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Climate change mitigation through policies on waste – intersectoral analysis

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Executive summary

This report provides an analysis on the completeness, consistency and policy effects of country-level reporting for policies and measures (PaMs) associated with the waste sector. The aim is to assess whether additional effort is required from this sector in support of the EU climate neutrality objective.

First, we present the current status of PaMs reporting by EU Member States (MS), Iceland, Norway and Switzerland under the EU Regulation on the Governance of the Energy Union and Climate Action[1] (Section 2) in order to provide insight in the scope and impact of the sectoral PaMs reporting. We find that regulatory PaMs referencing the Waste Framework Directive[2] and Landfill Directive cover the majority of PaMs being identified at national level. Few countries (14) report on national or subnational PaMs that do not relate (directly) to EU legislation. Municipal and organic wastes are the most common waste types being targeted by the reported PaMs, often through schemes associated with recycling and recovery stages of the waste hierarchy.

Only 31 of 204 (solid) waste PaMs were reported with quantified emissions savings, highlighting an implied barrier and/or difficulty to quantification of emission reductions from the sector. Just over half of the reporting countries attempted any quantification. The quantifications that are being reported are almost exclusively in relation to IPCC sector 5A (solid waste disposal sites) through implementation of the Landfill Directive.

Given the lack of reported PaMs quantification, we then analyse historical emissions data and trends in per capita emissions from the waste sector (Section 3) to highlight that the lack of PaMs quantification does not seem to imply a broader lack of progress in emission reductions from the sector. In fact, for the EU, it is evident that emissions from the sector have reduced consistently since the turn of the century. We also find substantial improvements across most EU countries in terms of per capita waste sector emissions, with the most substantial improvements between 2000 and 2021 being due to reductions associated with landfills. This also reflects the definition of the solid waste sector for the emissions reporting which only includes landfills, biological treatment and incineration without energy recovery. However, it is interesting to observe that some countries show an increase in waste sector emissions per capita across this timeframe, despite the regulatory framework in place. This may be due to national trends in waste generation and treatment pathways but could also be an artefact of poor quality / high uncertainty activity data.

The lack of quantified data on the impacts of policies and measures by countries is not indicative of an associated lack of progress in terms of emission reductions from the sector. However, some countries still can achieve significant sectoral emission reductions by catching up on implementation of existing waste Union policies.

We then provide a more detailed review of existing policy and its implementation across the reporting countries (Section 4). We find a clear synergy between historical reductions of GHG emissions and the diversion of biodegradable waste from landfills in response to the Landfill Directive. Many countries have applied effective bans on the landfilling of waste, either entirely, or for specific waste streams. Additionally and alternatively, countries have introduced separate collection of bio-waste. Ireland stands out as a country that has achieved significant progress in terms of reducing waste to landfills without introducing a direct landfill ban. Instead, benefits have largely been achieved by implementing a comparatively high

1 Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action: https://eur-lex.europa.eu/legal-content/EN/TXT/ ?toc=OJ:L:2018:328:TOC&uri =uriserv:OJ.L .2018.328.01.0001.01.ENG

2 Waste Framework Directive (2008/98/EC)

landfill tax, and through the targeting of specific waste streams through its national waste prevention programme. It should also be noted that a small portion of this achievement is likely due to the increased export of waste. In situations where waste exports are involved, it may be beneficial in terms of net GHG emissions depending on the capacity of the waste generating country to treat waste via less carbon intensive treatment pathways. We find clear evidence that for all measures, particularly those such as landfill taxes, that their effectiveness is closely linked to how they are designed, implemented and enforced based on the ability of policy makers and practitioners to apply them.

We also explore the potential PaMs reporting (and quantification) limitations countries may face due to the cross-sectoral nature of waste sector PaMs (Section 5). Emissions inventories, projections and PaMs under EU reporting structures are included in IPCC Sector 5. We identify a number of IPCC sectors that fall outside of IPCC sector 5 that are likely to be impacted due to waste PaMs. In fact, we identify examples of cross-sectoral emissions impacts from waste management options across all stages of the waste hierarchy.

Some of the most critical impacts in terms of GHG reductions as a result of waste sector PaMs are likely to be observed in other reporting sectors such as stationary energy due to the recovery of energy from waste incineration, and product manufacturing due to the impact of waste prevention, recycling and preparation of waste for re-use. These waste measures can reduce the need for new virgin materials or goods and the emissions emitted along their whole value chain. For this reason, the emissions impacts of waste PaMs may be realized in countries or regions outside of the implementing country where the trade of materials, products and energy is affected. We identify a risk of over-reliance on EfW facilities as a means for managing solid waste. Planning the capacity need of such installations alongside projected future waste generation and waste prevention effects is essential to avoid unintended outcomes such as demand-driven waste imports either within, or across national borders.

