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Potential of waste management to achieve the recycling rates of the EU Waste Framework Directive

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Abstract

Future waste streams and corresponding recycling rates are projected by use of a forecast model for the context of Germany. The model produces a forecast for the municipal waste amount based on the past waste generation, material compositions of the waste streams, economic (growth rates) and demographic (population) developments. Each waste stream is defined by a respective material composition that allows stream modelling on the level of material categories (e.g. paper, glass, plastics, organic) in the waste stream (e.g. residual household waste) by defining growth rates for the amount of each material category. The contribution of each municipal waste stream to the new recycling targets is estimated by respective factors taken from DESTATIS data and own calculations. In the chosen baseline scenario, the new WFD recycling targets will not be achieved. For this reason, further scenarios are defined with higher collection rates of certain waste material categories in the main municipal waste streams. This follows the approach to “divert” recyclable material from such municipal waste streams that contribute low amounts to recycling according to the new WFD (e.g. residual household waste), towards those municipal waste streams that are related to high recycling contributions (e.g. separately collected paper, glass, organic). It is the objective to explicitly point out the great challenge to meet future recycling rates, to express the need of appropriate and validated data for reliable scenario definitions and to demonstrate the functionality of the model. This results into the question how to implement appropriate waste management strategies that will realize the necessary higher collection rates to reach the future recycling targets.

Keywords

WFD recycling targets, municipal waste streams, forecast model, collection rates, recycling rates, waste management strategy

1 Introduction

The European Commission has adopted changes to the Waste Framework Directive (WFD). This affects the existing reporting system in Germany and the methodology for determining recycling rates for municipal waste (EU, 2018).

At present, the determination of recycling rates in Germany is based on the measurement of material input into waste treatment plants. As a result of the revision of the Di-

rective the measurement points for recycling will have to be changed in future. The Commission proposes to determine the recycled amount primarily on the basis of the input into final recycling plants or, under certain conditions, on the basis of the output of sorting plants. In addition, it is proposed to estimate recycling quantities by means of average waste specific loss rates.

The amendments to the WFD may have multiple and far-reaching consequences for the collection, processing and management of the statistical data and the legal framework. The municipal waste recycling target for 2020 remains unchanged at 50%, but will be gradually raised in the following years to 55% (2025), 60% (2030) and finally 65% (2035).

2 Modelling approach

2.1 Forecast of waste streams

2.1.1 Waste streams

For the forecast of the German recycling rates a projection of the amounts of the relevant municipal waste streams is necessary. For this purpose, the material-specific municipal waste streams are defined according to the municipal waste definition (EU, 2018) on the basis of the List-of-Waste (LoW) codes. The displayed amounts for the municipal waste streams correspond to the annual input into German waste treatment plants, reported under the respective LoW codes. This study focuses on five major municipal waste streams as material specific aggregates of the respective LoW codes:

- Residual Household & Business Waste (LoW: 20 03 01 00 - 02)
- Organic Waste (20 03 01 04, 20 02 01, 20 01 08, 20 03 02, 20 01 25)
- Paper & Cardboard Waste (15 01 01, 20 01 01)
- Mixed Packaging & Recyclables (15 01 06 00 - 02, 20 01 99 01, 15 01 05)
- Glass (20 01 02, 15 01 07)

It is important to note that the above mentioned waste streams are usually collected separately at source, directly. And so, the waste separation habits of the population have a major impact on the collection rates.

Further existing municipal waste streams are defined and modelled separately. But for reasons of readability and their quantitative importance (approx. 14% of the total municipal waste amount) they are aggregated here to one waste stream (Rest):

- Rest: bulky waste (20 30 07), wood (15 01 03, 20 01 38), plastic (15 01 02, 20 01 39), street cleaning (20 03 03), electronic equipment (20 01 23, 20 01 35, 20 01 36, 20 01 21), metal (15 01 04, 20 01 40, 15 01 11), textile (15 01 09, 20 01 10, 20 01 11), others (20 01 13-19, 20 01 26-34, 20 01 99 00, 20 03 99, 20 02 03, 15 01 10, 20 01 37, 20 01 41)

In comparison to the above mentioned major waste streams, the specific collection systems for these waste streams are usually not close to private households (except for bulky waste maybe). These collection systems are located closer to recycling centres, waste disposal companies or business actors. Waste separation habits of private consumers have less impact. It is assumed that collection rates are already high due to efficient waste separation practices in the non-private sector.

