mix.

Table 85 shows the share of the six WStatR treatment categories for each EWC-Stat category at the EU27 (w/o DE) level. As pointed out in Chapter 7.1.1, the treatment shares relate to waste from all economic activities and do not reflect specifically the treatment of C&I waste. Lacking more specific information, this general treatment mix is considered as the best available estimate.

Table 85: Treatment mix by waste category for the EU27 (w/o DE), based on data for 2016, in weight-%

EWC-Stat		**Recycling**	**Backfilling**	**Energy recovery (R1)**	**Incinera-tion (D10)**	**Landfill**	**Other disposal**	**Waste treatment**
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W012	Acid, alkaline or saline wastes	61.2%	0.0%	0.3%	<0.05%	11.8%	26.7%	100%
W02A	Chemical wastes	46.6%	1.2%	3.4%	4.6%	44.1%	<0.05%	100%
W032	Industrial effluent sludges	39.1%	0.9%	13.6%	4.5%	41.1%	0.9%	100%
W05	Health care and biological wastes	2.1%	0.0%	43.2%	35.5%	19.2%	0.0%	100%
W061	Metal wastes, ferrous	99.9%	<0.05%	<0.05%	<0.05%	<0.05%	<0.05%	100%
W062	Metal wastes, non-ferrous	99.9%	<0.05%	<0.05%	<0.05%	0.1%	<0.05%	100%
W063	Metal wastes, mixed ferrous and non-ferrous	99.9%	<0.05%	<0.05%	<0.05%	0.1%	<0.05%	100%
W071	Glass wastes	97.8%	<0.05%	<0.05%	<0.05%	1.7%	0.0%	100%
W072	Paper and cardboard wastes	98.9%	<0.05%	0.7%	<0.05%	0.3%	0.0%	100%
W073	Rubber wastes	62.2%	0.9%	36.4%	<0.05%	0.2%	0.2%	100%
W074	Plastic wastes	74.9%	1.0%	18.5%	0.5%	5.2%	<0.05%	100%
W075	Wood wastes	55.7%	<0.05%	42.4%	0.7%	1.2%	<0.05%	100%
W091, W092	Animal and vegetal waste	93.0%	<0.05%	4.1%	0.5%	2.0%	0.3%	100%
W101	Household and similar wastes	18.0%	<0.05%	35.5%	4.9%	41.6%	<0.05%	100%
W102	Mixed and undifferen-tiated materials	40.2%	1.1%	24.3%	1.7%	32.4%	0.2%	100%
W11	Common sludges	63.5%	0.5%	8.8%	8.0%	11.4%	7.8%	100%
W124	Combustion wastes	43.4%	5.3%	0.1%	<0.05%	49.3%	2.0%	100%
W12B	Other mineral wastes	8.5%	5.2%	<0.05%	<0.05%	77.7%	8.6%	100%

Table 85 shows high recycling rates for some waste categories. Although misclassification of treatment operations and overreporting of recycled quantities by countries cannot be excluded, the following aspects may explain the high rates:

- It is important to note that the WStatR concept focuses on the final treatment of waste and does not cover certain pre-treatment operations (see Chapter 3.2.3). The treatment data will thus mainly reflect the input into the final treatment or the output from pre-treatment respectively, where impurities in recyclable waste have already been removed. This may explain the high recycling rates in particular for metal wastes.
- The treatment category 'recycling' in EU statistics covers all recovery operations expect backfilling and energy recovery. Recovery operations other than energy recovery and backfilling that may not comply with the legal definition of recycling in the Waste Framework Directive will thus also be reported under 'recycling' in EU statistics.
- Finally, the displayed treatment mix refers to non-hazardous wastes only.

Table 86 shows the estimation for the treatment of C&I waste for the EU27 (w/o DE) in 2017. The data for Germany, which are taken from the partial report Germany, are displayed in Table 87. The resulting EU27 aggregate is shown in Table 88.

The treated waste total for the EU27 for 2017 amounts to 245 million tons. About 123 million tons or 50% of this total are recycled, 82 million tons (34%) are disposed of at landfills and 28 million tons (11%) are incinerated with energy recovery. Backfilling, incineration and other disposal account together for 5% of the treated waste (see Figure 35).

In Germany, the recycled share of the waste, which accounts for 21%, is considerably lower than at EU27 level. This is due to the high amount 'other mineral wastes' (W12B) that are disposed of at landfills. In Germany, the landfilling of the 'other mineral waste' alone accounts for 57% of the treated total.

The comparably small amounts of non-mineral wastes that are reported under the treatment category 'backfilling' by EU27 (w/o DE) countries are presumably misclassifications and should be considered as landfilled for the GHG balance.

The significant amount of 0.6 million tons of 'acid, alkaline or saline waste' (W012) reported under 'other disposal' by EU27 (w/o DE) countries can mainly be explained by the storage of sludges and liquid wastes from chemical industries in settlement ponds. The storage falls under treatment operation D4 'Surface impoundment, e.g. placement of liquid or sludgy discards into pits, ponds or lagoons' and is thus correctly assigned to 'other disposal'. The same explanation is presumably also valid for the 'other mineral wastes' (W12B) reported under 'other disposal'. This assumption, however, could not be verified.

Table 86: Treatment of C&I waste in the EU27 (w/o DE), 2017, in 1,000 t

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incinera tion (D10)	Landfill	Other disposal	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W012	Acid, alkaline or saline wastes	1,472	0	8	1	284	642	2,407
W02A	Chemical wastes	1,574	42	115	157	1,492	0	3,380
W032	Industrial effluent sludges	0	0	1,037	0	0	0	1,037
W05	Health care and biological wastes	7	0	150	124	67	0	348
W061	Metal wastes, ferrous	26,049	11	0	1	11	0	26,071

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incinera tion (D10)	Landfill	Other disposal	Waste treatment
W062	Metal wastes, non-ferrous	2,196	0	0	0	3	0	2,199
W063	Metal wastes, mixed ferrous and non-ferrous	2,636	0	0	1	2	0	2,640
W071	Glass wastes	1,759	9	0	1	30	0	1,800
W072	Paper and cardboard wastes	12,018	3	87	1	39	0	12,149
W073	Rubber wastes	948	14	555	0	3	3	1,524
W074	Plastic wastes	2,614	34	647	16	181	0	3,492
W075	Wood wastes	10,723	8	8,161	133	230	0	19,254
W091, W092	Animal and vegetal waste	27,208	3	1,201	158	579	96	29,245
W101	Household and similar wastes	1,938	4	3,831	526	4,485	0	10,785
W102	Mixed and undifferen-tiated materials	6,526	185	3,949	282	5,268	39	16,249
W124	Combustion wastes	12,786	1,551	26	0	14,512	591	29,466
W12B	Other mineral wastes	3,039	1,869	0	0	27,752	3,066	35,726
Total		**113,495**	**3,733**	**19,766**	**1,401**	**54,938**	**4,437**	**197,770**

Table 87: Treatment of C&I waste in Germany, 2017, in 1,000 t

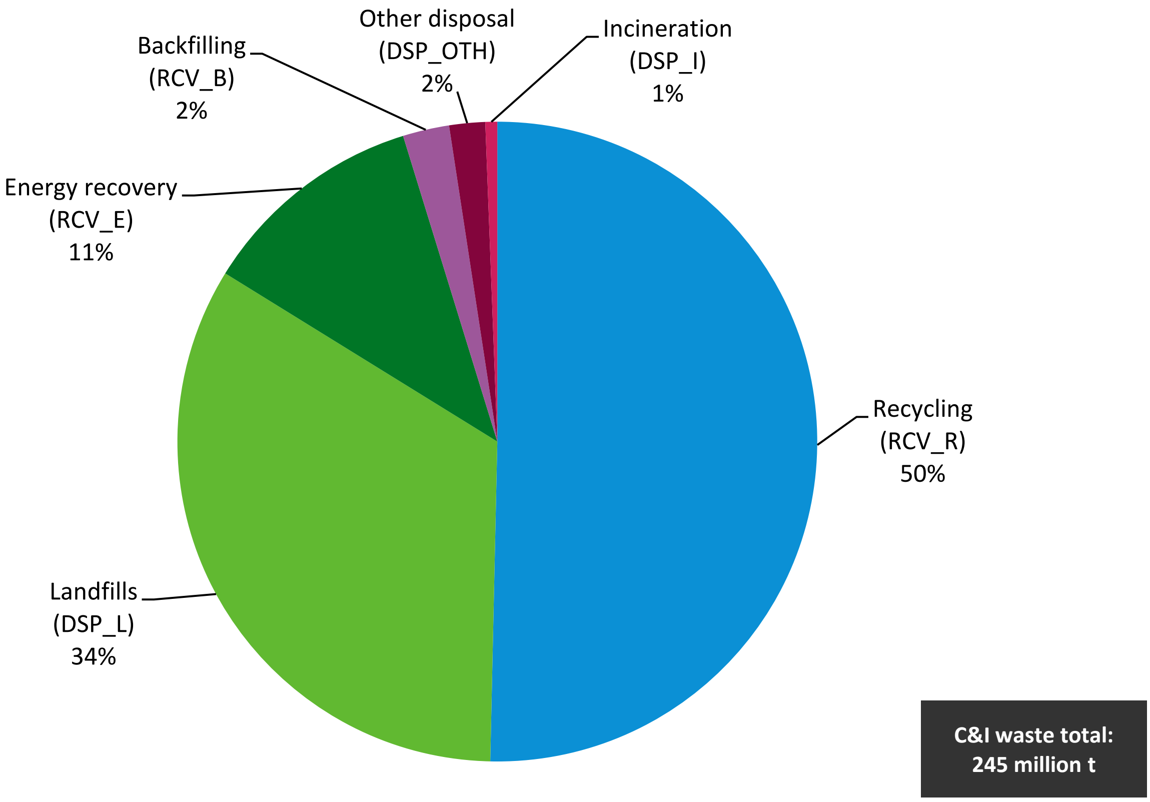
EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incinera tion (D10)	Landfill	Other disposal	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W012	Acid, alkaline or saline wastes	118	0	23	0	131	0	272
W02A	Chemical wastes	195	8	92	24	29	0	348
W032	Industrial effluent sludges	0	0	730	0	0	0	730
W05	Health care and biological wastes	0	0	315	45	0	0	360
W061	Metal wastes, ferrous	2,357	0	21	0	6	0	2,384
W062	Metal wastes, non-ferrous	391	0	0	0	0	0	391
W063	Metal wastes, mixed ferrous and non-ferrous	47	0	1	0	0	0	48
W071	Glass wastes	402	0	0	0	5	0	407
W072	Paper and cardboard wastes	0	0	0	0	0	0	0
W073	Rubber wastes	385	0	185	0	0	0	570
W074	Plastic wastes	421	0	106	1	0	0	529
W075	Wood wastes	0	0	3,627	0	0	0	3,627

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incinera tion (D10)	Landfill	Other disposal	Waste treatment
W091, W092	Animal and vegetal waste	2,768	0	781	0	0	0	3,548
W101	Household and similar wastes	0	0	0	0	0	0	0
W102	Mixed and undifferen-tiated materials	800	0	2,058	0	0	0	2,858
W124	Combustion wastes	632	808	96	0	2,435	0	3,971
W12B	Other mineral wastes	1,275	1,195	179	0	24,384	0	27,033
Total		**9,791**	**2,012**	**8,215**	**70**	**26,990**	**0**	**47,078**

Table 88: Treatment of C&I waste in the EU27, 2017, in 1,000 t

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incinera tion (D10)	Landfill	Other disposal	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W012	Acid, alkaline or saline wastes	1,590	0	31	1	415	642	2,679
W02A	Chemical wastes	1,768	50	208	180	1,522	0	3,728
W032	Industrial effluent sludges	0	0	1,767	0	0	0	1,767
W05	Health care and biological wastes	7	0	466	169	67	0	708
W061	Metal wastes, ferrous	28,406	11	21	1	17	0	28,456
W062	Metal wastes, non-ferrous	2,587	0	0	0	3	0	2,589
W063	Metal wastes, mixed ferrous and non-ferrous	2,683	0	1	1	2	0	2,688
W071	Glass wastes	2,162	9	0	1	35	0	2,207
W072	Paper and cardboard wastes	12,018	3	87	1	39	0	12,149
W073	Rubber wastes	1,333	14	740	0	3	3	2,094
W074	Plastic wastes	3,036	34	753	17	181	0	4,022
W075	Wood wastes	10,723	8	11,788	133	230	0	22,881
W091, W092	Animal and vegetal waste	29,975	3	1,982	158	579	96	32,793
W101	Household and similar wastes	1,938	4	3,831	526	4,485	0	10,785
W102	Mixed and undifferen-tiated materials	7,326	185	6,007	282	5,268	39	19,108
W124	Combustion wastes	13,418	2,359	122	0	16,947	591	33,436
W12B	Other mineral wastes	4,315	3,064	179	0	52,135	3,066	62,759
Total		123,286	5,745	27,981	14,71	81,928	4,437	244,848

Figure 35: Treatment of C&I waste by type of treatment in the EU27, 2017



Source: own illustration, Argus.

7.1.4 Base data for GHG balancing

Table 89 shows the data on the final treatment of C&I waste for the EU27 as used for the GHG balancing. Compared to the data presented in Table 88 in the previous chapter several adjustments were made as explained in the following.

- Several waste categories were completely excluded from the GHG balancing for the following reasons:
  - The waste categories 'acid, alkaline or saline wastes' (W012) and 'chemical wastes' (W02A) were excluded because no suitable ecoinvent data records for the GHG balancing could be found. Due to the poor data situation, the results for the GHG emissions would contain a high degree of uncertainty, and it is therefore unclear whether the results would point in the right direction.
  - As described in Chapter 7.1.1, for the waste category 'industrial effluent sludges' (W032) only wastes form the paper industry were considered. The wastes from other economic activities reported under this category are mainly attributable to wastewater treatment and are therefore not considered in this study. As the GHG emissions from paper production are considered in the GHG balance of 'waste paper' (W072), the sludges from paper production were excluded from the balancing to avoid double counting.
  - The waste category 'mixed and undifferentiated wastes' (W102) comprises further wastes from the paper industry together with a variety of unspecified wastes of unknown material composition. The wastes from the paper industry were excluded to avoid double counting (see previous bullet point). For the remaining wastes the

balancing of GHG emissions was not reasonably possible due to the unknow characteristics of the wastes.

- For the GHG balancing of 'household and similar wastes' (W101) from commercial and industrial activity, it was decided to follow the same methodological approach as for 'household and similar waste' managed under the MSW stream. Hence, the balance is not based on the WStatR treatment mix as for the other C&I wastes but on the data of the EEA waste flow model as described in Chapter 5. In Table 89, the WStatR treatment mix is therefore replaced by the treatment mix applied for the GHG balancing of MSW.
- For Germany, the statistically reported quantity of W072 'paper and cardboard wastes' (W072) are considered within the MSW balance. However, in comparison with association data on the use of domestic recovered paper quantities in paper mills, a statistical coverage gap of 7.2 million tons in 2017 seems to exist (see partial report Germany). This quantity is taken into account in the C&I waste balance.
- Small quantities of treated C&I wastes that account for less than 1% of the treated total of the respective waste category, were excluded and not considered in the balancing. The cut-off criterion was applied separately for the EU27 (w/o DE) and for Germany, i.e. the EU27 aggregate was built after application of the cut-off criterion.

As a result of the adjustments, the amount of C&I wastes considered for the GHG balance amounts to 224 million tons and is by 21 million tons lower than the C&I waste considered in the previous chapters.

Table 89: Base data for the GHG balancing of C&I waste treatment for EU27, 2017, in 1,000 tons

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incinera tion (D10)	Landfill	Other disposal	Mechanical-biological treatment[2)]	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH		TRT
W05	Health care and biological wastes	0	0	465	169	67	0	n.a.	701
W061	Metal wastes, ferrous	28,406	0	0	0	0	0	n.a.	28,406
W062	Metal wastes, non-ferrous	2,587	0	0	0	0	0	n.a.	2,587
W063	Metal wastes, mixed ferrous and non-ferrous	2,683	0	0	0	0	0	n.a.	2,683
W071	Glass wastes	2,161	0	0	0	35	0	n.a.	2,196
W072	Paper and cardboard wastes	19,218	0	0	0	0	0	n.a.	19,218
W073	Rubber wastes	1,333	0	740	0	0	0	n.a.	2,073
W074	Plastic wastes	3,035	0	753	0	181	0	n.a.	3,969
W075	Wood wastes	10,723	0	11,788	0	230	0	n.a.	22,740
W091, W092	Animal and vegetal waste	29,976	0	1,982	0	579	0	n.a.	32,537
W101	Household and similar wastes[1)]	0	0	3,559	0	3,128	0	4,098	10,785
W124	Combustion wastes	13,418	2,359	0	0	16,947	591	n.a.	33,315
W12B	Other mineral wastes	4,314	3,064	0	0	52,136	3,066	n.a.	62,580
Total		**117,855**	**5,423**	**19,934**	**169**	**72,763**	**3,656**	**3,990**	**223,791**

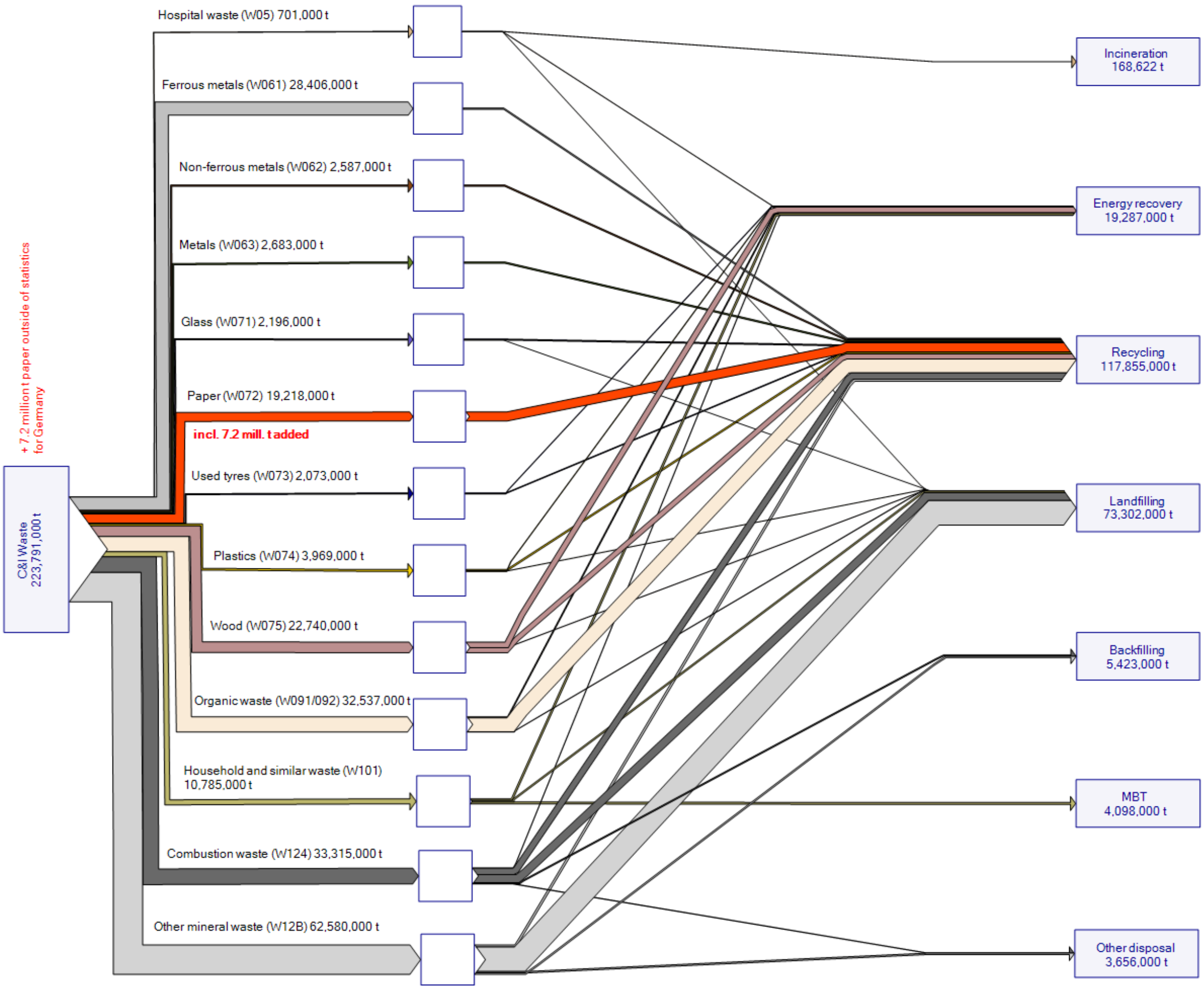
n.a.: not applicable

[1)] The amounts reported here represent the part of 'household and similar wastes' that is not assigned to the municipal waste stream (see Annex A.6.2 on the delimitation between C&I waste and MSW). The GHG balance for this waste is done in the same way as for the MSW and therefore based on the treatment mix from the EEA-model

[2)] Mechanical-biological treatment is applicable only for the waste category 'household and similar wastes' (W101) for which the GHG balance is based on the treatment mix according to the EEA-model.

In Figure 36, the quantities from Table 89 are shown in a form of Sankey diagram and in Figure 37 the waste amounts for final treatment as a bar chart according to the waste types. Both representations visualize that “other mineral waste” (W12B) is the most relevant fraction by mass. This waste fraction takes up to 28% of the total amount. This is followed by the combustion waste and organic waste (W091, W092) with each 15% mass fraction, and by ferrous metals with 13%. Most of the other waste fractions comprise between 1% and 10% of the total mass. Hospital waste, glass and used tyres have shares below 1%.

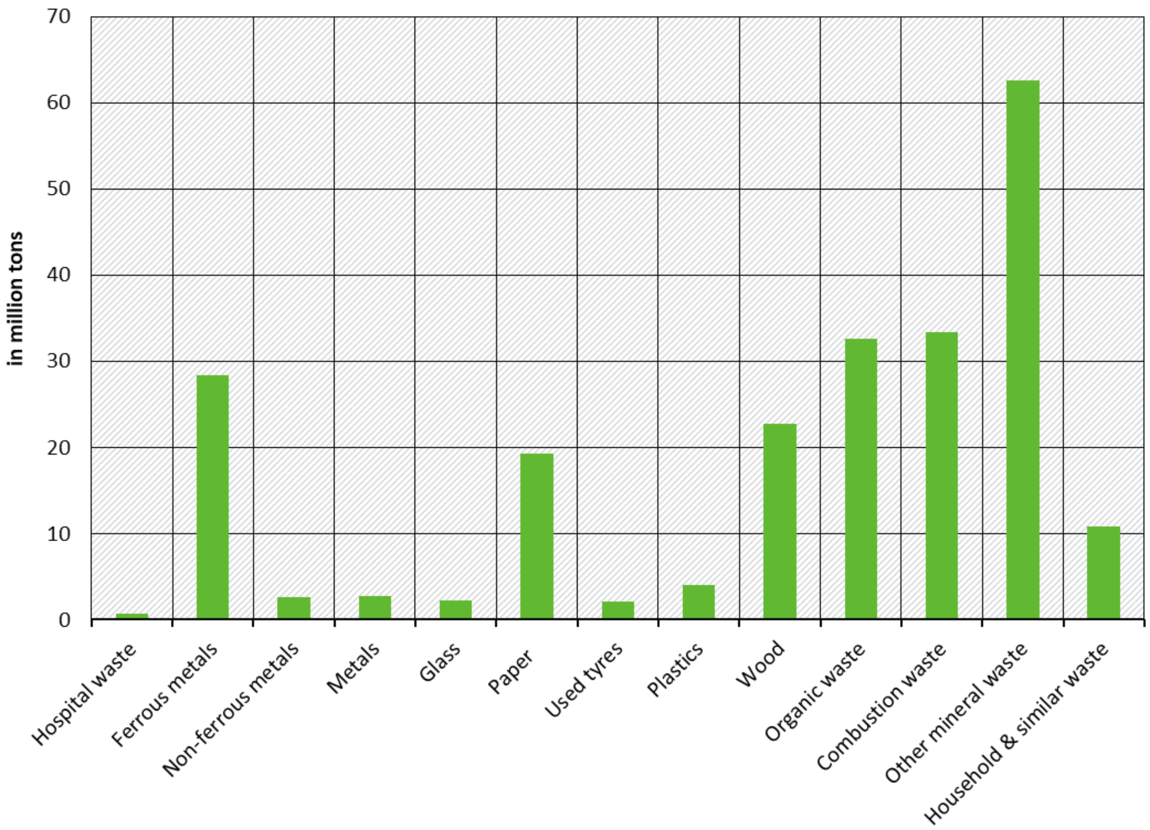
Figure 36: Sankey diagram C&I waste EU27 2017



The amounts shown in the Sankey diagram are rounded values.

Source: own illustration, ifeu.

Figure 37: Waste amounts for final treatment of C&I waste EU27 2017



Source: own illustration, ifeu.

7.2 Procedure balancing and waste parameters

The data base for C&I waste is identical for the EU27 (w/o DE) and for Germany. All the quantity data – those for the EU27 and those for Germany – are derived from European statistics using the same procedure. Therefore, no separate balance is required for C&I waste for Germany with the emission factors for electricity and heat of the EU27. For the scenario 2030, the scenario 2 of the German balance is used for EU27.

C&I waste is balanced according to the waste fractions and the final treatment specified in the previous chapter. As far as sorting costs from first treatment are relevant and can be mapped, as in the case of dry recyclables, input quantities for these are recalculated in the balance on the basis of sorting losses. The procedure for balancing is described below for the different waste fractions.

Dry recyclable materials (W061, W062, W063, W071, W072, W074)

The dry recyclables from the C&I waste – metals, glass, paper and plastics – are almost exclusively assigned to recycling after the final treatment. An exception is plastics that are assigned to energy recovery to 19% and 5% go to landfill. Also 2% of glass are going to landfill.

The calculation for the recycling of dry materials is basically carried out in the same way as the calculation for dry materials for MSW, as described in Chapter 4.2.6. For individual types of waste such as metals and plastics, higher yields are assumed to be recycled with justified reasons (Table 19). The division of the mixed metals into ferrous and non-ferrous metals is based on the division of the pure fractions and results for the metals from C&I waste as 92%

ferrous metals and 8% non-ferrous metals (Table 20). These differences also result in slightly different specific emission values.

There are no GHG emissions for the landfilling of glass or plastics due to the inert or fossil character of the wastes. For the proportionate energy recovery of plastics, the key data – calorific value and fossil carbon content – were calculated according to the market mix for plastics in EU27 (Table 21). The corresponding values according to IPCC (2006, Volume 5, Chapter 2) were used for the individual types of plastic waste. The calculated characteristics for the EU27 result as follows:

- Calorific value: 34.7 MJ/kg
- Fossil carbon content: 71.2%

The calculation of energy generation in waste incineration plants corresponds to the procedure described in Chapter 4.2.4. The energy efficiencies correspond to the calculated values in Table 15 for the EU27.

The recycling for dry recyclables in the EU also considers an estimated share of packaging waste. The calculation is described in Chapter 4.2.6.

Wood (W075)

In the EU27 in 2017, wood waste from C&I waste was mainly sent to energy recovery (52%) and recycling (47%). A small share of 1% was landfilled. The calculation for energy recovery and recycling corresponds to the procedure described in Chapter 4.2.8. The small share landfilled was not further considered.

Used tyres (W073)

64% of used tyres were recycled in the EU27 in 2017 and 36% were co-incinerated in cement kilns. For co-incineration, the calorific value was set at 28 MJ/kg. This value corresponds to the information in VDZ (2018) for used tyres, which has been reported unchanged since 2008 and is regarded as representative also for the EU27[52]. The fossil carbon content for used tyres is taken from Flamme et al. (2018) and set at 52.8%. In Vogt & Ludmann et al. (2019) the calorific value is rated at 26 MJ/kg and the fossil C content at 51.6%, so that the combination of calorific value and fossil C content selected for this study is considered representative. In addition to the equivalent calorific value substitution of the standard fuel coal, the steel content in used tyres is also taken into account for the co-incineration in cement kilns, which as in Schmidt et al. (2009) is set at 18% (range 15% -20%). The steel part replaces iron oxide, which is otherwise used for the production of cement clinker. In fact, this corresponds to a down cycling; pig iron can be replaced in the recycling of steel.

The modelling for the recycling of used tyres follows the knowledge e.g. from Schmidt et al. (2009). Used tyres are initially usually shredded in several stages (pre-shredding, granulation, fine grinding) and separated into the fractions of steel, textile cord and rubber granulate. The steel is recycled in the steel industry (substitution of pig iron). The textile fraction is co-incinerated in cement kilns (calorific value 28.3 MJ/kg, fossil carbon content 28.6%) and replaces the standard fuel coal with the calorific value equivalent. A smaller inert fraction, which has also been separated off, is deposited. The main fraction, the rubber granulate, can be produced in different grain sizes and different qualities. The possible applications are diverse and differ significantly in terms of their substitution potential:

- Floor coverings (replacement of PVC and PP)

[52] The calorific value of 30 MJ/kg given by Flamme et al. (2018) was not adopted.

- Rubber-modified bitumen (replacement od styrene-butadiene-styrene and bitumen)
- Infill in artificial turf (replacement of thermoplastic polymers (EPDM, TPE))
- Clay courts, equestrian grounds (replacement of sand)
- Building material (replacement of concrete, gravel and partly polyethylene)
- Rubber powder in new tires (theoretically between 2-20% possible, according to the German Rubber Association (wdk) not suitable for quality tires and shortens mileage and safety)

Information on the actual use of rubber granulate is not available. For this study, it was uniformly assumed for Germany and the EU that 50% fine rubber granulate is used in high-quality applications such as asphalt or infill in artificial turf, with fossil-based thermoplastics being replaced. The other 50% were assumed to be used as building materials or for clay courts, with mineral substances being replaced. In the first case there is a comparatively high GHG mitigation potential, in the second only a low one, since the provision of the inert primary raw materials is hardly associated with GHG emissions.

Organic waste (W091, W092)

In the EU27, organic waste was mainly recycled in 2017. About 6% are used for energy recovery and 2% are landfilled. The waste categories W091 and W092 are calculated in the special balance food waste. The final treatment split in the food waste balance corresponds well to the final treatment from C&I waste. For the rough calculation of C&I waste in this study, simplifying the average emission factors resulting for W091 and W092 from the calculation of food waste are used to evaluate the organic waste from C&I waste:

- Specific debit: 160 kg CO_2eq/t input
- Specific credit: -258 kg CO_2eq/t input
- Specific net result: -98 kg CO_2eq/t input

Combustion residues (W124)

In 2017, 51% of combustion residues were landfilled in the EU27, 7% backfilled, 40% recycled, 2% went to other disposal. For recycling the use in road and path construction was assumed. Backfilling, other disposal and landfilling is not associated with any GHG emissions since the ashes and slags are inert, non-biologically active material. Debits arise exclusively from transport, the influence of which is of minor importance.

Other mineral waste (W12B)

Other mineral waste, which has the highest share in C&I waste, was to 83% landfilled in 2017 in the EU27, 7% were recycled, 5% backfilled and 5% went to other disposal. The use in road and path construction was assumed for recycling. Since this waste fraction is an inert material, its disposal is not associated with any GHG emissions. Debits arise exclusively from transports, the influence of which is of minor importance despite the comparatively high proportion of mass.

Hospital waste (W05)

In 2017, 66% of hospital waste went for energy recovery, 24% was incinerated without energy generation, and 10% was landfilled. For the latter it is assumed that the landfilled share cannot be organic material due to sanitation reasons. Therefore, the landfilling is not combined with GHG emissions in the calculations. The characteristics for the combustion were uniformly taken from Vogt & Ludmann (2019) for all balance areas:

- Calorific value: 14.9 MJ/kg
- Fossil carbon content: 19.0%

The balancing of energy generation in thermal waste treatment plants corresponds to the procedure described in Chapter 4.2.4 with the energy efficiencies given in Table 15 for the EU27. Incineration without energy recovery derives no credit.

7.3 Description GHG balance scenario 2030 (C&I EU27 2030)

For C&I waste in the EU27, one future scenario is developed for the target year 2030, which is referred to as *C&I EU27 2030*. The scenario *C&I EU27 2030* is the aggregate of the scenario for the *EU27 (w/o DE)* and the scenario 2 for Germany (*C&I 2030 SC2*). The development of the scenario for the *EU27 (w/o DE)* is described in the following. For the description of the scenario for Germany (C&I 2030 SC2) please refer to partial report Germany.

7.3.1 Scenario assumptions for EU27 (w/o DE) for 2030

Waste generation

Since only a rough estimate is to be made for C&I wastes and given the large number and heterogeneity of these wastes, it is assumed that waste generation remains constant until 2030, both overall and at the level of the individual waste categories.

Waste treatment

The scenario assumptions for the development of waste management are essentially based on a comparison of the treatment mix between countries with less and more developed waste management systems for each waste category considered. It is assumed that the treatment mix of less developed countries will move towards the mix of more developed countries and will be equal by 2030.

On this basis, the following assumptions are made:

- Hospital waste (W05): Landfilling is reduced by 4 percent points; the respective amounts are shifted towards energy recovery.
- Plastic waste (W074): Due to the European requirements in the packaging area, an increase in recycling of 5 percent points is assumed. Landfilling and energy recovery both are reduced by 2 percent points.
- Animal and mixed food waste, vegetal waste (W091, W092): Quantities that go to landfills or incineration are shifted towards energy recovery, which increases accordingly by 3 percent points.
- Household waste and similar waste (W101): For commercial waste similar to household waste that is not considered in the MSW waste stream, it is assumed that the same treatment mix is applied as for W101 in scenario 1 (MSW EU27 2030 WFD) for the municipal waste stream.
- Combustion residues (W124): The amounts that were previously reported under “Other disposal” are assigned to landfills.
- A constant treatment mix is assumed for the following wastes:
  - Metal waste (W061, W062, W063)
  - Glass waste (W071)
  - Waste paper (W072)
  - Wood waste (W075)

- Other mineral waste (W12B)

7.3.2 C&I waste treatment according to the EU27 scenario for 2030 (C&D EU27 2030)

The aggregation of the scenario for EU27 (w/o DE) and the scenario 2 for Germany *(C&I 2030 SC2)* leads to the C&I waste treatment displayed in Table 90. The changes from base year 2017 to 2030 in 1,000 tons are shown in Table 91.

Table 90: Treated amounts of C&I waste in the EU27 in 2030 according to scenario C&I EU27 2030, in 1,000 tons

EWC-Stat		**Recycling**	**Backfilling**	**Energy recovery (R1)**	**Incinera tion (D10)**	**Landfill**	**Other disposal**	**Mechanical-biological treatment²⁾**	**Waste treatment**
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH		TRT
W05	Health care and biological wastes	0	0	465	169	67	0	n.a.	701
W061	Metal wastes, ferrous	28,406	0	0	0	0	0	n.a.	28,406
W062	Metal wastes, non-ferrous	2,587	0	0	0	0	0	n.a.	2,587
W063	Metal wastes, mixed ferrous and non-ferrous	2,683	0	0	0	0	0	n.a.	2,683
W071	Glass wastes	2,161	0	0	0	35	0	n.a.	2,196
W072	Paper and cardboard wastes	19,218	0	0	0	0	0	n.a.	19,218
W073	Rubber wastes	1,333	0	740	0	0	0	n.a.	2,073
W074	Plastic wastes	3,035	0	753	0	181	0	n.a.	3,969
W075	Wood wastes	10,723	0	11,788	0	230	0	n.a.	22,740
W091, W092	Animal and vegetal waste	29,976	0	1,982	0	579	0	n.a.	32,537
W101	Household and similar wastes[1)]	0	0	5,500	0	863	0	4,422	10,785
W124	Combustion wastes	13,418	2,359	0	0	16,947	591	n.a.	33,315
W12B	Other mineral wastes	4,314	3,064	0	0	52,136	3,066	n.a.	62,580
Total		**118,687**	**5,423**	**21,059**	**169**	**70,965**	**3,066**	**4,422**	**223,791**

n.a.: not applicable

[1)] The amounts reported here represent the part of 'household and similar wastes' that is not assigned to the municipal waste stream (see Annex A.6.2 on the delimitation between C&I waste and MSW). The GHG balance for this waste is done in the same way as for the MSW and therefore based on the treatment mix from the EEA MSW model

[2)] Mechanical-biological treatment is applicable only for the waste category 'household and similar wastes' (W101) for which the GHG balance is based on the treatment mix according to the EEA MSW model.

Table 91: Changes from 2017 to 2030 in the EU27, in 1 000 tons

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incinera tion (D10)	Landfill	Other disposal	Mechanical-biological treatment[2)]	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH		TRT
W05	Health care and biological wastes	0	0	+14	0	-14	0	n.a.	0
W061	Metal wastes, ferrous	0	0	0	0	0	0	n.a.	0
W062	Metal wastes, non-ferrous	0	0	0	0	0	0	n.a.	0
W063	Metal wastes, mixed ferrous and non-ferrous	0	0	0	0	0	0	n.a.	0
W071	Glass wastes	0	0	0	0	0	0	n.a.	0
W072	Paper and cardboard wastes	0	0	0	0	0	0	n.a.	0
W073	Rubber wastes	+29	0	-29	0	0	0	n.a.	0
W074	Plastic wastes	+192	0	-123	0	-70	0	n.a.	0
W075	Wood wastes	+363	0	-363	0	0	0	n.a.	0
W091, W092	Animal and vegetal waste	+248	0	+331	0	-579	0	n.a.	0
W101	Household and similar wastes[1)]	0	0	+1,941	0	-2,265	0	+324	0
W124	Combustion wastes	0	0	0	0	+591	-591	n.a.	0
W12B	Other mineral wastes	0	0	0	0	0	0	n.a.	0
Total		**+832**	**0**	**+1,773**	**0**	**-2,337**	**-591**	**+324**	**0**

n.a.: not applicable

1) The amounts reported here represent the part of 'household and similar wastes' that is not assigned to the municipal waste stream (see Annex A.6.2 on the delimitation between C&I waste and MSW). The GHG balance for this waste is done in the same way as for the MSW and therefore based on the treatment mix from the EEA MSW model

2) Mechanical-biological treatment is applicable only for the waste category 'household and similar wastes' (W101) for which the GHG balance is based on the treatment mix according to the EEA MSW model.

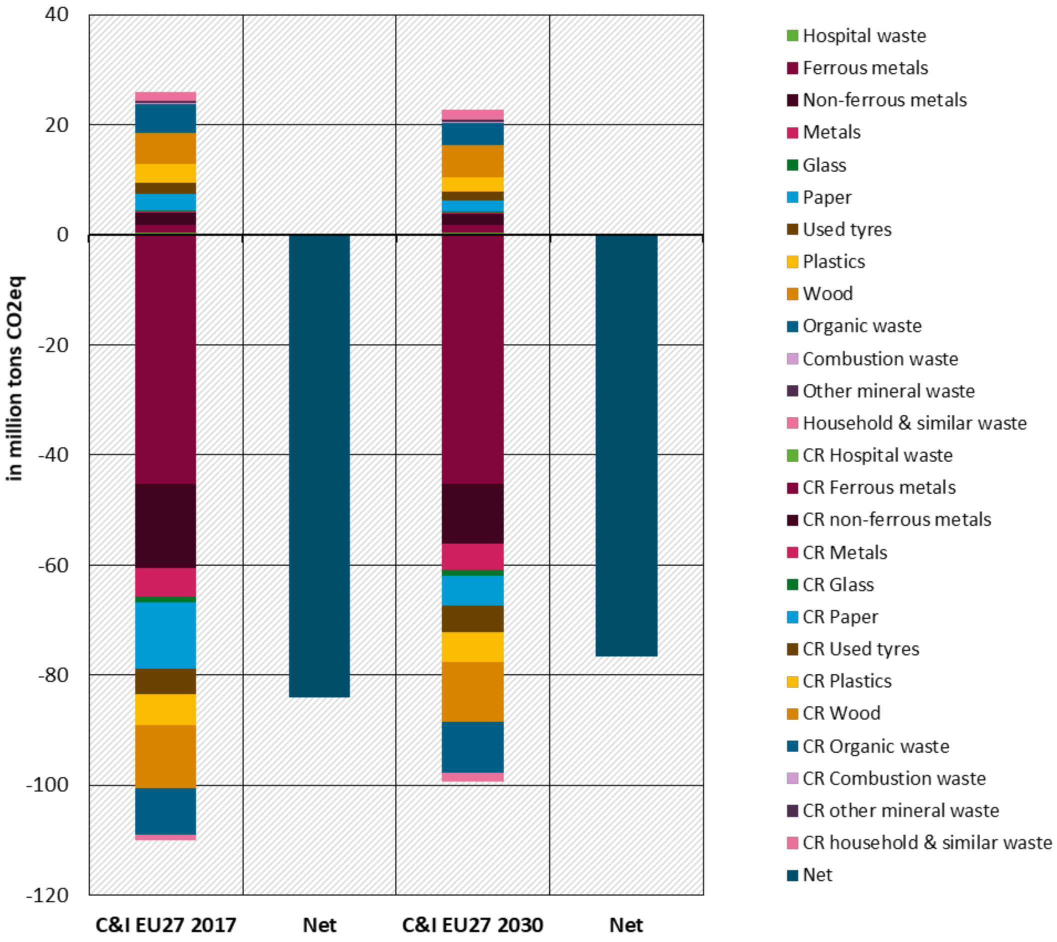
7.4 Results GHG balances

This chapter presents the results of the GHG balance for the base year 2017 in comparison with the scenario 2030. In principle, the results are to be understood as orienting due to the data uncertainties and data gaps. The following terms are used in the figures:

- Base 2017: „C&I EU27 2017“
- Scenario 2030: „C&I EU27 2030“

Figure 38 shows the absolute results according to the debits and credits for each waste fraction as well as the total net result in an annual comparison. For the **base year 2017**, the **absolute net emission savings potential is ca. -84.1 million tons CO_2eq**. The underlying debits amount to around 25.9 million tons CO_2eq, while the emission savings potential is -109.9 million tons CO_2eq. The figure shows that the dry recyclables, including metals in particular, make a significant contribution to the result, with a total volume share of 26%. Combustion waste and other mineral waste in turn do not have influence on the result because of their inert character. Moreover, the transportation considered for these waste fractions is of minor importance in the overall result despite the high mass shares. In addition to the dry recyclables, the treatment of wood and also of organic waste makes a visible contribution to the net savings potential.