We conclude that the lack of PaMs quantification by countries is not indicative of an associated lack of progress in terms of emission reductions from the sector. However, some countries are lagging behind others and have the opportunity to achieve significant sectoral emission reductions by catching up on implementation of existing EU directives (primarily the Waste Framework Directive and Landfill Directive). We attribute the lack of PaMs quantification by reporting countries to the complexity, and often cross-sectoral nature of waste PaMs, but the lack of national experts' priority and attention for the waste sector could also play a role. We speculate that this is not helped by the nature of the sectoral reporting structure as defined in the reporting guidelines for the emissions inventories, projections, and PaMs – specifically that the activity and emissions categorization does not support or encourage cross-sectoral working. The nature of waste management and the movement towards a circular economy model in Europe may need national teams to work outside of the bounds of sectoral reporting structures to achieve a more complete status in terms of PaMs and their emission reductions. This is further explored in the ETC CE project 'Circular economy and climate mitigation – guidance on including Circular Economy (CE) actions into climate reporting and policy making'.

The report covers the EU-27, Norway, Iceland and Switzerland. The basis for this analysis is the information reported by European countries under the Governance of the Energy Union and Climate Action Regulation.

1 Introduction

This report is the output of a task under the European Topic Centre for Climate Mitigation (ETC CM), aiming to analyse policies and measures (PaMs) for climate change mitigation in the waste sector across EU-27 Member States (MS) as well as Iceland, Norway and Switzerland.

Below, we introduce the objectives of the report (Section 1.2), and the methodology (Section 1.3) applied within the analysis before introducing the policy background (Section 1.4) that affects this sectoral analysis.

1.1 Scope of work and waste sector definition

The main basis for this analysis is the information reported by European countries under the Governance of the Energy Union and Climate Action Regulation[3]. This is a critical dataset reported by European countries on their PaMs for mitigating greenhouse gas emissions. The completeness and consistency of the reported data and information are essential for the accurate reflection of the policy landscape and policy effects of a sector. The analysis also uses data on historical and projected greenhouse gas emissions[4] and relevant waste data e.g. via Eurostat[5] to further explore the linkages between emissions, waste generation, treatment pathways and policy.

The term "waste sector" within this report refers to the sector (CRF sector 5) as defined by Intergovernmental Panel on Climate Change (IPCC) and EU mechanisms for greenhouse gas (GHG) emissions reporting. According to the IPCC 2006 Guidelines, emissions in the waste sector are estimated for four sub-categories: Solid waste disposal (CRF sub-category 5.A), Biological treatment of solid waste (CRF sub-category 5.B), Incineration and open burning of waste (CRF sub-category 5.C) and Wastewater treatment and discharge (CRF sub-category 5.D).

Of the above, the first three categories mainly refer to possible routes for treatment and disposal of solid waste. Whilst GHG emissions from wastewater can be of significance at both national and European level, PaMs are very separate in nature to those for solid wastes. Wastewater is therefore out of scope for this assessment in order to provide a greater depth of analysis into the PaMs pathways and reporting associated with solid waste generation in Europe.

For solid waste, the following treatment pathways are therefore included in the analysis:

- Solid waste disposal sites such as landfills and managed/unmanaged dumps.
- Biological treatment of solid waste such as anaerobic digestion and composting.
- Waste incineration (without energy recovery) and open burning.

Other waste treatment pathways and associated activities that may contribute to GHG emissions due to consumption of fuel / energy are not attributed to the "waste sector" under this definition. Such examples would include recycling facilities and transport/transfer of waste materials. Moreover, waste incineration with energy recovery processes is attributed to the energy sector. According to the IPCC scope, emissions

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3 Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action: https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ:L:2018:328:TOC&uri=uriserv:OJ.L_.2018.328.01.0001.01.ENG

4 Available: https://www.ceip.at/status-of-reporting-and-review-results; and https://www.eea.europa.eu/data-and-maps/data/greenhouse-gas-emission-projections-for-9

5 https://ec.europa.eu/eurostat/web/waste/data/database

are attributed to and accounted for at the point of treatment rather than their point (or nation) of origin in cases of national / international waste exportation.

1.2 Objectives of this report

The core objective of this report is to support EEA in the area of climate policy analysis, as well as to support Eionet countries and policymakers across Europe to strengthen and increase the effectiveness of climate change policymaking.