The Table 1 shows the corresponding amounts of municipal waste measured as input into German waste treatment plants with domestic origin (DESTATIS, 2011-2018). These inputs are considered as the past municipal waste potential. The future projection of these waste streams is the basis for the calculation of the respective recycling rates. Here, the latest available eight reporting years are used as period for trend analysis, and 2016 is considered as starting point for the forecast, so that 2017 will be the first forecast year.

Table 1 Reported municipal waste inputs into German waste treatment plants [Mio. t]

Waste stream / year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Res. Household & Business	17.9	18.0	18.1	17.7	17.7	17.6	17.5	17.8
Organic	9.3	9.6	9.9	10.0	9.8	10.8	11.0	11.5
Paper & Cardboard	8.1	8.0	8.1	8.1	7.6	8.0	8.1	7.8
Mix. Packaging & Recyclables	4.3	4.4	4.5	4.6	4.6	4.7	4.9	4.8
Glass	2.4	2.5	2.6	2.4	2.5	2.4	2.6	2.6
Rest	5.9	6.3	6.4	6.5	6.8	7.0	6.8	7.2
TOTAL	47.9	48.8	49.6	49.2	49.0	50.6	50.9	51.6

[DESTATIS, 2011-2018]

2.1.2 Composition of waste streams

Each projected municipal waste stream is defined by an average material composition. As validated average compositions for the domestic context are not yet available, the

compositions are assumed, based on extensive experience from related projects and studies. However, the average domestic material composition will be determined as result of an on-going waste analysis of the domestic residual household waste stream. The following Table 2 shows the assumed average material compositions for the major waste streams (only on the main material level for better readability).

Table 2 Average waste stream compositions [mass %]

waste stream material category	**Res. Household & Business Waste (stream)**	**Organic Waste (stream)**	**Paper Waste (stream)**	**Mix. Packaging/Rec. Waste (stream)**
Paper/cardboard	10.7%	0.0%	95.2%	7.4%
Glass	6.4%	0.0%	0.0%	3.2%
Plastic	7.2%	0.0%	1.9%	42.3%
Metal	2.0%	0.0%	2.9%	10.2%
Organic	47.0%	94.6%	0.0%	10.0%
Wood	1.0%	0.0%	0.0%	1.2%
Textile	3.6%	0.0%	0.0%	1.3%
Inert	2.0%	0.0%	0.0%	0.0%
Compound	6.9%	0.0%	0.0%	16.8%
Hazardous	0.5%	0.0%	0.0%	0.0%
Others	8.6%	5.4%	0.0%	0.3%
< 10 mm	4.2%	0.0%	0.0%	7.3%

[Example data from a municipality]

2.1.3 Growth rates of waste stream material categories

A further requirement for the forecast of municipal waste streams is the definition of the future development of the waste stream material categories. This is realized by definition of (constant or graded) growth rates that describe the expected change of mass per capita with reference to the previous year. In this case, constant annual growth rates are used.

Growth rates are defined on various levels. For a certain number of waste material categories, the future trends are projected based on an analysis of the net-domestic consumption, e.g. the annual net-domestic consumption of print paper per capita is associated to the generation of paper waste per capita (with certain time delay determined

through average product use time). As further requirement of the forecast, the generated waste per capita at the beginning of the forecast period (2016) has to be defined. This data is obtained from the reported municipal waste amounts (Chapter 2.1.1), the waste stream compositions (Chapter 2.1.2) and the past population figures of the respective years (Chapter 2.1.4).

The Table 3 summarizes the starting values of generated waste per capita and the respective expected annual growth rates (constant) obtained from net-domestic consumption trends. These growth definitions are applied to all waste streams.

Table 3 Growth rates of waste stream material categories by analysis of net-domestic consumption

material category	Generated waste (2016) [kg per cap.]	Expected future annual growth [+/-% p.a.]
Paper packaging	28.3	2.3%
Print paper & others	91.3	-1.1%
Glass	45.2	-2.0%
Plastic packaging	27.4	2.5%
Other plastics	29.0	-1.1%
Ferrous metal packaging	6.1	-0.8%
Compound packaging	12.4	-1.0%
Electronic equipment	12.2	-1.0% *
		*) modified value, based on net-domestic consumption trend

[DESTATIS, UBA, VDP, BKV, EUROSTAT, MULTIPLE YEARS, modified]

In a similar way, per capita starting values (2016) and growth rates are defined for all the other material categories that form part of a waste stream (Chapter 2.1.2). As an example, the following growth rates are considered in the forecast:

- Ferrous metals, not packaging (+0.7% p.a.)
- Wood (+1.8% p.a.)
- Textiles (+6% p.a.)
- ...