Figure 38: Scenario comparison C&I waste EU27



CR: credit, or emission savings potential

Source: own illustration, ifeu.

The **scenario 2030** shows reduced debits as well as lower emission savings potentials. The **absolute net emission savings potential is -76.6 million tons CO_2eq**. The debits for the scenario amount to ca. 22.7 million tons CO_2eq and the emission savings potential to ca. -99.3 million tons CO_2eq. The difference in the results – the overall lower net emissions savings potential compared to base year 2017 – is mainly due to the defossilisation of the energy system. On the one hand, the GHG debits from the energy demand decrease, but on the other hand also the substitution potential for energy and primary products, the production of which is associated with a relevant electricity demand (paper, aluminium, see Chapter 4.2.6). This is countered by the optimisations for 2030, specifically with the shift from landfilling to recycling and/or energy recovery, and from energy recovery to recycling. However, like for Germany, the assumptions address only selected waste fractions and the percentage shifts are moderate.

Table 92 shows the overall GHG net results for C&I waste by waste fraction in absolute values, specific per capita values as well as specific per ton values for the base year 2017 and for the scenario 2030.

Table 92: Absolute and specific net results by waste fraction – C&I waste EU27 2017 and 2030

Waste fraction	Absolute	Absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
C&I waste	**2017**	**2030**	**2017**	**2030**	**2017**	**2030**
	Million tons CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
Hospital waste	0.18	0.22	0.4	0.5	257	319
Ferrous metals	-43.70	-43.70	-98.1	-98.1	-1,538	-1,538
Non-ferrous metals	-13.01	-8.79	-29.2	-19.7	-5,029	-3,398
Metals	-4.91	-4.54	-11.0	-10.2	-1,830	-1,694
Glass	-1.01	-1.01	-2.3	-2.3	-461	-459
Paper	-8.85	-3.47	-19.9	-7.8	-461	-180
Used tyres	-2.77	-2.89	-6.2	-6.5	-1,338	-1,392
Plastics	-2.18	-3.09	-4.9	-6.9	-550	-779
Wood	-5.76	-4.97	-12.9	-11.2	-253	-219
Organic waste	-3.18	-5.24	-7.1	-11.8	-98	-161
Combustion waste	0.22	0.23	0.5	0.5	7	7
Other mineral waste	0.38	0.38	0.9	0.9	6	6
Household & similar waste	0.54	0.27	1.2	0.6	50	25
Sum/average	**-84.06**	**-76.60**	**-188.7**	**-171.9**	**-376**	**-342**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27)

Based on the **specific net results by waste fraction per ton of waste**, the differences in results can be explained as follows:

Ferrous metals, mixed metals (92% ferrous metals) and, in particular, non-ferrous metals show high specific net emission savings potentials. This result was already evident in the case of MSW, since the production of pig iron and aluminium is associated with comparatively high GHG emissions. Nevertheless, it cannot be ruled out that the assumed yields for metals are overestimated (Table 19). The net emission savings potential is relatively high for used tyres as well. The higher emission savings potential in this case is achieved through material recycling, even though only 50% of the used tyres are assumed to substitute fossil thermoplastics in high quality applications. Other dry waste fractions (glass, paper, plastics) predominantly show net emission savings potentials of similar amount in 2017. In contrast hospital waste and household & similar waste show debits in the net results. The results for the inert fractions, combustion waste and other mineral waste, include transportation, which have comparatively low significance despite a high mass share.

In the scenario 2030, the changed net specific results are due to defossilisation and/or assumed optimisations. The changes because of the defossilisation of the energy system for the dry recyclables are described in more detail for MSW (cf. Chapter 5.5.1.1). The impact on ferrous metals and glass is small. For non-ferrous metals, which are accounted for as aluminium, the specific net credit is lower in 2030 due to the estimated reduced GHG impact of the electricity-intensive primary production. This applies analogously to paper, here too the specific net credit decreases due to the estimated reduced GHG impact of the electricity-intensive primary production of wood and pulp. In the case of plastic waste, there is an increase in the specific net emission savings potential mainly due to the lower GHG impact for the electricity required for processing (defossilisation) and also due to the diversion from landfilling and energy recovery (R1) to recycling (reduction of fossil CO_2 emissions from incineration and substitution of virgin raw materials). The influence of the assumed increase in processing yield in plastics recycling on the results is small.

In the case of wood, the slightly reduced specific net emission savings potential is mainly due to the lower credits for energy generation (defossilisation), which are only partially compensated by the higher heat utilisation efficiency assumed for 2030. In addition, the increased share of recycling results in a reduced net emission savings potential, as chipboard recycling is associated with lower specific net emission savings (see Chapter 4.2.8).

For organic waste from C&I, the changes for recycling and energy recovery correspond to those described in the chapter on food waste. The higher net emission savings potential in 2030 is largely a result of the increase of anaerobic digestion and biodiesel production from edible oils and fats. In the case of used tyres, the slightly increased recycling results in a somewhat higher specific net emission savings potential. Proportionate co-incineration in the cement plant is unaffected by defossilisation; in the case of recycling, the GHG debits from electricity demand decrease.

For combustion waste and other mineral waste, the specific net results do not change (no optimisation potential, comparatively low GHG impacts from transport). In case of hospital waste the specific net debit increases due to the lower credits for generated energy (defossilisaton). Household and similar waste experiences a small reduction in the specific GHG debits mainly due to diversion from landfill (cf. Chapter 5.5.2).

8 Construction and demolition waste

C&D waste are roughly calculated in this study. The procedure for collecting the basic data is described in the following. The waste quantities are evaluated after the final treatment. Insofar as sorting expenses from the initial treatment are relevant and can be mapped, as with dry recyclable materials, input quantities are recalculated based on sorting losses.

8.1 Waste generation and treatment

8.1.1 Methodology

Generation of C&D waste

As outlined in Chapter 3.1, the waste stream construction & demolition (C&D) waste is defined for this study as all non-hazardous wastes listed in chapter 17 of the List of Wastes, except 'soil and stones' (LoW 17 05 04) and 'dredging spoil' (17 05 06). The List of Waste entries covered by the study and their assignment to the EWC-Stat categories are shown in Table 93.

In the WStatR data, C&D waste is mainly covered by the sector 'construction' (NACE F) but may also be reported under other economic activities, depending on the data collection approach in the Member States. The estimation of C&D waste generation for the EU is based on the WStatR data extrapolated to the reference year 2017, as described in Chapter 3.3.

Based on the extrapolated data, the estimation of the C&D waste generation was done according to the calculation rules laid down in Commission Decision 2011/753/EU, Annex III[53]. This decision specifies the calculation methods for the reporting of Member States on the C&D waste recovery rate to Eurostat. The decision stipulates that C&D waste generation shall be calculated based on WStatR data as the sum of the following EWC-Stat categories:

- Mineral C&D waste (W121): total generation over all NACE activities plus households
- Metal wastes (W06), glass wastes (W071), plastic wastes (W074), wood wastes (W075) generated by companies of NACE section F (Construction).

The listed EWC-Stat codes cover all LoW entries that belong to the scope of the present survey as described above. The scope of the C&D waste data for this study is illustrated in Table 150 in the Annex.

Furthermore, an estimate was produced on the generation and treatment of reclaimed asphalt. In the WStatR data, asphalt is not reported separately but as part of the waste category 'mineral C&D waste'. The estimate is based on annual statistics of the European Asphalt Pavement Association (EAPA) on reclaimed asphalt in EU countries. The EAPA data used and the detailed description of the estimation approach are available in Annex A.7.2.

Treatment of C&D waste

For all waste categories except for asphalt, the estimation of the C&D waste treatment is based on the WStatR treatment data for the reference year 2016. It is assumed that for each EWC-Stat category the treatment mix, i.e. the shares of the treatment operations, in 2017 is the same as in 2016. The treated amounts are then determined by multiplying the treatment mix with the estimated generation for each EWC-Stat category.

[53] OJ L310, 25.11.2011, p.11ff

The treatment mix is determined at the level of the EU27 (w/o DE). The data for Germany (see partial report Germany) are added to build the EU27 aggregate.

The general limitations of the WStatR data for accurately determining the treatment of the waste generated in the EU (i.e. the missing link of treated amounts to the generating activities; the imbalances between waste generation and waste treatment) are described already in Chapter 7.1.3 in the context of commercial and industrial waste. These limitations are also valid for C&D waste. The situation is more favourable for the EWC-Stat category 'mineral C&D waste' (W121), which accounts for the major part of the C&D waste. Here, the origin of the waste (i.e. the construction sector) is part of the definition of the waste category so that there is a direct link to the generating sector. Accordingly, the treatment data are specific for the waste from this sector.

Quality issues exist regarding data on backfilling. Countries often have difficulties to determine the backfilled amounts of waste because no specific treatment code (R-code) exists for this treatment operation, and because the definition of backfilling leaves some room for interpretation. As a result, data on backfilling are missing from some EU countries. For countries that have not reported data on backfilling under the WStatR, the respective amounts were therefore estimated on the basis of the average share of backfilling in the EU countries that reported data. The average share of backfilling was determined at 6.3% of the mineral C&D waste treated.

Gaps in the WStatR treatment data resulting from data confidentiality were closed through estimates. As the data gaps were mostly small, the impact of the estimates on data accuracy is neglectable.

For the waste category 'asphalt' the treatment is determined based on the data from EAPA cited above. The EAPA data and the description of the estimation approach are available in Annex A.7.2.

8.1.2 Generation of C&D waste

Table 93 shows the estimate for the waste generation in the EU27 as a whole and separately for EU27 (w/o DE) and for DE. The breakdown by waste category is further illustrated in Figure 39.

Table 94 shows the C&D waste generation by country for all 27 EU Member States including the data for Germany. The table also displays the amounts of reclaimed asphalt as estimated based on the EAPA-data.

C&D waste generation in the EU27 in 2017 is determined at 290 million tons or 651 kg/cap. With 92 million tons Germany generates nearly one third (32%) of the EU27 total.

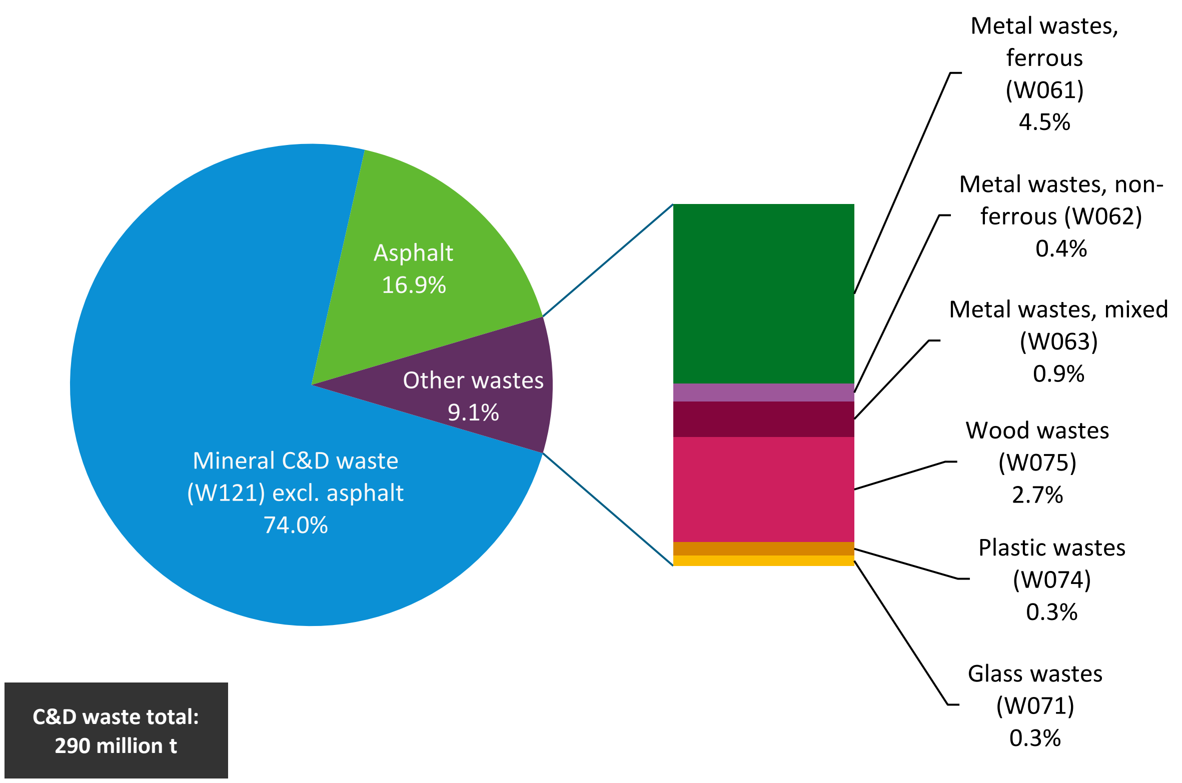
Mineral C&D waste (excl. asphalt) accounts for around 215 million tons or 74% of the total. The share of reclaimed asphalt is estimated at 49 million tons or 17% of the C&D waste total. Metal waste (W06) and wood waste (W075) contribute 5.9% and 2.7% respectively. Plastic and glass wastes account each for 0.3% of the generated C&D waste. Due to the estimation approach that considers only the share of metals, wood, plastic and glass waste reported under the construction sector, the share of these materials may be underestimated.

However, considering that 168 million tons or 92% of the mineral C&D waste in the EU27 (w/o DE) (see Table 150 in the Annex) is reported under the construction sector and assuming that the share is similar for other C&D waste, the potential error is limited.

Table 93: C&D waste generation in the EU27, 2017, in 1,000 t

EWC-Stat category			Generation		
Description	**EWC-Stat code**	**LoW-codes**	**EU27 w/o DE**	**DE**	**EU27**
Mineral C&D waste, excl. asphalt	W121(a)	17 01 01, 17 01 02, 17 01 03, 17 01 07, 17 05 08, 17 06 04, 17 08 02, 17 09 04	149,627	64,940	214,566
Asphalt	W121(b)	17 03 02	32,635	16,306	48,940
Metal wastes, ferrous	W061	17 04 05	6,771	6,395	13,166
Metal wastes, non-ferrous	W062	17 04 01, 17 04 02, 17 04 03, 17 04 04, 17 04 06, 17 04 11	843	456	1,299
Metal wastes, mixed ferrous, non-ferrous	W063	17 04 07	2,445	184	2,629
Glass wastes	W071	17 02 02	478	258	736
Plastic wastes	W074	17 02 03	894	110	1,004
Wood wastes	W075	17 02 01	4,667	3,020	7,688
Total			**198,360**	**91,669**	**290,029**

Figure 39: Breakdown of C&D waste generation by waste category in the EU27, 2017



Source: own illustration, Argus.

Table 94: C&D waste generation by EWC-Stat category and by country in EU27 Member States, 2017, in 1,000 t

Country	Mineral C&D waste (W121)	Of which:		Metal wastes, ferrous (W061)	Metal wastes, non-ferrous (W062)	Metal wastes, mixed (W063)	Glass wastes (W071)	Plastic wastes (W074)	Wood wastes (W075)	C&D waste total
		Asphalt	Other mineral C&D waste							
Belgium	19,538	1,240	18,298	200	10	43	24	42	490	20,346
Bulgaria	903	162	741	25	0	0	0	0	2	930
Czechia	3,613	2,600	1,013	91	3	0	2	4	13	3,726
Denmark	3,701	1,165	2,536	292	35	51	18	6	183	4,286
Germany	81,245	16,306	64,940	6,395	456	184	258	110	3,020	91,669
Estonia	812	145	667	9	0	0	0	0	5	826
Ireland	494	88	406	10	2	8	10	1	5	531
Greece	161	29	132	11	25	0	0	1	2	201
Spain	12,079	494	11,585	70	9	64	9	36	117	12,384
France	57,731	6,400	51,331	1,050	171	1,764	235	604	1,340	62,897
Croatia	603	80	523	87	5	3	3	1	2	704
Italy	34,368	9,000	25,368	3,390	426	190	90	35	200	38,699
Cyprus	303	54	249	1	0	1	0	0	0	306
Latvia	555	99	456	0	0	0	0	0	0	556
Lithuania	862	154	707	18	1	1	0	1	1	883
Luxembourg	585	105	480	21	2	1	1	2	5	617
Hungary	2,308	120	2,188	28	1	0	1	18	2	2,359
Malta	1,314	235	1,078	29	3	0	0	0	0	1,346
Netherlands	18,224	4,500	13,724	761	118	127	58	28	1,423	20,738
Austria	10,952	1,650	9,302	103	10	0	6	4	129	11,205
Poland	5,094	912	4,182	377	6	1	6	31	103	5,620
Portugal	1,327	238	1,089	58	3	18	2	4	14	1,425
Romania	1,283	230	1,053	26	0	0	0	0	6	1,315
Slovenia	631	84	547	10	1	0	5	0	1	648
Slovakia	684	50	634	2	0	0	1	1	3	690
Finland	1,379	1,200	179	43	3	70	0	8	264	1,767
Sweden	2,758	1,600	1,158	58	9	100	8	67	358	3,357
EU27 (w/o DE)	**182,261**	**32,635**	**149,627**	**6,771**	**843**	**2,445**	**478**	**894**	**4,667**	**198,360**
EU27	**263,507**	**48,940**	**214,566**	**13,166**	**1,299**	**2,629**	**736**	**1,004**	**7,688**	**290,029**

8.1.3 Treatment of C&D waste

As outlined in Chapter 8.1.1, the estimation of the C&D waste treatment for the EU27 (w/o DE) is based on the WStatR treatment data for the reference year 2016. The treatment mix per EWC-Stat category from 2016 is used as an estimate for the treatment in 2017. The treated amounts for 2017 are then estimated by multiplying the generated amount as determined in the previous chapter for each EWC-Stat category with the respective treatment mix.

Table 95 shows the share of the treatment operations for each EWC-Stat category at the EU27 (w/o DE) level. As pointed out earlier, the treatment shares for all EWC-Stat categories, except for category mineral C&D waste (W121), relate to waste from all economic activities and do not reflect the specific treatment of C&I waste. Whereas for plastic and metal waste the general shares of the treatment operations are considered as plausible, the treatment mix was adjusted for glass waste and for wood waste:

- The recycling rate for flat glass from C&D activities is usually lower than the recycling rate for packaging glass, which dominates the glass waste stream in terms of quantity. The share of recycling was therefore adjusted downwards from 97.5% to 90%. The share of landfilling was raised accordingly from 1.9% to 9.4%.
- Due to possible contamination, the recycling of wood waste from C&D activities is usually lower than for wood waste from other sources. For wood from construction, energy recovery is usually the preferred option. The share of recycling for the whole wood waste stream was therefore adjusted downwards from 55.6% to 30%. The share of energy recovery was raised accordingly.

The low treatment rates close to zero e.g. in the treatment category ‘other disposal’ are most likely misclassifications of individual countries.

Table 95: Treatment mix by waste category for the EU27 (w/o DE), based on data for 2016, in weight-%

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incine-ration (D10)	Landfill	Other disposal	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W121(a)	Mineral waste C&D waste excl. asphalt	76.0%	8.1%	0.4%	0.0%	15.4%	<0.05%	100%
W121(b)	Asphalt[1)]	90.0%	2.0%	0.0%	0.0%	8.0%	0.0%	100%
W061	Metal wastes, ferrous	99.9%	0.0%	<0.05%	<0.05%	0.0%	<0.05%	100%
W062	Metal wastes, non-ferrous	99.9%	<0.05%	<0.05%	<0.05%	0.1%	<0.05%	100%
W063	Metal wastes, mixed ferrous and non-ferrous	99.9%	<0.05%	<0.05%	0.0%	0.0%	<0.05%	100%
W071	Glass wastes	90.0%[2)]	0.5%	<0.05%	<0.05%	9.4%[2)]	0.0%	100%
W074	Plastic wastes	74.7%	1.0%	18.7%	0.5%	5.2%	<0.05%	100%
W075	Wood wastes	30.0%[3)]	0.0%	68.1%[3)]	0.7%	1.2%	<0.05%	100%

1) Treatment mix for asphalt is estimated based on EAPA data
2) Treatment mix for glass waste is adjusted; original WStatR values: RCV_R 97.5%; DSP_L 1.9%
3) Treatment mix for wood waste is adjusted; original WStatR values: RCV_R 55.6%; RCV_E 42.5%

The resulting estimate for waste treatment in the EU27 (w/o DE) is shown in Table 96. The treatment data for Germany are displayed in Table 97. In Table 98 both data sets are added up to the EU27 total.

Table 96: Treated amounts of C&D waste in the EU27 (w/o DE), 2017, in 1 000 t

EWC-Stat		**Recycling**	**Backfilling**	**Energy recovery (R1)**	**Incine-ration (D10)**	**Landfill**	**Other disposal**	**Waste treatment**
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W121(a)	Mineral waste C&D waste excl. asphalt	113,699	12,168	669	4	23,087	<0.5	149,627
W121(b)	Asphalt	29,371	653	0	0	2,611	0	32,635
W061	Metal wastes, ferrous	6,765	3	<0.5	<0.5	3	<0.5	6,771
W062	Metal wastes, non-ferrous	842	<0.5	<0.5	<0.5	1	<0.5	843
W063	Metal wastes, mixed ferrous and non-ferrous	2,443	<0.5	<0.5	1	1	<0.5	2,445
W071	Glass wastes	430	2	<0.5	<0.5	45	0	478
W074	Plastic wastes	667	9	167	4	46	<0.5	894
W075	Wood wastes	1,400	2	3,178	32	56	<0.5	4,667
Total		**155,619**	**12,837**	**4,014**	**41**	**25,849**	**<0.5**	**198,360**

Table 97: Treated amounts of C&D waste in Germany, 2017, in 1,000 t

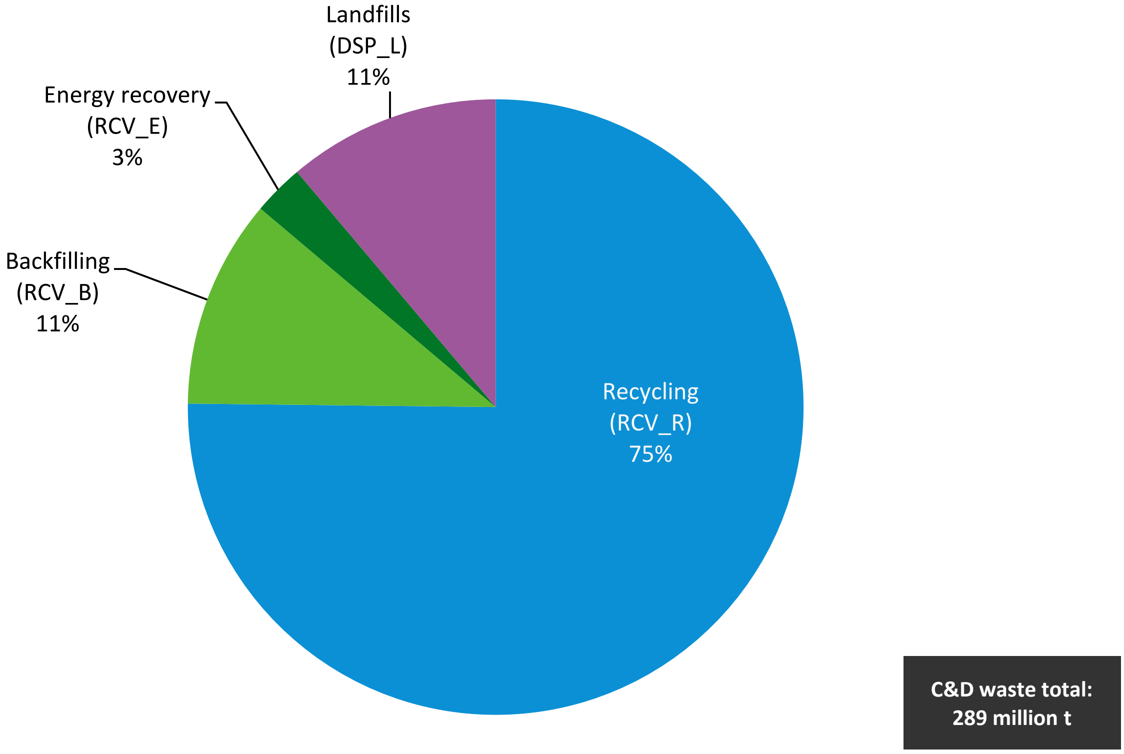
EWC-Stat		**Recycling**	**Backfilling**	**Energy recovery (R1)**	**Incine-ration (D10)**	**Landfill**	**Other disposal**	**Waste treatment**
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W121(a)	Mineral waste C&D waste excl. asphalt	38,224	18,428	1,236	0	5,640	0	63,529
W121(b)	Asphalt	15,264	400	0	0	336	0	16,000
W061	Metal wastes, ferrous	6,310	0	0	0	319	0	6,629
W062	Metal wastes, non-ferrous	442	0	0	0	23	0	465
W063	Metal wastes, mixed ferrous and non-ferrous	177	0	0	0	9	0	186
W071	Glass wastes	221	0	0	0	23	0	244
W074	Plastic wastes	73	0	36	0	0	0	109
W075	Wood wastes	553	0	2,452	0	0	0	3,005
Total		**61,263**	**18,828**	**3,724**	**0**	**6,350**	**0**	**90,166**

Table 98: Treated amounts of C&D waste in the EU27, 2017, in 1,000 tons

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incine-ration (D10)	Landfill	Other disposal	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W121(a)	Mineral waste C&D waste excl. asphalt	151,924	30,597	1,905	4	28,727	<0.5	213,156
W121(b)	Asphalt	44,635	1,053	0	0	2,947	0	48,635
W061	Metal wastes, ferrous	13,075	3	<0.5	<0.5	322	<0.5	13,400
W062	Metal wastes, non-ferrous	1,284	<0.5	<0.5	<0.5	24	<0.5	1,308
W063	Metal wastes, mixed ferrous and non-ferrous	2,619	<0.5	<0.5	1	10	<0.5	2,630
W071	Glass wastes	651	2	<0.5	<0.5	68	0	722
W074	Plastic wastes	740	9	203	4	46	<0.5	1,002
W075	Wood wastes	1,953	2	5,629	32	56	<0.5	7,672
Total		**216,882**	**31,665**	**7,738**	**41**	**32,200**	**<0.5**	**288,526**

The data show a high recycling rate for C&D waste of about 75% for the whole EU27. Together with the share of backfilled C&D waste which is estimated at 11%, this amounts to a material recovery rate of 86%. As outlined in Chapter 8.1.1, the backfilled amounts may be underestimated due to the countries' problems to collect the respective information. Mineral C&D waste (excl. asphalt) and reclaimed asphalt account for 70% and 21%, respectively, of the recycled quantities. 32 million tons or 11% of the C&D waste are disposed of at landfills.

Figure 40: Breakdown of C&D waste treatment by treatment category in the EU27, 2017



Source: own illustration, Argus.

8.1.4 Base data for GHG balancing

Table 99 shows the data on the final treatment of C&D waste for the EU27 as used for the balancing. The treated total amount is by 730 kt or 0.3% lower than the total displayed in Table 98 because small quantities, i.e. treated amounts that account for less than 1% of the treated total of a waste category, were excluded and not considered in the balancing. The cut-off criterion was applied separately for the EU27 (w/o DE) and for Germany, i.e. the EU27 aggregate was built after application of the cut-off criterion.

The treated amounts excluded as a result of the cut-off criterion include:

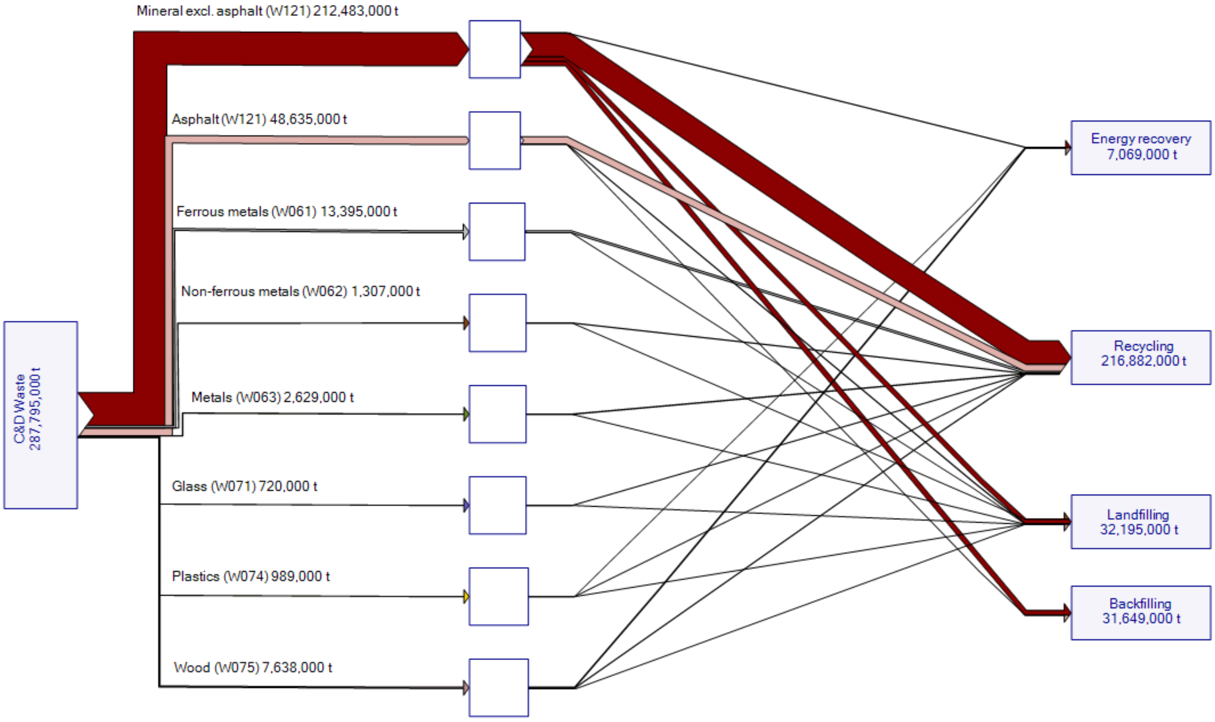
- Backfilling of materials other than mineral waste and asphalt
- Incineration and energy recovery of mineral waste (excl. asphalt).
- Other disposal of all waste categories.

Table 99: Base data for the balancing of C&D waste treatment for EU27, 2017, in 1,000 tons

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incine-ration (D10)	Landfill	Other disposal	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W121(a)	Mineral waste C&D waste excl. asphalt	151,924	30,597	1,236	0	28,727	0	212,483
W121(b)	Asphalt	44,635	1,053	0	0	2,947	0	48,635
W061	Metal wastes, ferrous	13,075	0	0	0	319	0	13,395
W062	Metal wastes, non-ferrous	1,284	0	0	0	23	0	1,307
W063	Metal wastes, mixed ferrous and non-ferrous	2,619	0	0	0	9	0	2,629
W071	Glass wastes	651	0	0	0	68	0	720
W074	Plastic wastes	740	0	203	0	46	0	989
W075	Wood wastes	1,953	0	5,629	0	56	0	7,638
Total		216,882	31,649	7,069	0	32,195	0	287,795

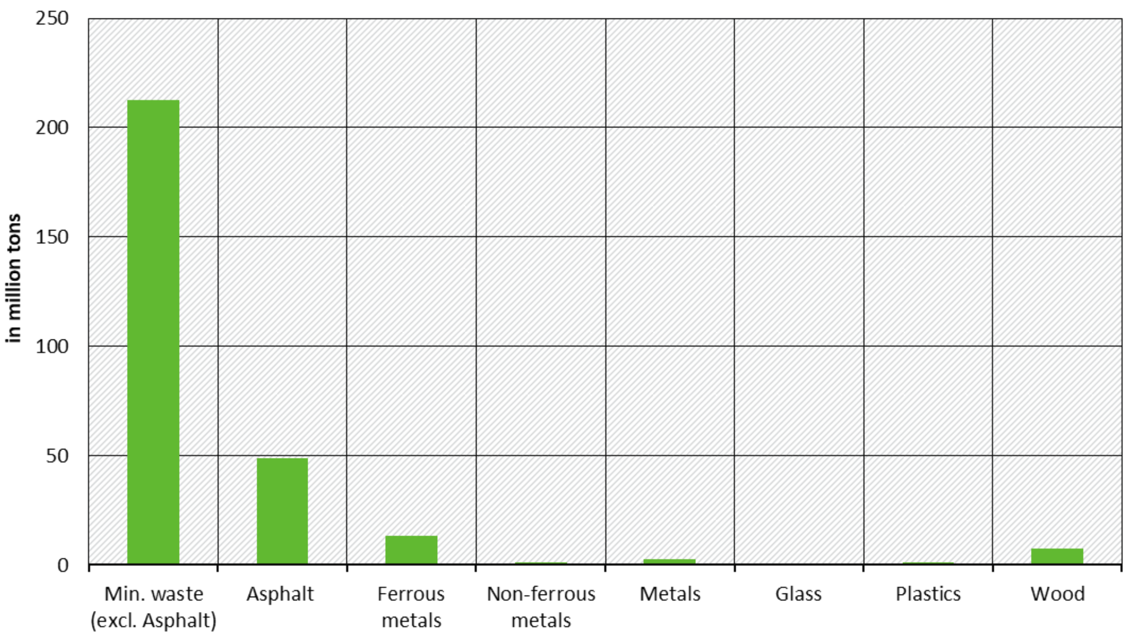
In Figure 41, the quantities from Table 99 are shown as a Sankey diagram and in Figure 42 the waste amounts for final treatment as a bar chart according to the waste types. Both representations visualize that C&D waste is characterized by “mineral waste” (W121) by mass. This waste fraction takes up 74% of the total amount. This is followed by the amount of asphalt considered separately from the “mineral waste” with a mass fraction of 17%. In the case of the other waste fractions, ferrous metals and wood account for 5% and 3% of the total. The percentage of the remaining waste fractions are around or below 1%.

Figure 41: Sankey diagram C&D waste EU27 2017



The amounts shown in the Sankey diagram are rounded values.
Source: own illustration, ifeu.

Figure 42: Waste amounts for final treatment of C&D waste EU27 2017



Source: own illustration, ifeu.

8.2 Procedure balancing and waste parameters

The data base for C&D waste is identical for the EU27 (w/o DE) and for Germany. All the quantity data – those for the EU27 and those for Germany – are derived from European statistics using the same procedure. Therefore, no separate balance is required for C&D waste for

Germany with the emission factors for electricity and heat of the EU27. For the scenario 2030, the scenario 2 of the German balance is used for EU27.

The calculation of the C&D waste is based on the waste fractions shown in the previous chapter and the specified final treatment. The procedure for balancing is described below according to the different waste fractions.

Dry recyclable materials (W061, W062, W063, W071, W072, W074)

The dry recyclable materials from the C&D waste – metals, glass and plastics – are mainly assigned to recycling after the final treatment. Around 2% of ferrous and non-ferrous metals fractions are also landfilled, with glass it is 9%, and with plastics 5%. 21% of plastics are also used for energy recovery.

The balancing for the recycling of dry materials is carried out in the same way as the balancing for dry materials in MSW as described in Chapter 4.2.6. In contrast to C&I waste for which higher yields were assumed in some cases (Table 19), since it is not waste from subsequent use, there are no justified deviations seen for the dry recyclable materials from C&D waste compared to the dry recyclable materials from MSW.

The division of the mixed metals into ferrous and non-ferrous metals is based on the division of the pure fractions and results for the metals from C&D waste for the EU27 as 91% ferrous metals and 9% non-ferrous metals (Table 20).

There are no GHG emissions from landfilling of metals, glass and plastics, due to their inert or fossil character. As for C&I waste, the key data – calorific value and fossil C content – for the proportionate energy recovery of plastics were calculated according to the market mix for plastics in EU27 (calorific value: 34.7 MJ/kg; fossil carbon content: 71.2%). The calculation of energy generation in thermal treatment plants corresponds to the procedure described in Chapter 4.2.4. The energy efficiencies correspond to the calculated values in Table 15 for the EU27.

Wood (W075)

Wood waste from C&D waste was 74% energetically recovered in the EU27 in 2017 and 26% was recycled. The balancing corresponds to the procedure described in Chapter 4.2.8. The very small amount to landfill from the EU27 (w/o DE) is a relict of the necessary procedure for the cut-off criterion, which had to be carried out separately for the EU27 (w/o DE) and for Germany in order to arrive at the same total quantities in the aggregated 2030 scenario, and was neglected.

Mineral waste (W121) excl. asphalt

In 2017, 71% of mineral waste, which makes up the bulk of C&D waste, was recycled in the EU27, 14% used for backfilling, and 14% landfilled. The remaining almost 1% for energy recovery results from the German balance (cut-off criterion attributed separately) and is calculated as described in the partial report Germany. For recycling, use in road and path construction or other earthwork was assumed. As this waste fraction is inert material, its disposal does not result in any GHG emissions. Debits result exclusively from transport, the influence of which is of minor importance despite the comparatively high proportion of mass. The same applies to the quantities used for backfilling.

Asphalt (W121)

For balancing, asphalt is considered separately from the mineral waste fraction due to the different type of recycling in which recycling asphalt is reused in asphalt mixing plants. In total, 92% of asphalt was recycled in the EU27 in 2017, 2% used for backfilling and 6% landfilled. Apart from transport costs, no other GHG emissions are charged for landfilling and backfilling, since the inert material is not subject to any biological degradation.

Recycling of asphalt in asphalt mixing plants partly replaces bitumen. According to Vogt et al. (2012), the proportion of fresh bitumen in asphalt products is around 4%. This proportion can be replaced by the use of recycling asphalt equivalent in mass. According to an operator, the production of new bitumen causes around 13 kg CO_2/ton of new asphalt. This value was also used for this study.

8.3 Description GHG balance scenarios 2030

For C&D waste in the EU27 one future scenario is developed for the target year 2030, which is referred to as C&D EU27 2030. The scenarios for the EU27 (w/o DE) and for Germany were developed separately and then aggregated to the EU27 scenario. The following text describes the assumptions for the EU27 (w/o DE) scenario. The development of the scenario for Germany (C&D 2030 SC2) is described in the partial report Germany.

8.3.1 Scenario assumptions for EU27 (w/o DE) for 2030

Waste generation

The amount of C&D waste in the EU27 (w/o DE) fluctuated between 185 million tons and 215 million tons between 2010 and 2016 and showed no clear trend. It is assumed that the estimated amount of 198 million tons for the EU26 for 2017 will remain constant until 2030.

A comparison between countries with less and more developed waste management systems shows that the latter usually report a higher proportion of metals, wood and glass in construction waste. We assume that this is due to better separation of recyclables at source.

For the scenario 2030, it is assumed that the separate collection of these recyclable materials in the EU27 (w/o DE) will match the level of the more developed countries overall. Since the total generation is set as constant, this assumption leads to a higher generation of metal, wood and glass waste, while the generation of the waste type 'mineral C&D waste' (W121), which also contains mixed C&D waste (LoW 170904), decreases accordingly.