Initially, our aim is to explore the present state of reporting and effort related to PaMs in the waste sector. This analysis intends to improve our comprehension of whether there is a need for increased effort within the sector. This is particularly relevant due to the ambition of the EU to achieve climate neutrality[6].

Another objective is to investigate if a lack of reporting is causing misrepresentation and/or potential underestimation of emissions savings from the sector. For this aim, it may be necessary to look beyond the PaMs reported under the Governance Regulation.

In many cases, PaMs primarily addressing the waste sector may have links to other "sectors" (as defined by IPCC reporting), for example energy production, industrial processes or broader environmental and socio-economic concerns such as circular economy goals. For this reason, the third aim is to enhance our understanding of the potential cross-sectoral linkages and impacts of those linkages on national-level PaMs reporting.

To achieve these objectives, three specific steps are identified:

I. To provide analysis and classification of climate PaMs focusing on the solid waste sector in EU MS, Iceland, Norway and Switzerland .
II. To understand emission reduction effects and potential gaps of existing waste sector PaMs when considered against historical GHG trends, per capita emissions and projections scenarios.
III. To consider evidence available from wider policy literature, national policy documentation and a cross-sectoral analysis to identify reasons for incomplete and/or inconsistent PaMs reporting and quantification of policy effects in the waste sector.

The Methodology section below presents how the analysis was conducted by the project team.

1.3 Methodology

1.3.1 Section 2

Section 2 of this report includes primary analysis conducted by the project team to investigate various aspects of the PaMs data. Below we outline the methods taken.

Analysis of PaMs reporting

The first analysis step is designed to understand the qualitative recording of PaMs information by countries in the EEA's PaMs database. By classifying the reported waste sector PaMs, it is hoped to identify any commonalities and differences in the way waste sector PaMs are being reported across countries. This will indicate:

- whether PaMs are being interpreted, presented and categorised consistently across countries

6 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

- the extent to which additional national (or regional/local) waste PaMs are being reported in addition to those that derive directly from EU legislation
- good practice examples in terms of reporting coverage and completeness of reporting

A first task was to assess how "specific" or detailed the PaMs reporting is performed. This aspect is not a reporting requirement under the Governance Regulation and was added based on a qualitative assessment of the reported information. This "specific" label covers clearly defined policies such as "*A tax is imposed on waste for incineration or landfilling. The taxes are DKK 475 per tonne for landfilling and DKK 60,9/GJ for incineration*". The "specific" PaMs were further split into "single" (like the example policy above) and "multiple" as some PaMs listed more than one specific measure, such as "*The following measures have been taken: supermarkets are required to offer agreements to authorized charities to make donations of unsold foodstuffs; distributors are prohibited from deliberately rendering unsold food unfit for consumption; the State, its public establishments and the local authorities have the obligation to set up an approach to fight against food waste in the collective catering services they manage*". This is not the same as a "group" PaM as reported to the PaMs database, which indicates an umbrella PaM under which additional individual ("single") PaMs are reported. These specificity labels have only been applied to the single PaMs. In the case of non-specific or "general" PaMs, this label covers a wide range, from national waste or climate plans to more ambiguous PaMs e.g. to reduce the environmental impact of a particular sector.

The analysis also covers a deeper investigation on the coverage of waste type than is automatically available from the reporting of PaMs information by countries. In the EEA's PaMs database, the sector a PaM relates to is not disaggregated beyond "Waste" and both waste type and waste hierarchy are not reported fields. As such, classifiers for waste hierarchy and IPCC sector code were added to the reported PaMs. The confidence in applying these classifiers was limited by the detail provided in the reported data, especially the description field, and therefore could not be completed for all PaMs. It is also important to note that multiple tags were applied in some cases for these classifiers e.g. a PaM to divert food waste from landfill to anaerobic digestion was given IPCC code labels of both 5A Solid waste disposal on land and 5B2 Composting. PaMs considered too broad, or outside of the scope of an IPCC waste sector, e.g. circular economy, recycling, general prevention, were not classified with an IPCC code.

The waste "type" being targeted through specific PaMs was identified using the PaM description where possible. However, assumptions were sometimes made based on the target sector or PaM name, e.g., if the PaM specified anaerobic digestion it was assumed to be targeting organic waste. The waste type was classified as "unspecified" where it was not possible to resolve this from the reported information. A label for the most applicable waste hierarchy classifier was applied where possible. Again, this field was left blank where it was not possible to resolve this from the reported information.

After the PaMs had been classified an initial assessment was undertaken. The results of this are presented in Section 2.