The respective trend analysis is not based on net-domestic consumption but on the reported municipal waste amounts, the waste stream compositions and the population figures. These growth rates are applied to all municipal waste streams, apart from the

Residual Household & Business Waste. In the case of the Residual Household & Business Waste, the material category growth rates result from specific waste analyses from several years.

2.1.4 Demography

Population figures from the past and the expected population size within the forecast period are necessary in order to normalize the municipal waste amounts, and to calculate the absolute waste amounts, respectively.

The official population data from the past and a certain population forecast scenario are integrated into the model. The Table 4 shows population figures for the starting year 2016 (DESTATIS, 2018a) and for selected years from the chosen future demographic scenario ("BEV-VARIANTE-05", DESTATIS, 2018b).

Table 4 Population scenario (selected years)

Year	***2016 (start)***	***2017***	**2018**	**2020**	**2025**	**2030**	**2035**
Population [Mio.]	*82.5*	*82.8*	81.7	81.6	81.1	80.2	79.0

As a remark, it should be noted that there is a major gap of approx. 1 million persons due to the shift from the past to the future time series between the years 2017 (past) and 2018 (scenario). This circumstance will have an effect on the absolute waste amounts in form of a discontinuity around these years.

For this study it is assumed that half of the population lives in (rural) conditions that lead to typically “rural” waste compositions, while the other half lives in (urban) conditions generating typical “urban” waste. This is especially relevant in terms of organic garden and kitchen waste generation.

2.2 Waste stream specific recycling factors

In future, the overall recycling rate has to be determined based on the output of waste treatment plants, or based on the input into recycling plants (Chapter 1). The recycling targets mentioned in Chapter 1 refer to this modification of the measurement points.

In a previous (not yet published) study, waste stream specific “recycling factors” were determined for each municipal waste stream that express the relation between the reported municipal waste input into the waste treatment plants and the expected output that can be considered recycled after the complete waste treatment process. Table 5

shows first rough approximations for the average recycling factors, based on the previous study results (for reference year 2015) and used in this forecast.

Table 5 Waste stream specific recycling factors (reference year 2015)

Waste stream	Recycling factors (2015)
Res. Household & Business	5%
Organic	70%
Paper & Cardboard	95%
Mix. Packaging & Recyclables	40%
Glass	90%
Rest	35%

Such factors are used to determine the future recycling amounts of each municipal waste stream by multiplication of the forecasted municipal waste amounts with the respective factors, i.e.

Municipal Waste Stream [t] x Recycling Factor [%] ≈ Recycled Amount [t]

This means for example, that only 5% of the residual household waste is recycled, while other municipal waste streams collected separately close to households show far higher recycling factors.

The recycling factors are also employed under the assumption that they will increase in future (see Chapter 2.3.3). This can be understood in the way that the existing waste treatment plant technology and the corresponding recycling efficiency will improve during the forecast period.

2.3 Scenario definition

2.3.1 Baseline

The baseline scenario describes the situation that the municipal waste streams are projected under the constraints mentioned in the previous chapters. Upon this base, the (constant) recycling factors (Table 5) are applied in order to calculate the respective

overall recycling rate, i.e. without consideration of measures that aim to raise collection rates.

2.3.2 Scenario A: Higher collection rates in collection systems close to private households

This scenario is defined by far higher collection rates of certain material categories in the main municipal waste streams than in the baseline scenario. This follows the approach to “divert” recyclable material from such municipal waste streams that contribute low amounts to recycling according to the new WFD (e.g. residual household waste), towards those municipal waste streams that are related to high recycling contributions (e.g. separately collected paper, glass, organic). Recycling factors in this scenario are the same as mentioned in Table 5 (constant over time).

For this scenario the collection rates defined in Table 6 are used. For example, the actual collection rate of paper packaging in the Paper & Cardboard Waste Stream is about 64%, i.e. this share of the total paper packaging potential in the municipal waste can be expected in this waste stream at the beginning of the forecast period (2016). It is targeted to raise the collection rates linearly to 90% in 2025 and then to 95% in 2035.