Treatment

With regard to waste treatment, it is assumed that the treatment mix for the different waste categories of less developed countries will correspond to the treatment mix of the more developed waste management systems by 2030. On this basis, the following assumptions are made for the treatment of C&D waste:

- For mineral C&D waste (W121) (excluding asphalt), recycling increases by 4 percentage points, while landfilling decreases by the same percentage.
- For asphalt, recycling increases by 3 percentage points, while landfilling decreases by the same percentage.
- The treatment mix for metals, glass, plastics and wood is assumed to be constant.

8.3.2 C&D waste treatment according to the EU27 scenario for 2030 (C&D EU27 2030)

The aggregation of the scenario for EU27 (w/o DE) and the scenario 2 for Germany (C&D 2030 SC2) leads to the C&D waste treatment displayed in Table 100, The changes from base year 2017 to 2030, which are shown in Table 101, can be summarized as follows:

- Increase in recycling by 13.2 million tons, distributed over the fractions W121 excl. asphalt (+9.1 million tons), asphalt (+2.0 million tons), metals (+1.3 million tons), wood (+0.6 million tons), glass (+0.1 million tons) and plastics (+ 0.02 million tons).
- Decrease in landfilling by 7.0 million tons, of which W121 (-5.8 million tons) and asphalt (-1.1 million tons).
- Decrease in backfilling of W121 by 6.7 million tons.
- Increase in energy recovery from wood by 0.7 million tons.

Table 100: Treated amounts of C&D waste in the EU27 in 2030 according to the scenario, in 1 000 tons

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incine-ration (D10)	Landfill	Other disposal	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W121(a)	Mineral waste C&D waste excl. asphalt	160,993	23,911	1,236	0	22,928	0	209,069
W121(b)	Asphalt	46,598	907	0	0	1,843	0	49,349
W061	Metal wastes, ferrous	14,347	0	0	0	187	0	14,534
W062	Metal wastes, non-ferrous	1,440	0	0	0	13	0	1,453
W063	Metal wastes, mixed ferrous and non-ferrous	2,616	0	0	0	5	0	2,621
W071	Glass wastes	767	0	0	0	70	0	837
W074	Plastic wastes	758	0	194	0	47	0	999
W075	Wood wastes	2,555	0	6,307	0	71	0	8,934
Total		**230,074**	**24,818**	**7,738**	**0**	**25,165**	**0**	**287,795**

Table 101: Changes in treated amounts between base year 2017 and scenario 2030 for EU27, in 1 000 tons

EWC-Stat		Recycling	Backfilling	Energy recovery (R1)	Incine-ration (D10)	Landfill	Other disposal	Waste treatment
Code	Description	RCV_R	RCV_B	RCV_E	DSP_I	DSP_L	DSP_OTH	TRT
W121(a)	Mineral waste C&D waste excl. asphalt	9,069	-6,685	0	-	-5,798	-	-3,415
W121(b)	Asphalt	1,963	-146	-	-	-1,103	-	714
W061	Metal wastes, ferrous	1,272	-	-	-	-133	-	1,140
W062	Metal wastes, non-ferrous	155	-	-	-	-9	-	146
W063	Metal wastes, mixed ferrous and non-ferrous	-3	-	-	-	-4	-	-7
W071	Glass wastes	116	-	-	-	1	-	117
W074	Plastic wastes	18	-	-9	-	1	-	10
W075	Wood wastes	602	-	678	-	16	-	1,295
Total		**13,192**	**-6,831**	**669**	**-**	**-7,030**	**-**	**0**

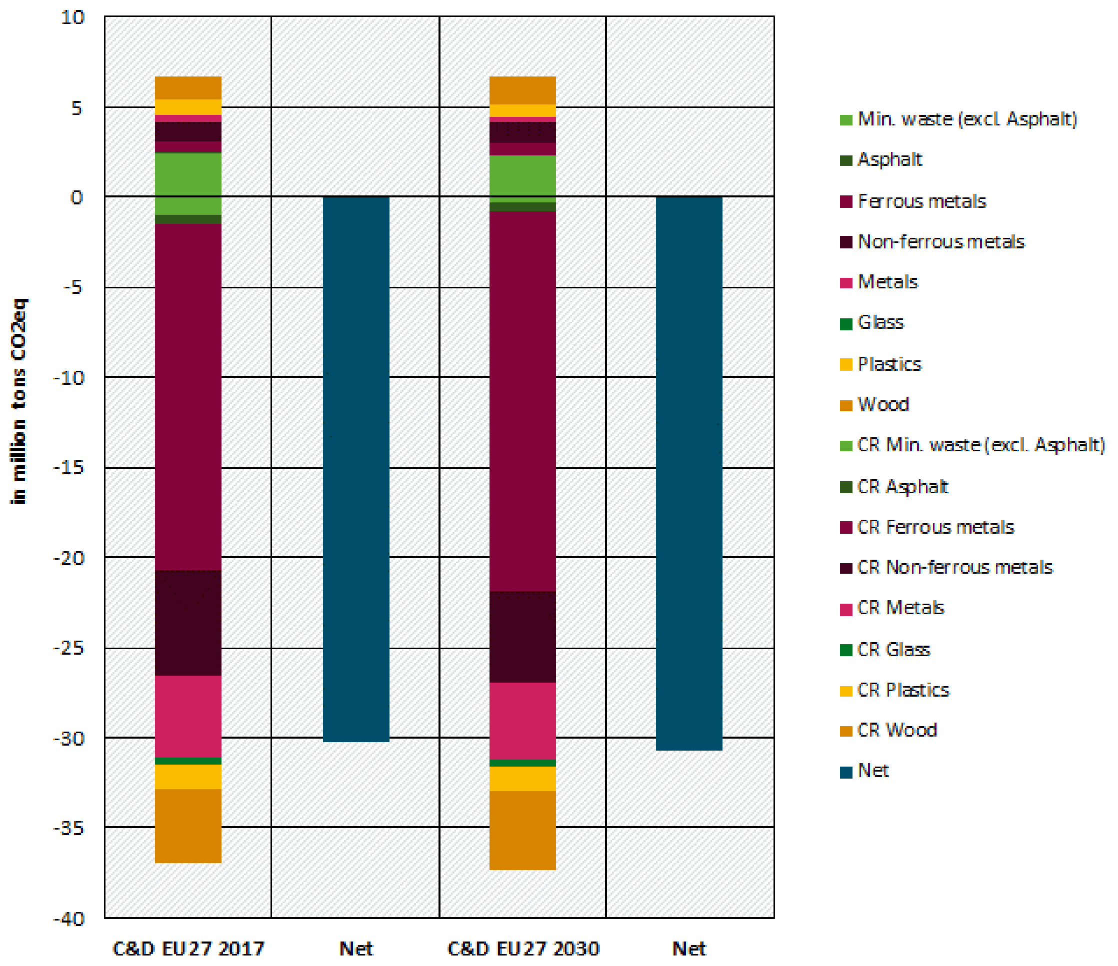
8.4 Results GHG balances

This chapter presents the results of the GHG balance of the base year 2017 (Table 99) in comparison to a scenario 2030 described above. In principle, the results are to be understood as orienting due to the data uncertainties and data gaps. The following terms are used in the figures:

- Base 2017: „C&D EU27 2017“
- Scenario 2030: „C&D EU27 2030“

Figure 43 represents the absolute results according to debits and credits for each waste fraction as well as the total net result in an annual comparison. For the **base year 2017**, there is an **absolute net emission savings potential of -30.3 million tons CO_2eq**. The underlying debits amount to ca. 6.7 million tons CO_2eq, while the credits are ca. -37 million tons CO_2eq. It is evident that metals and wood make a significant contribution to the result, while covering in total only 8.7% of the overall waste amount by mass. Separately collected plastics and glass only have mass share of < 0.5% and, therefore, play no role in the absolute overall result. The mineral waste, which makes up the main mass, has a net debit. The treatment of the inert main mass itself is not associated with any GHG emissions. The transportations taken into account are of secondary importance in the overall result despite the high mass shares. The small amount of mineral waste to energy recovery from the German balance is insignificant in the EU27 balance.

Figure 43: Scenario comparison C&D waste EU27



CR: credit, or emission savings potential
Source: own illustration, ifeu.

The **scenario 2030** has a slightly increased **absolute net emission savings potential of around -30.7 million tons CO_2eq**. The amount of underlying debits is nearly unchanged to the base year, while the credits increased to -37.4 million tons CO_2eq. The differences between the scenarios is less pronounced compared to MSW and C&I waste. This is due to the main influence of ferrous metals in the result. The recycling of ferrous metals is hardly influenced by defossilisation for the 2030 scenarios. The increase of the net emissions savings potential is also mainly due to ferrous metals which are diverted form mineral C&D waste in the 2030 scenario.

Table 102 shows the overall GHG net results for C&D waste by waste fraction in absolute values, specific per capita values as well as per ton values for the base year 2017 and scenario 2030.

Table 102: Absolute and specific net results by waste fraction – C&D waste EU27 2017 and 2030

Waste fraction	Absolute	Absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
C&D waste	**2017**	**2030**	**2017**	**2030**	**2017**	**2030**
	Million tons CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
Min. waste (excl. asphalt)	1.46	2.01	3.3	4.5	7	10
Asphalt	-0.43	-0.46	-1.0	-1.0	-9	-9
Ferrous metals	-18.62	-20.43	-41.8	-45.9	-1,390	-1,406
Non-ferrous metals	-4.78	-3.89	-10.7	-8.7	-3,657	-2,678
Metals	-4.26	-4.02	-9.6	-9.0	-1,623	-1,534
Glass	-0.31	-0.36	-0.7	-0.8	-430	-433
Plastics	-0.47	-0.65	-1.0	-1.4	-471	-650
Wood	-2.87	-2.88	-6.4	-6.5	-376	-323
Sum/average	**-30.28**	**-30.68**	**-68.0**	**-68.9**	**-105**	**-107**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27)

Based on the **specific net results by waste fraction per ton of waste**, the differences in results can be identified as follows:

As it was already the case for C&I waste (and for metals in MSW), ferrous metals, mixed metals (91% ferrous metals) and especially non-ferrous metals have high specific net emission savings potentials. The production of pig iron and aluminium is associated with comparatively high GHG emissions. The waste fractions of glass and wood have net reduction potentials of a similar magnitude in both scenarios. In contrast, the net emission savings potential for plastics is in similar level with glass and wood in 2017, but is significantly higher in 2030. The net reduction potential for asphalt is comparatively low. The treatment of mineral waste (excl. asphalt) shows a low debit in the specific net result.

In the scenario 2030, the specific net results that are changed, are affected by defossilisation and/or by assumed waste optimisations. The changes due to the defossilisation of the energy system for the dry recyclables have already been described in more detail for MSW (cf. Chapter 5.5.1.1). The impact on ferrous metals and glass is small. For non-ferrous metals, which are accounted for as aluminium, the specific net credit is lower due to the estimated reduced GHG impact of electricity-intensive primary production. This is somewhat counteracted by the assumed diversion from landfill to recycling.

In the case of plastic waste, there is an increase in the specific net emission savings potential mainly due to the lower GHG impact for the electricity demand for the processing (defossilisation) and also due to the redirection of energy recovery (R1) to recycling (reduction of fossil CO_2 emissions from incineration). The influence of the assumed increase in processing yield in plastics recycling on the results is small.

In the case of wood, the slightly reduced specific net emission savings potential is mainly due to the lower credits for energy generation (defossilisation), which are only partially compensated by the higher heat utilisation efficiency assumed for 2030. In addition, the slightly increased share of recycling results in a reduced net emission savings potential, as chipboard recycling is associated with lower specific net emission savings (see Chapter 4.2.8).

9 Overview results EU27

The results for the EU27 from the balance areas – MSW, C&I waste and C&D waste – are summarised here. The results for the special balance food waste are also mentioned, however, they are not additive but subset of the MSW and C&I waste balance areas. In principle, the results for C&I waste, C&D waste and food waste are to be understood as orientational due to data uncertainties and data gaps (cf. Chapter 1).

For the overall overview of the actual situation in EU27 and the potential situation for 2030, the following scenarios are used:

- MSW: base 2017 and lead scenario 2030
- C&I waste: base 2017 and scenario 2030
- C&D waste: base 2017 and scenario 2030

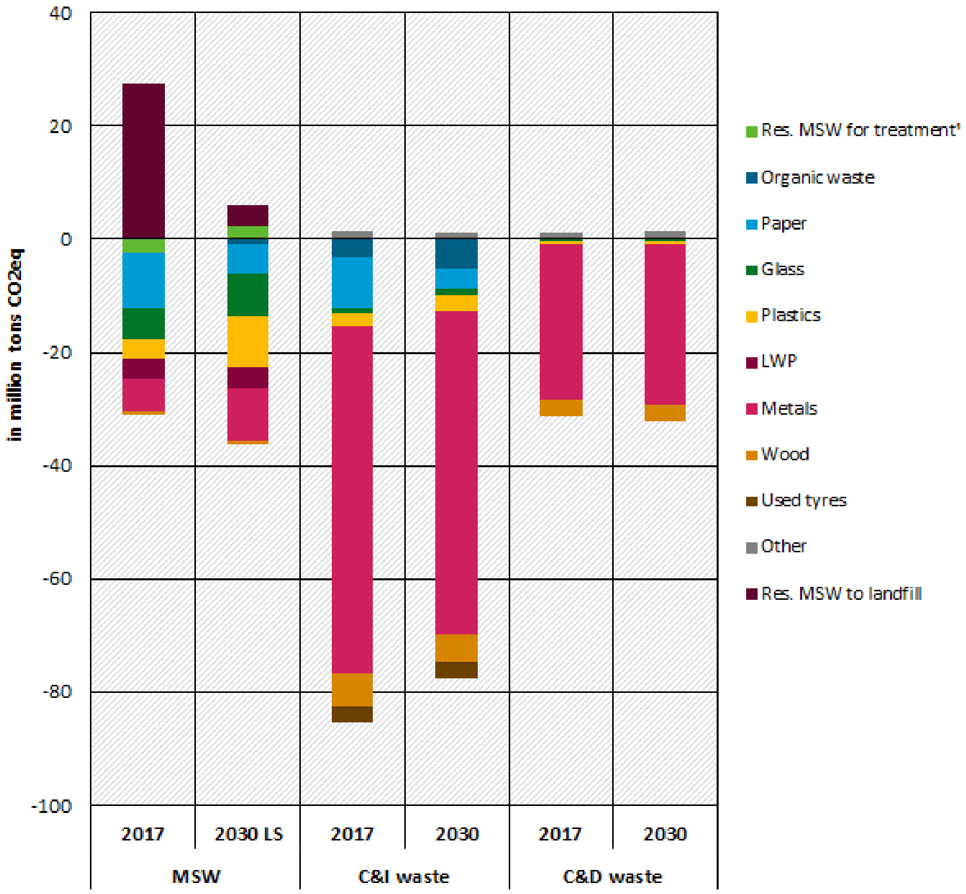
Figure 44 shows the absolute net results of the three waste source sectors by waste fraction. Under "Metals", the GHG results for C&I and C&D waste are summarised for ferrous metals, non-ferrous metals and metals. Under "Other", the results for hospital waste, household and similar waste, combustion waste and other mineral waste are summarised for C&I waste, and the results for mineral waste and asphalt are summarised for C&D waste.

The overview shows rather different results for the three areas of origin. By far the highest net savings potentials result from C&I waste and there is dominated by metals, which account for 15% by mass (33.7 million tons). The other contributions are made by the other dry recyclables, wood, organic waste and used tyres. The results for C&D waste are also dominated by metals. On absolute level the savings potentials are about half of those for metals in C&I waste because the amount of metals in C&D waste is only about half of that in C&I waste in the EU27. Other, albeit much smaller, contributions result from wood, the effect from the remaining fractions is negligible. The result for MSW is dominated by residual MSW to landfill in 2017, and therefore only achieves a poor net emission savings potential in total. This is significantly improved in the 2030 lead scenario mainly by diversion from landfill and increased recycling. In 2030, the total net savings potential lies in the range of that for C&D waste. Contributions to the net savings potential mainly result from dry recyclables, whereof that for metals is distinctly lower than that for C&I and also C&D waste due to the smaller quantities (3.9 million tons in 2017 and 6.6 million tons in 2030 LS).

Overall, the waste treatment in the three source areas results in a **total absolute net emission savings potential of -117.9 million tons CO_2eq for the EU27** for the balance year **2017**. The underlying debits amount to a total of around 110.6 million tons CO_2eq and the emission savings potential to around -228.5 million tons CO_2eq. For the scenarios for the year **2030**, the **total absolute net emission savings potential is around -137.3 million tons CO_2eq**. The underlying debits amount to about 84.76 million tons CO_2eq and the emission savings potential to about -222.02 million tons CO_2eq. The results for the various source sectors are explained in detail in the respective chapters.

Table 103 shows an overview of the waste quantities as well as the absolute and specific net results according to areas of origin and/or balance areas and as a total sum and/or specific average values. In terms of total generation, MSW and C&I waste are similarly high (29% and 31%, respectively). C&D waste accounts for 40%, but 91% consists of mineral waste (incl. asphalt), which contributes only minor GHG effects.

Figure 44: Waste EU27 - absolute GHG net results by origin and waste fraction



1) Includes the treatment via incineration, MBT and MT

Source: own illustration, ifeu.

Table 103: Waste EU27 – Amounts and absolute as well as specific net results by area of origin

Balance area	Amount	GHG absolute	GHG absolute	Specific per capita[1]	Specific per capita[1]	Specific per ton	Specific per ton
		2017	2030	2017	2030	2017	2030
	million tons	million tons CO_2eq		kg CO_2eq/cap		kg CO_2eq/t	
MSW	209.4	-3.5	-30.0	-8	-67	-17	-143
C&I waste	223.8	-84.1	-76.6	-189	-172	-376	-342
C&D waste	287.8	-30.3	-30.7	-68	-69	-105	-107
Total	**720.9**	**-117.9**	**-137.3**	**-265**	**-308**	**-163**	**-190**

1) Calculated with 445,529,136 inhabitants in 2017 (Table 27)

The study shows that the MSW has by far the largest influence on the total potential for reducing GHG emissions.

The special balance food waste accounts for a small share of the total volume, with a total of around 31.5 million tons of waste from the MSW and C&I waste balance areas. The absolute net emission savings potential for food waste in the base comparison is around -2.2 million tons CO_2eq for 2017 and around -3.8 million tons CO_2eq for 2030 (cf. Chap. 6.4.2).

10 Conclusions and recommendations

In addition to the area of origin of MSW, this study also examined the areas of origin of C&I and C&D waste and, as a special balance, food waste, which represents a subset of MSW and C&I waste. In addition to the overall balance for the EU27, two sub-areas, Cluster 1 and Cluster 2, were also examined more closely for MSW and the special balance food waste. For MSW and food waste, also a great deal of effort was put into integrating the more detailed results for Germany (partial report Germany) exactly 1:1. As a result, all evaluations were initially carried out separately for the EU27 (w/o DE) and Germany and then merged. This means that the results for Germany are more accurately represented, but conversely this also means that there are greater uncertainties for the other 26 EU member states for which only limited further investigations into the national circumstances could be carried out within the framework of this study. In the following the most relevant facts and findings from the study are described.

10.1 GHG balance results

The GHG balances in this study were carried out in more detail for MSW and food waste and roughly for C&I and C&D waste. Nevertheless, comprehensive efforts were made to represent waste material flows, characteristics data and GHG emissions from the treatment pathways as well as possible for all the balance areas. However, due to the high data uncertainties and data gaps, the GHG results for C&I and C&D waste and for the special balance food waste (C&I waste as a source area) are to be understood as orienting results.

The main contribution to net emission savings potentials in the EU27 in 2017 results from C&I waste, followed by C&D waste and is lowest for MSW (near zero). The percentages of total waste are 29% for MSW, 31% for C&I waste and 40% for C&D waste. The result for C&I waste is dominated by metals (and thereof ferrous metals), which account for 15% of the total C&I waste. The net emissions savings potential from C&D waste is less than half of that of C&I waste in 2017, and is also dominated by metals (thereof ferrous metals), which account for 6% of the total C&D waste.

The net emission savings potential for MSW in 2017 is near zero because of the high share of residual MSW landfilled in the EU27. The results for MSW for 2017 in Cluster 1 and Cluster 2 are therefore net debits (higher in Cluster 1 than in Cluster 2). On a specific basis the net debit is 300 kg CO_2eq per ton or about 103 kg CO_2eq per capita in Cluster 1, and 39 kg CO_2eq per ton or 19 kg CO_2eq per capita in Cluster 2. The specific net result for the EU27 in 2017 is -17 kg CO_2eq per ton or about -8 kg CO_2eq per capita. This clearly demonstrates the very different situation for MSW in the different EU Member States, and that **the greatest lever for GHG mitigation in the EU27 is to end landfilling of untreated MSW immediately.**

The separate balances for Germany (partial report Germany) show a different picture for 2017, because here the levels of climate protection potentials of the three balance areas MSW, C&I and C&D waste are about similar. On the one hand, the climate protection potential of the MSW is exploited to a higher degree due to the landfill restrictions in force since 2005, a higher share of separate collection for recycling (58%) than in the EU27 (42% derived from the EEA-model; for Cluster 1 23% and 33% for Cluster 2) and the fact that separately collected organic waste is mainly composted in the EU27, while in Germany anaerobic digestion takes place to a higher degree. On the other hand, Germany has a lower share of metals (6%) in C&I waste than in the EU27, which results in a comparatively lower climate protection potential for the type of waste.

Based on the initial situation for 2017 in the EU27, in particular regarding the MSW in Cluster 1 and Cluster 2, the most relevant optimisation measure is the diversion of MSW from landfill, and generally increasing the efforts for separate collection of organic and of dry recyclables, and optimising the treatment of this organic waste. Therefore, these optimisations are used to draft the scenarios for 2030 taking the legal requirements (especially WFD, landfill directive) into account. In consequence the 2030 scenarios for MSW result in a high total net emission savings potential, and a shift from net debits to net credits for Cluster 2 and, albeit slightly, also for Cluster 1. The effects from defossilisation[54] are also present here but have a much smaller influence than in the results for Germany where the net emissions savings potentials start to decrease in the 2030 scenarios due to defossilisation.

In particular, the **2030 scenarios for municipal solid waste** demonstrate that the measures of decreased landfilling of residual MSW, increased separate collection of recyclables, increased recycling and technical optimisation make important contributions to climate protection in all the EU balance areas. For the EU27, the total net emission savings potential increases from -3.5 million tons CO_2eq to about -30 million tons CO_2eq in the lead scenario (WFD), which means that the net emission savings potential increased by factor 8 compared to 2017.In the lead scenario, the further landfilling of about 4.3 million tons of residual MSW (Cluster 1) is assumed in accordance with the possibilities under the landfill directive. If landfilling would be completely stopped in all EU Member States by 2030 additional about 4 million tons CO_2eq would be avoidable.

The effects of the defossilisation are most clearly visible for residual MSW for treatment. In the lead scenario 2030 (WFD), the result is reversed from a net emission saving potential to a net debit. This is mainly due to the lower credits for energy from waste, which cannot be compensated by the assumed higher net efficiencies. The separately collected waste fractions are also influenced by defossilisation (e.g. biogas use, biomass CHP), but still show net emission savings potentials.

The lead scenario 2030 (WFD) demonstrates that in order to meet the legal requirements (recycling quota) and to mobilize the climate protection potentials

- extensive amounts of recyclable materials must be removed from residual MSW and collected separately,
- infrastructure for separate collection and considerable treatment capacities have to be build,
- the ambitious increase in separate collection should not be accompanied by relevant losses in quality. For example, contaminants of fossil-based plastic waste in separately collected organic waste should be avoided as far as possible.

From a pure climate protection point of view, according to the model-theoretical consideration in the “scenario with home composting in the RC rate" the reduced ambition level of separate collection would lead to a loss of about 5 million tons CO_2eq net emission savings potential (whereby this would only apply if home composting would be climate-neutral).

For MSW, the most important measures to fully and synergistically exploit the climate protection potential are diversion from landfill and increase of recycling. This is also evident in the special scenarios. The special scenario 2030 for Cluster 2 takes MSW amounts into account that may continue to be landfilled according to the legal requirements. This increases the landfill quantities compared to the lead scenario and consequently the emission savings potential is reduced by 8.4 million tons CO_2eq compared to the lead scenario 2030. The special scenario

[54] GHG emissions for energy use decrease with the energy transition, and thus also credits for energy from waste. In addition, decreased GHG emissions for electricity are taken into account for electricity-intensive production of primary products (paper, aluminium) also resulting in reduced saving potentials.

demonstrates that ambition in the implementation of the waste related directives has an impact on the climate mitigation potential of the EU27.

The special scenario 2030 for Cluster 1 shows that the emission savings potential is reduced by 0.5 million tons CO_2eq compared to the lead scenario 2030 under the assumption that the EU recycling goals may not be fully achieved and 10% less dry and organic recyclables are collected separately and treated as residual MSW. Residual MSW to landfill is almost the same as in the 2030 lead scenario, so there is no difference here.

GHG emissions from biological treatment are always significantly lower than those from landfilling. However, especially the Cluster 1 countries use IPCC default values (Table 25), which are higher than measured values for methane emissions from composting, and therefore may be overestimated. In addition, there is still room for optimisation in composting and anaerobic digestion, such as the application of best practice to lower GHG emissions from composting (e.g. by proper surface-volume-relation, the right carbon-nitrogen content, sufficient aeration, and sufficient water) and implementation of efficient anaerobic digestion plants with low GHG emissions, which have become technically available in the last decade (see partial report Germany). Furthermore, new treatment methods like the soldier fly larvae treatment may be an alternative especially in EU Member States, where the heat demand for the process can be provided by ambient temperature to a relevant extent.

In the case of **C&I and C&D waste**, the GHG results show that, from a climate protection perspective, it is mainly metals (and thereof ferrous metals) that define the net emission saving potential. For C&I waste, further on, dry recyclables, wood and organic waste also offer net emission savings potentials. The mineral and other inert waste fractions (about 44 million tons or 20% in C&I waste, and about 260 million tons or 91% in C&D waste) have only minor GHG effects. They are mainly used or disposed of in road and path construction, for backfilling and as landfill substitute construction material. These wastes are relevant with regard to resource conservation (RC building materials) and possible pollutant contents and should be considered separately under this focus.

For C&D waste in the 2030 scenario it was assumed that the mineral fraction still contains recyclables, for which the separation can be improved. The thus higher share of metal recycling is the main reason for the somewhat higher net emission savings potential. For C&D waste the potential of metals in the mineral waste fraction should be investigated in future studies to improve the data base on this climate relevant waste type. In order to be able to recycle these, construction waste should already be kept separate during demolition or dismantling.

For C&I waste no increase of separate collection could be assumed on the current data base. The data base for C&I waste is not specific enough and the variety of waste types (LoW-codes) and the assumptions required for their treatment are too great for blanket considerations to lead to clear conclusions. The assumptions for the 2030 scenario consider optimisations for less advanced EU Member States to reach the status of more developed countries, and refer only to some waste streams. The 2030 scenario results in a reduced net emission savings potential, which reflects this optimisation potential level and is due to defossilisation effects (lower saving potential for electricity-intensive primary production of aluminium, paper). Due to the high data uncertainties recommendations are accordingly directed at improving the data situation with focus on the above-mentioned GHG-relevant waste types, the metals, and especially on their type and quality. Furthermore, in the case of C&I waste, waste streams that are also thermally treated (especially plastics) should be kept in focus.

For the special balance area of **food waste**, there are also considerable data uncertainties and assumptions and estimates had to be made in many cases. Knowledge and data on the amount, type and quality of food waste as well as about the anaerobic digestion processes (assumed main type of treatment) is very limited. For MSW food waste the calculated amount is strongly dependent on the data on waste composition available in the EEA model. The quality of this data is very likely to vary considerably from country to country. In addition, for this study it was assumed that the treatment mix for food waste from C&I waste is comparable to that for Germany, and was generally estimated to 80% anaerobic digestion, 20% composting for 2017. The GHG emissions and emission savings potentials determined for food waste in general and for anaerobic digestion in particular for the EU may be over- or underestimated therefore, and improvement of base data is essential to cast a better picture of the food waste related climate mitigation potential in future.

In addition, this study uses food waste as an example to illustrate the inclusion of complete **waste prevention** (waste is not produced in the first place due to more effective purchasing behaviour or optimised production processes) in the LCA method of waste management. The climate protection potentials that can be achieved in this way in the special balance food waste are considerable. Preventing about 5.2 million tons MSW food waste (50% of the amount considered in this study) in the EU27 by 2030 results in a net emission savings potential higher by a factor 3 compared to the lead scenario 2030 without food waste prevention. In case of Cluster 1, where a 30% reduction of MSW food waste was assumed (about 200,000 tons), the net emission savings potential would be 2 times higher than in the lead scenario. The GHG emission savings potential is based on data for Germany, for the MSW food waste composition and the GHG impact for its production.

10.2 Data base on waste generation and treatment

To cover all waste streams investigated in this study, it was necessary to use and combine different data sources. The data collection under the Waste Statistics Regulation (WStatR) provides the most comprehensive data set on waste at EU level, as it covers all waste types and all areas of origin (all economic activities and households). However, for the purposes of the LCA method in waste management, the use of the WStatR data is conceptually limited by an insufficient level of detail in view of the breakdown by waste categories, missing information on the first treatment step and further limitations like the unsatisfactory link between the data on waste generation and waste treatment. In spite of these limitations, the WStatR data were considered as the most suitable data source for the production of the base data for the waste streams *C&I waste* (incl. food waste from commercial and industrial sources) and *C&D waste*. For the waste stream *MSW* (incl. food waste from municipal sources), MSW data from Eurostat were used in combination with the European Reference Model on Municipal Waste Generation and Management (EEA 2018a).

The data on MSW generation and treatment that are collected annually by Eurostat in cooperation with the OECD, provide solid information on the total generation and treatment of MSW for the EU and the Member States. However, the level of detail of the data is insufficient for mapping the treatment of the MSW (i.e., no breakdown by material and missing information on the first treatment). Therefore, the Eurostat MSW data for reference year were fed into the EEA-model in order to produce the required data for the LCA approach.

The main limitations and quality issues with MSW data are the following:

- The accuracy of the modelling is highly dependent on composition data for MSW. The accuracy of composition data for some countries is limited.

- Data in the model on waste treatment (e.g. treatment splits, reject rates, etc) are not always up-to-date and missing information may be based on estimates or data from other countries.

For the waste streams C&I and C&D waste and for the special balance food waste, the data situation is clearly more difficult than for MSW. The main limitations of the WStatR data used for these waste streams are outlined above. Whereas the generation of the respective waste streams can be determined from waste statistics, there exist considerable data uncertainties and data gaps with regard to waste treatment and the associated environmental impacts. It is particularly difficult to assess C&I waste based on EWC-Stat categories as some of these categories include a large number of List of Waste (LoW) entries. Data availability is particularly poor with regard to the generation and treatment of food waste from commercial sources.

A certain improvement of the data availability and data quality for MSW and partly also for food waste can be expected from new reporting requirements laid down in Directive 2008/98/EC that become effective with reference year 2020. This includes in particular a more detailed reporting of MSW generation and treatment (i.e. breakdown by materials) and more accurate data on recycling due to new calculation rules for the MSW recycling rate. The new reporting obligation on food waste and food waste prevention will hopefully allow to replace the estimates for food waste generation by more solid country data.

The data collection under the WStatR should be further developed conceptually, especially with regard to a better linking of the data on generation and treatment and a more complete representation of waste treatment, e.g. the inclusion of pre-treatment operations in the data collection.

10.3 Summary recommendations

With regard to the GHG mitigation potential the main findings and recommendations are:

- The study shows that in the EU27 the municipal solid waste (MSW) has by far the largest GHG mitigation potential. The low net saving potential in 2017 of -3.53 million tons CO_2eq could be increased by a factor 8 to about -30 million tons CO_2eq in 2030 in the lead scenario mainly by diversion of MSW from landfill and increased separate collection for recycling. For 2017 the overall GHG emission from landfilling of residual MSW is about 13.5 million tons CO_2eq in Cluster 1 and 13 million tons CO_2eq in Cluster 2. In the lead scenario these emissions are cut down to zero in Cluster 2, and to about 4 million tons CO_2eq in Cluster 1, which demonstrates the high relevance of diversion from landfill and that this significantly shapes the GHG mitigation potential in the EU27 for MSW. In addition, this shows that a further 4 million tons CO_2eq could be mitigated if MSW landfilling would be also stopped completely in Cluster 1 by 2030. To achieve the GHG mitigation potential the following aspects should be considered:
  - Emphasis should be put on supporting those EU Member States, which still landfill residual MSW, in their swift transition of their waste management systems. The landfilling of untreated MSW should be stopped completely and as soon as possible. From a climate protection perspective derogation periods should be avoided. This is sustained by interviews with experts of selected waste management associations, which also mentioned that the deadline for phasing out of landfilling might be too long. It was also discussed that the transition to a cost-covering separate collection and biological treatment needs to take an increase of landfill fees into account, which could reach at least 100 Euro/ton.

   - The authors of this study regard financial measures like a landfill fee or funding as the most promising options to support diversion from landfill. For example, grants to support the separation of organic waste from MSW (and C&I waste) in order to mobilize the full mitigation potential of the EU27 and also to achieve the recycling quota. Tightening legal requirements, in the authors experience, is a lengthy process, and enforcement of a landfill ban has not been successful to date. Also, the proposal to adopt a biowaste ordinance in order to have clear specifications for alternatives to landfill found no response at EU political level so far.

- The model-theoretical scenario with home composting in the RC rate indicates how a low level of ambition in separate collection and recycling decreases the emission savings potentials. From the climate protection point of view, it is important not to be content with a low ambition level.

- The lead scenario 2030 (WFD) calculated in this study assumes a high ambition level with regard to implementing separate collection and of alternative treatment capacities needed. Here, politics is called upon to identify and implement supporting measures together with the waste management actors. The waste management associations proposed in the interview a regulatory framework with regard to need of outlets for the separately collected dry recyclables, public (financial) support for separate collection and treatment options for rejects. From the point of view of the authors here again financial incentives seem more promising. Most relevant aspects and ideas for improvement are:

   - The member states should pay special attention and give support for the organisation and infrastructure of separate collection and the development of treatment capacities especially for organic waste. The lead scenario's potential is based on about 51 million tons or 42% additionally separated from residual MSW in the EU27, thereof about 26 million tons in Cluster 2 and 13 million tons in Cluster 1. In each case, the main share is on organic waste (>50%). For Cluster 1 this means that for about 7 million tons organic waste treatment capacities need to be built until 2030. Considering an average yearly plant capacity of 30,000 tons, this would mean about 240 new treatment plants in Cluster 1 alone. From a climate protection point of view, anaerobic digestion, the combined material and energy use of organic waste, should be preferred, suitability given. In order to achieve the implementation of new treatment capacities needed, many of the Member States, especially those in Cluster 1, might also need support in analysing the composition of the residual MSW and identifying suitable options for the treatment of organic waste.

   - For organic waste from households, the success of increasing separate collection with low impurities depends on the cooperation of citizens. Clear incentives are needed here, such as a cost-free, adequate collection system and frequency, taking hygiene aspects into account, accompanied by public relation campaigns to inform citizens about proper handling.

   - An ambitious increase in separate collection for dry recyclables from MSW, which significantly contributes to the increase of the net emission savings by circular economy, also needs supportive measures from the political sector (EU wide or nationally). As data, e.g. on the amount of paper, glass, plastics, etc. in residual MSW, are key to proper planning, most relevant initial measures are analysis of the current situation, investigations to optimise the collection systems, development of a roadmap for further increasing separate collection under the premise of good separation qualities, and pilot projects.

- For C&I and C&D waste, the orienting GHG results show that, from a climate protection perspective, it is mainly metals (and thereof ferrous metals) that define the net emission saving potential. For C&I waste, further on, dry recyclables, wood and organic waste also offer net emission savings potentials. The main mass, mineral and other inert waste types, have only minor GHG effects. In general, the data base is insufficient, especially for C&I waste with the large variety of waste types, and the data gaps on treatment. In order to determine the climate protection potentials from C&I and C&D waste, it is recommended for future studies to focus on the GHG-relevant waste types, mainly the metals. Information is needed on type and quality of the metals for C&I waste, and the potential of metals in the mineral waste fraction for C&D waste. Furthermore, for C&I waste, waste streams should be kept in focus that are also thermally treated (especially plastics).
- Thermal waste treatment is vital for a functional waste management system, as it eliminates the non-recyclable and more contaminated parts of MSW, C&I and C&D wastes. In this function it is essential for a circular economy. The contribution to climate protection through the assumed increased net efficiency for 2030 in this study is no self-fulfilling scenario. For thermal treatment plants as well as for biomass power plants, possibilities to increase net efficiency would need to be further examined and their implementation supported. For example, the implementation or expansion of local and district heating networks can help to increase heat utilisation. The co-incineration of refuse-derived fuels in cement kilns offers a relevant – and, compared to thermal treatment, higher – contribution to climate protection as long as coal may still be used as a regular fuel, which can be substituted by RDF. In this respect, it is also important to support MBT plants in optimisation efforts such as mitigating GHG emissions from biological treatment or increase of efficiency.
- Waste prevention as shown for food waste is highly relevant and can contribute significantly to climate protection. With food waste prevention the primary production of foods is avoided, which is combined with much higher GHG emissions than the savings potentials which can be derived from treatment of food waste. For the EU27, the assumed prevention of 50% or about 5.2 million tons of MSW food waste leads to a net emission savings potential that is higher by a factor 3 compared to the lead scenario 2030. In case of Cluster 1, where a 30% reduction of MSW food waste was assumed (about 200,000 tons), the net emission savings potential would be 2 times higher than in the lead scenario. The calculated GHG emission savings potential through food waste prevention are sufficiently valid for Germany, where data are available for both the MSW food waste composition and the GHG impact for its production. For the EU countries similar studies are to be recommended for MSW food waste composition based on which a prevention factors can be derived as for Germany.

The most relevant findings and recommendations from the study regarding the data on waste at EU level are:

- The data collection under the WStatR should be further developed conceptually, especially with regard to a better linking of the data on generation and treatment and a more complete representation of waste treatment, e.g. the inclusion of pre-treatment operations in the data collection.
- Sorting analyses of the residual waste are generally a prerequisite in order to be able to identify the potential for increasing separate collection and recycling. This applies to all EU Member States. Representative waste analyses on national level are necessary to allow a

better understanding of not only the recycling and collection, but especially the climate mitigation potentials. Even in Germany, where a comprehensive household waste analysis has been carried out to improve the data base on MSW considerably, there is still a lack of information on the composition of commercial MSW and bulky waste.

Finally, it is recommended that future investigations into the circular economy should also consider the environmental impact of resource conservation in addition to GHG emissions. As more measures are implemented in order to achieve the goal of zero emissions and avert the climate catastrophe, simultaneously the climate protection potentials diminish, and GHG balances will become zero. However, the goal of climate neutrality is not only accompanied by decreasing potential climate protection contributions, but conversely also by a demand for raw materials, especially for renewable energy production plants. This should be kept in view. The aspect of resource conservation is essentially linked to the circular economy. In future projects, it should first be determined which areas and/or resources are relevant for an investigation of resource conservation and how these should be evaluated.