PaMs quantification

This analysis looks to highlight and analyse the reported current impact (as potential emissions savings) of the waste sector PaMs. The most complete indicator of both past and future emissions at EU and country level is available through national inventories and projections[4]. These quality assured and internationally reviewed datasets present emissions profiles taking into account PaMs that are already adopted and implemented into national legislation. For future emissions, this is commonly referred to as the "with existing measures" (WEM) scenario. The reporting of PaMs at the national level provides countries the opportunity to disaggregate their projected emissions savings for the WEM scenario. Critically, it also allows countries to report PaMs that are planned or considered but that are not yet adopted into national legislation. This "with additional measures" (WAM) scenario of PaMs reporting can be assessed to identify additional scope, or gaps that may be occurring between the official projections data and a potential, more ambitious level of emissions savings from the waste sector. The quality and disaggregation of these PaMs varies, and they are rarely fully quantified. By considering the quantification levels across reporting countries, in combination with the qualitative analysis outlined above, it is possible to indicate the coverage and potential gaps of existing waste sector PaMs.

Firstly, an indicator of potential PaMs impact was developed by comparing the quantified emissions savings of the reported PaMs at national level against the national waste sector emissions total for 2021. From this, it could be deduced whether countries that quantified a greater number of their PaMs were projecting to reduce a greater proportion of their emissions, or vice versa.

Secondly, the PaMs impact for each country was compared to the percentage change in waste emissions across the historical timeseries (2000-2021). This provided a deeper assessment on if and how the impact of reported waste sector PaMs correlates/contrasts with the historical achievements made by countries (as emission reductions). Critically, it sought to reveal any outliers from the expected outcome. For example, it will be interesting if a country is identified as i) having both lower historical emissions savings and low PaMs impact, which might indicate lower ambition; or ii) having both a high historical emissions savings and high PaMs impact, which might indicate best practice from which recommendations for sectoral reporting and/or enhanced national policy can be made.

These indicators and discussion of findings are presented in **Annex 1**.

An analysis was also completed to examine whether there is a visible discrepancy between the reported GHG projections and reductions reported for the climate PaMs. For this, the 2023[7] reporting year projections were used. Reductions within the PaMs database are reported as kt CO_2e / yr and therefore to calculate an equivalent value for comparison for the PaMs the reductions for a single year were also calculated. Only the “5. Waste” sector “Total GHG emissions” emissions were considered and two reduction scenarios from the reported projections data were calculated:

- The difference between the without measures scenario (WOM) and the with existing measures (WEM) and with additional measures (WAM) scenarios
- The difference between the WEM and WAM scenarios

It is possible within the reporting under the Governance Regulation for a PaM to be reported as related to more than one sector. Around 38 % of PaMs relating to the waste sector were also reported as related to another sector. As quantification of the emissions is not disaggregated on a sector basis therefore only PaMs solely relating to the Waste sector were included in this analysis. It would not be possible to immediately determine the impact on the waste sector for those cross-sectoral PaMs in the database.

The total reductions by countries from both the projections and the EEA PaMs database were compared and the difference calculated. The results are presented in **Annex 2**.

1.3.2 Section 3

This analysis reviews historical waste sector emissions and projections at EU level before using per capita emissions analysis as an indicator of how the GHG intensity and profile of waste sector emissions appears to have changed across Europe since the turn of the century. Data reported under the Governance Regulation is used to present the emissions timeseries for EU 27, Norway, Switzerland and Iceland. Eurostat data on waste generation and population has then been accessed and presented. Emissions on a per capita basis were calculated by country, firstly for the ‘total’ solid waste sector (including all solid waste sector emissions reported under CRF categories 5A-5C) and subsequently at disaggregated category level.

[7] Reported GHG projections https://www.eea.europa.eu/en/datahub/datahubitem-view/4b8d94a4-aed7-4e67-a54c-0623a50f48e8

1.3.3 Section 4

The project team reviewed existing literature and EU-level analysis, including EEA and European Topic Centre on Circular Economy (ETC/CE) early warning assessments[8] in order to further consider the way in which EU countries have responded to key legislation, and hence the progress they have made in adapting their preferred waste treatment pathways to meet those requirements. This information provides a critical link to the profile and trends in sectoral national emissions.

1.3.4 Section 5

The project team, using available literature to support their own knowledge, developed a table to outline the potential cross-sectoral linkages for each of the primary solid waste treatment pathways. The project team propose a hypothetical improvement to achieving completeness of waste PaMs by better aligning the analysis of waste PaMs with stages of the waste hierarchy to encourage cross-sectoral analysis. To explore this, further literature was identified to develop case studies and examples of how cross-sectoral linkages may play out using real world examples.