Table 6 Collection rates of Scenario A

Collection rate		**actual**	target	target
OF material category:	IN waste stream:	**2016**	2025	2035
Paper packaging	Paper & Cardboard	**64%**	90%	95%
Print paper & others	Paper & Cardboard	**80%**	90%	95%
Glass	Glass	**65%**	90%	93%
Plastic packaging	Mix. Packaging & Rec.	**53%**	70%	85%
Compound packaging	Mix. Packaging & Rec.	**49%**	50%	55%
Ferrous metal pack.	Mix. Packaging & Rec.	**62%**	80%	85%
Other ferrous metals	Mix. Packaging & Rec.	**25%**	40%	40%
Other plastics	Mix. Packaging & Rec.	**32%**	40%	45%
Garden Waste	Organic (urban collection)	**91%**	95%	95%
Kitchen Waste	Organic (urban collection)	**34%**	65%	70%
Garden Waste	Organic (rural collection)	**86%**	95%	95%
Kitchen Waste	Organic (rural collection)	**9%**	65%	70%

All collection rates are determined with the aim to divert the necessary mass for reaching the targeted collection rates from the Residual Household & Business Waste. The limited presence of the necessary material mass to be shifted is a limitation for the definition of the collection rates. In principle, the masses could be taken from other waste streams, too.

2.3.3 Scenario B: Higher recycling factors of selected waste streams and higher collection rates in collection systems close to private households

This scenario setting is similar to the one in Scenario A, with the difference that the recycling factors of selected waste streams are raised linearly over time until reaching +10% in 2035 (with reference to the starting values in 2015 mentioned in Table 5). As recycling factors of the waste streams Glass and Paper & Cardboard are already on a high level, the increase in recycling efficiency is only expected for the waste streams Residual Household & Business, Organic, Mixed Packaging & Recyclables and Rest (see Table 7).

Table 7 Expected recycling factors (2020 to 2035)

Waste stream	Recycling factors (2015)	2020	2025	2030	2035
Res. Household & Business	5%	5%	5%	5%	6%
Organic	70%	72%	74%	75%	77%
Paper & Cardboard	95%	95%	95%	95%	95%
Mix. Packaging & Recyclables	40%	41%	42%	43%	44%
Glass	90%	90%	90%	90%	90%
Rest	35%	36%	37%	38%	39%

The recycling factors are increased in order to observe the impact on the overall recycling rate if these waste streams would be recycled with higher efficiency. If recycling targets are met or even surpassed then certain collection rates could be decreased perhaps (compared to Scenario A).

3 Forecast results

3.1 Waste stream potential

As a next step, the total expected municipal waste amount is projected on the level of material categories. The forecast results for the municipal waste streams of Scenarios Baseline, A and B are given in Table 8.

Table 8 Expected municipal waste amount for Scenarios Baseline, A and B [Mio. t]

year / waste stream	2020 Base	2020 A/B	2025 Base	2025 A/B	2030 Base	2030 A/B	2035 Base	2035 A/B
Res. Household & Business	17.3	13.0	17.0	7.2	16.7	6.0	16.4	4.8
Organic	11.4	14.4	11.3	18.0	11.2	18.2	11.1	18.4
Paper & Cardboard	7.8	8.4	7.6	9.0	7.5	9.1	7.4	9.3
Mix. Packaging & Recyclables	4.7	5.1	4.8	5.7	5.0	6.2	5.1	6.7
Glass	2.3	2.7	2.1	2.9	1.9	2.6	1.7	2.4
Rest	7.1	7.1	7.4	7.4	7.8	7.8	8.2	8.2
TOTAL	**50.6**	**50.6**	**50.3**	**50.3**	**50.0**	**50.0**	**49.8**	**49.8**

For the baseline scenario in general, it can be expected that the major municipal waste streams will stay on a constant level, however with slightly falling tendency.

The huge impact of the specified collection rates (Chapter 2.3.2) on the waste stream amounts (and thus on the composition of the municipal waste stream) can be observed (Scenario A and B). For example, the total amount of Residual Household & Business Waste is strongly decreased during the whole forecast period. By 2025, approx. 10 Million t of this waste stream would be shifted to other waste streams (mainly towards Organic, i.e. +7 Million t), as a consequence of the defined challenging collection rates and because the residual household waste stream acts as the “source” for other waste streams. All other waste streams are increasing compared to the baseline (except waste stream Rest that is excluded from modifications by collection rates, see Chapter 2.1.1).