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A Appendix

A.1 Comparison of all relevant breakdowns in percent used in the EEA-model 2015 and 2017 and adjustment of major inconsistencies, validation of residual waste composition

A.1.1 Total MSW composition, capture rates and loss rates for dry recyclables and organic wastes from the EEA-model

Table 104: Total MSW composition from the EEA-model, 2015 & 2017, in percent

Country	Country-Code	Year	Food	Garden	Other biowastes	Wood	Paper / Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumulators*	*Haz (excl. WEEE)*	Fines	Inerts	Other	Total MSW generation [1,000tons]
Bulgaria	BG	2015	23%	18%	0%	2%	19%	2%	6%	3%	11%	3%	0%	0%	1%	0%	10%	3%	3011
		2017	23%	18%	0%	2%	19%	2%	6%	3%	11%	3%	0%	0%	1%	0%	10%	3%	3080
Estonia	EE	2015	21%	3%	1%	2%	23%	4%	9%	6%	15%	2%	0%	0%	1%	0%	3%	11%	473
		2017	21%	3%	1%	2%	23%	4%	9%	6%	15%	2%	0%	0%	1%	0%	3%	11%	514
Greece	EL	2015	41%	3%	0%	0%	22%	0%	4%	4%	14%	0%	0%	0%	0%	0%	0%	11%	5277
		2017	41%	3%	0%	0%	22%	0%	4%	4%	14%	0%	0%	0%	0%	0%	0%	11%	5415
Croatia	HR	2015	21%	7%	1%	1%	28%	2%	6%	2%	17%	1%	2%	0%	0%	0%	0%	11%	1654
		2017	21%	7%	1%	1%	28%	2%	6%	2%	17%	1%	2%	0%	0%	0%	0%	11%	1716
Cyprus	CY	2015	30%	12%	0%	2%	24%	6%	4%	3%	15%	1%	0%	0%	0%	0%	1%	3%	541
		2017	30%	12%	0%	2%	24%	6%	4%	3%	15%	1%	0%	0%	0%	0%	1%	3%	547
Latvia	LV	2015	15%	4%	7%	3%	29%	2%	9%	2%	8%	0%	2%	0%	0%	12%	3%	3%	798
		2017	15%	4%	7%	3%	29%	2%	9%	2%	8%	0%	2%	0%	0%	12%	3%	3%	798
Lithuania	LT	2015	10%	9%	8%	1%	13%	5%	7%	7%	11%	2%	0%	0%	0%	0%	10%	17%	1300
		2017	10%	9%	8%	1%	13%	5%	7%	7%	11%	2%	0%	0%	0%	0%	10%	17%	1286
Hungary	HU	2015	21%	6%	0%	1%	19%	3%	3%	6%	16%	1%	0%	0%	1%	12%	4%	9%	3712
		2017	21%	6%	0%	1%	19%	3%	3%	6%	16%	1%	0%	0%	1%	12%	4%	9%	3768
Malta	MT	2015	40%	2%	0%	1%	20%	3%	5%	4%	12%	1%	0%	0%	0%	2%	0%	10%	270
		2017	40%	2%	0%	1%	20%	3%	5%	4%	12%	1%	0%	0%	0%	2%	0%	10%	283
Poland	PL	2015	21%	12%	0%	0%	11%	3%	10%	2%	12%	0%	0%	0%	1%	10%	4%	14%	10863
		2017	21%	12%	0%	0%	11%	3%	10%	2%	12%	0%	0%	0%	1%	10%	4%	14%	11969
Romania	RO	2015	45%	15%	0%	2%	13%	1%	5%	3%	13%	1%	0%	0%	0%	0%	0%	3%	4904
		2017	45%	15%	0%	2%	13%	1%	5%	3%	13%	1%	0%	0%	0%	0%	0%	3%	5325

Country	Country-Code	Year	Food	Garden	Other biowastes	Wood	Paper / Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumulators*	*Haz (excl. WEEE)*	Fines	Inerts	Other	Total MSW generation [1,000tons]
Slovakia	SK	2015	24%	21%	0%	3%	13%	3%	8%	4%	10%	0%	3%	0%	1%	0%	1%	9%	1784
		2017	24%	21%	0%	3%	13%	3%	8%	4%	10%	0%	3%	0%	1%	0%	1%	9%	2058
Czech Republic	CZ	2015	24%	13%	0%	5%	18%	4%	8%	4%	15%	1%	0%	0%	0%	0%	3%	6%	3337
		2017	24%	13%	0%	5%	18%	4%	8%	4%	15%	1%	0%	0%	0%	0%	3%	6%	3643
Denmark	DK	2015	25%	22%	0%	4%	20%	0%	6%	5%	7%	2%	0%	0%	0%	0%	1%	8%	4485
		2017	25%	22%	0%	4%	20%	0%	6%	5%	7%	2%	0%	0%	0%	0%	1%	8%	4503
Ireland	IE	2015	16%	6%	0%	3%	24%	5%	8%	4%	12%	3%	0%	0%	1%	8%	0%	9%	2619
		2017	16%	6%	0%	3%	24%	5%	8%	4%	12%	3%	0%	0%	1%	8%	0%	9%	2763
Spain	ES	2015	40%	9%	0%	2%	16%	5%	8%	3%	9%	0%	0%	0%	0%	0%	0%	9%	21158
		2017	40%	9%	0%	2%	16%	5%	8%	3%	9%	0%	0%	0%	0%	0%	0%	9%	21530
France	FR	2015	20%	17%	0%	3%	20%	2%	13%	6%	11%	4%	0%	0%	0%	2%	2%	1%	34284
		2017	20%	17%	0%	3%	20%	2%	13%	6%	11%	4%	0%	0%	0%	2%	2%	1%	34393
Portugal	PT	2015	29%	7%	5%	1%	14%	4%	7%	2%	11%	0%	0%	0%	0%	11%	0%	11%	4769
		2017	29%	7%	5%	1%	14%	4%	7%	2%	11%	0%	0%	0%	0%	11%	0%	11%	5012
Finland	FI	2015	27%	3%	2%	2%	30%	2%	4%	6%	12%	3%	1%	0%	0%	0%	1%	6%	2738
		2017	27%	3%	2%	2%	30%	2%	4%	6%	12%	3%	1%	0%	0%	0%	1%	6%	2812
Sweden	SE	2015	24%	9%	0%	5%	25%	2%	5%	5%	10%	4%	0%	0%	0%	0%	0%	12%	4422
		2017	24%	9%	0%	5%	25%	2%	5%	5%	10%	4%	0%	0%	0%	0%	0%	12%	4551
Belgium	BE	2015	9%	16%	5%	6%	18%	3%	8%	3%	7%	2%	0%	0%	1%	0%	3%	18%	4643
		2017	9%	16%	5%	6%	18%	3%	8%	3%	7%	2%	0%	0%	1%	0%	3%	18%	4659
Germany	DE	2015	19%	12%	0%	3%	21%	3%	7%	2%	17%	2%	0%	0%	0%	5%	2%	8%	51625
		2017	19%	12%	0%	3%	21%	3%	7%	2%	17%	2%	0%	0%	0%	5%	2%	8%	52342
Italy	IT	2015	21%	11%	2%	3%	23%	4%	8%	3%	13%	1%	0%	0%	0%	0%	1%	11%	29524
		2017	21%	11%	2%	3%	23%	4%	8%	3%	13%	1%	0%	0%	0%	0%	1%	11%	29583
Luxembourg	LU	2015	22%	13%	0%	4%	19%	3%	7%	2%	10%	2%	0%	1%	1%	4%	3%	11%	346
		2017	22%	13%	0%	4%	19%	3%	7%	2%	10%	2%	0%	1%	1%	4%	3%	11%	362
Netherlands	NL	2015	13%	19%	11%	5%	19%	3%	6%	3%	8%	1%	1%	0%	0%	0%	0%	11%	8866
		2017	13%	19%	11%	5%	19%	3%	6%	3%	8%	1%	1%	0%	0%	0%	0%	11%	8787
Austria	AT	2015	18%	19%	0%	5%	17%	3%	6%	4%	10%	2%	0%	0%	1%	3%	2%	11%	4836
		2017	18%	19%	0%	5%	17%	3%	6%	4%	10%	2%	0%	0%	1%	3%	2%	11%	5018
Slovenia	SI	2015	13%	8%	1%	7%	26%	1%	8%	5%	8%	1%	0%	0%	1%	0%	0%	22%	926
		2017	13%	8%	1%	7%	26%	1%	8%	5%	8%	1%	0%	0%	1%	0%	0%	22%	974
United Kingdom	UK	2015	17%	16%	2%	4%	19%	3%	7%	4%	10%	2%	2%	0%	1%	1%	0%	12%	31475
		2017	17%	16%	2%	4%	19%	3%	7%	4%	10%	2%	2%	0%	1%	1%	0%	12%	30911

Table 105: Capture rates for dry recyclables and organic wastes from the EEA-model, 2015 & 2017, in percent

Country	Country-Code	Year	Food	Garden	Other biowastes	Wood	Paper / Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumulators*	*Haz (excl. WEEE)*	Fines	Inerts	Other
Austria	AT	2015	72%	100%	0%	100%	78%	18%	76%	64%	33%	100%	0%	82%	0%	0%	0%	5%
		2017	72%	100%	0%	100%	78%	18%	76%	64%	33%	100%	0%	82%	0%	0%	0%	5%
Belgium	BE	2015	12%	88%	98%	77%	77%	50%	90%	78%	43%	100%	0%	40%	62%	0%	0%	17%
		2017	29%	88%	98%	77%	79%	52%	90%	82%	48%	100%	0%	41%	62%	1%	1%	18%
Bulgaria	BG	2015	25%	25%	0%	25%	41%	1%	25%	51%	23%	100%	100%	100%	44%	0%	0%	58%
		2017	25%	27%	0%	25%	45%	4%	35%	52%	28%	100%	100%	100%	44%	0%	0%	58%
Croatia	HR	2015	2%	21%	45%	27%	25%	3%	32%	9%	9%	70%	0%	23%	0%	0%	0%	41%
		2017	2%	23%	45%	27%	33%	4%	37%	28%	13%	70%	0%	23%	0%	0%	0%	41%
Cyprus*	CY	2015	0%	15%	0%	0%	44%	4%	38%	70%	15%	**106%**	0%	**130%**	0%	0%	0%	0%
		2017	0%	15%	0%	0%	44%	4%	38%	70%	15%	**100%**	0%	**100%**	0%	0%	0%	0%
Czech Republic	CZ	2015	2%	77%	0%	0%	67%	6%	62%	59%	50%	100%	0%	0%	0%	0%	0%	0%
		2017	11%	77%	0%	7%	67%	19%	64%	64%	50%	100%	0%	0%	0%	0%	7%	7%
Denmark	DK	2015	4%	84%	0%	100%	43%	100%	80%	68%	14%	90%	0%	60%	0%	0%	0%	15%
		2017	10%	84%	0%	100%	50%	100%	80%	74%	20%	90%	0%	60%	0%	0%	0%	15%
Estonia	EE	2015	12%	12%	11%	21%	59%	5%	62%	43%	19%	43%	0%	100%	20%	0%	0%	17%
		2017	12%	32%	11%	21%	59%	14%	62%	49%	23%	43%	0%	100%	20%	0%	0%	17%
Finland	FI	2015	37%	37%	37%	5%	60%	0%	67%	76%	2%	85%	0%	0%	0%	0%	0%	5%
		2017	37%	47%	37%	5%	61%	10%	67%	76%	11%	85%	0%	0%	0%	0%	0%	5%
France	FR	2015	13%	87%	0%	0%	17%	0%	68%	65%	34%	74%	0%	0%	0%	0%	0%	0%
		2017	13%	87%	0%	0%	17%	0%	68%	65%	34%	74%	0%	0%	0%	0%	0%	0%
Germany	DE	2015	45%	66%	0%	0%	88%	0%	100%	100%	67%	100%	0%	0%	33%	0%	0%	63%
		2017	46%	69%	0%	3%	88%	8%	100%	100%	67%	100%	0%	0%	35%	3%	3%	64%
Greece	EL	2015	5%	2%	0%	0%	41%	0%	18%	41%	18%	0%	0%	0%	0%	0%	0%	15%
		2017	5%	23%	0%	0%	48%	0%	39%	44%	22%	0%	0%	0%	0%	0%	0%	15%

Country	Country-Code	Year	Food	Garden	Other biowastes	Wood	Paper / Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumulators*	*Haz (excl. WEEE)*	Fines	Inerts	Other
Hungary	HU	2015	20%	20%	0%	100%	37%	2%	31%	60%	9%	100%	0%	0%	0%	0%	0%	21%
		2017	20%	29%	0%	100%	44%	8%	41%	67%	16%	100%	0%	0%	1%	1%	1%	21%
Ireland	IE	2015	25%	21%	0%	98%	52%	0%	69%	58%	23%	98%	0%	0%	0%	0%	0%	0%
		2017	25%	37%	0%	98%	58%	14%	70%	63%	27%	98%	0%	0%	0%	0%	0%	0%
Italy	IT	2015	66%	58%	100%	79%	47%	12%	79%	33%	31%	95%	0%	0%	0%	0%	0%	3%
		2017	66%	65%	100%	79%	56%	24%	79%	50%	35%	95%	0%	0%	0%	0%	0%	3%
Latvia	LV	2015	1%	0%	84%	44%	64%	0%	32%	5%	21%	84%	84%	84%	0%	0%	0%	0%
		2017	1%	6%	84%	44%	64%	3%	38%	20%	26%	84%	84%	84%	0%	0%	0%	0%
Lithuania	LT	2015	3%	51%	0%	37%	61%	3%	52%	78%	13%	77%	0%	0%	0%	0%	0%	10%
		2017	4%	52%	2%	38%	61%	9%	54%	78%	18%	77%	0%	2%	2%	0%	2%	12%
Luxembourg	LU	2015	34%	90%	0%	91%	47%	39%	79%	49%	5%	85%	100%	100%	35%	0%	77%	29%
		2017	34%	90%	0%	91%	47%	39%	79%	49%	5%	85%	100%	100%	35%	0%	77%	29%
Malta	MT	2015	1%	0%	0%	0%	29%	2%	24%	30%	10%	74%	100%	100%	12%	0%	0%	0%
		2017	1%	22%	0%	3%	39%	5%	39%	34%	17%	75%	100%	100%	15%	3%	0%	3%
Netherlands	NL	2015	23%	89%	60%	68%	47%	24%	57%	24%	13%	100%	100%	100%	71%	0%	0%	45%
		2017	29%	89%	60%	68%	55%	31%	63%	40%	23%	100%	100%	100%	71%	0%	0%	45%
Poland	PL	2015	19%	19%	0%	0%	20%	1%	39%	8%	23%	0%	0%	0%	1%	0%	0%	37%
		2017	19%	34%	0%	0%	38%	11%	48%	32%	25%	0%	0%	0%	1%	0%	0%	37%
Portugal	PT	2015	2%	20%	1%	32%	26%	0%	57%	5%	21%	35%	0%	0%	0%	0%	0%	8%
		2017	2%	21%	4%	34%	33%	1%	57%	19%	21%	37%	0%	0%	2%	2%	0%	10%
Romania	RO	2015	13%	13%	0%	5%	9%	0%	7%	7%	10%	50%	0%	0%	0%	0%	0%	66%
		2017	13%	19%	0%	5%	22%	3%	20%	18%	14%	50%	0%	0%	0%	0%	0%	66%
Slovakia	SK	2015	1%	36%	100%	17%	31%	8%	39%	48%	20%	100%	23%	100%	0%	0%	0%	2%
		2017	2%	40%	100%	19%	46%	12%	49%	49%	23%	100%	24%	100%	2%	0%	2%	4%
Slovenia	SI	2015	51%	55%	12%	63%	67%	10%	61%	59%	35%	57%	0%	0%	65%	0%	0%	53%
		2017	51%	55%	12%	63%	67%	10%	61%	59%	35%	57%	0%	0%	65%	0%	0%	53%
Spain	ES	2015	7%	12%	0%	30%	46%	5%	61%	20%	17%	0%	0%	0%	0%	0%	0%	0%
		2017	7%	12%	0%	30%	46%	5%	61%	20%	17%	0%	0%	0%	0%	0%	0%	0%
Sweden	SE	2015	42%	64%	0%	0%	62%	3%	87%	77%	20%	75%	0%	100%	100%	0%	0%	49%
		2017	43%	68%	0%	0%	65%	14%	87%	78%	26%	75%	0%	100%	100%	0%	0%	49%
United Kingdom*	UK	2015	10%	63%	**216%**	71%	52%	18%	64%	54%	21%	51%	**174%**	38%	0%	0%	0%	14%
		2017	11%	64%	**100%**	71%	55%	21%	66%	59%	23%	51%	**100%**	38%	0%	0%	0%	14%

*Capture rates above 100% for Cyprus and UK were corrected to 100% to avoid negative values in residual waste.

Table 106: Reject rates for dry recyclables and organic wastes from the EEA-model, 2015 & 2017 and the rates used in the scenarios 2030, in percent

Country	Country-Code	Year	Food	Garden	Other biowastes	Wood	Paper /Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumulators*	*Haz (excl. WEEE)*	Fines	Inerts	Other
Austria	AT	2015	5%	5%	10%	10%	15%	14%	3%	10%	33%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	14%	3%	10%	33%	10%	10%	10%	10%	10%	10%	10%
Belgium	BE	2015	5%	5%	10%	10%	15%	14%	1%	10%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	14%	1%	10%	32%	10%	10%	10%	10%	10%	10%	10%
Bulgaria	BG	2015	5%	5%	10%	10%	15%	18%	7%	9%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	14%	17%	6%	9%	32%	10%	10%	10%	10%	10%	10%	10%
Croatia	HR	2015	5%	5%	10%	10%	19%	20%	10%	10%	27%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	17%	19%	9%	10%	28%	10%	10%	10%	10%	10%	10%	10%
Cyprus	CY	**2013***	5%	5%	10%	10%	18%	20%	10%	10%	27%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	18%	20%	10%	10%	27%	10%	10%	10%	10%	10%	10%	10%
Czech Republic	CZ	2015	5%	5%	10%	10%	14%	15%	4%	10%	31%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	15%	4%	10%	32%	10%	10%	10%	10%	10%	10%	10%
Denmark	DK	2015	5%	5%	10%	10%	14%	14%	3%	10%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	14%	3%	10%	32%	10%	10%	10%	10%	10%	10%	10%
Estonia	EE	2015	5%	5%	10%	10%	14%	17%	7%	9%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	14%	16%	6%	9%	32%	10%	10%	10%	10%	10%	10%	10%
Finland	FI	2015	5%	5%	10%	10%	14%	0%	4%	10%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	15%	4%	10%	32%	10%	10%	10%	10%	10%	10%	10%
France	FR	2015	5%	5%	10%	10%	14%	0%	2%	9%	31%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	14%	0%	2%	9%	31%	10%	10%	10%	10%	10%	10%	10%
Germany	DE	2015	5%	5%	10%	10%	15%	0%	3%	10%	33%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	14%	3%	10%	33%	10%	10%	10%	10%	10%	10%	10%
Greece	EL	2015	5%	5%	10%	10%	19%	0%	10%	10%	27%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	18%	0%	10%	10%	28%	10%	10%	10%	10%	10%	10%	10%
Hungary	HU	2015	5%	5%	10%	10%	18%	20%	10%	10%	28%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	17%	19%	9%	10%	30%	10%	10%	10%	10%	10%	10%	10%
Ireland	IE	2015	5%	5%	10%	10%	13%	15%	2%	9%	30%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	13%	15%	1%	9%	30%	10%	10%	10%	10%	10%	10%	10%
Italy	IT	2015	5%	5%	10%	10%	15%	14%	3%	10%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	14%	3%	10%	32%	10%	10%	10%	10%	10%	10%	10%
Latvia	LV	2015	5%	0%	10%	10%	14%	17%	6%	9%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	14%	16%	5%	9%	32%	10%	10%	10%	10%	10%	10%	10%
Lithuania	LT	2015	5%	5%	10%	10%	16%	19%	9%	10%	31%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	18%	8%	10%	32%	10%	10%	10%	10%	10%	10%	10%

Country	Country-Code	Year	Food	Garden	Other biowastes	Wood	Paper /Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumulators*	*Haz (excl. WEEE)*	Fines	Inerts	Other
Luxembourg	LU	2015	5%	5%	10%	10%	15%	14%	2%	10%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	14%	2%	10%	32%	10%	10%	10%	10%	10%	10%	10%
Malta	MT	2015	5%	0%	10%	10%	20%	20%	10%	10%	25%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	19%	20%	10%	10%	26%	10%	10%	10%	10%	10%	10%	10%
Netherlands	NL	2015	5%	5%	10%	10%	15%	14%	2%	10%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	14%	2%	10%	32%	10%	10%	10%	10%	10%	10%	10%
Poland	PL	2015	5%	5%	10%	10%	18%	20%	10%	10%	28%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	17%	19%	8%	10%	30%	10%	10%	10%	10%	10%	10%	10%
Portugal	PT	2015	5%	5%	10%	10%	19%	0%	10%	10%	25%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	19%	5%	10%	10%	26%	10%	10%	10%	10%	10%	10%	10%
Romania	RO	2015	5%	5%	10%	10%	19%	20%	10%	10%	25%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	19%	20%	10%	10%	27%	10%	10%	10%	10%	10%	10%	10%
Slovakia	SK	2015	5%	5%	10%	10%	18%	20%	10%	10%	28%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	17%	19%	9%	10%	30%	10%	10%	10%	10%	10%	10%	10%
Slovenia	SI	2015	5%	5%	10%	10%	15%	14%	2%	10%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	14%	2%	10%	32%	10%	10%	10%	10%	10%	10%	10%
Spain	ES	**2014***	5%	5%	10%	10%	18%	20%	10%	10%	27%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	18%	20%	10%	10%	27%	10%	10%	10%	10%	10%	10%	10%
Sweden	SE	2015	5%	5%	10%	10%	15%	14%	3%	10%	32%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	15%	14%	3%	10%	32%	10%	10%	10%	10%	10%	10%	10%
United Kingdom	UK	2015	5%	5%	10%	10%	14%	14%	1%	10%	31%	10%	10%	10%	10%	10%	10%	10%
		2017	5%	5%	10%	10%	14%	14%	1%	10%	31%	10%	10%	10%	10%	10%	10%	10%
EU27 (w/o DE)	**EU**	**2017**	**5%**	**5%**	**10%**	**10%**	**16%**	**14%**	**5%**	**10%**	**30%**	**10%**	**10%**	**10%**	**10%**	**10%**	**10%**	**10%**
Germany	**DE**	**2030**	**5%**	**5%**		**1.6%**	**1%**		**3%**	**10%**	**20%**							
EU27 (w/o DE)	**EU**	**2030**	**5%**	**5%**		**5%**	**5%**		**5%**	**10%**	**30%**							

*For Cyprus and Spain, the EEA-model did not contain loss rates for 2015 or later. Therefore, the latest available annual data were used as estimate for 2017 as displayed.

A.1.2 Breakdown of residual waste and organic waste treatment

Table 107: Breakdown of residual waste treatment from the EEA-model, 2015 & 2017, in percent

Country	Country-Code	Year	direct MBT	direct INC	direct LF	MBT 1	MBT 2	MBT 3	MBT 4	MBT 5	INC 1	INC 2	INC 3	INC 4
Austria	AT	2015	28%	71%	1%	44%	46%	0%	0%	10%	6%	65%	29%	0%
		2017	27%	71%	1%	44%	46%	0%	0%	10%	6%	65%	29%	0%
Belgium	BE	2015	9%	91%	1%	0%	63%	0%	0%	37%	98%	0%	0%	2%
		2017	9%	91%	1%	0%	63%	0%	0%	37%	90%	8%	0%	2%
Bulgaria*	BG	2015	35%	4%	61%	70%	0%	0%	30%	0%	0%	100%	0%	0%
		2017	37%	4%	59%	70%	0%	0%	30%	**0%**	0%	100%	0%	0%
Croatia	HR	2015	1%	0%	99%	0%	100%	0%	0%	0%	100%	0%	0%	0%
		2017	10%	0%	90%	0%	100%	0%	0%	0%	100%	0%	0%	0%
Cyprus	CY	2015	35%	0%	65%	100%	0%	0%	0%	0%	0%	0%	100%	0%
		2017	44%	0%	56%	81%	0%	0%	0%	19%	0%	0%	100%	0%
Czech Republic	CZ	2015	0%	20%	80%	0%	0%	0%	0%	100%	0%	100%	0%	0%
		2017	6%	23%	71%	0%	0%	0%	0%	100%	0%	100%	0%	0%
Denmark	DK	2015	0%	96%	4%	100%	0%	0%	0%	0%	18%	82%	0%	0%
		2017	0%	96%	4%	100%	0%	0%	0%	0%	16%	84%	0%	0%
Estonia	EE	2015	16%	74%	11%	0%	100%	0%	0%	0%	0%	100%	0%	0%
		2017	16%	76%	8%	0%	100%	0%	0%	0%	0%	100%	0%	0%
Finland	FI	2015	2%	80%	18%	0%	0%	0%	0%	100%	0%	100%	0%	0%
		2017	11%	76%	12%	0%	0%	0%	30%	70%	0%	100%	0%	0%
France	FR	2015	6%	55%	39%	0%	0%	0%	100%	0%	100%	0%	0%	0%
		2017	6%	55%	39%	0%	0%	0%	100%	0%	100%	0%	0%	0%
Germany	DE	2015	18%	82%	0%	30%	0%	5%	0%	65%	10%	80%	10%	0%
		2017	18%	82%	0%	30%	0%	5%	0%	65%	10%	80%	10%	0%
Greece*	EL	2015	4%	0%	96%	85%	15%	0%	0%	0%	100%	0%	0%	0%
		2017	**15%**	0%	**85%**	85%	15%	0%	0%	0%	100%	0%	0%	0%
Hungary	HU	2015	87%	13%	0%	28%	0%	0%	0%	72%	0%	100%	0%	0%
		2017	87%	13%	0%	28%	0%	0%	0%	72%	0%	100%	0%	0%
Ireland	IE	2015	15%	13%	72%	50%	0%	0%	0%	50%	100%	0%	0%	0%
		2017	13%	26%	61%	50%	0%	0%	0%	50%	100%	0%	0%	0%
Italy*	IT	2015	72%	20%	8%	100%	0%	0%	0%	0%	57%	43%	0%	0%
		2017	**65%**	**27%**	**9%**	100%	0%	0%	0%	0%	57%	43%	0%	0%
Latvia	LV	2015	100%	0%	0%	100%	0%	0%	0%	0%	100%	0%	0%	0%
		2017	**20%**	0%	**80%**	77%	0%	0%	0%	23%	100%	0%	0%	0%
Lithuania	LT	2015	43%	0%	57%	39%	0%	31%	19%	11%	0%	100%	0%	0%

Country	Country-Code	Year	direct MBT	direct INC	direct LF	MBT 1	MBT 2	MBT 3	MBT 4	MBT 5	INC 1	INC 2	INC 3	INC 4
		2017	54%	0%	46%	39%	0%	29%	22%	10%	0%	100%	0%	0%
Luxembourg	LU	2015	13%	66%	21%	100%	0%	0%	0%	0%	100%	0%	0%	0%
		2017	14%	68%	18%	100%	0%	0%	0%	0%	100%	0%	0%	0%
Malta	MT	2015	17%	0%	83%	0%	0%	0%	100%	0%	100%	0%	0%	0%
		2017	31%	0%	69%	0%	0%	0%	100%	0%	100%	0%	0%	0%
Netherlands	NL	2015	8%	90%	2%	0%	0%	0%	100%	0%	0%	100%	0%	0%
		2017	9%	89%	2%	0%	0%	0%	100%	0%	0%	100%	0%	0%
Poland	PL	2015	86%	9%	5%	0%	0%	0%	0%	100%	0%	100%	0%	0%
		2017	86%	9%	5%	0%	0%	0%	0%	100%	0%	100%	0%	0%
Portugal	PT	2015	38%	23%	39%	0%	0%	80%	20%	0%	100%	0%	0%	0%
		2017	39%	24%	38%	0%	0%	80%	20%	0%	100%	0%	0%	0%
Romania	RO	2015	0%	0%	100%	0%	0%	0%	0%	100%	100%	0%	0%	0%
		2017	2%	0%	98%	0%	0%	0%	0%	100%	100%	0%	0%	0%
Slovakia	SK	2015	3%	10%	86%	0%	0%	0%	0%	100%	100%	0%	0%	0%
		2017	4%	11%	85%	0%	0%	0%	0%	100%	100%	0%	0%	0%
Slovenia	SI	2015	86%	0%	14%	55%	0%	0%	45%	0%	0%	96%	0%	4%
		2017	90%	0%	10%	55%	0%	0%	45%	0%	0%	96%	0%	4%
Spain	ES	2015	69%	5%	25%	71%	0%	0%	29%	0%	100%	0%	0%	0%
		2017	70%	6%	24%	71%	0%	0%	29%	0%	100%	0%	0%	0%
Sweden	SE	2015	0%	98%	2%	0%	0%	0%	0%	100%	0%	97%	3%	0%
		2017	0%	98%	2%	0%	0%	0%	0%	100%	0%	97%	3%	0%
United Kingdom	UK	2015	32%	37%	31%	11%	37%	0%	23%	29%	75%	25%	0%	0%
		2017	33%	39%	28%	11%	37%	0%	23%	29%	75%	25%	0%	0%

*For Bulgaria, the MBT-Split 2017 was larger 100% and was corrected by setting MBT-5 from 12% to 0%. Greece had more precise information on the amounts treated by MBT in the Quality report delivered with the Eurostat data 2017. Therefore the breakdown for 2017 was adjusted to the actually reported one. For Italy, the data 2017 of Eurostat indicated that the breakdown of 2015 should be kept. For Latvia, metadata delivered with the MW data 2017 suggests that activities regarded as MBT occur directly on landfill, so that the split was adjusted accordingly.

Table 108: Breakdown of organic waste treatment from the EEA-model, 2015 & 2017, by stream, in percent

Country	Country-Code	Year	Food			Garden			Other biowaste		
			Open Air Windrow	In-Vessel Composting	Anaerobic Digestion	Open Air Windrow	In-Vessel Composting	Anaerobic Digestion	Open Air Windrow	In-Vessel Composting	Anaerobic Digestion
Austria	AT	2015	26%	26%	48%	47%	47%	7%	32%	32%	36%
		2017	26%	26%	48%	47%	47%	7%	32%	32%	36%
Belgium	BE	2015	0%	0%	100%	90%	9%	1%	70%	0%	30%
		2017	0%	0%	100%	90%	9%	1%	70%	0%	30%
Bulgaria	BG	2015	26%	26%	48%	38%	38%	24%	33%	33%	34%
		2017	26%	26%	48%	38%	38%	24%	33%	33%	34%
Croatia	HR	2015	97%	0%	3%	99%	0%	1%	98%	0%	2%
		2017	97%	0%	3%	99%	0%	1%	98%	0%	2%
Cyprus	CY	2015	71%	29%	0%	83%	17%	0%	33%	33%	34%
		2017	100%	0%	0%	80%	20%	0%	33%	33%	34%
Czech Republic	CZ	2015	25%	50%	25%	50%	50%	0%	33%	33%	34%
		2017	25%	50%	25%	50%	50%	0%	33%	33%	34%
Denmark	DK	2015	10%	66%	24%	90%	10%	0%	33%	33%	34%
		2017	10%	66%	24%	90%	10%	0%	33%	33%	34%
Estonia	EE	2015	20%	80%	0%	20%	80%	0%	20%	80%	0%
		2017	20%	80%	0%	20%	80%	0%	20%	80%	0%
Finland	FI	2015	11%	60%	29%	11%	60%	29%	11%	60%	29%
		2017	11%	60%	29%	11%	60%	29%	11%	60%	29%
France	FR	2015	0%	98%	2%	0%	98%	2%	0%	98%	2%
		2017	0%	98%	2%	0%	98%	2%	0%	98%	2%
Germany	DE	2015	45%	45%	10%	45%	45%	10%	33%	33%	34%
		2017	45%	45%	10%	45%	45%	10%	33%	33%	34%
Greece	EL	2015	0%	100%	0%	80%	20%	0%	33%	33%	34%
		2017	0%	100%	0%	80%	20%	0%	33%	33%	34%
Hungary	HU	2015	50%	50%	0%	80%	20%	0%	33%	33%	34%
		2017	50%	50%	0%	80%	20%	0%	33%	33%	34%
Ireland	IE	2015	13%	75%	12%	93%	7%	0%	36%	27%	37%
		2017	13%	75%	12%	93%	7%	0%	36%	27%	37%
Italy	IT	2015	0%	60%	40%	40%	60%	0%	5%	55%	40%
		2017	0%	60%	40%	40%	60%	0%	5%	55%	40%
Latvia	LV	2015	100%	0%	0%	100%	0%	0%	100%	0%	0%
		2017	100%	0%	0%	100%	0%	0%	100%	0%	0%
Lithuania	LT	2015	52%	32%	16%	70%	0%	30%	34%	47%	19%
		2017	52%	32%	16%	70%	0%	30%	34%	47%	19%

Country	Country-Code	Year	Food			Garden			Other biowaste		
			Open Air	In-Vessel	Anaerobic Digestion	Open Air Windrow	In-Vessel	Anaerobic	Open Air	In-Vessel	Anaerobic
Luxembourg	LU	2015	1%	0%	99%	89%	0%	11%	33%	33%	34%
		2017	1%	0%	99%	89%	0%	11%	33%	33%	34%
Malta	MT	2015	4%	4%	91%	38%	38%	24%	6%	6%	89%
		2017	0%	0%	100%	38%	38%	24%	0%	0%	100%
Netherlands	NL	2015	43%	37%	20%	100%	0%	0%	33%	33%	34%
		2017	42%	37%	21%	100%	0%	0%	33%	33%	34%
Poland	PL	2015	100%	0%	0%	80%	20%	0%	33%	33%	34%
		2017	100%	0%	0%	80%	20%	0%	33%	33%	34%
Portugal	PT	2015	26%	26%	48%	38%	38%	24%	33%	33%	34%
		2017	26%	26%	48%	38%	38%	24%	33%	33%	34%
Romania	RO	2015	88%	13%	0%	88%	13%	0%	88%	13%	0%
		2017	88%	13%	0%	88%	13%	0%	88%	13%	0%
Slovakia	SK	2015	80%	0%	20%	100%	0%	0%	50%	0%	50%
		2017	80%	0%	20%	100%	0%	0%	50%	0%	50%
Slovenia	SI	2015	38%	32%	30%	38%	33%	29%	3%	5%	92%
		2017	26%	32%	42%	26%	33%	41%	3%	5%	92%
Spain	ES	2015	50%	0%	50%	55%	40%	5%	33%	33%	34%
		2017	50%	0%	50%	55%	40%	5%	33%	33%	34%
Sweden	SE	2015	9%	10%	81%	50%	50%	0%	0%	100%	0%
		2017	9%	10%	81%	50%	50%	0%	0%	100%	0%
United Kingdom	UK	2015	2%	17%	81%	87%	12%	2%	16%	77%	7%
		2017	2%	17%	81%	87%	12%	2%	16%	77%	7%

Table 109: Breakdown of anaerobic digestion from the EEA-model, 2015 & 2017, in percent

Country	Country-Code	Year	AD 1	AD 2	AD 3	AD 4	AD 5
Austria	AT	2015	48%	48%	4%	1%	0%
		2017	48%	48%	4%	1%	0%
Belgium	BE	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Bulgaria	BG	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Croatia	HR	2015	100%	0%	0%	0%	0%
		2017	100%	0%	0%	0%	0%
Cyprus	CY	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Czech Republic	CZ	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Denmark	DK	2015	60%	3%	37%	0%	0%
		2017	60%	3%	37%	0%	0%
Estonia	EE	2015	0%	0%	0%	0%	100%
		2017	0%	0%	0%	0%	100%
Finland	FI	2015	0%	69%	0%	24%	7%
		2017	0%	69%	0%	25%	6%
France	FR	2015	100%	0%	0%	0%	0%
		2017	100%	0%	0%	0%	0%
Germany	DE	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Greece	EL	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Hungary	HU	2015	100%	0%	0%	0%	0%
		2017	100%	0%	0%	0%	0%
Ireland	IE	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Italy	IT	2015	100%	0%	0%	0%	0%
		2017	92%	0%	2%	6%	0%
Latvia	LV	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Lithuania	LT	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Luxembourg	LU	2015	0%	34%	66%	0%	0%
		2017	0%	34%	66%	0%	0%
Malta	MT	2015	100%	0%	0%	0%	0%
		2017	60%	40%	0%	0%	0%
Netherlands	NL	2015	100%	0%	0%	0%	0%
		2017	100%	0%	0%	0%	0%
Poland	PL	2015	100%	0%	0%	0%	0%
		2017	100%	0%	0%	0%	0%
Portugal	PT	2015	100%	0%	0%	0%	0%
		2017	100%	0%	0%	0%	0%
Romania	RO	2015	100%	0%	0%	0%	0%
		2017	100%	0%	0%	0%	0%
Slovakia	SK	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Slovenia	SI	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Spain	ES	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%
Sweden	SE	2015	8%	3%	17%	69%	3%
		2017	8%	4%	18%	66%	4%
United Kingdom	UK	2015	0%	100%	0%	0%	0%
		2017	0%	100%	0%	0%	0%

A.1.3 Residual waste composition for all countries and validation and adjustment with available waste analysis data for some countries

Table 110: Residual waste composition 2017 from the EEA-model (for countries without literature data on composition), in %

Country	Country-Code	Food	Garden	Other biowastes	Wood	Paper / Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall Total***	**Total within scope**
Bulgaria	BG	25%	19%	0%	2%	15%	3%	6%	2%	11%	0%	0%	0%	1%	0%	14%	2%	**100%**	**99%**
Cyprus	CY	37%	12%	0%	3%	17%	7%	3%	1%	15%	0%	0%	0%	0%	0%	2%	3%	**100%**	**100%**
Latvia	LV	23%	6%	2%	2%	16%	3%	9%	2%	9%	0%	0%	0%	0%	19%	4%	5%	**100%**	**100%**
Lithuania	LT	13%	6%	11%	1%	7%	7%	5%	2%	12%	1%	0%	0%	0%	0%	13%	21%	**100%**	**99%**
Malta	MT	47%	2%	0%	1%	15%	4%	4%	3%	12%	0%	0%	0%	0%	2%	0%	11%	**100%**	**100%**
Poland	PL	23%	10%	0%	1%	10%	3%	7%	2%	13%	0%	0%	0%	1%	13%	6%	12%	**100%**	**99%**
Slovakia	SK	31%	17%	0%	3%	9%	3%	6%	3%	11%	0%	3%	0%	1%	0%	1%	12%	**100%**	**96%**
Denmark	DK	42%	7%	0%	0%	19%	0%	2%	2%	11%	0%	0%	0%	0%	0%	2%	14%	**100%**	**99%**
Portugal	PT	33%	6%	6%	1%	11%	4%	3%	2%	10%	0%	0%	0%	0%	13%	0%	12%	**100%**	**100%**
Finland	FI	23%	9%	2%	4%	20%	4%	2%	2%	18%	1%	2%	0%	0%	0%	2%	9%	**100%**	**97%**
Sweden	SE	26%	8%	0%	11%	19%	3%	1%	3%	15%	2%	0%	0%	0%	0%	0%	13%	**100%**	**98%**
Belgium	BE	17%	5%	0%	4%	10%	4%	2%	1%	10%	0%	0%	0%	1%	1%	7%	37%	**100%**	**99%**
Austria	AT	14%	0%	0%	0%	10%	7%	4%	4%	17%	0%	0%	0%	2%	7%	5%	30%	**100%**	**98%**
Slovenia	SI	13%	9%	2%	6%	19%	2%	7%	4%	12%	1%	0%	0%	1%	0%	0%	23%	**100%**	**98%**

Table 111: Residual waste composition 2017 from the EEA-model (for countries with literature data on composition), before and after adjustment, in %

Country	Country-Code	Composition type	Year	Food	Garden	Other biowastes	Wood	Paper / cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumulators*	*Haz. (excl. WEEE)*	Fines	Inerts	Other
Estonia	EE	Model	2017	28%	3%	1%	2%	14%	5%	5%	4%	18%	*2%*	*0%*	*0%*	*1%*	0%	4%	13%
		Model adjusted	2017	**27%**	3%	1%	2%	14%	5%	5%	4%	18%	*2%*	*0%*	*0%*	*1%*	0%	4%	13%
		Literature[1]	2015	32%				14%		5%	5%	18%							27%
Croatia	HR	Model	2017	26%	7%	0%	1%	24%	3%	5%	2%	19%	*1%*	*3%*	*0%*	*0%*	0%	0%	8%
		Model adjusted	2017	26%	7%	0%	1%	24%	3%	5%	2%	19%	*1%*	*3%*	*0%*	*0%*	0%	0%	8%
		Literature[2]	2015	31%	6%	1%	1%	23%	4%	4%	2%	23%		0%					6%
Hungary	HU	Model	2017	22%	5%	0%	0%	14%	4%	3%	2%	17%	*0%*	*0%*	*0%*	*1%*	16%	6%	10%
		Model adjusted	2017	22%	5%	0%	0%	14%	4%	3%	2%	17%	*0%*	*0%*	*0%*	*1%*	16%	6%	10%
		Literature[3]	2015	23%				13%		4%	2%	15%							44%
Greece	EL	Model	2017	50%	3%	0%	0%	15%	0%	3%	3%	14%	*0%*	*0%*	*0%*	*0%*	0%	0%	12%
		Model adjusted	2017	**42%**	3%	0%	**5%**	**22%**	0%	**4%**	**4%**	14%	*0%*	*0%*	*0%*	*0%*	0%	0%	**8%**
		Literature[4]	2011	44%			5%	22%		4%	4%	14%							6,8%
Romania	RO	Model	2017	47%	15%	0%	2%	12%	1%	5%	3%	14%	*1%*	*0%*	*0%*	*0%*	0%	0%	1%
		Model adjusted	2017	47%	15%	0%	2%	12%	1%	5%	3%	14%	*1%*	*0%*	*0%*	*0%*	0%	0%	1%
		Literature[5]	2014	62%			2%	12%	1%	5%	3%	14%	*1%*						0%
Ireland	IE	Model	2017	20%	6%	0%	0%	17%	8%	4%	2%	14%	*0%*	*0%*	*0%*	*1%*	12%	0%	15%
		Model adjusted	2017	**16%**	**5%**	0%	0%	17%	8%	4%	**4%**	**18%**	*0%*	*0%*	*0%*	*1%*	12%	0%	15%
		Literature[6]	2017	14%	3%		1%	15%	10%	3%	5%	19%	*1%*			*1%*	12%	2%	16%
Czech Republic	CZ	Model	2017	37%	5%	0%	8%	11%	6%	5%	2%	13%	*0%*	*0%*	*0%*	*0%*	0%	5%	10%
		Model adjusted	2017	37%	5%	0%	8%	11%	6%	5%	2%	13%	*0%*	*0%*	*0%*	*0%*	0%	5%	10%
		Literature[7]	2016	34%				8%	2%	4%	3%	11%	*1%*			*1%*	9%	4%	23%