1.4 Policy background

The Effort Sharing Legislation, made up of the Effort Sharing Decision (ESD) covering the years 2013-2020 and Effort Sharing Regulation (ESR) for 2021-2030 sets Member States (MS) targets for reducing total GHG emissions. This includes emissions from the waste sector, although there are no targets for individual sectors so far. Under Article 18 of Governance Regulation [9] and Annex XXIV of the Commission Implementing Regulation 2020/1208[10] MS are required to report Policies and Measures (PaMs) relating to climate change.

The reporting of the climate PaMs legislation is implemented through Commission Implementing Regulation EU 2020/1208[11] and is mandatory for all EU Member States but voluntary for the non-EU member countries of the EEA (Switzerland, Iceland, Norway, Liechtenstein and Turkey). Reporting is done to the EEA via a web-form on Reportnet 3[12] and is conducted biennially, although annual updates in non-mandatory-reporting years are requested as well if there are substantial changes. The Implementing Regulation specifies which elements are 'mandatory' and which are reported on a 'voluntary' basis. A set of quality checks is integrated in the reporting webform, and it is not possible to submit information if any 'mandatory' fields are missing. Furthermore, the guidelines for reporting clarify the rules to reporting countries[13]. The reporting covers:

- Detailed information on PaMs such as the objective, description, type and status of reporting.
- Results of expected and achieved emission reductions as well as cost and benefits where this information is available.
- Indicators for monitoring policies where these are used.
- A qualitive document/report explaining links between PaMs and projections.

8 EEA and ETC CE (2023), EEA early warning assessments related to the 2025 targets for municipal waste and packaging waste

9 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018R1999&from=EN

10 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32020R1208&from=EN

11 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R1208

12 To view 2023 PaM dataflow, download reported data and check supporting documents: https://reportnet.europa.eu/public/dataflow/900

13 https://www.eionet.europa.eu/reportnet/docs/govreg/policies-and-measures/reporting-guidelines-dataflow-9-to-14-policies-and-measures.pdf/view

There are a number of EU policies applicable to the waste sector. One of the most important EU policy for the management and treatment of waste is the Waste Framework Directive (WFD)[14], adopted in 2008 and amended in 2018[15]. The aim of the WFD is not primarily to reduce GHG emissions from waste as such, but to reduce environmental impacts from waste (including the move towards a circular economy and minimize disposal). In turn, this has the potential to reduce GHG emissions from waste. Box 1 provides additional detail on the WFD.

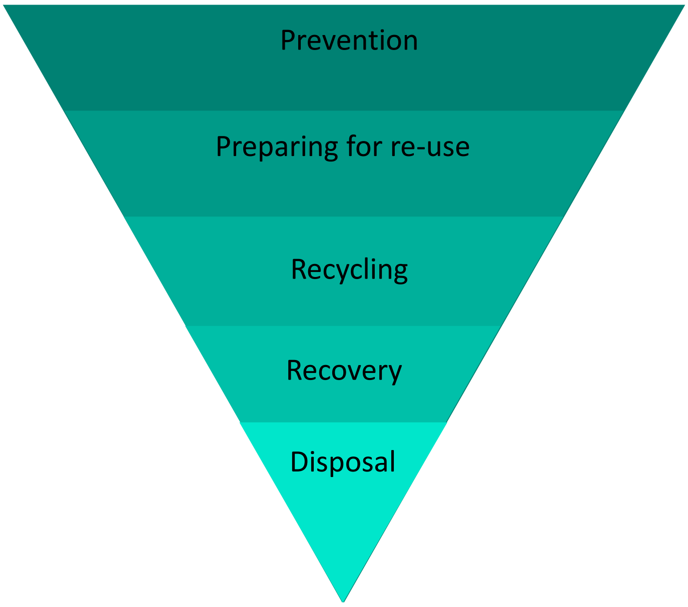
14 https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

15 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0851&from=EN

Box 1.1 The Waste Framework Directive

The WFD established the waste hierarchy, a ranking of waste management by what is most beneficial to the environment, Figure 1. Preventing waste was established as the most desirable of the options followed by preparing for re-use, recycling, recovery and finally disposal.