Country	Country-Code	Composition type	Year	Food	Garden	Other biowastes	Wood	Paper / cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumulators*	*Haz. (excl. WEEE)*	Fines	Inerts	Other
Spain	ES	Model	2017	46%	9%	0%	2%	10%	6%	4%	3%	9%	0%	0%	0%	0%	0%	0%	11%
		Model adjusted	2017	**45%**	9%	0%	2%	**11%**	**5%**	**5%**	3%	9%	0%	0%	0%	0%	0%	0%	**10%**
		Literature[8]	2012	54%			2%	11%	5%	5%	3%	9%							9%
France	FR	Model	2017	29%	4%	0%	4%	27%	4%	7%	3%	12%	2%	0%	0%	1%	3%	4%	2%
		Model adjusted	2017	29%	4%	0%	**5%**	**16%**	4%	**6%**	3%	**15%**	2%	0%	0%	1%	**6%**	**3%**	**8%**
		Literature[9]	2017	34%			5%	15%	3%	5%	3%	15%				1%	8%	2%	11%
Luxembourg	LU	Model	2017	27%	2%	0%	1%	19%	3%	3%	2%	18%	0%	0%	0%	1%	7%	1%	15%
		Model adjusted	2017	27%	2%	0%	1%	19%	3%	3%	2%	18%	0%	0%	0%	1%	7%	1%	15%
		Literature[10]	2015	30%				19%	3%	3%	2%	18%							24%
Netherlands	NL	Model	2017	21%	5%	10%	4%	20%	5%	5%	4%	14%	0%	0%	0%	0%	0%	0%	13%
		Model adjusted	2017	21%	5%	10%	4%	20%	5%	5%	4%	14%	0%	0%	0%	0%	0%	0%	13%
		Literature[11]	2016	32%				20%	5%	5%	4%	14%				0%			19%
Italy	IT	Model	2017	15%	8%	0%	1%	21%	6%	3%	3%	18%	0%	0%	0%	0%	0%	2%	22%
		Model adjusted	2017	15%	8%	0%	1%	21%	6%	3%	3%	18%	0%	0%	0%	0%	0%	2%	22%
		Literature[12]	2008-	28%			1%	26%	8%	3%	4%	19%	0%					2%	10%
United Kingdom	UK	Model	2017	26%	10%	0%	2%	15%	4%	4%	3%	14%	2%	0%	0%	1%	2%	0%	17%
		Model adjusted	2017	26%	10%	0%	2%	15%	4%	4%	3%	14%	2%	0%	0%	1%	2%	0%	17%
		Literature[13]	2015	34%				15%	4%	2%	3%	19%							23%
Germany	DE	Model	2017	28%	10%	0%	9%	7%	7%	0%	0%	15%	0%	0%	0%	0%	12%	4%	8%
		Model adjusted	2017	**27%**	**9%**	0%	**8%**	**6%**	7%	**4%**	**4%**	**8%**	0%	0%	0%	0%	**7%**	4%	**17%**
		Literature[14]	2018	36%			8%	5%	7%	4%	4%	8%	1%			0%	7%	3%	17%

1 [Blonskaja and Põldnurk 2014]
2 [Vlada Republike Hrvatske 2017]
3 [The Ministry of Agriculture 2015]
4 [Delphiengineering 2014]
5 [Muşuroaea, et al. 2017]
6 [EPA 2018]
7 (Grolmus 2017)]
8 [MAPA 2015]
9 (ADEME 2019)]
10 (eurostat 2017)]
11 (Ministerie van Infrastructuur en Waterstaat (lenW) 2018)]
12 [ISPRA 2017]
13 [Defra 2015]
14 [UBA 2019]

A.1.4 Mass flow assumptions of the EEA-model for MBT

Table 112: Percentage distribution of treatment of MBT output and mass losses by type of MBT as applied in the EEA-model

MBT-type	Treatment of output	Food	Garden	Other biowastes	Wood	Paper /Card-board	*Textiles*	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other
MBT 1 - Biostabilisation	Recycling								63%	10%			70%				
	Energy recovery																
	Land recovery	25%	30%	25%	20%	25%	10%	35%	7%	15%	5%	10%	5%	0%	0%	0%	0%
	Mass loss	60%	40%	60%	20%	35%	25%			5%							
	Landfill	15%	30%	15%	60%	40%	65%	65%	30%	70%	95%	90%	25%	100%	100%	100%	100%
	Total	**100%**	**100%**	**100%**	**100**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
MBT 2 - Biodrying no plastics recycling	Recycling								63%				70%				
	Energy recovery	55%	60%	55%	80%	80%	85%	20%	20%	95%	50%	50%	20%	100%	100%	100%	100%
	Land recovery																
	Mass loss	40%	35%	40%	5%	20%	10%										
	Landfill	5%	5%	5%	15%	0%	5%	80%	17%	5%	50%	50%	10%	0%	0%	0%	0%
	Total	**100%**	**100%**	**100%**	**100**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
MBT 3 - Biodrying with plastics recycling	Recycling								63%	10%			70%				
	Energy recovery	55%	60%	55%	80%	80%	85%	20%	20%	85%	50%	50%	20%	100%	100%	100%	100%
	Land recovery																
	Mass loss	40%	35%	40%	5%	20%	10%										
	Landfill	5%	5%	5%	15%	0%	5%	80%	17%	5%	50%	50%	10%	0%	0%	0%	0%
	Total	**100%**	**100%**	**100%**	**100**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
MBT 4 - AD based	Recycling								63%	10%			70%				
	Energy recovery																
	Land recovery	30%	30%	30%	20%	25%	10%	35%	5%	15%	5%	10%	5%	0%	30%	10%	
	Mass loss	50%	50%	50%	20%	35%	25%			5%					50%		
	Landfill	20%	20%	20%	60%	40%	65%	65%	32%	70%	95%	90%	25%	100%	20%	90%	100%
	Total	**100%**	**100%**	**100%**	**100**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
MBT 5 - basic sorting + energy generation	Recycling					20%			63%	10%			63%				
	Energy recovery	100%	100%	100%	100	80%	100%	100%	37%	90%	50%	100%	37%	100%	100%	30%	100%
	Land recovery																
	Mass loss																
	Landfill										50%	0%	0%	0%	0%	70%	0%
	Total	**100%**	**100%**	**100%**	**100**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

A.2 Additional Information

A.2.1 Municipal waste definition and coverage by LoW codes[55]

OECD / Eurostat municipal waste definition

MSW statistics data have been collected in the European Union on the basis of an OECD/Eurostat joint questionnaire (JQ) since the 1990s. In effect, the data of the existing time series is essentially collected based on the MSW definition of the JQ. Apparently, the parameter 'municipal waste generated' is defined by the following set of criteria:

- Waste materials/fractions
- Type of collection
- Origin of waste

In the following, the traditional wording of the definition on MSW taken from the JQ is shown. The parts of the wording of the definition which refer to one of the abovementioned criteria are marked in the respective colour.

Wording from the Definition-Section of the Joint Questionnaire

Municipal waste includes household waste and similar waste.

It also includes:

A bulky waste (e.g. white goods, old furniture, mattresses), and

B yard waste, leaves, grass clippings, street sweepings, the content of litter containers, and market cleansing waste,

if managed as waste.

It includes waste originating from:

A households,

B commerce and trade, small businesses, office buildings and institutions (schools, hospitals, government buildings).

It also includes:

C waste from selected municipal services i.e. waste from park and garden maintenance, waste from street cleaning services (street sweepings, the content of litter containers, market cleansing waste),

if managed as waste.

It includes waste from these sources collected:

D door-to-door trough traditional collection (mixed household waste), and

E fractions collected separately for recovery operations (through door-to-door collection and/or through voluntary deposits).

For the purpose of this questionnaire municipal waste refers to waste defined as above, collected by or on behalf of municipalities.

The definition also includes waste from the same sources and similar in nature and composition which:

F are collected directly by the private sector (business or private non-profit institutions) not on behalf of municipalities (mainly separate collection for recovery purposes),

G originate from rural areas not served by a regular waste service, even if they are disposed by the generator.

The definition excludes:

1) waste from municipal sewage network and treatment,

2) municipal construction and demolition waste.

55 European Commission, Eurostat – Unit E2 – Environmental statistics and accounts; sustainable development, Guidance on municipal waste data collection - May 2017, downloaded at 6th April 2019 from https://ec.europa.eu/eurostat/documents/342366/351811/Municipal+Waste+guidance

Coverage of Municipal Waste based on selected LoW codes

Chapter 20: Municipal wastes (Household waste and similar commercial, industrial and institutional wastes) including separately collected fractions

20 01 separately collected fractions (except 15 01)

20 01 01	paper and cardboard
20 01 02	glass
20 01 08	biodegradable kitchen and canteen waste
20 01 10	clothes
20 01 11	textiles
20 01 13*	solvents
20 01 14*	acids
20 01 15*	alkalines
20 01 17*	photochemicals
20 01 19*	pesticides
20 01 21*	fluorescent tubes and other mercury-containing waste
20 01 23*	discarded equipment containing chlorofluorocarbons
20 01 25	edible oil and fat
20 01 26*	oil and fat other than those mentioned in 20 01 25
20 01 27*	paint, inks, adhesives and resins containing dangerous substances
20 01 28	paint, inks, adhesives and resins other than those mentioned in 20 01 27
20 01 29*	detergents containing dangerous substances
20 01 30	detergents other than those mentioned in 20 01 29
20 01 31*	cytotoxic and cytostatic medicines
20 01 32	medicines other than those mentioned in 20 01 31
20 01 33*	batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries
20 01 34	batteries and accumulators other than those mentioned in 20 01 33
20 01 35*	discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components
20 01 36	discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35
20 01 37*	wood containing dangerous substances
20 01 38	wood other than that mentioned in 20 01 37
20 01 39	plastics
20 01 40	metals
20 01 41	wastes from chimney sweeping
20 01 99	other fractions not otherwise specified

20 02 garden and park wastes (including cemetery waste)

20 02 01	biodegradable waste
20 02 03	other non-biodegradable wastes

20 03 other municipal wastes

20 03 01	mixed municipal waste
20 03 02	waste from markets
20 03 03	street-cleaning residues
20 03 07	bulky waste
20 03 99	municipal wastes not otherwise specified

Chapter 15 Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified

15 01 packaging (including separately collected municipal packaging waste)

15 01 01	paper and cardboard packaging
15 01 02	plastic packaging
15 01 03	wooden packaging
15 01 04	metallic packaging
15 01 05	composite packaging
15 01 06	mixed packaging
15 01 07	glass packaging
15 01 09	textile packaging
15 01 10*	packaging containing residues of or contaminated by dangerous substances
15 01 11*	metallic packaging containing a dangerous solid porous matrix (for example asbestos), including empty pressure containers

Any waste marked with an asterisk (*) is considered as a hazardous waste; some codes cover WEEE and batteries and accumulators.

A.2.2 Coverage of MSW by materials of the EEA-model and corresponding EWC-Stat codes for the delimitation

Table 113: List of MSW materials covered by this study and the EWC-Stat codes, where the materials are assigned to (for proportional subtraction from the WStatR sectors)

Material in EEA-model	EWC-Stat code	EWC-Stat description	Comment
Food Garden Other biowastes	W091 W092	Animal and mixed food waste Vegetal wastes	The three materials are part of both EWC-Stat categories and are subtracted proportionally from the sum of the categories
Wood	W075	Wood wastes	-
Paper / Cardboard	W072	Paper and cardboard wastes	-
Textiles	W076	Textile wastes	-
Glass	W071	Glass wastes	-
Metals	W063	Metal wastes, mixed ferrous	-
Plastics	W074	Plastic wastes	-
Inerts	W12B	Other mineral waste	
Fines Other	W102	Mixed and undifferentiated materials	Both materials are subtracted from one EWC-
Mixed (residual) waste	**W101**	**Household and similar wastes**	**Mixed (residual) waste as a whole to be subtracted**

Hazardous waste (excl. WEEE), WEEE, Batteries and accumulators and rubble, soil are not listed since these streams are disregarded in this study.

A.2.3 General description and background of the European Waste Model

The EEA-Model was created to assess the current and likely future performance of Member States (MS) concerning the management of MSW. It also serves as a modelling tool for MSW generation and management at an aggregate European level.

The current model was developed in the broader context of the project "Impact Assessment on Options Reviewing Targets in the Waste Framework Directive, Landfill Directive and Packaging and Packaging Waste Directive". The model development was done under a separate contract by a consortium led by Eunomia Research & Consulting (Bristol, UK) in co-operation with the Copenhagen Resource Institute (Denmark).

The currently used 'European Reference Model on Municipal Waste Generation and Management' (Gibbs et al. 2014b) (referred to as Waste Model) evaluates how MS perform and estimate their performance in the future. It is now the basis for the "Early Warning Mechanism" which aims at anticipating potential difficulties for MS to reach the targets set by the Directive ahead of the deadline.

The Microsoft Excel tool includes projections of different waste flow scenarios and additional analysis of costs and benefits, employment and other indicators. The model is not only intended for the Commission and the EEA distance to target evaluation but also as a tool for national waste management strategy, planning and policy-making. Individual MS and overall EU performance can be assessed against existing targets relating to municipal waste.

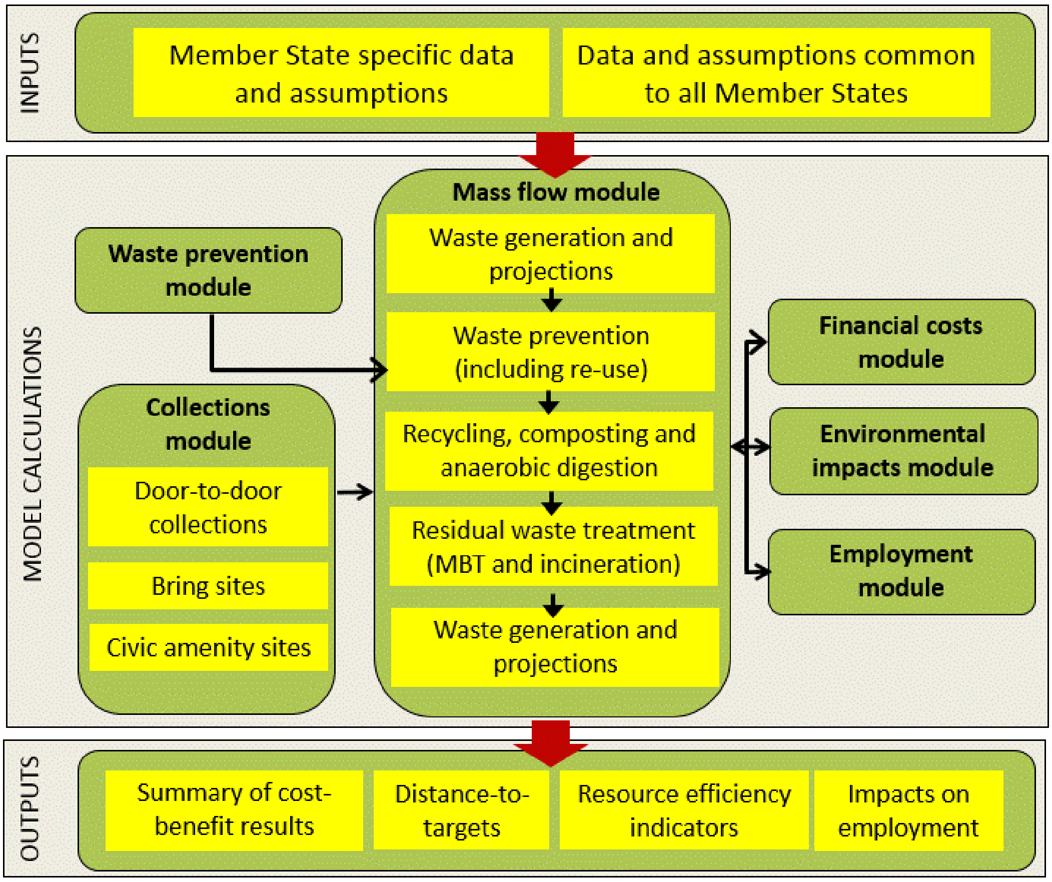
The basis for the first data input for reference year was compiled in a multi-step approach. First of all, the relevant authorities in all MS were identified[56] and a detailed questionnaire sent which requested country specific information. The questionnaire aimed to better understand the gaps prior to the country visit and compile detailed information that would make a country visit for some countries obsolete. Nineteen MS were visited by members of the project team while for eight countries the performance of the country and the available information from literature and the questionnaire were adequate for the model input.

In addition, online consultation for industry stakeholders was hosted on the project's official website which collected information on:

- Waste composition;
- Collection systems operated in MSs and collection costs; and
- Treatment system costs.

These sources of information were used as sources of input data for the model. From the schematic of the overall model in Figure 1, it can be seen that the main model calculations consist of six modules.

Figure 45: Overall Schematic of the European Reference Model



Source: (Gibbs et al. 2014b)

56 Mainly: Environmental Ministries, National Statistical Offices, Environmental Agencies/Institutes.

These modules include:

1. **Mass Flow Module** – the central core of the model where all data and material flows, inputs and data on treatment/management are entered;
2. **Waste Prevention Module** – this module calculates the impacts and implementation costs of various waste prevention initiatives;
3. **Collections Module** – in this module, the fundamentals, costs and logistics of the municipal waste collection are defined;
4. **Financial Costs Module** – based on the mass flow of waste this module calculates the costs of waste management (e.g. via landfill, incineration and/or recycling);
5. **Environmental Impacts Module** – this module calculates the Greenhouse gas (GHG) as well as local air emissions; and
6. **Employment Module** – calculates the possible impacts of policy changes on employment.

The outputs of the model are summarised in the following modules:

- Cost-Benefit Analysis results;
- distance to European waste directive targets (corresponds to the “Early Warning Mechanism”);
- resource efficiency indicators; and
- anticipated impacts on employment.

The country data used in the model can be found in separate country data reports summarised in Appendix 1 to the headline report (Gibbs et al. 2014b)

It is important to note that the Impact Assessment exercise explained above for the circular economy package 2014 was repeated for the revised circular economy package in 2015. In the course of this project labelled "Further development of the European reference Model on Waste Generation and Management", the following major changes to the model were implemented:

- Changes to the Financial Costs Module (secondary material revenues, labour cost ratios, country-specific deflators, update of costs to 2015 real prices, etc.);
- Adjustment of employment intensity factors;
- Changes to collection module and the “goal seek” function to increase their accuracy;
- Development of a separate C&D model; and
- Updating of waste data for three countries concerning waste composition and chosen option for WFD compliance reporting on household waste.

In addition, the country data reports for individual MS were refurbished by adding the information in a more standardised way (e.g. tables) and presented in Appendix 3 of the new headline report (Gibbs et al. 2014b).

In 2017, the model data were updated for the reference year 2015, a task performed by the waste management team of the European Topic Centre on Waste and Materials in a Green Economy (ETC/WMGE). The data were collected by a consortium led by Eunomia Research & Consulting as part of a study (D. Hogg et al. 2018) for the European Commission to identify the Member States at risk of non-compliance with the 2020 recycling target of the Waste Framework Directive.

The ETC/WMGE prepared a questionnaire, in cooperation with Eunomia, requesting up-to-date statistics, as well as information on expected future developments, and strategies on the management of MSW in Member States. The questionnaire aimed to get an update on the most relevant data in the model.

The questionnaire covered the following topics:

- the current situation of MSW generation and treatment (incl. existing treatment capacities) and MSW composition;
- likely development in the future, i.e. projections of MSW generation, impact of policies under implementation in the near future, future treatment capacity, and planned and potential changes to the collection systems;
- measures for increasing MSW recycling rates under planning and recent implementation.

Eunomia collected data through the questionnaires and meetings with Member State representatives, similar to the original approach described above. At the time of this report, the model is published and can be downloaded from the European Environment Information and Observation Network (Eionet)[57].

A.3 Detailed MSW data by countries and clusters

A.3.1 Mixed (residual) waste

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57 Eionet, European Environment Information and Observation Network: https://www.eionet.europa.eu/etcs/etc-wmge/etc-wmge-files/eurm_mswm.zip

Table 114: Mixed (residual) waste collected, by waste materials, 2017, in 1,000 tons

Country	Country-Code	Food	Garden	Other biowastes	Wood	Paper / Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall Total***	**Total within scope**
Bulgaria	BG	482	354	0	46	284	53	109	38	216	*0*	*0*	*0*	*12*	0	273	38	***1904***	**1893**
Estonia	EE	90	11	4	7	46	16	18	14	59	*6*	*0*	*0*	*5*	0	13	43	***331***	**320**
Greece	EL	1832	118	0	200	942	0	171	156	606	*0*	*0*	*0*	*0*	0	0	339	***4364***	**4364**
Croatia	HR	337	88	5	13	307	39	60	27	248	*7*	*39*	*0*	*1*	0	0	102	***1273***	**1225**
Cyprus	CY	163	55	0	12	74	32	13	5	69	*0*	*0*	*0*	*0*	0	7	15	***445***	**445**
Latvia	LV	128	35	10	13	89	20	48	13	53	*0*	*2*	*0*	*0*	106	22	28	***567***	**564**
Lithuania	LT	109	53	91	9	59	54	40	18	101	*4*	*0*	*0*	*2*	0	110	171	***820***	**813**
Hungary	HU	637	155	0	0	400	102	75	71	500	*0*	*0*	*0*	*21*	454	167	278	***2860***	**2839**
Malta	MT	121	5	0	2	38	9	10	8	30	*1*	*0*	*0*	*0*	5	0	29	***259***	**258**
Poland	PL	1997	907	0	47	835	275	612	187	1095	*0*	*0*	*0*	*93*	1161	497	1023	***8730***	**8636**
Romania	RO	1939	603	0	92	484	41	196	128	560	*25*	*0*	*0*	*0*	0	0	46	***4115***	**4091**
Slovakia	SK	311	170	0	29	93	35	55	26	107	*0*	*32*	*0*	*11*	0	15	119	***1002***	**959**
Czech Republic	CZ	813	117	0	178	234	124	108	50	283	*0*	*0*	*0*	*0*	0	107	214	***2227***	**2227**
Denmark	DK	998	159	0	0	448	0	50	56	264	*8*	*0*	*5*	*0*	0	50	325	***2363***	**2350**
Ireland	IE	345	107	0	2	293	133	71	38	250	*2*	*0*	*0*	*25*	219	0	269	***1753***	**1726**
Spain	ES	7846	1586	0	276	1915	966	903	593	1653	*0*	*0*	*0*	*0*	0	0	1826	***17564***	**17564**
France	FR	5868	737	0	969	3319	722	1156	660	3099	*347*	*0*	*0*	*164*	1256	638	1560	***20497***	**19985**
Portugal	PT	1455	268	245	32	477	181	150	79	444	*7*	*0*	*0*	*14*	564	0	524	***4441***	**4420**
Finland	FI	382	152	38	59	323	61	40	38	301	*12*	*37*	*3*	*6*	0	34	156	***1640***	**1583**
Sweden	SE	620	197	0	249	439	73	35	60	349	*44*	*0*	*0*	*0*	0	0	299	***2365***	**2321**
Belgium	BE	333	95	6	75	194	82	40	26	196	*0*	*0*	*5*	*13*	20	137	731	***1952***	**1934**
Italy	IT	2099	1180	0	189	2973	858	462	403	2463	*13*	*0*	*0*	*0*	0	237	3083	***13958***	**13945**
Luxembourg	LU	47	4	0	1	32	5	5	3	31	*1*	*0*	*0*	*2*	12	2	26	***171***	**169**
Netherlands	NL	841	201	426	147	794	187	210	152	559	*0*	*0*	*0*	*6*	0	0	544	***4067***	**4061**
Austria	AT	245	0	0	1	178	121	67	62	296	*0*	*0*	*0*	*28*	126	86	510	***1721***	**1692**
Slovenia	SI	52	38	9	24	79	9	28	18	47	*5*	*0*	*0*	*2*	0	0	93	***405***	**398**
United Kingdom	UK	4615	1805	0	321	2658	722	720	472	2457	*363*	*0*	*17*	*169*	413	0	3057	***17791***	**17241**
Cluster 1		**8144**	**2554**	**109**	**471**	**3651**	**674**	**1408**	**691**	**3644**	***43***	***73***	***1***	***146***	**1725**	**1104**	**2231**	***26669***	**26406**
Cluster 2		**18326**	**3322**	**282**	**1766**	**7448**	**2260**	**2514**	**1574**	**6642**	***420***	***37***	***8***	***209***	**2039**	**829**	**5172**	***52849***	**52176**
EU27 (w/o DE)		**30087**	**7395**	**833**	**2673**	**15349**	**4197**	**4734**	**2929**	**13878**	***481***	***110***	***14***	***406***	**3922**	**2394**	**12391**	***101793***	**100781**
EU28 (w/o DE)		**34703**	**9200**	**833**	**2994**	**18007**	**4919**	**5454**	**3401**	**16335**	***844***	***110***	***31***	***575***	**4335**	**2394**	**15448**	***119584***	**118022**

Table 115: Mixed (residual) waste collected, by waste materials, 2017, in kg/cap

Country	Country-Code	Food	Garden	Other biowastes	Wood	Paper / Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall Total***	**Total within scope**
Bulgaria	BG	68	50	0	6	40	8	15	5	30	0	0	0	2	0	38	5	**268**	**266**
Estonia	EE	68	9	3	5	35	12	13	11	45	5	0	0	4	0	10	33	**251**	**243**
Greece	EL	170	11	0	19	88	0	16	14	56	0	0	0	0	0	0	31	**405**	**405**
Croatia	HR	81	21	1	3	74	9	15	6	60	2	9	0	0	0	0	25	**307**	**295**
Cyprus	CY	191	64	0	14	87	37	16	6	80	0	0	0	0	0	8	17	**520**	**520**
Latvia	LV	65	18	5	7	46	10	25	7	27	0	1	0	0	54	11	14	**291**	**289**
Lithuania	LT	38	18	32	3	21	19	14	6	35	1	0	0	1	0	39	60	**288**	**285**
Hungary	HU	65	16	0	0	41	10	8	7	51	0	0	0	2	46	17	28	**292**	**290**
Malta	MT	262	11	0	4	83	20	22	18	66	2	0	0	1	10	0	64	**563**	**560**
Poland	PL	53	24	0	1	22	7	16	5	29	0	0	0	2	31	13	27	**230**	**227**
Romania	RO	99	31	0	5	25	2	10	7	29	1	0	0	0	0	0	2	**209**	**208**
Slovakia	SK	57	31	0	5	17	6	10	5	20	0	6	0	2	0	3	22	**184**	**177**
Czech Republic	CZ	77	11	0	17	22	12	10	5	27	0	0	0	0	0	10	20	**211**	**211**
Denmark	DK	174	28	0	0	78	0	9	10	46	1	0	1	0	0	9	57	**411**	**409**
Ireland	IE	72	22	0	0	61	28	15	8	52	0	0	0	5	46	0	56	**366**	**361**
Spain	ES	169	34	0	6	41	21	19	13	36	0	0	0	0	0	0	39	**378**	**378**
France	FR	88	11	0	15	50	11	17	10	46	5	0	0	2	19	10	23	**307**	**299**
Portugal	PT	141	26	24	3	46	18	15	8	43	1	0	0	1	55	0	51	**431**	**429**
Finland	FI	69	28	7	11	59	11	7	7	55	2	7	1	1	0	6	28	**298**	**288**
Sweden	SE	62	20	0	25	44	7	4	6	35	4	0	0	0	0	0	30	**237**	**232**
Belgium	BE	29	8	0	7	17	7	3	2	17	0	0	0	1	2	12	64	**172**	**170**
Italy	IT	35	19	0	3	49	14	8	7	41	0	0	0	0	0	4	51	**230**	**230**
Luxembourg	LU	79	7	0	2	55	9	8	6	52	1	0	0	3	20	3	45	**290**	**286**
Netherlands	NL	49	12	25	9	46	11	12	9	33	0	0	0	0	0	0	32	**238**	**238**
Austria	AT	28	0	0	0	20	14	8	7	34	0	0	0	3	14	10	58	**196**	**193**
Slovenia	SI	25	19	5	12	38	4	13	9	23	3	0	0	1	0	0	45	**196**	**193**
United Kingdom	UK	70	27	0	5	40	11	11	7	37	6	0	0	3	6	0	46	**270**	**262**
Cluster 1		**80**	**25**	**1**	**5**	**36**	**7**	**14**	**7**	**36**	**0**	**1**	**0**	**1**	**17**	**11**	**22**	**261**	**258**
Cluster 2		**114**	**21**	**2**	**11**	**46**	**14**	**16**	**10**	**41**	**3**	**0**	**0**	**1**	**13**	**5**	**32**	**330**	**326**
EU27 (w/o DE)		**83**	**20**	**2**	**7**	**42**	**12**	**13**	**8**	**38**	**1**	**0**	**0**	**1**	**11**	**7**	**34**	**280**	**278**
EU28 (w/o DE)		**81**	**21**	**2**	**7**	**42**	**11**	**13**	**8**	**38**	**2**	**0**	**0**	**1**	**10**	**6**	**36**	**279**	**275**

Table 116: Mixed (residual) waste not collected, by waste materials, 2017, in 1,000 tons

Country	Country-Code	Food	Garden	Other biowastes	Wood	Paper / Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall Total***	**Total within scope**
Estonia	EE	2	0	0	0	1	0	0	0	1	*0*	*0*	*0*	*0*	0	0	1	**7**	**6**
Croatia	HR	5	1	0	0	4	1	1	0	4	*0*	*1*	*0*	*0*	0	0	1	**19**	**18**
Romania	RO	204	64	0	10	51	4	21	14	59	*3*	*0*	*0*	*0*	0	0	5	**433**	**431**
Ireland	IE	9	3	0	0	7	3	2	1	6	*0*	*0*	*0*	*1*	6	0	7	**45**	**44**
Cluster 1		**211**	**65**	**0**	**10**	**56**	**5**	**22**	**14**	**64**	***3***	***1***	***0***	***0***	**0**	**0**	**7**	**459**	**455**
Cluster 2		**9**	**3**	**0**	**0**	**7**	**3**	**2**	**1**	**6**	***0***	***0***	***0***	***1***	**6**	**0**	**7**	**45**	**44**
EU27 (w/o DE)		**220**	**68**	**0**	**10**	**64**	**9**	**24**	**15**	**70**	***3***	***1***	***0***	***1***	**6**	**0**	**14**	**503**	**499**
EU28 (w/o DE)		**220**	**68**	**0**	**10**	**64**	**9**	**24**	**15**	**70**	***3***	***1***	***0***	***1***	**6**	**0**	**14**	**503**	**499**

Note: Uncollected waste is assumed as being landfilled; this is considered by adding these amounts to direct landfill under final treatment (Table 135).

Table 117: Mixed (residual) waste not collected, by waste materials, 2017, in kg/cap

Country	Country-Code	Food	Garden	Other biowastes	Wood	Paper / Cardboard	Textiles	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall Total***	**Total within scope**
Estonia	EE	1	0	0	0	1	0	0	0	1	*0*	*0*	*0*	*0*	0	0	1	**5**	**5**
Croatia	HR	1	0	0	0	1	0	0	0	1	*0*	*0*	*0*	*0*	0	0	0	**4**	**4**
Romania	RO	10	3	0	0	3	0	1	1	3	*0*	*0*	*0*	*0*	0	0	0	**22**	**22**
Ireland	IE	2	1	0	0	2	1	0	0	1	*0*	*0*	*0*	*0*	1	0	1	**9**	**9**
Cluster 1		**2**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	***0***	***0***	***0***	***0***	**0**	**0**	**0**	**4**	**4**
Cluster 2		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	***0***	***0***	***0***	***0***	**0**	**0**	**0**	**0**	**0**
EU27 (w/o DE)		**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	***0***	***0***	***0***	***0***	**0**	**0**	**0**	**1**	**1**
EU28 (w/o DE)		**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	***0***	***0***	***0***	***0***	**0**	**0**	**0**	**1**	**1**

Note: Uncollected waste is assumed as being landfilled; this is considered by adding these amounts to direct landfill under final treatment (Table 136).

Table 118: Treatment of mixed (residual) waste collected, by treatment categories, 2017, in 1,000 tons

Country	Country-Code	MBT	MBT 1	MBT 2	MBT 3	MBT 4	MBT 5	INC	INC 1	INC 2	INC 3	INC 4	LF	Total
Bulgaria	BG	691	484	0	0	207	0	83	0	83	0	0	1119	1893
Estonia	EE	52	0	52	0	0	0	243	0	243	0	0	25	320
Greece	EL	480	409	72	0	0	0	0	0	0	0	0	3883	4364
Croatia	HR	119	0	119	0	0	0	0	0	0	0	0	1106	1225
Cyprus	CY	194	158	0	0	0	36	0	0	0	0	0	251	445
Latvia	LV	113	87	0	0	0	26	0	0	0	0	0	451	564
Lithuania	LT	440	173	0	127	96	43	0	0	0	0	0	373	813
Hungary	HU	2481	695	0	0	0	1786	358	0	358	0	0	0	2839
Malta	MT	79	0	0	0	79	0	0	0	0	0	0	178	258
Poland	PL	7233	2531	723	723	2170	1085	432	0	432	0	0	972	8636
Romania	RO	227	0	0	0	0	227	0	0	0	0	0	3863	4091
Slovakia	SK	36	0	0	0	0	36	105	105	0	0	0	819	959
Czech Republic	CZ	132	0	0	0	0	132	473	0	473	0	0	1622	2227
Denmark	DK	0	0	0	0	0	0	2260	353	1907	0	0	90	2350
Ireland	IE	229	114	0	0	0	114	443	443	0	0	0	1055	1726
Spain	ES	11812	8387	0	0	3426	0	2025	2025	0	0	0	3727	17564
France	FR	1289	0	0	0	1289	0	11759	11759	0	0	0	6937	19985
Portugal	PT	1717	0	0	1374	343	0	1041	1041	0	0	0	1662	4420
Finland	FI	177	0	0	0	52	125	1209	0	1209	0	0	197	1583
Sweden	SE	0	0	0	0	0	0	2281	0	2213	68	0	39	2321
Belgium	BE	168	0	106	0	0	62	1751	1576	140	0	35	15	1934
Italy	IT	9553	9553	0	0	0	0	3765	2146	1619	0	0	628	13945
Luxembourg	LU	24	24	0	0	0	0	115	115	0	0	0	30	169
Netherlands	NL	355	0	0	0	355	0	3612	0	3612	0	0	94	4061
Austria	AT	461	203	212	0	0	46	1208	72	785	350	0	24	1692
Slovenia	SI	358	197	0	0	161	0	0	0	0	0	0	40	398
United Kingdom	UK	5767	634	2134	0	1326	1672	6708	5031	1677	0	0	4766	17241
Cluster 1		12145	4537	965	851	2552	3240	1220	105	1115	0	0	13040	26406
Cluster 2		15357	8501	0	1374	5111	371	21491	15620	5802	68	0	15329	52176
EU27 (w/o DE)		38420	23014	1283	2225	8179	3719	33163	19635	13074	419	35	29199	100781
EU28 (w/o DE)		44186	23648	3417	2225	9506	5391	39871	24666	14751	419	35	33965	118022

Table 119: Treatment of mixed (residual) waste collected, by treatment categories, 2017, in kg/cap

Country	Country-Code	MBT	MBT 1	MBT 2	MBT 3	MBT 4	MBT 5	INC	INC 1	INC 2	INC 3	INC 4	LF	Total
Bulgaria	BG	**97**	68	0	0	29	0	**12**	0	12	0	0	158	**266**
Estonia	EE	**39**	0	39	0	0	0	**185**	0	185	0	0	19	**243**
Greece	EL	**45**	38	7	0	0	0	**0**	0	0	0	0	361	**405**
Croatia	HR	**29**	0	29	0	0	0	**0**	0	0	0	0	266	**295**
Cyprus	CY	**227**	185	0	0	0	42	**0**	0	0	0	0	293	**520**
Latvia	LV	**58**	45	0	0	0	13	**0**	0	0	0	0	231	**289**
Lithuania	LT	**154**	61	0	45	34	15	**0**	0	0	0	0	131	**285**
Hungary	HU	**253**	71	0	0	0	182	**36**	0	36	0	0	0	**290**
Malta	MT	**173**	0	0	0	173	0	**0**	0	0	0	0	388	**560**
Poland	PL	**190**	67	19	19	57	29	**11**	0	11	0	0	26	**227**
Romania	RO	**12**	0	0	0	0	12	**0**	0	0	0	0	197	**208**
Slovakia	SK	**7**	0	0	0	0	7	**19**	19	0	0	0	151	**177**
Czech Republic	CZ	**12**	0	0	0	0	12	**45**	0	45	0	0	153	**211**
Denmark	DK	**0**	0	0	0	0	0	**393**	61	332	0	0	16	**409**
Ireland	IE	**48**	24	0	0	0	24	**93**	93	0	0	0	221	**361**
Spain	ES	**254**	180	0	0	74	0	**44**	44	0	0	0	80	**378**
France	FR	**19**	0	0	0	19	0	**176**	176	0	0	0	104	**299**
Portugal	PT	**167**	0	0	133	33	0	**101**	101	0	0	0	161	**429**
Finland	FI	**32**	0	0	0	10	23	**220**	0	220	0	0	36	**288**
Sweden	SE	**0**	0	0	0	0	0	**228**	0	221	7	0	4	**232**
Belgium	BE	**15**	0	9	0	0	5	**154**	139	12	0	3	1	**170**
Italy	IT	**158**	158	0	0	0	0	**62**	35	27	0	0	10	**230**
Luxembourg	LU	**40**	40	0	0	0	0	**195**	195	0	0	0	51	**286**
Netherlands	NL	**21**	0	0	0	21	0	**211**	0	211	0	0	5	**238**
Austria	AT	**52**	23	24	0	0	5	**138**	8	90	40	0	3	**193**
Slovenia	SI	**173**	95	0	0	78	0	**0**	0	0	0	0	19	**193**
United Kingdom	UK	**88**	10	32	0	20	25	**102**	76	25	0	0	72	**262**
Cluster 1		**119**	**44**	**9**	**8**	**25**	**32**	**12**	**1**	**11**	**0**	**0**	**127**	**258**
Cluster 2		**96**	**53**	**0**	**9**	**32**	**2**	**134**	**97**	**36**	**0**	**0**	**96**	**326**
EU27 (w/o DE)		**106**	**63**	**4**	**6**	**23**	**10**	**91**	**54**	**36**	**1**	**0**	**80**	**278**
EU28 (w/o DE)		**103**	**55**	**8**	**5**	**22**	**13**	**93**	**58**	**34**	**1**	**0**	**79**	**275**

Table 120: Outputs from MBT, by treatment categories, 2017, in 1,000 tons

Country	Country-Code	Landfill	Energy recovery	Land recovery	Recycling	Mass loss	**Total**
Bulgaria	BG	324	0	146	17	204	**691**
Estonia	EE	4	38	0	1	8	**52**
Greece	EL	167	49	87	16	161	**480**
Croatia	HR	9	86	0	2	23	**119**
Cyprus	CY	64	34	34	6	57	**194**
Latvia	LV	49	24	15	4	21	**113**
Lithuania	LT	175	134	41	12	77	**440**
Hungary	HU	1809	280	103	133	155	**2481**
Malta	MT	33	0	18	3	25	**79**
Poland	PL	2655	2065	891	202	1420	**7233**
Romania	RO	0	214	0	13	0	**227**
Slovakia	SK	0	34	0	2	0	**36**
Czech Republic	CZ	4	121	0	6	0	**132**
Denmark	DK	0	0	0	0	0	**0**
Ireland	IE	67	107	18	10	26	**229**
Spain	ES	4729	0	2545	362	4177	**11812**
France	FR	595	0	285	47	363	**1289**
Portugal	PT	223	985	80	37	393	**1717**
Finland	FI	27	113	11	11	15	**177**
Sweden	SE	0	0	0	0	0	**0**
Belgium	BE	8	145	0	3	12	**168**
Italy	IT	5476	0	1579	342	2156	**9553**
Luxembourg	LU	13	0	4	1	6	**24**
Netherlands	NL	170	0	74	13	98	**355**
Austria	AT	155	218	23	16	49	**461**
Slovenia	SI	200	0	64	14	79	**358**
United Kingdom	UK	1122	3135	385	203	922	**5767**
Cluster 1		**5290**	**2958**	**1336**	**410**	**2151**	**12145**
Cluster 2		**5644**	**1327**	**2939**	**474**	**4974**	**15357**
EU27 (w/o DE)		**16955**	**4648**	**6020**	**1274**	**9524**	**38420**
EU28 (w/o DE)		**18077**	**7783**	**6404**	**1476**	**10447**	**44186**

Table 121: Outputs from MBT, by treatment categories, 2017, in kg/cap

Country	Country-Code	Landfill	Energy recovery	Land recovery	Recycling	Mass loss	**Total**
Bulgaria	BG	46	0	21	2	29	**97**
Estonia	EE	3	29	0	1	6	**39**
Greece	EL	16	5	8	2	15	**45**
Croatia	HR	2	21	0	0	5	**29**
Cyprus	CY	74	40	40	7	66	**227**
Latvia	LV	25	12	8	2	11	**58**
Lithuania	LT	61	47	15	4	27	**154**
Hungary	HU	185	29	11	14	16	**253**
Malta	MT	72	0	39	6	55	**173**
Poland	PL	70	54	23	5	37	**190**
Romania	RO	0	11	0	1	0	**12**
Slovakia	SK	0	6	0	0	0	**7**
Czech Republic	CZ	0	11	0	1	0	**12**
Denmark	DK	0	0	0	0	0	**0**
Ireland	IE	14	22	4	2	6	**48**
Spain	ES	102	0	55	8	90	**254**
France	FR	9	0	4	1	5	**19**
Portugal	PT	22	96	8	4	38	**167**
Finland	FI	5	21	2	2	3	**32**
Sweden	SE	0	0	0	0	0	**0**
Belgium	BE	1	13	0	0	1	**15**
Italy	IT	90	0	26	6	36	**158**
Luxembourg	LU	22	0	7	1	10	**40**
Netherlands	NL	10	0	4	1	6	**21**
Austria	AT	18	25	3	2	6	**52**
Slovenia	SI	97	0	31	7	38	**173**
United Kingdom	UK	17	48	6	3	14	**88**
Cluster 1		**52**	**29**	**13**	**4**	**21**	**119**
Cluster 2		**35**	**8**	**18**	**3**	**31**	**96**
5		**47**	**13**	**17**	**4**	**26**	**106**
EU28 (w/o DE)		**42**	**18**	**15**	**3**	**24**	**103**

A.3.2 Organic waste

Table 122: Organic waste (separately) collected, by waste materials, 2017, in 1,000 tons

Country	Country-Code	Food	Garden	Other biowastes	Total
Bulgaria	BG	139	117	0	256
Estonia	EE	13	6	1	20
Greece	EL	27	63	0	91
Croatia	HR	7	36	5	48
Cyprus	CY	0	4	0	4
Latvia	LV	1	2	57	61
Lithuania	LT	11	136	5	151
Hungary	HU	54	221	0	275
Malta	MT	0	0	0	1
Poland	PL	313	572	0	885
Romania	RO	80	290	0	370
Slovakia	SK	12	211	1	225
Czech Republic	CZ	22	249	0	271
Denmark	DK	110	852	0	963
Ireland	IE	94	51	0	144
Spain	ES	658	222	0	880
France	FR	933	5285	0	6218
Portugal	PT	27	76	9	112
Finland	FI	241	107	23	371
Sweden	SE	433	248	0	681
Belgium	BE	116	595	229	941
Italy	IT	3636	1943	649	6228
Luxembourg	LU	35	53	0	88
Netherlands	NL	325	1507	597	2429
Austria	AT	520	1142	0	1662
Slovenia	SI	76	73	2	151
United Kingdom	UK	579	3206	697	4481
Cluster 1		659	1660	**69**	2388
Cluster 2		2519	7088	**32**	9639
EU27 (w/o DE)		**7886**	**14062**	**1578**	**23526**
EU28 (w/o DE)		**8465**	**17268**	**2275**	**28007**

Table 123: Organic waste (separately) collected, by waste materials, 2017, in kg/cap

Country	Country-Code	Food	Garden	Other biowastes	**Total**
Bulgaria	BG	20	17	0	**36**
Estonia	EE	10	5	0	**15**
Greece	EL	3	6	0	**8**
Croatia	HR	2	9	1	**12**
Cyprus	CY	0	4	0	**4**
Latvia	LV	1	1	29	**31**
Lithuania	LT	4	48	2	**53**
Hungary	HU	6	23	0	**28**
Malta	MT	1	1	0	**2**
Poland	PL	8	15	0	**23**
Romania	RO	4	15	0	**19**
Slovakia	SK	2	39	0	**41**
Czech Republic	CZ	2	23	0	**26**
Denmark	DK	19	148	0	**167**
Ireland	IE	20	11	0	**30**
Spain	ES	14	5	0	**19**
France	FR	14	79	0	**93**
Portugal	PT	3	7	1	**11**
Finland	FI	44	19	4	**67**
Sweden	SE	43	25	0	**68**
Belgium	BE	10	52	20	**83**
Italy	IT	60	32	11	**103**
Luxembourg	LU	59	90	0	**149**
Netherlands	NL	19	88	35	**142**
Austria	AT	59	130	0	**189**
Slovenia	SI	37	36	1	**73**
United Kingdom	UK	9	49	11	**68**
Cluster 1		6	16	1	**23**
Cluster 2		16	44	0	**60**
EU27 (w/o DE)		**22**	**39**	**4**	**65**
EU28 (w/o DE)		**20**	**40**	**5**	**65**

Table 124: Organic waste treatment - Food in 1,000 t

No.	Cluster	Country	Country-Code	Open Air Windrow	In-Vessel Composting	Anaerobic Digestion	AD 1	AD 2	AD 3	AD 4	AD 5	Total
2	1	Bulgaria	BG	36	36	67	0	67	0	0	0	139
6	1	Estonia	EE	3	11	0	0	0	0	0	0	13
8	1	Greece	EL	0	27	0	0	0	0	0	0	27
11	1	Croatia	HR	7	0	0	0	0	0	0	0	7
13	1	Cyprus	CY	0	0	0	0	0	0	0	0	0
14	1	Latvia	LV	1	0	0	0	0	0	0	0	1
15	1	Lithuania	LT	6	3	2	0	2	0	0	0	11
17	1	Hungary	HU	27	27	0	0	0	0	0	0	54
18	1	Malta	MT	0	0	0	0	0	0	0	0	0
21	1	Poland	PL	313	0	0	0	0	0	0	0	313
23	1	Romania	RO	70	10	0	0	0	0	0	0	80
25	1	Slovakia	SK	9	0	2	0	2	0	0	0	12
3	2	Czech Republic	CZ	6	11	6	0	6	0	0	0	22
4	2	Denmark	DK	11	73	26	16	1	10	0	0	110
7	2	Ireland	IE	12	70	11	0	11	0	0	0	94
9	2	Spain	ES	329	0	329	0	329	0	0	0	658
10	2	France	FR	0	915	19	19	0	0	0	0	933
22	2	Portugal	PT	7	7	13	13	0	0	0	0	27
26	2	Finland	FI	27	145	70	0	48	0	18	4	241
27	2	Sweden	SE	39	43	351	29	13	64	233	13	433
1	3	Belgium	BE	0	0	116	0	116	0	0	0	116
5	3	Germany	DE	1124	1124	250	0	250	0	0	0	2497
12	3	Italy	IT	0	2182	1454	1338	0	29	87	0	3636
16	3	Luxembourg	LU	0	0	35	0	12	23	0	0	35
19	3	Netherlands	NL	137	120	68	68	0	0	0	0	325
20	3	Austria	AT	135	135	250	119	119	10	2	0	520
24	3	Slovenia	SI	20	24	32	0	32	0	0	0	76
28	3	United Kingdom	UK	12	98	469	0	469	0	0	0	579
29		Cluster 1		473	115	71	0	71	0	0	0	659
30		Cluster 3		430	1264	825	76	408	74	251	17	2519
31		Cluster 3		1427	3683	2673	1525	997	62	90	0	7784
32		EU27 (w/o UK)		2318	4963	3101	1602	1007	135	340	17	10383
33		EU28		2330	5062	3570	1602	1476	135	340	17	10961
32 a		**EU27 (w/o DE)**		1195	3840	2851	1602	757	135	340	17	7886
33 a		**EU28 (w/o DE)**		1206	3938	3320	1602	1226	135	340	17	8465

Table 125: Organic waste treatment - Garden in 1,000 t

No.	Cluster	Country	Country-Code	Open Air Windrow	In-Vessel Composting	Anaerobic Digestion	AD 1	AD 2	AD 3	AD 4	AD 5	**Total**
2	1	Bulgaria	BG	45	45	28	0	28	0	0	0	117
6	1	Estonia	EE	1	5	0	0	0	0	0	0	6
8	1	Greece	EL	51	13	0	0	0	0	0	0	63
11	1	Croatia	HR	36	0	0	0	0	0	0	0	36
13	1	Cyprus	CY	3	1	0	0	0	0	0	0	4
14	1	Latvia	LV	2	0	0	0	0	0	0	0	2
15	1	Lithuania	LT	95	0	41	0	41	0	0	0	136
17	1	Hungary	HU	177	44	0	0	0	0	0	0	221
18	1	Malta	MT	0	0	0	0	0	0	0	0	0
21	1	Poland	PL	458	114	0	0	0	0	0	0	572
23	1	Romania	RO	254	36	0	0	0	0	0	0	290
25	1	Slovakia	SK	211	0	0	0	0	0	0	0	211
3	2	Czech Republic	CZ	124	124	0	0	0	0	0	0	249
4	2	Denmark	DK	767	85	0	0	0	0	0	0	852
7	2	Ireland	IE	47	4	0	0	0	0	0	0	51
9	2	Spain	ES	122	89	11	0	11	0	0	0	222
10	2	France	FR	0	5179	106	106	0	0	0	0	5285
22	2	Portugal	PT	29	29	18	18	0	0	0	0	76
26	2	Finland	FI	12	64	31	0	21	0	8	2	107
27	2	Sweden	SE	124	124	0	0	0	0	0	0	248
1	3	Belgium	BE	536	54	6	0	6	0	0	0	595
5	3	Germany	DE	2975	2975	661	0	661	0	0	0	6612
12	3	Italy	IT	777	1166	0	0	0	0	0	0	1943
16	3	Luxembourg	LU	47	0	6	0	2	4	0	0	53
19	3	Netherlands	NL	1507	0	0	0	0	0	0	0	1507
20	3	Austria	AT	531	531	80	38	38	3	1	0	1142
24	3	Slovenia	SI	19	24	30	0	30	0	0	0	73
28	3	United Kingdom	UK	2784	372	50	0	50	0	0	0	3206
29		Cluster 1		1332	258	70	1	69	0	0	0	1660
30		Cluster 2		1225	5697	166	124	32	0	8	2	7088
31		Cluster 3		9177	5122	833	38	788	7	1	0	15132
32		EU27 (w/o UK)		8949	10706	1019	162	839	7	9	2	20674
33		EU28		11734	11077	1069	162	889	7	9	2	23880
32 a		**EU27 (w/o DE)**		5974	7730	357	162	177	7	9	2	14062
33 a		**EU28 (w/o DE)**		8758	8102	408	162	228	7	9	2	17268

Table 126: Organic waste treatment - other in 1,000 t

No.	Cluster	Country	Country-Code	Open Air Windrow	In-Vessel Composting	Anaerobic Digestion	AD 1	AD 2	AD 3	AD 4	AD 5	**Total**
2	1	Bulgaria	BG	0	0	0	0	0	0	0	0	0
6	1	Estonia	EE	0	0	0	0	0	0	0	0	1
8	1	Greece	EL	0	0	0	0	0	0	0	0	0
11	1	Croatia	HR	5	0	0	0	0	0	0	0	5
13	1	Cyprus	CY	0	0	0	0	0	0	0	0	0
14	1	Latvia	LV	57	0	0	0	0	0	0	0	57
15	1	Lithuania	LT	2	2	1	0	1	0	0	0	5
17	1	Hungary	HU	0	0	0	0	0	0	0	0	0
18	1	Malta	MT	0	0	0	0	0	0	0	0	0
21	1	Poland	PL	0	0	0	0	0	0	0	0	0
23	1	Romania	RO	0	0	0	0	0	0	0	0	0
25	1	Slovakia	SK	1	0	1	0	1	0	0	0	1
3	2	Czech Republic	CZ	0	0	0	0	0	0	0	0	0
4	2	Denmark	DK	0	0	0	0	0	0	0	0	0
7	2	Ireland	IE	0	0	0	0	0	0	0	0	0
9	2	Spain	ES	0	0	0	0	0	0	0	0	0
10	2	France	FR	0	0	0	0	0	0	0	0	0
22	2	Portugal	PT	3	3	3	3	0	0	0	0	9
26	2	Finland	FI	3	14	7	0	5	0	2	0	23
27	2	Sweden	SE	0	0	0	0	0	0	0	0	0
1	3	Belgium	BE	160	0	69	0	69	0	0	0	229
5	3	Germany	DE	0	0	0	0	0	0	0	0	0
12	3	Italy	IT	32	357	259	239	0	5	16	0	649
16	3	Luxembourg	LU	0	0	0	0	0	0	0	0	0
19	3	Netherlands	NL	197	197	203	203	0	0	0	0	597
20	3	Austria	AT	0	0	0	0	0	0	0	0	0
24	3	Slovenia	SI	0	0	2	0	2	0	0	0	2
28	3	United Kingdom	UK	109	539	49	0	49	0	0	0	697
29		Cluster 1		65	3	2	0	2	0	0	0	69
30		Cluster 2		5	17	10	3	5	0	2	0	32
31		Cluster 3		498	1093	582	442	119	5	16	0	2173
32		EU27 (w/o UK)		460	573	544	445	77	5	17	0	1578
33		EU28		569	1112	593	445	126	5	17	0	2275
32 a		**EU27 (w/o DE)**		460	573	544	445	77	5	17	0	1578
33 a		**EU28 (w/o DE)**		569	1112	593	445	126	5	17	0	2275

Table 127: Municipal organic waste treatment, by treatment categories, 2017, in 1,000 tons

Country	Country-Code	Open Air Windrow	In-Vessel Composting	Anaerobic Digestion	AD 1	AD 2	AD 3	AD 4	AD 5	Total
Bulgaria	BG	**81**	**81**	**95**	0	95	0	0	0	256
Estonia	EE	**4**	**16**	**0**	0	0	0	0	0	20
Greece	EL	**51**	**40**	**0**	0	0	0	0	0	91
Croatia	HR	**48**	**0**	**1**	1	0	0	0	0	48
Cyprus	CY	**3**	**1**	**0**	0	0	0	0	0	4
Latvia	LV	**61**	**0**	**0**	0	0	0	0	0	61
Lithuania	LT	**102**	**6**	**43**	0	43	0	0	0	151
Hungary	HU	**204**	**71**	**0**	0	0	0	0	0	275
Malta	MT	**0**	**0**	**0**	0	0	0	0	0	1
Poland	PL	**771**	**114**	**0**	0	0	0	0	0	885
Romania	RO	**324**	**46**	**0**	0	0	0	0	0	370
Slovakia	SK	**221**	**0**	**3**	0	3	0	0	0	225
Czech Republic	CZ	**130**	**135**	**6**	0	6	0	0	0	271
Denmark	DK	**778**	**158**	**26**	16	1	10	0	0	963
Ireland	IE	**59**	**74**	**11**	0	11	0	0	0	144
Spain	ES	**451**	**89**	**340**	0	340	0	0	0	880
France	FR	**0**	**6094**	**124**	124	0	0	0	0	6218
Portugal	PT	**39**	**39**	**34**	34	0	0	0	0	112
Finland	FI	**41**	**223**	**108**	0	74	0	27	6	371
Sweden	SE	**163**	**167**	**351**	29	13	64	233	13	681
Belgium	BE	**696**	**54**	**191**	0	191	0	0	0	941
Italy	IT	**810**	**3704**	**1714**	1577	0	34	103	0	6228
Luxembourg	LU	**48**	**0**	**41**	0	14	27	0	0	88
Netherlands	NL	**1840**	**317**	**271**	271	0	0	0	0	2429
Austria	AT	**666**	**666**	**330**	157	157	13	3	0	1662
Slovenia	SI	**39**	**48**	**64**	0	64	0	0	0	151
United Kingdom	UK	**2904**	**1009**	**568**	0	568	0	0	0	4481
Cluster 1		**1870**	**375**	**143**	1	142	0	0	0	2388
Cluster 2		**1661**	**6978**	**1001**	203	445	74	260	19	9639
EU27 (w/o DE)		**7629**	**12143**	**3753**	**2209**	**1012**	**148**	**366**	**19**	**23526**
EU28 (w/o DE)		**10534**	**13152**	**4321**	**2209**	**1580**	**148**	**366**	**19**	**28007**

Table 128: Municipal organic waste treatment, by treatment categories, 2017, in kg/cap

Country	Country-Code	Open Air Windrow	In-Vessel Composting	Anaerobic Digestion	AD 1	AD 2	AD 3	AD 4	AD 5	Total
Bulgaria	BG	**11**	**11**	**13**	0	13	0	0	0	36
Estonia	EE	**3**	**12**	**0**	0	0	0	0	0	15
Greece	EL	**5**	**4**	**0**	0	0	0	0	0	8
Croatia	HR	**11**	**0**	**0**	0	0	0	0	0	12
Cyprus	CY	**4**	**1**	**0**	0	0	0	0	0	4
Latvia	LV	**31**	**0**	**0**	0	0	0	0	0	31
Lithuania	LT	**36**	**2**	**15**	0	15	0	0	0	53
Hungary	HU	**21**	**7**	**0**	0	0	0	0	0	28
Malta	MT	**0**	**0**	**1**	1	0	0	0	0	2
Poland	PL	**20**	**3**	**0**	0	0	0	0	0	23
Romania	RO	**16**	**2**	**0**	0	0	0	0	0	19
Slovakia	SK	**41**	**0**	**1**	0	1	0	0	0	41
Czech Republic	CZ	**12**	**13**	**1**	0	1	0	0	0	26
Denmark	DK	**135**	**27**	**5**	3	0	2	0	0	167
Ireland	IE	**12**	**15**	**2**	0	2	0	0	0	30
Spain	ES	**10**	**2**	**7**	0	7	0	0	0	19
France	FR	**0**	**91**	**2**	2	0	0	0	0	93
Portugal	PT	**4**	**4**	**3**	3	0	0	0	0	11
Finland	FI	**7**	**40**	**20**	0	13	0	5	1	67
Sweden	SE	**16**	**17**	**35**	3	1	6	23	1	68
Belgium	BE	**61**	**5**	**17**	0	17	0	0	0	83
Italy	IT	**13**	**61**	**28**	26	0	1	2	0	103
Luxembourg	LU	**81**	**0**	**69**	0	23	45	0	0	149
Netherlands	NL	**108**	**19**	**16**	16	0	0	0	0	142
Austria	AT	**76**	**76**	**38**	18	18	2	0	0	189
Slovenia	SI	**19**	**23**	**31**	0	31	0	0	0	73
United Kingdom	UK	**44**	**15**	**9**	0	9	0	0	0	68
Cluster 1		**18**	**4**	**1**	0	1	0	0	0	23
Cluster 2		**10**	**44**	**6**	1	3	0	2	0	60
EU27 (w/o DE)		**21**	**33**	**10**	**6**	**3**	**0**	**1**	**0**	**65**
EU28 (w/o DE)		**25**	**31**	**10**	**5**	**4**	**0**	**1**	**0**	**65**

A.3.3 Dry recyclables waste and residue calculation for all separately collected fractions (incl. organic waste)

Table 129: Dry recyclables collected, by waste materials, 2017, in 1,000 tons

Country	Country-Code	Wood	Paper/ Cardboard	*Textiles*	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall Total***	**Total within scope**
Bulgaria	BG	25	368	*3*	91	63	129	*135*	*5*	*1*	*15*	0	0	84	**919**	**760**
Estonia	EE	2	71	*3*	31	15	19	*5*	*0*	*0*	*1*	0	0	9	**156**	**147**
Greece	EL	0	546	*0*	86	88	154	*0*	*0*	*0*	*0*	0	0	87	**961**	**961**
Croatia	HR	6	174	*2*	41	12	44	*18*	*0*	*0*	*0*	0	0	80	**376**	**356**
Cyprus	CY	0	61	*1*	8	13	12	*3*	*0*	*0*	*0*	0	0	0	**99**	**95**
Latvia	LV	8	114	*0*	22	2	14	*2*	*9*	*0*	*0*	0	0	0	**170**	**159**
Lithuania	LT	6	106	*6*	53	70	26	*16*	*0*	*0*	*0*	0	3	27	**315**	**292**
Hungary	HU	19	266	*8*	44	123	80	*23*	*0*	*0*	*0*	4	1	64	**633**	**602**
Malta	MT	0	19	*0*	5	3	5	*2*	*0*	*0*	*0*	0	0	1	**36**	**33**
Poland	PL	0	556	*36*	618	93	390	*0*	*0*	*0*	*1*	0	0	660	**2354**	**2317**
Romania	RO	5	132	*1*	48	27	88	*24*	*0*	*0*	*0*	0	0	88	**415**	**390**
Slovakia	SK	25	297	*17*	197	94	119	*24*	*37*	*1*	*1*	0	1	17	**831**	**751**
Czech Republic	CZ	14	480	*30*	195	92	289	*21*	*0*	*0*	*0*	0	8	16	**1145**	**1094**
Denmark	DK	159	454	*0*	205	165	67	*70*	*0*	*8*	*0*	0	0	55	**1184**	**1106**
Ireland	IE	84	359	*20*	147	58	84	*69*	*0*	*0*	*0*	0	0	0	**821**	**732**
Spain	ES	121	1669	*67*	1058	156	351	*0*	*0*	*0*	*0*	0	0	153	**3574**	**3507**
France	FR	0	1367	*0*	3285	1366	1366	*1089*	*0*	*0*	*0*	0	0	0	**8473**	**7384**
Portugal	PT	11	162	*1*	138	12	82	*3*	*0*	*0*	*0*	10	0	40	**460**	**456**
Finland	FI	3	492	*6*	78	115	34	*64*	*0*	*0*	*0*	0	0	8	**801**	**730**
Sweden	SE	0	671	*10*	188	172	103	*111*	*0*	*8*	*4*	0	0	238	**1505**	**1372**
Belgium	BE	222	639	*79*	324	105	158	*90*	*0*	*3*	*19*	0	1	139	**1779**	**1588**
Italy	IT	765	4165	*291*	1925	434	1482	*246*	*0*	*0*	*0*	0	0	89	**9397**	**8861**
Luxembourg	LU	13	34	*4*	21	4	2	*6*	*1*	*2*	*1*	0	8	13	**107**	**94**
Netherlands	NL	279	853	*75*	310	88	143	*62*	*77*	*2*	*14*	0	0	389	**2291**	**2061**
Austria	AT	255	689	*35*	228	126	171	*83*	*0*	*2*	*1*	3	2	40	**1634**	**1514**
Slovenia	SI	42	162	*1*	45	26	26	*7*	*0*	*0*	*4*	0	0	106	**418**	**406**
United Kingdom	UK	776	3306	*192*	1411	680	747	*372*	*643*	*10*	*1*	0	0	501	**8639**	**7421**
Cluster 1		**96**	**2711**	***78***	**1245**	**605**	**1081**	***252***	***51***	***3***	***19***	**4**	**5**	**1118**	**7265**	**6863**
Cluster 2		**392**	**5654**	***134***	**5293**	**2136**	**2377**	***1428***	***0***	***16***	***4***	**10**	**8**	**510**	**17962**	**16380**
EU27 (w/o DE)		**2063**	**14906**	***697***	**9391**	**3523**	**5440**	***2172***	***129***	***28***	***61***	**17**	**24**	**2403**	**40854**	**37767**
EU28 (w/o DE)		**2839**	**18212**	***889***	**10802**	**4203**	**6187**	***2544***	***772***	***38***	***62***	**17**	**24**	**2904**	**49493**	**45188**

Table 130: Dry recyclables collected, by waste materials, 2017, in kg/cap

Country	Country-Code	Wood	Paper/ Cardboard	*Textiles*	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	**Overall Total**	**Total within scope**
Bulgaria	BG	3	52	*0*	13	9	18	*19*	*1*	*0*	*2*	0	0	12	**129**	**107**
Estonia	EE	1	54	*2*	24	11	14	*4*	*0*	*0*	*1*	0	0	7	**119**	**112**
Greece	EL	0	51	*0*	8	8	14	*0*	*0*	*0*	*0*	0	0	8	**89**	**89**
Croatia	HR	1	42	*0*	10	3	11	*4*	*0*	*0*	*0*	0	0	19	**91**	**86**
Cyprus	CY	0	71	*1*	10	15	14	*4*	*0*	*0*	*0*	0	0	0	**116**	**111**
Latvia	LV	4	59	*0*	11	1	7	*1*	*4*	*0*	*0*	0	0	0	**87**	**82**
Lithuania	LT	2	37	*2*	19	25	9	*6*	*0*	*0*	*0*	0	1	10	**111**	**103**
Hungary	HU	2	27	*1*	5	13	8	*2*	*0*	*0*	*0*	0	0	7	**65**	**61**
Malta	MT	0	41	*1*	11	7	11	*4*	*0*	*0*	*0*	0	0	2	**77**	**72**
Poland	PL	0	15	*1*	16	2	10	*0*	*0*	*0*	*0*	0	0	17	**62**	**61**
Romania	RO	0	7	*0*	2	1	4	*1*	*0*	*0*	*0*	0	0	4	**21**	**20**
Slovakia	SK	5	55	*3*	36	17	22	*4*	*7*	*0*	*0*	0	0	3	**153**	**138**
Czech Republic	CZ	1	45	*3*	18	9	27	*2*	*0*	*0*	*0*	0	1	2	**108**	**103**
Denmark	DK	28	79	*0*	36	29	12	*12*	*0*	*1*	*0*	0	0	10	**206**	**192**
Ireland	IE	18	75	*4*	31	12	18	*14*	*0*	*0*	*0*	0	0	0	**172**	**153**
Spain	ES	3	36	*1*	23	3	8	*0*	*0*	*0*	*0*	0	0	3	**77**	**75**
France	FR	0	20	*0*	49	20	20	*16*	*0*	*0*	*0*	0	0	0	**127**	**111**
Portugal	PT	1	16	*0*	13	1	8	*0*	*0*	*0*	*0*	1	0	4	**45**	**44**
Finland	FI	1	89	*1*	14	21	6	*12*	*0*	*0*	*0*	0	0	1	**146**	**133**
Sweden	SE	0	67	*1*	19	17	10	*11*	*0*	*1*	*0*	0	0	24	**151**	**137**
Belgium	BE	20	56	*7*	29	9	14	*8*	*0*	*0*	*2*	0	0	12	**157**	**140**
Italy	IT	13	69	*5*	32	7	24	*4*	*0*	*0*	*0*	0	0	1	**155**	**146**
Luxembourg	LU	21	57	*7*	36	7	3	*10*	*2*	*3*	*2*	0	13	21	**182**	**159**
Netherlands	NL	16	50	*4*	18	5	8	*4*	*5*	*0*	*1*	0	0	23	**134**	**121**
Austria	AT	29	79	*4*	26	14	19	*9*	*0*	*0*	*0*	0	0	5	**186**	**173**
Slovenia	SI	20	78	*0*	22	12	12	*3*	*0*	*0*	*2*	0	0	51	**202**	**197**
United Kingdom	UK	12	50	*3*	21	10	11	*6*	*10*	*0*	*0*	0	0	8	**131**	**113**
Cluster 1		1	26	*1*	12	6	11	*2*	*0*	*0*	*0*	0	0	11	**71**	**67**
Cluster 2		2	35	*1*	33	13	15	*9*	*0*	*0*	*0*	0	0	3	**112**	**102**
EU27 (w/o DE)		**6**	**41**	***2***	**26**	**10**	**15**	***6***	***0***	***0***	***0***	**0**	**0**	**7**	**113**	**104**
EU28 (w/o DE)		**7**	**42**	***2***	**25**	**10**	**14**	***6***	***2***	***0***	***0***	**0**	**0**	**7**	**115**	**105**

Table 131: Recycling and residues for all municipal recyclables, by material, 2017, in 1,000 tons

Country	Country-Code	Stream	Food	Garden	Other biowastes	**Organic waste total**	Wood	Paper /Card-board	*Textiles*	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall total dry recycle-ables***	**Total within scope dry recycle-ables**
Bulgaria	BG	Recycled	132	111	0	**244**	22	317	*3*	86	57	89	*122*	*4*	*1*	*13*	0	0	75	**789**	**646**
		Residues	7	6	0	**13**	2	51	*1*	5	6	41	*14*	*0*	*0*	*1*	0	0	8	**130**	**114**
Estonia	EE	Recycled	13	6	0	**19**	2	61	*2*	29	13	13	*4*	*0*	*0*	*1*	0	0	8	**135**	**127**
		Residues	1	0	0	**1**	0	10	*0*	2	1	6	*0*	*0*	*0*	*0*	0	0	1	**21**	**20**
Greece	EL	Recycled	26	60	0	**86**	0	449	*0*	78	80	110	*0*	*0*	*0*	*0*	0	0	79	**795**	**795**
		Residues	1	3	0	**5**	0	96	*0*	8	9	44	*0*	*0*	*0*	*0*	0	0	9	**165**	**165**
Croatia	HR	Recycled	7	34	5	**46**	5	143	*2*	37	11	31	*17*	*0*	*0*	*0*	0	0	72	**318**	**299**
		Residues	0	2	1	**3**	1	30	*0*	4	1	13	*2*	*0*	*0*	*0*	0	0	8	**58**	**56**
Cyprus	CY	Recycled	0	4	0	**4**	0	50	*1*	8	12	9	*3*	*0*	*0*	*0*	0	0	0	**82**	**78**
		Residues	0	0	0	**0**	0	11	*0*	1	1	3	*0*	*0*	*0*	*0*	0	0	0	**17**	**17**
Latvia	LV	Recycled	1	2	52	**55**	7	98	*0*	21	2	9	*2*	*8*	*0*	*0*	0	0	0	**147**	**137**
		Residues	0	0	6	**6**	1	16	*0*	1	0	4	*0*	*1*	*0*	*0*	0	0	0	**24**	**23**
Lithuania	LT	Recycled	10	129	4	**144**	6	91	*5*	49	64	18	*15*	*0*	*0*	*0*	0	2	25	**274**	**254**
		Residues	1	7	0	**8**	1	16	*1*	4	7	8	*2*	*0*	*0*	*0*	0	0	3	**41**	**38**
Hungary	HU	Recycled	52	210	0	**262**	17	222	*6*	40	111	56	*20*	*0*	*0*	*0*	3	1	58	**536**	**509**
		Residues	3	11	0	**14**	2	44	*1*	4	12	24	*2*	*0*	*0*	*0*	0	0	6	**97**	**93**
Malta	MT	Recycled	0	0	0	**1**	0	15	*0*	5	3	4	*2*	*0*	*0*	*0*	0	0	1	**30**	**27**
		Residues	0	0	0	**0**	0	4	*0*	1	0	1	*0*	*0*	*0*	*0*	0	0	0	**6**	**6**
Poland	PL	Recycled	297	543	0	**841**	0	465	*29*	566	84	274	*0*	*0*	*0*	*1*	0	0	594	**2012**	**1982**
		Residues	16	29	0	**44**	0	92	*7*	52	9	116	*0*	*0*	*0*	*0*	0	0	66	**342**	**335**
Romania	RO	Recycled	76	275	0	**352**	5	108	*1*	43	25	65	*22*	*0*	*0*	*0*	0	0	79	**347**	**324**
		Residues	4	14	0	**19**	1	25	*0*	5	3	24	*2*	*0*	*0*	*0*	0	0	9	**68**	**65**
Slovakia	SK	Recycled	11	201	1	**213**	23	247	*14*	180	85	84	*21*	*34*	*1*	*1*	0	1	15	**706**	**635**
		Residues	1	11	0	**11**	3	49	*3*	18	9	36	*2*	*4*	*0*	*0*	0	0	2	**126**	**116**
Czech Republic	CZ	Recycled	21	236	0	**257**	12	410	*25*	187	83	197	*19*	*0*	*0*	*0*	0	7	15	**955**	**911**
		Residues	1	12	0	**14**	1	70	*4*	8	9	93	*2*	*0*	*0*	*0*	0	1	2	**189**	**183**
Denmark	DK	Recycled	105	810	0	**915**	143	388	*0*	200	149	46	*63*	*0*	*7*	*0*	0	0	50	**1045**	**975**
		Residues	6	43	0	**48**	16	66	*0*	5	16	22	*7*	*0*	*1*	*0*	0	0	6	**138**	**131**
Ireland	IE	Recycled	89	48	0	**137**	76	311	*17*	146	53	59	*62*	*0*	*0*	*0*	0	0	0	**723**	**644**
		Residues	5	3	0	**7**	8	48	*3*	2	5	25	*7*	*0*	*0*	*0*	0	0	0	**98**	**88**

Country	Country-Code	Stream	Food	Garden	Other biowastes	**Organic waste total**	Wood	Paper /Card-board	*Textiles*	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall total dry recycle-ables***	**Total within scope dry recycle-ables**
Spain	ES	Recycled	592	211	0	**803**	109	1395	*58*	994	141	255	*0*	*0*	*0*	*0*	0	0	137	**3089**	**3031**
		Residues	66	11	0	**77**	12	274	*9*	63	16	96	*0*	*0*	*0*	*0*	0	0	15	**484**	**476**
France	FR	Recycled	887	5021	0	**5907**	0	1178	*0*	3209	1239	948	*981*	*0*	*0*	*0*	0	0	0	**7553**	**6573**
		Residues	47	264	0	**311**	0	189	*0*	76	127	419	*109*	*0*	*0*	*0*	0	0	0	**920**	**811**
Portugal	PT	Recycled	26	72	8	**106**	10	132	*1*	124	11	61	*3*	*0*	*0*	*0*	9	0	36	**386**	**382**
		Residues	1	4	1	**6**	1	31	*0*	14	1	21	*0*	*0*	*0*	*0*	1	0	4	**74**	**73**
Finland	FI	Recycled	229	101	21	**351**	3	420	*5*	75	104	23	*58*	*0*	*0*	*0*	0	0	7	**695**	**632**
		Residues	12	5	2	**20**	0	72	*1*	3	11	11	*6*	*0*	*0*	*0*	0	0	1	**106**	**98**
Sweden	SE	Recycled	411	235	0	**647**	0	571	*8*	183	155	70	*100*	*0*	*7*	*4*	0	0	214	**1313**	**1193**
		Residues	22	12	0	**34**	0	100	*1*	5	17	33	*11*	*0*	*1*	*0*	0	0	24	**193**	**179**
Belgium	BE	Recycled	111	566	206	**882**	199	543	*68*	320	95	107	*81*	*0*	*3*	*17*	0	1	125	**1560**	**1390**
		Residues	6	30	23	**58**	22	96	*11*	4	11	51	*9*	*0*	*0*	*2*	0	0	14	**219**	**197**
Italy	IT	Recycled	3454	1846	584	**5884**	689	3545	*249*	1867	391	1001	*221*	*0*	*0*	*0*	0	0	80	**8043**	**7572**
		Residues	182	97	65	**344**	77	620	*42*	58	43	481	*25*	*0*	*0*	*0*	0	0	9	**1355**	**1288**
Luxembourg	LU	Recycled	33	50	0	**84**	11	29	*3*	21	3	1	*5*	*1*	*2*	*1*	0	7	11	**96**	**84**
		Residues	2	3	0	**4**	1	5	*1*	0	0	1	*1*	*0*	*0*	*0*	0	1	1	**11**	**10**
Netherlands	NL	Recycled	309	1431	537	**2278**	251	726	*64*	304	79	97	*56*	*69*	*2*	*12*	0	0	350	**2010**	**1806**
		Residues	16	75	60	**151**	28	127	*10*	6	9	46	*6*	*8*	*0*	*1*	0	0	39	**281**	**255**
Austria	AT	Recycled	494	1085	0	**1579**	229	586	*30*	221	113	115	*74*	*0*	*2*	*1*	3	2	36	**1411**	**1304**
		Residues	26	57	0	**83**	25	103	*5*	8	13	56	*8*	*0*	*0*	*0*	0	0	4	**223**	**210**
Slovenia	SI	Recycled	72	70	2	**143**	38	138	*1*	44	23	17	*6*	*0*	*0*	*4*	0	0	96	**366**	**355**
		Residues	4	4	0	**8**	4	24	*0*	1	3	8	*1*	*0*	*0*	*0*	0	0	11	**52**	**51**
United Kingdom	UK	Recycled	550	3046	627	**4222**	698	2834	*165*	1394	615	515	*335*	*579*	*9*	*1*	0	0	451	**7596**	**6507**
		Residues	29	160	70	**259**	78	472	*27*	17	65	232	*37*	*64*	*1*	*0*	0	0	50	**1043**	**913**
Cluster 1		Recycled	626	1577	63	**2265**	86	2267	*64*	1142	546	761	*226*	*46*	*2*	*17*	3	5	1006	**6169**	**5815**
		Residues	33	83	7	**123**	10	444	*15*	104	59	320	*25*	*5*	*0*	*2*	0	1	112	**1096**	**1049**
Cluster 2		Recycled	2360	6734	29	**9123**	353	4805	*115*	5117	1934	1658	*1285*	*0*	*14*	*4*	9	7	459	**15761**	**14341**
		Residues	159	354	3	**516**	39	849	*18*	176	202	719	*143*	*0*	*2*	*0*	1	1	51	**2202**	**2039**
EU27 (w/o DE)		recycled	**7459**	**13359**	**1420**	**22238**	**1857**	**12637**	***596***	**9034**	**3184**	**3757**	***1955***	***116***	***25***	***55***	**15**	**22**	**2162**	**35415**	**32668**
		Residues	**427**	**703**	**158**	**1288**	**206**	**2268**	***102***	**357**	**339**	**1683**	***217***	***13***	***3***	***6***	**2**	**2**	**240**	**5440**	**5099**
EU28 (w/o DE)		Recycled	**8008**	**16404**	**2047**	**26460**	**2555**	**15471**	***761***	**10428**	**3799**	**4272**	***2290***	***695***	***34***	***56***	**15**	**22**	**2613**	**43011**	**39175**
		Residues	**456**	**863**	**227**	**1547**	**284**	**2740**	***129***	**374**	**404**	**1915**	***254***	***77***	***4***	***6***	**2**	**2**	**290**	**6483**	**6012**

Table 132: Recycling and rejects for all municipal recyclables, by material, 2017, in kg/cap