Figure 1 The waste hierarchy



The definitions of the hierarchy are as below:

- Prevention: measures taken before a substance, material or product has become waste.
- Re-use: operations by which products or components that are not waste are used again for the same purpose for which they were conceived.
- Preparing for re-use: checking, cleaning or repairing products or components of products so that they can be re-used without any other pre-processing.
- Recycling: recovery operations where waste materials are reprocessed into products, materials or substances for both the original and other purposes. This includes composting but not energy recovery or processing of waste for use as fuels.
- Recovery: operations where the principal result is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, in the plant or wider economy.
- Disposal: landfill and incineration without energy recovery.

The WFD also establishes the "polluter-pays principle" and "extended producer responsibility". In addition, the legislation set the following targets for preparing for re-use, recycling and recovery:

- 50% of certain types of waste from households and similar waste by weight to be prepared for re-use or recycled by 2020.
- 70% of non-hazardous construction and demolition waste to be prepared for re-use, recycled or recovered (incl. backfilling) by 2020.
- 55%, 60% and 65% of municipal waste by weight to be prepared for re-use or recycled by 2025, 2030 and 2035 respectively.
- Reduce food waste to contribute to the Sustainable development goal of 50% reduction of food waste by 2030.

There are two policies which establish regulations for sites for the treatment and disposal of waste. The Industrial Emissions Directive[16] (Box 1.2) and The Landfill Directive[17] (Box 1.3).

Box 1.2 The Industrial Emissions Directive

The Industrial Emissions Directive (IED) establishes a framework to reduce the environmental impact of industrial sites across Europe undertaking activities within Annex I of the legislation. The activities applicable to waste are:

- Disposal or recovery of hazardous waste with a capacity of 10 tonnes per day.
- Disposal or recovery of waste in (co-)waste incineration plants for non-hazardous waste with a capacity of 3 tonnes per hour and for hazardous waste with a capacity of 10 tonnes per hour.
- Disposal of non-hazardous waste with a capacity of 50 tonnes per day.
- Recovery or a mix of recovery and disposal of non-hazardous waste with a capacity of 75 tonnes per day, although anaerobic digestion has a higher threshold of 100 tonnes per day.
- Landfills receiving more than 10 tonnes per day of waste or with a total capacity of over 25,000 tonnes (excluding landfills for inert waste only).
- Temporary storage of hazardous waste with a capacity of over 50 tonnes, excluding temporary storage pending collection where the waste was generated.
- Underground storage of waste with a capacity of over 50 tonnes.
- Disposal or recycling of animal carcasses or animal waste with a treatment capacity exceeding 10 tonnes per day.

The legislation establishes the requirement for the adoption and application of Best Available Techniques (BAT) which are continuously reviewed and made more stringent. It also requires all entities within scope of the legislation to operate with a permit which should be consistent with the obligations of the IED. Chapter IV of the IED includes special measures for waste (co-)incinerators, with no minimum capacity, excluding those that incinerate specific wastes such as radioactive waste and animal carcasses.

Note: At the time of writing this report, the IED review was in its final stages but had not yet been adopted by the European Parliament and Council.

[16] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0075&from=EN

[17] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31999L0031; https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018L0850

Box 1.3 The Landfill Directive

The Landfill Directive, adopted in 1999 and amended in 2018, establishes strict requirements for the operation of landfills to prevent or minimize their environmental impact. Wastes such as clinical waste are banned from disposal in landfill sites and requirements for operation and permits are established; in particular measures for leachate management and gas control.

- Historical targets:
  - Biodegradable MSW disposed in landfills must be reduced to 75% of the total amount of biodegradable municipal waste produced in 1995 by 2006.
  - Biodegradable MSW disposed in landfills must be reduced to 50% of the total amount of biodegradable municipal waste produced in 1995 by 2009.
  - Biodegradable MSW disposed in landfills must be reduced to 35% of the total amount of biodegradable municipal waste produced in 1995 by 2016.
- 2018 amendment:
  - The amount of MSW disposed in landfills must be reduced to 10% of the MSW generated by 2035. This can however be postponed if an MS landfilled more than 60% of its MSW generated in 2013 and notifies the Commission and delivers an implementation plan.
  - If an MS postpones the deadline, the MS must reduce the amount of MSW landfilled to 25% of the MSW generated by 2035.

In addition, there are a few directives targeting particular waste types, for example addressing packaging, waste from electrical and electronic equipment, end-of life vehicles and batteries. This is by no means an exhaustive list. All these directives include quantified targets for collection and/or recycling.