Country	Country-Code	Stream	Food	Garden	Other biowastes	**Organic waste total**	Wood	Paper /Card-board	*Textiles*	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall Total dry recycle-ables***	**Total within scope dry recycle-ables**
Bulgaria	BG	Recycled	19	16	0	**34**	3	45	*0*	12	8	12	17	1	0	2	0	0	11	**111**	**70**
		Residues	1	1	0	**2**	0	7	*0*	1	1	6	2	0	0	0	0	0	1	**18**	**12**
Estonia	EE	Recycled	10	4	0	**14**	1	47	*2*	22	10	10	3	0	0	1	0	0	6	**103**	**89**
		Residues	1	0	0	**1**	0	8	*0*	1	1	5	0	0	0	0	0	0	1	**16**	**14**
Greece	EL	Recycled	2	6	0	**8**	0	42	*0*	7	7	10	0	0	0	0	0	0	7	**74**	**52**
		Residues	0	0	0	**0**	0	9	*0*	1	1	4	0	0	0	0	0	0	1	**15**	**9**
Croatia	HR	Recycled	2	8	1	**11**	1	34	*0*	9	3	8	4	0	0	0	0	0	17	**76**	**60**
		Residues	0	0	0	**1**	0	7	*0*	1	0	3	0	0	0	0	0	0	2	**14**	**13**
Cyprus	CY	Recycled	0	4	0	**4**	0	58	*1*	9	14	10	3	0	0	0	0	0	0	**96**	**52**
		Residues	0	0	0	**0**	0	13	*0*	1	2	4	0	0	0	0	0	0	0	**20**	**9**
Latvia	LV	Recycled	1	1	27	**28**	4	50	*0*	11	1	5	1	4	0	0	0	0	0	**75**	**17**
		Residues	0	0	3	**3**	0	8	*0*	1	0	2	0	0	0	0	0	0	0	**12**	**3**
Lithuania	LT	Recycled	4	45	2	**50**	2	32	*2*	17	22	6	5	0	0	0	0	1	9	**96**	**117**
		Residues	0	2	0	**3**	0	6	*0*	1	2	3	1	0	0	0	0	0	1	**14**	**21**
Hungary	HU	Recycled	5	21	0	**27**	2	23	*1*	4	11	6	2	0	0	0	0	0	6	**55**	**86**
		Residues	0	1	0	**1**	0	4	*0*	0	1	2	0	0	0	0	0	0	1	**10**	**17**
Malta	MT	Recycled	1	1	0	**2**	0	33	*1*	10	7	8	4	0	0	0	0	0	2	**64**	**170**
		Residues	0	0	0	**0**	0	8	*0*	1	1	3	0	0	0	0	0	0	0	**13**	**23**
Poland	PL	Recycled	8	14	0	**22**	0	12	*1*	15	2	7	0	0	0	0	0	0	16	**53**	**135**
		Residues	0	1	0	**1**	0	2	*0*	1	0	3	0	0	0	0	0	0	2	**9**	**18**
Romania	RO	Recycled	4	14	0	**18**	0	5	*0*	2	1	3	1	0	0	0	0	0	4	**18**	**65**
		Residues	0	1	0	**1**	0	1	*0*	0	0	1	0	0	0	0	0	0	0	**3**	**10**
Slovakia	SK	Recycled	2	37	0	**39**	4	46	*3*	33	16	15	4	6	0	0	0	0	3	**130**	**70**
		Residues	0	2	0	**2**	0	9	*1*	3	2	7	0	1	0	0	0	0	0	**23**	**12**
Czech Republic	CZ	Recycled	2	22	0	**24**	1	39	*2*	18	8	19	2	0	0	0	0	1	1	**90**	**89**
		Residues	0	1	0	**1**	0	7	*0*	1	1	9	0	0	0	0	0	0	0	**18**	**14**
Denmark	DK	Recycled	18	141	0	**159**	25	67	*0*	35	26	8	11	0	1	0	0	0	9	**182**	**52**
		Residues	1	7	0	**8**	3	12	*0*	1	3	4	1	0	0	0	0	0	1	**24**	**9**
Ireland	IE	Recycled	19	10	0	**29**	16	65	*4*	30	11	12	13	0	0	0	0	0	0	**151**	**60**
		Residues	1	1	0	**2**	2	10	*1*	0	1	5	1	0	0	0	0	0	0	**20**	**13**
Spain	ES	Recycled	13	5	0	**17**	2	30	*1*	21	3	5	0	0	0	0	0	0	3	**66**	**52**
		Residues	1	0	0	**2**	0	6	*0*	1	0	2	0	0	0	0	0	0	0	**10**	**9**

Country	Country-Code	Stream	Food	Garden	Other biowastes	**Organic waste total**	Wood	Paper /Card-board	*Textiles*	Glass	Metals	Plastics	*WEEE*	Rubble, soil	*Batteries/ accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	***Overall Total dry recycle-ables***	**Total within scope dry recycle-ables**
France	FR	Recycled	13	75	0	**5**	0	18	*0*	48	19	14	15	0	0	0	0	0	0	**113**	**98**
		Residues	1	4	0	**10**	0	3	*0*	1	2	6	2	0	0	0	0	0	0	**14**	**12**
Portugal	PT	Recycled	2	7	1	**1**	1	13	*0*	12	1	6	0	0	0	0	1	0	3	**37**	**37**
		Residues	0	0	0	**64**	0	3	*0*	1	0	2	0	0	0	0	0	0	0	**7**	**7**
Finland	FI	Recycled	42	18	4	**4**	0	76	*1*	14	19	4	11	0	0	0	0	0	1	**126**	**115**
		Residues	2	1	0	**65**	0	13	*0*	1	2	2	1	0	0	0	0	0	0	**19**	**18**
Sweden	SE	Recycled	41	24	0	**3**	0	57	*1*	18	16	7	10	0	1	0	0	0	21	**131**	**119**
		Residues	2	1	0	**78**	0	10	*0*	0	2	3	1	0	0	0	0	0	2	**19**	**18**
Belgium	BE	Recycled	10	50	18	**5**	18	48	*6*	28	8	9	7	0	0	2	0	0	11	**137**	**122**
		Residues	1	3	2	**5**	2	8	*1*	0	1	4	1	0	0	0	0	0	1	**19**	**17**
Italy	IT	Recycled	57	30	10	**97**	11	59	*4*	31	6	17	4	0	0	0	0	0	1	**133**	**125**
		Residues	3	2	1	**6**	1	10	*1*	1	1	8	0	0	0	0	0	0	0	**22**	**21**
Luxembourg	LU	Recycled	56	85	0	**142**	19	49	*6*	35	6	2	9	1	3	1	0	12	19	**163**	**142**
		Residues	3	4	0	**7**	2	8	*1*	1	1	1	1	0	0	0	0	1	2	**19**	**16**
Netherlands	NL	Recycled	18	84	31	**133**	15	42	*4*	18	5	6	3	4	0	1	0	0	20	**118**	**106**
		Residues	1	4	3	**9**	2	7	*1*	0	1	3	0	0	0	0	0	0	2	**16**	**15**
Austria	AT	Recycled	56	124	0	**180**	26	67	*3*	25	13	13	8	0	0	0	0	0	4	**161**	**149**
		Residues	3	7	0	**9**	3	12	*1*	1	1	6	1	0	0	0	0	0	0	**25**	**24**
Slovenia	SI	Recycled	35	34	1	**69**	18	67	*0*	21	11	8	3	0	0	2	0	0	46	**177**	**172**
		Residues	2	2	0	**4**	2	12	*0*	1	1	4	0	0	0	0	0	0	5	**25**	**25**
United Kingdom	UK	Recycled	8	46	10	**64**	11	43	*3*	21	9	8	5	9	0	0	0	0	7	**115**	**99**
		Residues	0	2	1	**4**	1	7	*0*	0	1	4	1	1	0	0	0	0	1	**16**	**14**
Cluster 1		Recycled	6	15	1	**22**	1	22	*1*	11	5	7	2	0	0	0	0	0	10	**60**	**57**
		Residues	0	1	0	**1**	0	4	*0*	1	1	3	0	0	0	0	0	0	1	**11**	**10**
Cluster 2		Recycled	15	42	0	**57**	2	30	*1*	32	12	10	8	0	0	0	0	0	3	**98**	**89**
		Residues	1	2	0	**3**	0	5	*0*	1	1	4	1	0	0	0	0	0	0	**14**	**13**
EU27 (w/o DE)		recycled	**21**	**37**	**4**	61	**5**	**35**	***2***	**25**	**9**	**10**	**5**	**0**	**0**	**0**	**0**	**0**	**6**	98	90
		Residues	**1**	**2**	**0**	4	**1**	**6**	***0***	**1**	**1**	**5**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	15	14
EU28 (w/o DE)		Recycled	**19**	**38**	**5**	62	**6**	**36**	***2***	**24**	**9**	**10**	**5**	**2**	**0**	**0**	**0**	**0**	**6**	100	91
		Residues	**1**	**2**	**1**	4	**1**	**6**	***0***	**1**	**1**	**4**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	15	14

Table 133: Treatment of residues for all municipal recyclables, by material, 2017, in 1,000 tons

Country	Country-Code	Treatment	Food	Garden	Other biowastes	**Organic waste total**	Wood	Paper /Card-board	*Textiles*	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries / accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	*Overall Total dry recycle-ables*	Total within scope dry recycle-ables
Bulgaria	BG	Landfill	6	5	0	**12**	2	48	*0*	5	5	38	13	0	0	1	0	0	8	**121**	**106**
		Incineratio	0	0	0	**1**	0	4	*0*	0	0	3	1	0	0	0	0	0	1	**9**	**8**
Estonia	EE	Landfill	0	0	0	**0**	0	1	*0*	0	0	1	0	0	0	0	0	0	0	**2**	**2**
		Incineratio	1	0	0	**1**	0	9	*0*	2	1	5	0	0	0	0	0	0	1	**19**	**18**
Greece	EL	Landfill	1	3	0	**5**	0	96	*0*	8	9	44	0	0	0	0	0	0	9	**165**	**165**
		Incineratio	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Croatia	HR	Landfill	0	2	1	**3**	1	30	*0*	4	1	13	2	0	0	0	0	0	8	**58**	**56**
		Incineratio	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Cyprus	CY	Landfill	0	0	0	**0**	0	11	*0*	1	1	3	0	0	0	0	0	0	0	**17**	**17**
		Incineratio	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Latvia	LV	Landfill	0	0	5	**5**	1	14	*0*	1	0	4	0	1	0	0	0	0	0	**21**	**20**
		Incineratio	0	0	1	**1**	0	2	*0*	0	0	0	0	0	0	0	0	0	0	**2**	**2**
Lithuania	LT	Landfill	1	7	0	**8**	1	16	*1*	4	7	8	2	0	0	0	0	0	3	**41**	**38**
		Incineratio	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Hungary	HU	Landfill	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
		Incineratio	3	11	0	**14**	2	44	*1*	4	12	24	2	0	0	0	0	0	6	**97**	**93**
Malta	MT	Landfill	0	0	0	**0**	0	4	*0*	1	0	1	0	0	0	0	0	0	0	**6**	**6**
		Incineratio	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Poland	PL	Landfill	11	20	0	**31**	0	64	*5*	36	6	80	0	0	0	0	0	0	46	**237**	**232**
		Incineratio	5	9	0	**14**	0	28	*2*	16	3	36	0	0	0	0	0	0	20	**105**	**103**
Romania	RO	Landfill	4	14	0	**19**	1	25	*0*	5	3	24	2	0	0	0	0	0	9	**68**	**65**
		Incineratio	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Slovakia	SK	Landfill	1	9	0	**10**	2	44	*3*	16	8	32	2	3	0	0	0	0	1	**111**	**103**
		Incineratio	0	1	0	**1**	0	6	*0*	2	1	4	0	0	0	0	0	0	0	**14**	**13**
Czech Republic	CZ	Landfill	1	10	0	**10**	1	54	*3*	6	7	72	2	0	0	0	0	1	1	**147**	**142**
		Incineratio	0	3	0	**3**	0	16	*1*	2	2	21	0	0	0	0	0	0	0	**43**	**41**
Denmark	DK	Landfill	0	2	0	**2**	1	3	*0*	0	1	1	0	0	0	0	0	0	0	**5**	**5**
		Incineratio	5	41	0	**46**	15	64	*0*	5	15	21	7	0	1	0	0	0	5	**133**	**126**
Ireland	IE	Landfill	3	2	0	**5**	6	34	*2*	1	4	18	5	0	0	0	0	0	0	**69**	**62**
		Incineratio	1	1	0	**2**	2	14	*1*	0	2	7	2	0	0	0	0	0	0	**29**	**26**

Country	Country-Code	Treatment	Food	Garden	Other biowastes	**Organic waste total**	Wood	Paper /Card-board	*Textiles*	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries / accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	*Overall Total dry recycle-ables*	Total within scope dry recycle-ables
Spain	ES	Landfill	43	7	0	**50**	8	177	*6*	41	10	62	0	0	0	0	0	0	10	**314**	**308**
		Incineratio	23	4	0	**27**	4	96	*3*	22	5	34	0	0	0	0	0	0	5	**171**	**168**
France	FR	Landfill	17	98	0	**115**	0	70	*0*	28	47	155	40	0	0	0	0	0	0	**341**	**301**
		Incineratio	29	166	0	**196**	0	119	*0*	48	80	263	69	0	0	0	0	0	0	**579**	**510**
Portugal	PT	Landfill	1	2	1	**4**	1	19	*0*	8	1	13	0	0	0	0	1	0	2	**45**	**45**
		Incineratio	1	1	0	**2**	0	12	*0*	5	0	8	0	0	0	0	0	0	2	**28**	**28**
Finland	FI	Landfill	2	1	0	**3**	0	10	*0*	0	2	2	1	0	0	0	0	0	0	**15**	**14**
		Incineratio	10	5	2	**17**	0	62	*1*	3	10	10	6	0	0	0	0	0	1	**91**	**85**
Sweden	SE	Landfill	0	0	0	**1**	0	2	*0*	0	0	1	0	0	0	0	0	0	0	**3**	**3**
		Incineratio	21	12	0	**33**	0	98	*1*	5	17	33	11	0	1	0	0	0	23	**189**	**176**
Belgium	BE	Landfill	0	0	0	**1**	0	1	*0*	0	0	0	0	0	0	0	0	0	0	**2**	**2**
		Incineratio	6	30	23	**58**	22	95	*11*	4	10	50	9	0	0	2	0	0	14	**217**	**196**
Italy	IT	Landfill	26	14	9	**49**	11	89	*6*	8	6	69	4	0	0	0	0	0	1	**194**	**184**
		Incineratio	156	83	56	**295**	66	532	*36*	50	37	413	21	0	0	0	0	0	8	**1161**	**1104**
Luxembourg	LU	Landfill	0	1	0	**1**	0	1	*0*	0	0	0	0	0	0	0	0	0	0	**2**	**2**
		Incineratio	1	2	0	**3**	1	4	*0*	0	0	0	0	0	0	0	0	1	1	**9**	**8**
Netherlands	NL	Landfill	0	2	2	**4**	1	3	*0*	0	0	1	0	0	0	0	0	0	1	**7**	**6**
		Incineratio	16	73	58	**147**	27	124	*10*	6	9	45	6	7	0	1	0	0	38	**274**	**249**
Austria	AT	Landfill	0	1	0	**2**	0	2	*0*	0	0	1	0	0	0	0	0	0	0	**4**	**4**
		Incineratio	26	56	0	**82**	25	101	*5*	8	12	55	8	0	0	0	0	0	4	**219**	**206**
Slovenia	SI	Landfill	4	4	0	**8**	4	24	*0*	1	3	8	1	0	0	0	0	0	11	**52**	**51**
		Incineratio	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
United Kingdom	UK	Landfill	12	67	29	**108**	32	196	*11*	7	27	96	15	27	0	0	0	0	21	**433**	**379**
		Incineratio	17	94	41	**151**	45	276	*16*	10	38	136	22	38	1	0	0	0	29	**610**	**534**
Cluster 1		Landfill	24	61	6	**92**	7	352	*10*	80	41	248	21	5	0	2	0	0	83	**849**	**811**
		Incineratio	9	22	1	**31**	3	92	*4*	24	18	73	4	1	0	0	0	0	28	**247**	**238**
Cluster 2		Landfill	67	122	1	**190**	16	368	*11*	86	71	323	48	0	0	0	1	1	14	**939**	**879**
		Incineratio	92	233	2	**327**	23	481	*7*	90	131	396	94	0	2	0	0	0	37	**1263**	**1159**
EU27 (w/o DE)		Landfill	**123**	**204**	**18**	**345**	**40**	**840**	***28***	**175**	**122**	**650**	**74**	**5**	**0**	**2**	**1**	**1**	**111**	**2050**	**1950**
		Incineratio	**305**	**499**	**139**	**943**	**166**	**1428**	***74***	**182**	**217**	**1033**	**143**	**8**	**2**	**4**	**1**	**1**	**129**	**3390**	**3159**
EU28 (w/o DE)		Landfill	**135**	**271**	**47**	**453**	**72**	**1036**	***39***	**182**	**149**	**747**	**90**	**31**	**1**	**2**	**1**	**1**	**132**	**2483**	**2319**
		Incineratio	**322**	**593**	**180**	**1094**	**212**	**1704**	***89***	**192**	**255**	**1169**	**165**	**46**	**3**	**4**	**1**	**1**	**159**	**4000**	**3693**

Table 134: Treatment of rejects for all municipal recyclables, by material, 2017, in kg/cap

Country	Country-Code	Treatment	Food	Garden	Other biowastes	**Organic waste total**	Wood	Paper /Card-board	*Textiles*	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries / accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	*Overll Total dry recycle-ables*	Total within scope dry recycle-ables
Bulgaria	BG	Landfill	1	1	0	**2**	0	7	*0*	1	1	5	2	0	0	0	0	0	1	**17**	**15**
		Incineration	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**1**	**1**
Estonia	EE	Landfill	0	0	0	**0**	0	1	*0*	0	0	0	0	0	0	0	0	0	0	**2**	**1**
		Incineration	0	0	0	**1**	0	7	*0*	1	1	4	0	0	0	0	0	0	1	**15**	**14**
Greece	EL	Landfill	0	0	0	**0**	0	9	*0*	1	1	4	0	0	0	0	0	0	1	**15**	**15**
		Incineration	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Croatia	HR	Landfill	0	0	0	**1**	0	7	*0*	1	0	3	0	0	0	0	0	0	2	**14**	**14**
		Incineration	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Cyprus	CY	Landfill	0	0	0	**0**	0	13	*0*	1	2	4	0	0	0	0	0	0	0	**20**	**20**
		Incineration	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Latvia	LV	Landfill	0	0	3	**3**	0	7	*0*	1	0	2	0	0	0	0	0	0	0	**11**	**10**
		Incineration	0	0	0	**0**	0	1	*0*	0	0	0	0	0	0	0	0	0	0	**1**	**1**
Lithuania	LT	Landfill	0	2	0	**3**	0	6	*0*	1	2	3	1	0	0	0	0	0	1	**14**	**14**
		Incineration	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Hungary	HU	Landfill	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
		Incineration	0	1	0	**1**	0	4	*0*	0	1	2	0	0	0	0	0	0	1	**10**	**9**
Malta	MT	Landfill	0	0	0	**0**	0	8	*0*	1	1	3	0	0	0	0	0	0	0	**13**	**13**
		Incineration	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Poland	PL	Landfill	0	1	0	**1**	0	2	*0*	1	0	2	0	0	0	0	0	0	1	**6**	**6**
		Incineration	0	0	0	**0**	0	1	*0*	0	0	1	0	0	0	0	0	0	1	**3**	**3**
Romania	RO	Landfill	0	1	0	**1**	0	1	*0*	0	0	1	0	0	0	0	0	0	0	**3**	**3**
		Incineration	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**0**	**0**
Slovakia	SK	Landfill	0	2	0	**2**	0	8	*1*	3	2	6	0	1	0	0	0	0	0	**21**	**19**
		Incineration	0	0	0	**0**	0	1	*0*	0	0	1	0	0	0	0	0	0	0	**3**	**2**
Czech Republic	CZ	Landfill	0	1	0	**1**	0	5	*0*	1	1	7	0	0	0	0	0	0	0	**14**	**13**
		Incineration	0	0	0	**0**	0	1	*0*	0	0	2	0	0	0	0	0	0	0	**4**	**4**
Denmark	DK	Landfill	0	0	0	**0**	0	0	*0*	0	0	0	0	0	0	0	0	0	0	**1**	**1**
		Incineration	1	7	0	**8**	3	11	*0*	1	3	4	1	0	0	0	0	0	1	**23**	**22**
Ireland	IE	Landfill	1	0	0	**1**	1	7	*0*	0	1	4	1	0	0	0	0	0	0	**14**	**13**
		Incineration	0	0	0	**0**	1	3	*0*	0	0	2	0	0	0	0	0	0	0	**6**	**5**

Country	Country-Code	Treatment	Food	Garden	Other biowastes	**Organic waste total**	Wood	Paper /Card-board	*Textiles*	Glass	Metals	Plastics	*WEEE*	*Rubble, soil*	*Batteries / accumu-lators*	*Haz (exc WEEE)*	Fines	Inerts	Other	*Overll Total dry recycle-ables*	Total within scope dry recycl e-ables
Spain	ES	Landfill	1	0	0	1	0	4	0	1	0	1	0	0	0	0	0	0	0	7	7
		Incineration	0	0	0	1	0	2	0	0	0	1	0	0	0	0	0	0	0	4	4
France	FR	Landfill	0	1	0	2	0	1	0	0	1	2	1	0	0	0	0	0	0	5	5
		Incineration	0	2	0	3	0	2	0	1	1	4	1	0	0	0	0	0	0	9	8
Portugal	PT	Landfill	0	0	0	0	0	2	0	1	0	1	0	0	0	0	0	0	0	4	4
		Incineration	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	3	3
Finland	FI	Landfill	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	3	3
		Incineration	2	1	0	3	0	11	0	1	2	2	1	0	0	0	0	0	0	17	15
Sweden	SE	Landfill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Incineration	2	1	0	3	0	10	0	0	2	3	1	0	0	0	0	0	2	19	18
Belgium	BE	Landfill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Incineration	1	3	2	5	2	8	1	0	1	4	1	0	0	0	0	0	1	19	17
Italy	IT	Landfill	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	3	3
		Incineration	3	1	1	5	1	9	1	1	1	7	0	0	0	0	0	0	0	19	18
Luxembourg	LU	Landfill	1	1	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	4	3
		Incineration	2	4	0	6	2	7	1	1	1	1	1	0	0	0	0	1	2	15	13
Netherlands	NL	Landfill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Incineration	1	4	3	9	2	7	1	0	0	3	0	0	0	0	0	0	2	16	15
Austria	AT	Landfill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Incineration	3	6	0	9	3	12	1	1	1	6	1	0	0	0	0	0	0	25	23
Slovenia	SI	Landfill	2	2	0	4	2	12	0	1	1	4	0	0	0	0	0	0	5	25	25
		Incineration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Kingdom	UK	Landfill	0	1	0	2	0	3	0	0	0	1	0	0	0	0	0	0	0	7	6
		Incineration	0	1	1	2	1	4	0	0	1	2	0	1	0	0	0	0	0	9	8
Cluster 1		Landfill	0	1	0	1	0	3	0	1	0	2	0	0	0	0	0	0	1	8	8
		Incineration	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	2
Cluster 2		Landfill	0	1	0	1	0	2	0	1	0	2	0	0	0	0	0	0	0	6	5
		Incineration	1	1	0	2	0	3	0	1	1	2	1	0	0	0	0	0	0	8	7
EU27 (w/o DE)		Landfill	**0**	**1**	**0**	1	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	6	5
		Incineration	**1**	**1**	**0**	3	**0**	**4**	**0**	**1**	**1**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9	9
EU28 (w/o DE)		Landfill	**0**	**1**	**0**	1	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	6	5
		Incineration	**1**	**1**	**0**	3	**0**	**4**	**0**	**0**	**1**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	9	9

A.3.4 Final treatment of all municipal waste generated

Table 135: Final treatment for the whole municipal waste, by treatment type, 2017, in 1000 tons

Country	Country-Code	Stream	Landfill	Incineration	INC 1	INC 2	INC 3	INC 4	Energy recovery	Land recovery	Material Recycling	Organic waste Recycling	Mass loss	Total
Bulgaria	BG	direct	1119	**83**	0	83	0	0						**1202**
		Output	442	**9**	0	9	0	0	0	146	663	244	204	**1708**
Estonia[1)]	EE	direct	31	**243**	0	243	0	0						**274**
		Output	6	**19**	0	19	0	0	38	0	128	19	8	**219**
Greece	EL	direct	3883	**0**	0	0	0	0						**3883**
		Output	337	**0**	0	0	0	0	49	87	812	86	161	**1532**
Croatia[1)]	HR	direct	1124	**0**	0	0	0	0						**1125**
		Output	68	**0**	0	0	0	0	86	0	301	46	23	**523**
Cyprus	CY	direct	251	**0**	0	0	0	0						**251**
		Output	81	**0**	0	0	0	0	34	34	84	4	57	**292**
Latvia	LV	direct	451	**0**	0	0	0	0						**451**
		Output	753	**3**	3	0	0	0	24	15	140	55	21	**333**
Lithuania	LT	direct	373	**0**	0	0	0	0						**373**
		Output	221	**0**	0	0	0	0	134	41	266	144	77	**883**
Hungary	HU	direct	0	**358**	0	358	0	0						**358**
		Output	1809	**107**	0	107	0	0	280	103	643	262	155	**3359**
Malta	MT	direct	178	**0**	0	0	0	0						**179**
		Output	39	**0**	0	0	0	0	0	18	30	1	25	**113**
Poland	PL	direct	972	**432**	0	432	0	0						**1403**
		Output	2918	**117**	0	117	0	0	2065	891	2184	841	1420	**10435**
Romania[1)]	RO	direct	4294	**0**	0	0	0	0						**4294**
		Output	84	**0**	0	0	0	0	214	0	337	352	0	**987**
Slovakia	SK	direct	819	**105**	105	0	0	0						**923**
		Output	113	**14**	14	0	0	0	34	0	636	213	0	**1011**
Czech Republic	CZ	direct	1622	**473**	0	473	0	0						**2095**
		Output	156	**44**	0	44	0	0	121	0	917	257	0	**1497**
Denmark	DK	direct	90	**2260**	353	1907	0	0						**2350**
		Output	7	**172**	27	145	0	0	0	0	975	915	0	**2068**
Ireland[1)]	IE	direct	1099	**443**	443	0	0	0						**1542**
		Output	134	**28**	28	0	0	0	107	18	655	137	26	**1105**
Spain	ES	direct	3727	**2025**	2025	0	0	0						**5752**

Country	Country-Code	Stream	Landfill	Incineration	INC 1	INC 2	INC 3	INC 4	Energy recovery	Land recovery	Material Recycling	Organic waste Recycling	Mass loss	Total
		Output	5087	**195**	195	0	0	0	0	2545	3393	803	4177	**16199**
France	FR	direct	6937	**11759**	11759	0	0	0						**18696**
		Output	1011	**706**	706	0	0	0	0	285	6620	5907	363	**14891**
Portugal	PT	direct	1662	**1041**	1041	0	0	0						**2702**
		Output	271	**30**	30	0	0	0	985	80	419	106	393	**2285**
Finland	FI	direct	197	**1209**	0	1209	0	0						**1406**
		Output	43	**101**	0	101	0	0	113	11	643	351	15	**1278**
Sweden	SE	direct	39	**2281**	0	2213	68	0						**2321**
		Output	4	**209**	0	203	6	0	0	0	1193	647	0	**2053**
Belgium	BE	direct	15	**1751**	1576	140	0	35						**1766**
		Output	10	**254**	228	20	0	5	145	0	1394	882	12	**2697**
Italy	IT	direct	628	**3765**	2146	1619	0	0						**4393**
		Output	5709	**1399**	797	602	0	0	0	1579	7915	5884	2156	**24641**
Luxembourg	LU	direct	30	**115**	115	0	0	0						**145**
		Output	16	**11**	11	0	0	0	0	4	85	84	6	**206**
Netherlands	NL	direct	94	**3612**	0	3612	0	0						**3706**
		Output	180	**396**	0	396	0	0	0	74	1820	2278	98	**4845**
Austria	AT	direct	24	**1208**	72	785	350	0						**1232**
		Output	161	**287**	17	187	83	0	218	23	1320	1579	49	**3636**
Slovenia	SI	direct	40	**0**	0	0	0	0						**40**
		Output	258	**0**	0	0	0	0	0	64	369	143	79	**915**
United Kingdom	UK	direct	4766	**6708**	5031	1677	0	0						**11475**
		Output	1609	**685**	514	171	0	0	3135	385	6710	4222	922	**17669**
Cluster 1		direct	13495	**1220**	105	1115	0	0						**14715**
		Output	6193	**269**	17	252	0	0	2958	1336	6225	2265	2251	**21397**
Cluster 2		direct	15373	**21491**	15620	5802	68	0						**36864**
		Output	6713	**1486**	986	494	6	0	1327	2939	14815	9123	4974	**41376**
EU27 (w/o DE)		direct	**29698**	**33163**	**19635**	**13074**	**419**	**35**						**62861**
		Output	**19918**	**4102**	**2057**	**1950**	**90**	**5**	**4648**	**6020**	**33941**	**22238**	**9524**	**99712**
EU28 (w/o DE)		direct	**34464**	**39871**	**24666**	**14751**	**419**	**35**						**74335**
		Output	**21527**	**4787**	**2571**	**2122**	**90**	**5**	**7783**	**6404**	**40652**	**26460**	**10447**	**117381**

Note: 1) Amounts of direct landfilling include uncollected residual waste, which is assumed as being landfilled (Table 116)

Table 136: Final treatment for the whole municipal waste, by treatment type, 2017, in kg/cap

Country	Country-Code	Stream	Landfill	**Incineration**	INC 1	INC 2	INC 3	INC 4	Energy recovery	Land recovery	Material Recycling	Organic waste Recycling	Mass loss	**Total**
Bulgaria	BG	direct	158	**12**	0	12	0	0						**169**
		Output	62	**1**	0	1	0	0	0	21	93	34	29	**240**
Estonia[1)]	EE	direct	24	**185**	0	185	0	0						**209**
		Output	5	**15**	0	15	0	0	29	0	98	14	6	**166**
Greece	EL	direct	361	**0**	0	0	0	0						**361**
		Output	31	**0**	0	0	0	0	5	8	75	8	15	**142**
Croatia[1)]	HR	direct	271	**0**	0	0	0	0						**271**
		Output	16	**0**	0	0	0	0	21	0	72	11	5	**126**
Cyprus	CY	direct	293	**0**	0	0	0	0						**293**
		Output	94	**0**	0	0	0	0	40	40	98	4	66	**342**
Latvia	LV	direct	231	**0**	0	0	0	0						**231**
		Output	38	**1**	1	0	0	0	61	12	8	72	11	**171**
Lithuania	LT	direct	131	**0**	0	0	0	0						**131**
		Output	78	**0**	0	0	0	0	47	15	93	50	27	**310**
Hungary	HU	direct	0	**36**	0	36	0	0						**36**
		Output	185	**11**	0	11	0	0	29	11	66	27	16	**343**
Malta	MT	direct	388	**0**	0	0	0	0						**388**
		Output	85	**0**	0	0	0	0	0	39	65	2	55	**246**
Poland	PL	direct	26	**11**	0	11	0	0						**37**
		Output	77	**3**	0	3	0	0	54	23	58	22	37	**275**
Romania[1)]	RO	direct	219	**0**	0	0	0	0						**219**
		Output	4	**0**	0	0	0	0	11	0	17	18	0	**50**
Slovakia	SK	direct	151	**19**	19	0	0	0						**170**
		Output	21	**3**	3	0	0	0	6	0	117	39	0	**186**
Czech Republic	CZ	direct	153	**45**	0	45	0	0						**198**
		Output	15	**4**	0	4	0	0	11	0	87	24	0	**141**
Denmark	DK	direct	16	**393**	61	332	0	0						**409**
		Output	1	**30**	5	25	0	0	0	0	170	159	0	**360**
Ireland[1)]	IE	direct	230	**93**	93	0	0	0						**322**
		Output	28	**6**	6	0	0	0	22	4	137	29	6	**231**
Spain	ES	direct	80	**44**	44	0	0	0						**124**
		Output	109	**4**	4	0	0	0	0	55	73	17	90	**348**
France	FR	direct	104	**176**	176	0	0	0						**280**
		Output	15	**11**	11	0	0	0	0	4	99	88	5	**223**

Country	Country-Code	Stream	Landfill	**Incineration**	INC 1	INC 2	INC 3	INC 4	Energy recovery	Land recovery	Material Recycling	Organic waste Recycling	Mass loss	**Total**
Portugal	PT	direct	161	**101**	101	0	0	0						**262**
		Output	26	**3**	3	0	0	0	96	8	41	10	38	**222**
Finland	FI	direct	36	**220**	0	220	0	0						**255**
		Output	8	**18**	0	18	0	0	21	2	117	64	3	**232**
Sweden	SE	direct	4	**228**	0	221	7	0						**232**
		Output	0	**21**	0	20	1	0	0	0	119	65	0	**205**
Belgium	BE	direct	1	**154**	139	12	0	3						**156**
		Output	1	**22**	20	2	0	0	13	0	123	78	1	**238**
Italy	IT	direct	10	**62**	35	27	0	0						**73**
		Output	94	**23**	13	10	0	0	0	26	131	97	36	**407**
Luxembourg	LU	direct	51	**195**	195	0	0	0						**246**
		Output	27	**19**	19	0	0	0	0	7	144	142	10	**348**
Netherlands	NL	direct	5	**211**	0	211	0	0						**217**
		Output	11	**23**	0	23	0	0	0	4	107	133	6	**284**
Austria	AT	direct	3	**138**	8	90	40	0						**140**
		Output	18	**33**	2	21	10	0	25	3	150	180	6	**415**
Slovenia	SI	direct	19	**0**	0	0	0	0						**19**
		Output	125	**0**	0	0	0	0	0	31	179	69	38	**443**
United Kingdom	UK	direct	72	**102**	76	25	0	0						**174**
		Output	24	**10**	8	3	0	0	48	6	102	64	14	**268**
Cluster 1		direct	132	**12**	1	11	0	0						**144**
		Output	61	**3**	0	2	0	0	29	13	61	22	21	**209**
Cluster 2		direct	96	**134**	97	36	0	0						**230**
		Output	42	**9**	6	3	0	0	8	18	92	57	31	**258**
EU27 (w/o DE)		direct	**82**	**91**	**54**	**36**	**1**	**0**						**173**
		Output	**53**	**11**	**6**	**5**	**0**	**0**	**13**	**17**	**94**	**61**	**26**	**275**
EU28 (w/o DE)		direct	**80**	**93**	**58**	**34**	**1**	**0**						**173**
		Output	**49**	**11**	**6**	**5**	**0**	**0**	**18**	**15**	**95**	**62**	**24**	**274**

Note: 1) Amounts of direct landfilling include uncollected residual waste, which is assumed as being landfilled (Table 117)

A.4 Data tables for all EU scenarios, including key data from Germany

A.4.1 First treatment of residual waste 2030 for EU lead scenarios

Table 137: Adjustments to first treatment of residual waste 2030 for EU lead scenarios (1,000 t)

Cluster	Code	Country	MBT	WtE	Landfill	Organic waste treatment	Dry Recyclables sorting	Total Generation	Landfill before adjustment	adjustment of LF	adjustment of INC and/or MBT	Description of adjustments
1	Bulgaria	BG	691	233	186	705	1095	2910	336	-150	+150	LF > 0 within target, INC capacities deducted from LF
1	Estonia	EE	0	186	0	86	221	493	-108	+108	-108	LF < 0, LF set to zero, MBT set to zero, INC reduced
1	Greece	EL	480	250	1322	1415	1947	5415	1572	-250	+250	LF > 0 within target, INC capacities deducted from LF
1	Croatia	HR	157	0	461	344	685	1647	499	-38	+38	LF > 0 above target, LF reduced to target and added to MBT
1	Cyprus	CY	194	0	11	141	197	543	11	0	0	LF > 0 within target, nothing done
1	Latvia	LV	113	0	184	187	300	784	184	0	0	LF > 0 within target, nothing done
1	Lithuania	LT	440	0	50	337	431	1257	50	0	0	LF > 0 within target, nothing done
1	Hungary	HU	1063	358	0	945	1351	3717	-1419	+1419	-1419	LF < 0, LF set to zero, MBT reduced
1	Malta	MT	79	0	33	84	95	292	33	0	0	LF > 0 within target, nothing done
1	Poland	PL	4140	432	0	3214	4052	11838	-3093	+3093	-3093	LF < 0, LF set to zero, MBT reduced
1	Romania	RO	336	250	1479	1778	1438	5281	1838	-359	+359	LF > 0 above target, INC cap. deducted from LF, LF further reduced, added to MBT
1	Slovakia	SK	36	144	541	361	852	1935	580	-39	+39	LF > 0 above target, LF reduced to target and added to INC
2	Czech Republic	CZ	402	743	0	894	1553	3592	540	-540	+540	LF > 0, set to zero and added equally to MBT and INC
2	Denmark	DK	0	1507	0	1363	1548	4418	-753	+753	-753	LF < 0, LF set to zero, INC reduced
2	Ireland	IE	336	550	0	654	1108	2647	214	-214	+214	LF > 0, set to zero and added equally to MBT and INC
2	Spain	ES	5302	2025	0	6777	7848	21951	-6511	+6511	-6511	LF < 0, LF set to zero, MBT reduced
2	France	FR	1133	10355	0	10256	11843	33587	-1560	+1560	-1560	LF < 0, LF set to zero, INC & MBT proportionally reduced
2	Portugal	PT	1067	607	0	1693	1620	4987	-1084	+1084	-1084	LF < 0, LF set to zero, INC & MBT proportionally reduced
2	Finland	FI	128	767	0	767	1022	2684	-491	+491	-491	LF < 0, LF set to zero, INC & MBT proportionally reduced
2	Sweden	SE	0	1461	0	1176	1737	4374	-821	+821	-821	LF < 0, LF set to zero, INC reduced
3	Belgium	BE	124	1355	0	1111	1872	4463	-440	+440	-440	LF < 0, LF set to zero, INC & MBT proportionally reduced
3	Italy	IT	5726	3765	0	7897	11646	29034	-3827	+3827	-3827	LF < 0, LF set to zero, MBT reduced
3	Luxembourg	LU	24	97	0	106	124	351	-18	+18	-18	LF < 0, LF set to zero, INC reduced
3	Netherlands	NL	247	2638	0	2870	2797	8551	-1083	+1083	-1083	LF < 0, LF set to zero, INC & MBT proportionally reduced
3	Austria	AT	459	1191	0	1678	1540	4868	-19	+19	-19	LF < 0, LF set to zero, INC & MBT proportionally reduced
3	Slovenia	SI	314	0	0	182	458	955	-44	+44	-44	LF < 0, LF set to zero, MBT reduced

A.4.2 EU lead scenarios (MSW 2030 WFD)

This Annex presents the data on waste generation and treatment for the lead scenarios of Cluster 1, Cluster 2, the EU27 (w/o DE), all in the formats of the EEA-model. In addition, the lead scenario for Germany is copied in from the German report, in the formats presented in the main text (Chapter 5.4.1). The following measures were taken to adapt the formats of the EEA-model to the formats presented in the main text (Table 47 to Table 49) and arrive at a format, which allowed to merge the European data for EU27 (w/o DE) with the German data:

- MBT 1 to MBT 4 were aggregated to MBT.
- MBT 5 was displayed as "Mixed waste" sorting.
- “Composting open air windrow” and “in-vessel composting” were aggregated as composting.
- „Waste bio bin “from the German data is added to “other biowaste” in the European data.

After these adaptations, the data from Table 140 and Table 141 were merged to arrive at Table 49.