As mentioned above, it is often the objective of national and international waste policy to promote and improve metrics and circumstances in the wider environmental and socio-economic landscape, rather than to directly reduce GHG emissions per se. GHG emissions may be impacted by a direct reduction in potential emissions by policies that are targeted at waste prevention and recycling. Alternatively, emissions may be reduced or displaced by policies that have a greater focus on recycling and recovery. For this reason, it is critical to identify linkages between nationally adopted PaMs and the wider EU policy context. Any synergies and/or gaps in reporting of national PaMs data can then be better understood from the viewpoint of GHG emissions trends and potential future impacts.

2 Status of reporting on policies and measures

Key Messages

- The number of reported PaMs in the waste sector, and the "specificity" of reporting to the EEA (i.e. whether the policy or measure is a single measure or is reported at a more aggregated level) varies considerably across reporting countries. For example, France, Hungary, Luxembourg and Denmark stand out as countries with a high number of PaMs. However, the "number of PaMs" alone is not a reliable indicator of effort and/or completeness of national reporting.
- For the waste sector, regulatory PaMs are common, reflecting the substantial regulatory requirements to be met by countries within EU waste legislation. 76 % of the reported PaMs affecting waste sector are linked to EU Policy, especially the Waste Framework Directive and Landfill Directive are referenced.
- Waste sector PaMs tend to focus on municipal waste and organic waste types, as these are the wastes generating emissions from landfills and biological treatment. Accordingly, when reported PaMs in the waste sector could be classified with an IPCC code, they were mostly linked to the IPCC sub-category 5A – solid waste disposal on landfills and managed/unmanaged dumps. Some are also associated with the energy sector (1A) due to the role of energy recovery facilities in waste management.
- Only 15% of waste sector PaMs have been quantified, and nearly all quantified PaMs refer to the reduction of emissions from landfills, reflecting the high share of landfill emissions in total waste sector emissions.

2.1 Analysis of PaMs reporting

In this section an overall assessment of the waste sector policies and measures reported in the 2023 EEA PaMs database is presented[18]. This begins with a general assessment of the number of PaMs reported by countries followed by assessment of the "specificity" of the PaMs and whether the PaMs derive from national or EU legislation. Also considered are the geographical scope, policy instrument and implementation status of the PaMs. These elements are reported under the Governance Regulation directly by countries via a webform and disseminated through the EEA's PaMs database. The analysis then considers further classifications that have been applied to the reported PaMs by the project team, principally to assess the coverage of waste PaMs in terms of the affected waste type, the waste hierarchy element reflected by the PaMs, and the IPCC sector code.

2.1.1 Overview

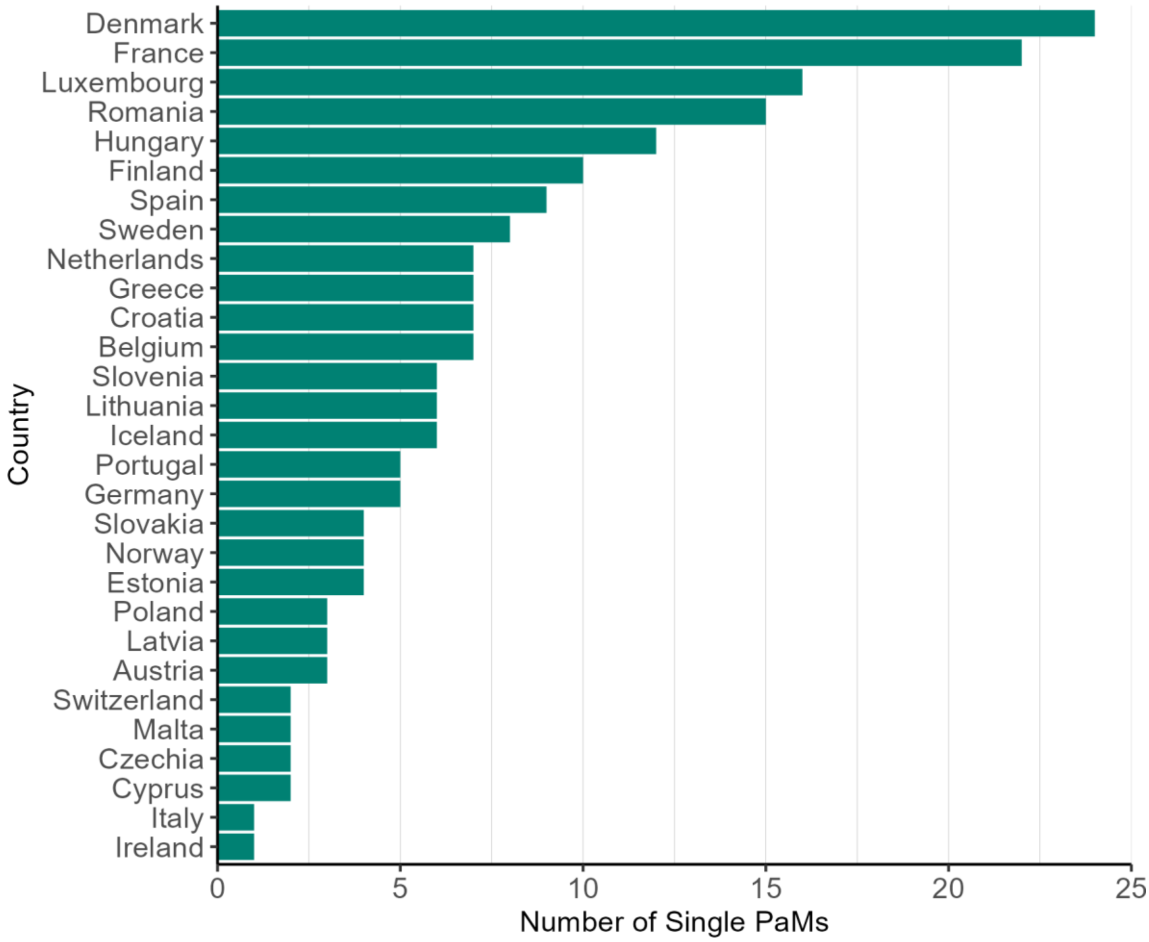
Countries can report either single PaMs or group PaMs in the database. Group PaMs offer the opportunity for countries to aggregate single PaMs under a group/umbrella heading. It is meant to be used when the effects of single PaMs cannot be split. However, it appears that group designations are rarely used, and that is the case for the waste PaMs analysed here.