Table 138: Generation and first treatment 2017 and 2030, Cluster 1, lead scenario (MSW CL1 2030 WFD), in the formats of the EEA-model

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
Residual waste	**26,861**	**13,849**	**-48%**
Landfill	13,495	4,268	-68%
INC	1,220	1,853	52%
MBT	12,145	7,729	-36%
Organic waste	**2,388**	**9,598**	**302%**
Food	659	5,773	777%
Garden	1,660	3,755	126%
other	69	69	0%
Dry Recyclables	**5,737**	**11,539**	**101%**
Paper	2,711	4,824	78%
Glass	1,245	2,461	98%
Wood	96	351	266%
Metal	605	1,204	99%
Plastic	1,081	2,699	150%
Total MSW generation	**34,986**	**34,986**	**0%**
MBTs	**12,145**	**7,729**	**-36%**
MBT 1 - Biostabilisation	4,537	454	-90%
MBT 2 - Biodrying no plastics	965	965	0%
MBT 3 - Biodrying with plastics	851	851	0%

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
MBT 4 - AD based	2,552	2,219	-13%
MBT 5 - basic sorting + energy	3,240	3,240	0%
Organic waste	**2,388**	**9,598**	**302%**
Food - soldier fly larvae		115	-
Food - composting open air	473	366	-23%
Food - in-vessel composting	115	2,140	1768%
Food - anaerobic digestion	71	3,152	4310%
Garden - composting open air	1,332	1,464	10%
Garden - in-vessel composting	258	2,140	730%
Garden - anaerobic digestion	70	150	116%
Other - composting open air	65	65	0%
Other - in-vessel composting	3	3	0%
Other - anaerobic digestion	2	2	0%
Wood	**96**	**351**	**266%**
Wood - recycling	96	351	266%
Wood - pyrolysis	0	0	-

Table 139: Generation and first treatment 2017 and 2030, Cluster 2, lead scenario (MSW CL2 2030 WFD), in the formats of the EEA-model

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
Residual waste	**52,220**	**26,383**	**-49%**
Landfill	15,373	0	-100%
INC	21,491	18,015	-16%
MBT	15,357	8,367	-46%
Organic waste	**9,639**	**23,581**	**145%**
Food	2,519	13,800	448%
Garden	7,088	9,748	38%
other	32	32	0%
Dry Recyclables	**15,852**	**27,749**	**75%**
Paper	5,654	10,089	78%
Glass	5,293	7,432	40%
Wood	392	1,318	236%
Metal	2,136	3,475	63%
Plastic	2,377	5,435	129%
Total MSW generation	**77,712**	**77,712**	**0%**

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
MBTs	**15,357**	**8,367**	**-46%**
MBT 1 - Biostabilisation	8,501	0	-100%
MBT 2 - Biodrying no plastics	0	0	-
MBT 3 - Biodrying with plastics	1,374	1,677	22%
MBT 4 - AD based	5,111	6,238	22%
MBT 5 - basic sorting + energy	371	452	22%
Organic waste	**9,639**	**23,581**	**145%**
Food - soldier fly larvae	0	276	-
Food - composting open air	430	276	-36%
Food - in-vessel composting	1,264	3,864	206%
Food - anaerobic digestion	825	9,384	1038%
Garden - composting open air	1,225	1,684	38%
Garden - in-vessel composting	5,697	7,836	38%
Garden - anaerobic digestion	166	228	38%
Other - composting open air	5	5	0%
Other - in-vessel composting	17	17	0%
Other - anaerobic digestion	10	10	0%
Wood	**392**	**1,318**	**236%**
Wood - recycling	392	1,252	219%
Wood - pyrolysis	0	66	-

Table 140: Generation and first treatment 2017 and 2030, EU27 without Germany, lead scenario (MSW EU27 (w/o DE) 2030 WFD), in the formats of the EEA-model

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
	1,000 t	1,000 t	%
Residual waste	**101,280**	**56,171**	**-45%**
Landfill	29,698	4,268	-86%
INC	33,163	28,914	-13%
MBT	38,420	22,989	-40%
Organic waste	**23,526**	**47,023**	**100%**
Food	7,886	25,489	223%
Garden	14,062	19,955	42%
other	1,578	1,578	0%
Dry Recyclables	**35,323**	**56,935**	**61%**
Paper	14,906	23,190	56%

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
Glass	9,391	13,394	43%
Wood	2,063	3,430	66%
Metal	3,523	5,992	70%
Plastic	5,440	10,929	101%
Total MSW generation	**160,129**	**160,129**	**0%**
MBTs	**38,420**	**22,989**	**-40%**
MBT 1 - Biostabilisation	23,014	2,460	-89%
MBT 2 - Biodrying no plastics	1,283	1,283	0%
MBT 3 - Biodrying with plastics	2,225	2,528	14%
MBT 4 - AD based	8,179	12,234	50%
MBT 5 - basic sorting + energy	3,719	4,484	21%
Organic waste	**23,526**	**47,023**	**100%**
Food - soldier fly larvae	0	391	-
Food - composting open air	1,195	820	-31%
Food - in-vessel composting	3,840	8,726	127%
Food - anaerobic digestion	2,851	15,553	445%
Garden - composting open air	5,974	4,955	-17%
Garden - in-vessel composting	7,730	14,493	87%
Garden - anaerobic digestion	357	507	42%
Other - composting open air	460	460	0%
Other - in-vessel composting	573	573	0%
Other - anaerobic digestion	544	544	0%
Wood	**2,063**	**3,430**	**66%**
Wood - recycling	2,063	3,276	59%
Wood - pyrolysis	0	154	-

Table 141: Generation and first treatment 2017 and 2030, DE, lead scenario (MSW DE 2030 WFD), from German report

Waste fraction	2017 in tons	2030 in tons	Difference in %
Residual waste landfill	5,100	0	-100%
Residual waste INC	13,960,376	9,904,331	-29%
Residual waste MBTs	2,970,388	2,107,372	-29%
"Mixed waste" sorting	3,885,200	2,756,395	-29%
Waste bio bin	4,478,900	7,677,593	71%
thereof composting	2,497,600	2,497,600	0%

Waste fraction	2017 in tons	2030 in tons	Difference in %
thereof anaerobic digestion	1,981,300	5,104,993	158%
thereof HTC		25,000	
thereof soldier fly larvae		50,000	
Garden waste	5,681,500	5,681,500	0%
thereof composting	4,673,400	4,206,060	-10%
thereof anaerobic digestion	686,050	1,153,390	68%
thereof biomass power plant	322,050	322,050	0%
Kitchen/canteen waste	982,300	982,300	0%
thereof composting	55,200	0	-100%
thereof anaerobic digestion	927,100	982,300	6%
Paper	7,789,700	8,641,592	11%
Glass	2,575,200	3,121,446	21%
Plastics	1,136,700	2,065,254	82%
LWP	4,029,700	4,029,700	0%
Metals	371,700	606,035	63%
Wood	1,365,700	1,658,946	21%
thereof pyrolysis		100,000	
Total	**49,232,464**	**49,232,464**	**0%**

Source: 'Partial report Germany'

A.4.3 EU special scenarios for Cluster 1 and 2 (2030 SS) and scenario with home composting for EU27 (2030 HC)

This Annex presents the data on waste generation and treatment for the lead scenarios of Cluster 1, Cluster 2, the EU27 (w/o DE), all in the formats of the EEA-model. In addition, the lead scenario for Germany is copied in from the German report, in the formats presented in the main text (Chapter 5.4.2). The following measures were taken to adapt the formats of the EEA-model to the formats presented in the main text (Table 54,Table 59 and Table 60) and arrive at a format, which allowed to merge the European data for EU27 (w/o DE) with the German data:

- MBT 1 to MBT4 were aggregated to MBT.
- MBT 5 was displayed as "Mixed waste" sorting.
- “Composting open air windrow” and “in-vessel composting” were aggregated as composting.
- „Waste bio bin “from the German data is added to “other biowaste” in the European data.

After these adaptations, the data from Table 144 and Table 145 were merged to arrive at Table 54.

Table 142: Generation and first treatment 2017 and 2030, Cluster 1, special scenario (MSW CL1 2030 SS), in the formats of the EEA-model

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
Residual waste	**26,861**	**13,976**	**-48%**
Landfill	13,495	3,657	-73%
INC	1,220	3,695	203%
MBT	12,145	6,624	-45%
Organic waste	**2,388**	**8,645**	**262%**
Food	659	5,196	689%
Garden	1,660	3,379	104%
other	69	69	0%
Dry Recyclables	**5,737**	**10,385**	**81%**
Paper	2,711	4,341	60%
Glass	1,245	2,215	78%
Wood	96	316	229%
Metal	605	1,084	79%
Plastic	1,081	2,429	125%
Ash from residual waste - landfill	**0**	**1,980**	**-**
Total MSW generation	**34,986**	**34,986**	**0%**
MBTs	**12,145**	**6,624**	**-45%**
MBT 1 - Biostabilisation	4,537	389	-91%
MBT 2 - Biodrying no plastics recycling	965	827	-14%
MBT 3 - Biodrying with plastics recycling	851	729	-14%
MBT 4 - AD based	2,552	1,902	-25%
MBT 5 - basic sorting + energy generation	3,240	2,777	-14%
Organic waste	**2,388**	**8,645**	**262%**
Food - soldier fly larvae		104	-
Food - composting open air windrow	473	329	-30%
Food - in-vessel composting	115	1,926	1581%
Food - anaerobic digestion	71	2,836	3869%

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
Garden - composting open air windrow	1,332	1,318	-1%
Garden - in-vessel composting	258	1,926	647%
Garden - anaerobic digestion	70	135	94%
Other - composting open air windrow	65	65	0%
Other - in-vessel composting	3	3	0%
Other - anaerobic digestion	2	2	0%
Wood	**96**	**316**	**229%**
Wood - recycling	96	316	229%
Wood - pyrolysis	0	0	-

Table 143: Generation and first treatment 2017 and 2030, Cluster 2, special scenario (MSW CL2 2030 SS), in the formats of the EEA-model

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
Residual waste	**52,220**	**31,512**	**-40%**
Landfill	15,373	8,817	-43%
INC	21,491	15,497	-28%
MBT	15,357	7,198	-53%
Organic waste	**9,639**	**21,226**	**120%**
Food	2,519	12,420	393%
Garden	7,088	8,773	24%
other	32	32	0%
Dry Recyclables	**15,852**	**24,974**	**58%**
Paper	5,654	9,080	61%
Glass	5,293	6,689	26%
Wood	392	1,186	202%
Metal	2,136	3,127	46%
Plastic	2,377	4,892	106%
Total MSW generation	**77,712**	**77,712**	**0%**
MBTs	**15,357**	**7,198**	**-53%**
MBT 1 - Biostabilisation	8,501	0	-100%

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
MBT 2 - Biodrying no plastics recycling	0	0	-
MBT 3 - Biodrying with plastics recycling	1,374	1,442	5%
MBT 4 - AD based	5,111	5,366	5%
MBT 5 - basic sorting + energy generation	371	389	5%
Organic waste	**9,639**	**21,226**	**120%**
Food - soldier fly larvae	0	248	-
Food - composting open air windrow	430	248	-42%
Food - in-vessel composting	1,264	3,478	175%
Food - anaerobic digestion	825	8,446	924%
Garden - composting open air windrow	1,225	1,516	24%
Garden - in-vessel composting	5,697	7,052	24%
Garden - anaerobic digestion	166	205	24%
Other - composting open air windrow	5	5	0%
Other - in-vessel composting	17	17	0%
Other - anaerobic digestion	10	10	0%
Wood	**392**	**1,186**	**202%**
Wood - recycling	392	1,127	187%
Wood - pyrolysis	0	59	-

Table 144: Generation and first treatment 2017 and 2030, EU27 (w/o DE), scenario with home composting (MSW EU27 (w/o DE), 2030 HC), in the formats of the EEA-model

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
Residual waste	**101,280**	**70,912**	**-30%**
Landfill	29,698	5,388	-82%
INC	33,163	36,502	10%
MBT	38,420	29,023	-24%
Organic waste	**23,526**	**40,355**	**72%**
Food	7,886	21,749	176%

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
Garden	14,062	17,027	21%
other	1,578	1,578	0%
Dry Recyclables	**35,323**	**48,862**	**38%**
Paper	14,906	19,902	34%
Glass	9,391	11,495	22%
Wood	2,063	2,943	43%
Metal	3,523	5,142	46%
Plastic	5,440	9,379	72%
Home composting	**32,294**	**32,294**	**0%**
Total MSW generation	**192,424**	**192,424**	**0%**
MBTs	**38,420**	**29,023**	**-24%**
MBT 1 - Biostabilisation	23,014	3,106	-87%
MBT 2 - Biodrying no plastics recycling	1,283	1,620	26%
MBT 3 - Biodrying with plastics recycling	2,225	3,191	43%
MBT 4 - AD based	8,179	15,444	89%
MBT 5 - basic sorting + energy generation	3,719	5,661	52%
Organic waste	**23,526**	**40,355**	**72%**
Food - soldier fly larvae	0	334	-
Food - composting open air windrow	1,195	699	-41%
Food - in-vessel composting	3,840	7,445	94%
Food - anaerobic digestion	2,851	13,271	365%
Garden - composting open air windrow	5,974	4,228	-29%
Garden - in-vessel composting	7,730	12,366	60%
Garden - anaerobic digestion	357	433	21%
Other - composting open air windrow	460	460	0%
Other - in-vessel composting	573	573	0%
Other - anaerobic digestion	544	544	0%
Wood	**2,063**	**2,943**	**43%**

Waste stream	2017 in 1,000 t	2030 in 1,000 t	Difference in %
Wood - recycling	2,063	2,811	36%
Wood - pyrolysis	0	132	-

Table 145: Generation and first treatment 2017 and 2030, DE, scenario with home composting (MSW DE 2030 HC), from German report

Waste fraction	2017 in tons	2030 in tons	Difference in %
Residual waste landfill	5,100	0	-100%
Residual waste INC	13,960,376	12,128,375	-13%
Residual waste MBTs	2,970,388	2,580,588	-13%
"Mixed waste" sorting	3,885,200	3,375,351	-13%
Waste bio bin	4,478,900	5,990,590	34%
thereof composting	2,497,600	2,497,600	0%
thereof anaerobic digestion	1,981,300	3,417,990	73%
thereof HTC		25,000	
thereof soldier fly larvae		50,000	
Garden waste	5,681,500	5,681,500	0%
thereof composting	4,673,400	4,206,060	-10%
thereof anaerobic digestion	686,050	1,153,390	68%
thereof biomass power plant	322,050	322,050	0%
Kitchen/canteen waste	982,300	982,300	0%
thereof composting	55,200	0	-100%
thereof anaerobic digestion	927,100	982,300	6%
Paper	7,789,700	8,165,876	5%
Glass	2,575,200	2,825,228	11%
Plastics	1,136,700	1,555,371	37%
LWP	4,029,700	4,029,700	0%
Metals	371,700	478,574	29%
Wood	1,365,700	1,439,012	5%
thereof pyrolysis		100,000	
Home composting	7,900,000	7,900,000	0%
Total	**57,132,464**	**57,132,464**	**0%**

Source: 'Partial report Germany'

A.5 Food waste: Explanatory information

Table 146: EWC-Stat categories and assigned LoW entries that contain food waste and estimated share of food waste by LoW-code

EWC-Stat category		Assigned List of Waste (LoW) entries		Estimated share of food waste (weight-%)
Code	Description	Code	Description	
W091	Animal and mixed food waste	02 01 02	animal-tissue waste	67%
		02 02 01	sludges from washing and cleaning	31%
		02 02 02	animal-tissue waste	100%
		02 02 03	materials unsuitable for consumption or processing	55%
		02 03 02	wastes from preserving agents	0%
		02 05 01	materials unsuitable for consumption or processing	100%
		02 06 02	wastes from preserving agents	0%
		19 08 09	grease and oil mixture from oil/water separation containing only edible oil and fats	100%
		20 01 08	biodegradable kitchen and canteen waste	100%
		20 01 25	edible oil and fat	100%
W092	Vegetal wastes	02 01 01	sludges from washing and cleaning	0%
		02 01 03	plant-tissue waste	13%
		02 01 07	wastes from forestry	0%
		02 03 01	sludges from washing, cleaning, peeling, centrifuging and separation	61%
		02 03 03	wastes from solvent extraction	49%
		02 03 04	materials unsuitable for consumption or processing	67%
		02 06 01	materials unsuitable for consumption or processing	100%
		02 07 01	wastes from washing, cleaning and mechanical reduction of raw materials	25%
		02 07 02	wastes from spirits distillation	38%
		02 07 04	materials unsuitable for consumption or processing	83%
		20 02 01	biodegradable waste	13%
W101	Household and similar wastes	20 03 01	mixed municipal waste	Country specific food waste shares based on EEA-model
		20 03 02	waste from markets	
		20 03 03	street-cleaning residues	
		20 03 07	bulky waste	
		20 03 99	municipal wastes not otherwise specified	

A.6 C&I waste: Methodological descriptions and data tables

A.6.1 Estimation of C&I waste generation for base year 2018

Table 147: C&I waste generation: Extrapolated base data for EU27 (w/o DE), 2017, and scope of investigation, in 1,000 t

EWC-Stat category	NACE	A	B	C	D	E36, E37, E39	E38	F	G-U (excl. 46.77)	G46.77	EP_HH	TOTAL_HH
Code	Description	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply; sewerage	Waste collection, treatment and disposal activities; materials recovery	Construction	Services (except wholesale of waste and scrap)	Wholesale of waste and scrap	Households	Total waste
W012	Acid, alkaline or saline wastes	12	28	2,395	3	39	31	0	12	0	0	2,520
W02A	Chemical wastes	6	1	3,300	89	35	65	10	80	3	11	3,601
W032	Industrial effluent sludges	13	551	4,757	272	1,083	1,467	121	453	8	6	8,730
W05	Health care and biological wastes	5	0	8	0	0	7	1	340	0	0	360
W06	Metal wastes	92	295	23,080	370	136	15,338	10,059	9,328	5,276	2,025	65,999
W071	Glass wastes	9	0	1,800	4	51	2,262	478	959	88	6,859	12,510
W072	Paper and cardboard wastes	50	7	7,825	34	68	4,649	625	9,532	496	9,697	32,984
W073	Rubber wastes	65	7	159	1	2	297	25	1,365	22	220	2,162
W074	Plastic wastes	353	15	3,492	18	62	3,643	894	1,354	268	2,938	13,037
W075	Wood wastes	139	39	17,082	214	79	3,843	4,667	2,172	150	3,291	31,675
W091, W092	Animal and vegetal waste (excl. slurry and manure)	4,528	2	20,012	71	118	3,470	1,497	8,778	5	18,818	57,299
W101	Household and similar wastes	200	21	1,928	58	164	641	1,513	16,181	27	90,833	111,566
W102	Mixed and undifferentiated materials	955	404	12,897	940	1,071	5,107	3,031	3,353	97	2,434	30,288
W11	Common sludges	174	19	3,767	72	9,622	586	147	563	1	106	15,058
W121	Mineral construction and demolition waste	283	372	3,210	695	1,631	2,869	167,907	2,481	183	2,630	182,261
W124	Combustion wastes	25	60	28,413	55,121	151	3,666	203	1,053	6	5	88,702
W12B	Other mineral wastes	7	615,152	33,992	420	1,392	2,254	935	1,734	104	3,116	659,106
Total		6,915	616,971	168,117	58,381	15,706	50,196	192,113	59,738	6,733	142,988	1,317,859

Commercial & industrial waste

Potential overlap of commercial & industrial waste and municipal solid waste

A.6.2 Delimitation between C&I waste and MSW

Table 147 shows the extrapolated WStatR generation data for the EU27 (w/o DE) for the reference year 2017 by economic activity and by EWC-Stat category. The table displays all economic activities plus the sector households, as well as those EWC-Stat categories that are subject to this study.

The cells of the generation matrix that are defined as C&I wastes for the purposes of this study are marked by blue shading. The dark blue shading marks those wastes, that are assigned completely to the C&I waste stream. The light blue shading marks those wastes that may be partially or completely collected as municipal solid waste. All waste that is collected together with waste from households as MSW is assigned to the MSW stream and deducted from the C&I waste in order to avoid double counting.

The delimitation between MSW and C&I waste is shown in Table 148. The aim of the delimitation is to determine how much of the MSW comes from commercial sources and has to be deducted from the C&I waste. For this purpose, it needs to be estimated under which sectors of the WStatR matrix the MSW waste is reported. The allocation is based on the assumption that waste which is similar to and managed together with waste from households, is generated primarily by the service sector. Hence, the waste generated by the service sector is split between the waste streams C&I waste and MSW. The sector allocation is done at the level of the EWC-Stat categories as follows:

- Waste reported in the WStatR data under sector 'households' is generally considered as part of the MSW.
- MSW amounts that exceed the amounts reported under the sector 'households' are assumed to come from the service sector.
- For some EWC-Stat categories, the MSW amounts exceed the sum of the waste reported under the sectors 'households' and 'services'. The excess amounts are assumed to come from the NACE division E38 (Waste collection, treatment and disposal activities; materials recovery), representing for instance waste that was separated from mixed waste streams (mixed collection of packaging waste, mixed municipal waste).

This approach leads to the following results:

- Glass waste (W071) and plastic waste (W074) from the service sector are collected and managed completely as part of the MSW.
- Metal waste (W06), paper waste (W072), organic waste (W091, W092) and mixed municipal waste (W101) from services are managed partly as MSW and partly outside of the MSW regime.
- Other waste from the service sector like wood waste (W075), inert waste (W12B) and mixed and undifferentiated waste (W102) is managed outside of the MSW regime.

Overall, the amount of waste that comes from the service sector and is managed as part of the MSW is estimated at 23.7 million t. This amount is deducted from the C&I waste accordingly.

Table 148: Delimitation of commercial and industrial (C&I) waste and municipal solid waste (MSW), in 1,000 t and in weight-%

EWC-Stat category		Waste from 'services' (NACE G-U, excl. 46.77), in 1 000 t			Waste from 'services' (NACE G-U, excl. 46.77), in %		
		Total	Of which covered by:		Total	Of which covered by:	
Code	Description		C&I waste	MSW		C&I waste	MSW
W06	Metal wastes	9,328	7,829	1,498	100%	84%	16%
W071	Glass wastes	959	0	959	100%	0%	100%
W072	Paper and cardboard wastes	9,532	4,323	5,209	100%	45%	55%
W074	Plastic wastes	1,354	0	1,354	100%	0%	100%
W075	Wood wastes	2,172	2,172	0	100%	100%	0%
W091, W092	Animal and vegetal waste	8,778	4,069	4,708	100%	46%	54%
W101	Household and similar wastes	16,181	6,232	9,948	100%	39%	61%
W102	Mixed and undifferentiated materials	3,353	3,353	0	100%	100%	0%
W12B	Other mineral wastes	1,734	1,734	0	100%	100%	0%
Sum		**53,391**	**29,714**	**23,678**	**100%**	**56%**	**44%**

A.6.3 Relation between data on waste generation and treatment by EWC-Stat category

As indicated in Chapter 7.1.1 , the treated waste quantities do not equal the generated amount. Table 149 shows the total waste generation and the total waste treatment, including the waste from all economic activities and households, in the EU27 (w/o DE) for the reference year 2016, and the resulting ratio between treatment and generation. With the exception of the EWC-Stat category 'Other mineral wastes' (W12B), for which generation and treatment are balanced, the treated amounts are generally lower than the generated amounts. The ratios are mostly between 80% and 90% but are low for 'chemical wastes' (W02A) (31%), 'industrial effluent sludges' (W032) (42%), 'common sludges' (W11) (60%) and 'health care and biological wastes' (W05). The reasons for the imbalances are discussed in the following in order to identify whether the imbalances may have a negative impact on the estimation of the treated amounts:

- Imports/ exports of waste:
  The WStatR treatment data reflect the amount of waste that is treated within the EU countries. The data include imported wastes and do not cover waste that is exported for treatment. This affects in particular the balance of recyclable materials that are traded internationally and for which the EU is a net exporter. This is for instance the case for metal, paper and rubber waste (end-of-life tyres). According to international trade statistics, the net exports of these wastes in 2016 amounted to 7.2 million tons (metals), 4.9 million t (paper) and 0.27 million t (rubber) which corresponds well to the differences between generated and treated amounts for these materials. For plastic waste, trade statistics record net exports of 1.1 million t which explains only a part of the difference. Assuming that exported waste is treated abroad in the same way as in the EU, the imbalances shouldn't have a negative impact on the estimation.
- Change of EWC-Stat category through (pre-)treatment:
  Waste treatment changes the character of the treated material. The treatment outputs may thus be reported under a different EWC-Stat category than the generated primary waste. This may explain the differences between generation and treatment for 'household and similar wastes' (W101) or for 'mixed and undifferentiated materials' (W102) that undergo mechanical treatment or sorting. The outputs of such operations may be reported for instance under the EWC-Stat category 'sorting residues' (W103) or under the recyclable fractions (e.g. metals) if sorted out from the mixed waste. This phenomenon might lead to a bias with regard to the treatment but the impact is assumed to be limited.
- Material and water losses during (pre-)treatment:
  The differences between generation and treatment for the waste categories 'common sludges' (W11), 'industrial effluent sludges' (032) and 'chemical wastes' (W02A) are assumed to be due to a significant extent to water losses during treatment. According to the WStatR, the waste categories W032 and W11 should be reported in dry weight which should eliminate the impacts of dewatering. However, not all countries may be able to provide data on sludges in dry weight. If this assumption is correct the imbalance would not affect the treatment mix.

Lacking more specific data, the WStatR-based treatment mix is considered as an appropriate basis for estimating the treated quantities, in spite of the observed imbalances.

Table 149: Relation between waste treatment and waste generation by EWC-Stat category in the EU27 (w/o DE) in 2016

EWC-Stat		**Total waste generation**	**Total waste treatment**	**Ratio Treatment / Generation**
Code	Description	(1,000 t)	(1,000 t)	(%)
W012	Acid, alkaline or saline wastes	2,433	2,170	89%
W02A	Chemical wastes	3,869	1,198	31%
W032	Industrial effluent sludges	8,517	3,568	42%
W05	Health care and biological wastes	367	223	61%
W06	Metal wastes	65,649	59,188	90%
W071	Glass wastes	12,416	10,843	87%
W072	Paper and cardboard wastes	33,563	27,715	83%
W073	Rubber wastes	2,163	1,890	87%
W074	Plastic wastes	12,292	7,471	61%
W075	Wood wastes	35,296	32,976	93%
W091, W092	Animal and vegetal waste	56,542	44,804	79%
W101	Household and similar wastes	114,680	93,669	82%
W102	Mixed and undifferentiated materials	31,583	23,913	76%
W11	Common sludges	15,065	9,048	60%
W124	Combustion wastes	86,315	77,531	90%
W12B	Other mineral wastes	636,656	634,142	100%
Total		1,117,405	1,030,350	92%

A.7 C&D waste: Methodological information and data tables

A.7.1 Estimation of C&D waste generation for base year 2017

Table 150 shows the extrapolated WStatR generation data for the EU27 (w/o DE) for the reference year 2017 and illustrates the coverage of the C&D waste data within the WStatR data structure. The cells of the generation matrix that are defined as C&D wastes for this study are marked by brown shading. The estimate results in a C&D waste total in the EU27 (w/o DE) of 198 million tons for 2017.

Table 150: C&D waste generation: Extrapolated base data for EU27 (w/o DE), 2017, and scope of investigation, in t

EWC-Stat category	NACE	Manufacturing	Construction	Services (except wholesale of waste and scrap)	Other sectors	Households	Total C&D waste	Total waste from all sectors
Code	Description	C	F	G-U (excl. 46.77)	A, B, D, E, G46.77	EP_HH		Total_HH
W012	Acid, alkaline or saline wastes	2,394,860	48	12,194	113,270	24	0	2,520,396
W02A	Chemical wastes	3,300,317	9,551	79,795	200,052	11,353	0	3,601,068
W032	Industrial effluent sludges	4,756,949	120,686	453,419	3,393,255	5,987	0	8,730,296
W05	Health care and biological wastes	7,958	509	340,129	11,764	119	0	360,479
W06	Metal wastes	23,080,356	10,059,250	7,829,317	21,506,582	3,523,285	10,059,250	65,998,790
W071	Glass wastes	1,799,546	478,206	0	840,563	9,391,236	478,206	12,509,551
W072	Paper and cardboard wastes	7,825,209	624,533	4,323,391	5,305,126	14,905,733	0	32,983,992
W073	Rubber wastes	158,503	25,290	1,365,142	393,513	219,849	0	2,162,297
W074	Plastic wastes	3,492,336	893,787	0	3,210,702	5,439,904	893,787	13,036,729
W075	Wood wastes	17,081,686	4,667,476	2,172,192	5,690,582	2,062,969	4,667,476	31,674,905
W091, W092	Animal and vegetal waste	20,012,385	1,496,657	4,069,478	8,195,094	23,525,811	0	57,299,425
W101	Household and similar wastes	1,927,774	1,513,451	6,232,488	1,110,931	100,781,167	0	111,565,812
W102	Mixed and undifferentiated materials	12,896,622	3,030,753	3,352,720	8,588,824	2,419,250	0	30,288,169
W11	Common sludges	3,767,392	146,859	562,958	10,474,331	106,260	0	15,057,800
W121	Mineral C&D waste	3,210,390	167,907,342	2,480,562	6,032,960	2,630,161	182,261,416	182,261,416
W124	Combustion wastes	28,412,906	203,416	1,052,610	59,028,382	5,014	0	88,702,328
W12B	Other mineral wastes	33,991,916	935,324	1,734,011	622,419,912	24,385	0	659,105,548
Total C&D waste		**3,210,390**	**184,006,061**	**2,480,562**	**6,032,960**	**2,630,161**	**198,360,135**	
Total of all waste categories		**168,117,105**	**192,113,139**	**36,060,405**	**756,515,843**	**165,052,507**		**1,317,859,000**

C&D waste covered by this study

A.7.2 Estimation of asphalt generation and treatment

The estimate of asphalt generation and treatment in Chapter 7 for EU27 w/o DE is based on data from the European Asphalt Pavement Association (EAPA). The association publishes annual statistics on the use of reclaimed asphalt in the countries of their member associations. Table 151 shows the EAPA data used for determining the arising and treatment of reclaimed asphalt in the EU. The estimate is based on data for reference yeas 2017[58], supplemented with data for 2016[59] for a few countries.

Data on the arising of reclaimed asphalt are available from 14 EU countries. In Table 152, the amounts according to EAPA are related to the generation of EWC-Stat category 'mineral construction and demolition waste' (W121) according to the WStatR and the share of the reclaimed asphalt within the generated mineral C&D waste is calculated. The average share of 17.9% of reclaimed asphalt in mineral C&D waste is then used as estimate to determine the asphalt arising in the EU-countries for which no data are available. The results are displayed in Table 94 in Chapter 8.1.2.

At country level, the share of asphalt within mineral C&D waste ranges between 4% in Spain and 87% in Finland. Assuming that the asphalt data are accurate, the high shares of asphalt in W121 in the countries Finland (87%), Czechia (72%) and Sweden (58%) are likely to indicate an underestimation of mineral C&D waste in EU statistics.

Table 151: Generation and treatment of reclaimed asphalt according to EAPA

Country	**Ref. year**	**Reclaimed asphalt** (in 1,000 t)	**% of available reclaimed asphalt used in:**					
			Hot and Warm Mix Asphalt Production	Half Warm Mix Asphalt Production	Cold Recycling*	Unbound Road Layers	Other Civil EngineeringA pplications	Landfill/Other applications/ Unknown
Austria	2017	1,650	60	no data	no data	no data	no data	no data
Belgium	2016	1,240	81	no data	no data	no data	no data	no data
Croatia	2016	80	50	0	50	0	0	0
Czechia	2017	2,600	14	0	30	20	10	26
Denmark	2017	1,165	66	0	0	8	0	26
Finland	2017	1,200	100	0	0	0	0	0
France	2017	6,400	70	no data	no data	no data	no data	no data
Hungary	2017	120	95	0	0	0	4	1
Italy	2017	9,000	23	no data	no data	no data	no data	no data
Netherlands	2017	4,500	71	0	11	0	0	18
Slovakia	2017	50	96	0	2	1	1	0
Slovenia	2017	84	24	0	6	10	0	60
Spain	2017	494	83	0	0	14	0	3
Sweden	2016	1,600	84	6	5	5	0	0

* Cold recycling includes stabilisation with bitumen emulsion, foamed bitumen and/or cement

Complete data on the recovery and disposal of the reclaimed asphalt are available form 10 countries. The different types of asphalt treatment in the EAPA data are aggregated according to the treatment categories of EU waste statistics as follows:

[58] Asphalt in figures 2017; source: (EAPA 2017)
[59] Asphalt in figures 2016; source: (EAPA 2016)

- The production of hot, warm and half-warm asphalt, the cold recycling and the use of asphalt for unbound road layer are assigned to 'recycling' (RCV_R);
- Other civil engineering applications are assigned to 'backfilling' (RCV_B);
- The category landfill/other applications/unknown is assigned to 'recycling' (RCV_R) and 'landfilling' (DSP_L) in the ratio 50:50.

The resulting treatment mix (see framed cells in bottom line of Table 152) is used as basis to estimating the asphalt treatment in EU-countries for which no asphalt data are available. The resulting data for the EU27 w/o DE is displayed in Table 96 in Chapter 8.1.3.

Table 152: Estimates of generation and treatment of asphalt for countries not included by EAPA data

Country	Generation			Treatment		
	Reclaimed asphalt acc. to EAPA (in 1,000 t)	Mineral C&D waste (W121)	Share of reclaimed asphalt in W121 (weight-%)	Recycling (RVC_R)	Backfilling (RCV_B)	Landfilling (DSP_L)
Austria	1,650	10,952	15%			
Belgium	1,240	19,538	6%			
Croatia	80	603	13%	80	0	0
Czechia	2,600	3,613	72%	1,664	260	676
Denmark	1,165	3,701	31%	862	0	303
Finland	1,200	1,379	87%	1,200	0	0
France	6,400	57,731	11%			
Hungary	120	2,308	5%	114	5	1
Italy	9,000	34,368	26%			
Netherlands	4,500	18,224	25%	3,690	0	810
Slovakia	50	684	7%	50	1	0
Slovenia	84	631	13%	34	0	50
Spain	494	12,079	4%	479	0	15
Sweden	1,600	2,758	58%	1,600	0	0
Total	**30,183**	**168,569**	**17.9%**	**9,772**	**265**	**1,855**
				90%	**2%**	**8%**

A.8 Structure of EU waste statistics data (WStatR reporting formats)

Table 153: WStatR reporting format on waste generation (simplified[60])

EWC-Stat code	EWC-Stat description	1 A Agriculture, forestry and fishing	2 B Mining and quarrying	3-12 C Manufacture	13 D Electricity, gas, steam and air conditioning supply	14 E36, E37, E39 Water collection, treatment and supply; sewerage; remediation activities ..	15 E38 Waste collection, treatment and disposal activities; materials recovery	16 F Construction	17 G-U excl. G4677 Services (except wholesale of waste and scrap)	18 G4677 Wholesale of waste and scrap	19 EP_HH Households	**20** **TOTAL_HH** **All NACE activities plus households**
W012	Acid, alkaline or saline wastes											
W02A	Chemical wastes											
W032	Industrial effluent sludges											
W033	Sludges and liquid wastes from waste											
W05	Health care and biological wastes											
W061	Metal wastes, ferrous											
W062	Metal wastes, non-ferrous											
W063	Metal wastes, mixed ferrous and non-											
W071	Glass wastes											
W072	Paper and cardboard wastes											
W073	Rubber wastes											
W074	Plastic wastes											
W075	Wood wastes											
W076	Textile wastes											
W08A	Discarded equipment (except discarded											
W081	Discarded vehicles											
W0841	Batteries and accumulators wastes											
W091	Animal and mixed food waste											
W092	Vegetal wastes											
W093	Animal faeces, urine and manure											
W101	Household and similar wastes											
W102	Mixed and undifferentiated materials											
W103	Sorting residues											
W11	Common sludges											
W121	Mineral waste from construction and											
W12B	Other mineral wastes											
W124	Combustion wastes											
W126	Soils											
W127	Dredging spoils											
W128_13	Mineral wastes from waste treatment											
TOTAL	**Total waste**											

[60] Information not displayed in the table: 10 sub-sectors of NACE division C 'Manufacturing' and 21 hazardous waste categories

Table 154: WStatR reporting format on waste treatment (simplified) [61]

EWC-Stat code	EWC-Stat description	Recovery – recycling (R2 – R11, excl. backfilling) RCV_R	Recovery - backfilling RCV_B	Recovery - energy recovery (R1) RCV_E	Disposal - incineration (D10) DSP_I	Disposal - landfill (D1, D5, D12) DSP_L	Disposal - landfill and other (D1-D7, D12) DSP_OTH	**Total waste treatment TRT**
W012	Acid, alkaline or saline wastes							
W02A	Chemical wastes							
W032	Industrial effluent sludges							
W033	Sludges and liquid wastes from waste							
W05	Health care and biological wastes							
W061	Metal wastes, ferrous							
W062	Metal wastes, non-ferrous							
W063	Metal wastes, mixed ferrous and non-							
W071	Glass wastes							
W072	Paper and cardboard wastes							
W073	Rubber wastes							
W074	Plastic wastes							
W075	Wood wastes							
W076	Textile wastes							
W08A	Discarded equipment (except discarded							
W081	Discarded vehicles							
W0841	Batteries and accumulators wastes							
W091	Animal and mixed food waste							
W092	Vegetal wastes							
W093	Animal faeces, urine and manure							
W101	Household and similar wastes							
W102	Mixed and undifferentiated materials							
W103	Sorting residues							
W11	Common sludges							
W121	Mineral waste from construction and							
W12B	Other mineral wastes							
W124	Combustion wastes							
W126	Soils							
W127	Dredging spoils							
W128_13	Mineral wastes from waste treatment							
TOTAL	**Total waste**							

[61] Information not displayed in the table: 21 hazardous waste categories

B Appendix

B.1 Comparison with previous studies

Climate protection potentials of MSW management have been investigated in two previous studies. The EU27 (with UK, without Croatia) was last examined more comprehensively for the balance year 2007 for MSW in Dehoust et al. (2010). A rough calculation was done for the EU28 for the year 2012 in Vogt et al. (2015).

A comparison of the results is only possible on the basis of specific results. In addition, the results for 2012 were given in a different and less comprehensive systematic. Instead of results per waste fraction, the results were derived per treatment option. For a comparison, the results from this study and the results from the previous studies have been modified to the different systematic as far as possible:

- Residual MSW for treatment → Incineration, MBT, MT
- Organic recyclables → Biological treatment
- Dry recyclables (incl. wood) → Recycling

In both previous studies the treatment option "refuse composting", in which GHG emissions from composting of residual MSW and compost use in the agriculture is described, was investigated. For the comparison this treatment was not assigned to "M(B)T" as the calculation systematic is different and also different between the previous studies as the diverse net results show. The background data for the calculation for 2012 is not available. In addition, in the study for 2012 the collection, transportation and sorting were reported separately. In turn, GHG emissions from collection, transportation and sorting are included in the GHG net results of the waste fractions for 2007, while the current study only considers the GHG emissions from transport and sorting in the net results. Therefore, the specific results for the treatment for the year 2012 are little lower than in the other studies. However, GHG emissions from collection, transportation and sorting are of minor importance in the whole life cycle.

Table 155: Specific GHG net results per treatment option – MSW – in kg CO_2eq/t

Waste fraction	EU27 2017	EU28 2017	EU28 2012	EU27 2007
	This study	This study	Vogt et al (2015)	Dehoust et al. (2010)
Res. MSW for treatment	-24	-29	-4	-100
Biological treatment	-1	7	7	22
Recycling	-549	-575	-1,109	-663
Res. MSW to landfill	929	876	729	1,039
Refuse composting			1,644	75
Collection, sorting, transportation			22	
Total	**-17**	**-29**	**-35**	**313**

From the overall results it can be seen that a net debit in 2007 shifted to a net credit already for 2012, and also in this study. This is mainly due to diversion from landfilling. The specific net results for landfill are more or less in the same magnitude. The higher value for 2007 is mainly due to the general gas collection efficiency of 20%, which was used for all the member states. The slightly lower value for 2012 compared to 2017 may be explained by different DOC values. Otherwise, the parameters used in the different studies have been the default values from IPCC (2006) or are close to these default values (see Chapter 4.2.3).

The higher GHG net results for residual MSW for treatment for 2007 demonstrate the influence of differently used substitution potentials for energy from waste. In Vogt et al. (2015) electricity generation was credited with an average grid emission factor of 507 g CO_2eq/kWh for the EU28. This was done as a simplification, since it was not possible to determine the marginal mix for each OECD member state. In this study, also the average grid emission factor is used (2017: 429 g CO_2eq/kWh), here to respect the influence of the energy transition (see Chapter 4.1.2). The somewhat higher GHG net result in this study compared to 2012 is due to assumptions for mechanical treatment and the high share of RDF (MBT 5, Chapter 4.2.5)

The results for biological treatment are more or less in the same range and typical for composting. The difference between the EU27 and EU28 in this study is mainly due to a different share of anaerobic digestion. The higher value for recycling in the study for 2007 compared to this study is partly due to the different calculation for wood, where the saving of wood was included for wood and paper with comparably relevant GHG mitigation effects. Other reasons are the actualized emission factors in this study with partly lower values, and the energy use of residues with the lower substitution potentials due to the energy transition (explanations see also partial report Germany). The higher value for the year 2012 is partly explained by the fact that transport and sorting are reported separately. In addition, the balance for 2012 could only be done as a rough estimation, therefore, losses of processing residues are maybe underestimated (e.g. no special consideration of packaging waste, LWP).

B.2 Characteristics of waste fractions

Table 156: Overview calorific value and carbon content of residual waste for the different MSW balance areas and scenarios

MSW balance areas	calorific value in MJ/kg	fossil C content in % wet waste	biogenic C content in % wet waste
EU27 (w/o DE), 2017	10.1	11.5	15.1
EU27 (w/o DE), lead scenario	11.0	14.0	14.4
EU27 (w/o DE), scenario with home composting in the RC rate	10.5	12.6	14.8
Cluster 2, 2017	9.8	10.6	15.5
Cluster 2, lead scenario	10.7	13.0	14.8
Cluster 2, special scenario	10.7	13.0	14.8
Cluster 1, 2017	9.5	10.9	14.2
Cluster 1, lead scenario	10.2	13.2	13.1
Cluster 1, special scenario	11.1	14.1	14.7
Germany, 2017	9.2	9.4	15.7
Germany, lead scenario	9.1	8.9	15.9
Germany, scenario with home composting in the RC rate	9.2	9.2	15.8

Table 157: Overview calorific value and fossil carbon content waste fractions

Waste fractions	calorific value in MJ/kg	fossil C content in % waste	Source
Refuse derived fuel (RDF)	13	15%	(Flamme et al. 2018)
Wood waste	16	2.3%	(Flamme et al. 2018)
Impurities organic waste	12	21%	calculated (Chapter 4.2.7)
Rejects paper industry	9.94	1.2%	(UBA 2006)
Plastic waste, C&I waste EU	34.7	71.2%	caclulated (Chapter 4.2.6)
Hospital waste	14.9	19%	(Vogt / Ludmann 2019)
Waste tyres	28	52.8%	H_i (VDZ 2018); C_{foss} (Flamme et al. 2018)

(Corresponds to data for Germany, see partial report Germany)