In 2023, there were 218 single PaMs and 15 group PaMs linked to the reported waste sector PaMs. The following analysis excludes group PaMs to avoid duplication with their associated single PaMs. In addition, 15 of these PaMs related to wastewater treatment and were therefore considered out of scope for this analysis (See section 1.1). As such the following analysis was only undertaken on the 203 single PaMs relating to solid waste management. A full list of single PaMs identified for this analysis is provided in Annex 3.

[18] Draft internal dataset received by email, 17/10/2023. Published data available: http://pam.apps.eea.europa.eu/

Denmark and France reported the most waste sector PaMs, 24 and 22 respectively (Figure 2). Ireland and Italy reported only one single PaM relating to waste. Additionally, Bulgaria reported no waste sector PaMs. However, the "number of PaMs" alone is clearly neither a reliable indicator of a country's ambition level, nor is it necessarily reflecting the completeness of reported data across reporting countries or the "real" situation in terms of policy landscape.

Figure 2 Number of waste sector PaMs by country



Many of the reported single PaMs were a national plan or a combination of specific actions or interventions. Table 1 details the number of PaMs of each specificity classification. Section 1.3 details the definitions of the specificity classifications, as well as the numbers of PaMs identified as implementing directly to EU legislation, or as PaMs that are not (directly) related to EU legislation[19]. Denmark reports the highest number of PaMs, with almost all specific single PaMs implementing EU policy. In comparison France, who reports the second largest number of PaMs, reports a high number of "general" PaMs which could potentially involve a large number of measures. 11 of France's PaMs are reported as not related to EU legislation. This could indicate a higher level of ambition in reducing emissions from the waste sector or be a result of interpretation when classifying PaMs. Luxembourg and Netherlands also stand out as countries with a high number of PaMs that are not related to EU legislation.

[19] It is noted that many PaMs identified as not related to EU legislation may still contribute to the achievement of European level goals and targets e.g. Effort Sharing targets. Interpretation of this classification may also impact on variance between countries.

Table 1 Number of waste sector PaMs by specificity of the PaM and whether it is the implementation of EU legislation

	Specificity of PaM			Implementation of EU legislation	
Country	General	Specific-single	Specific-multi	Related	Non related
Austria		1	2	3	
Belgium	1	5	1	7	
Croatia	3	3	1	7	
Cyprus		1	1	2	
Czechia	2			2	
Denmark	2	20	1	23	
Estonia	3		1	4	
Finland	3	6	1	4	
France	7	13	2	11	11
Germany		5		4	1
Greece	5	2		7	
Hungary	8	3	1	10	2
Iceland		4	2	5	1
Ireland	1			1	
Italy	1				1
Latvia		2	1	3	
Lithuania	1	2	3	5	1
Luxembourg	9	4	3	9	7
Malta	1	1		2	
Netherlands	4	3		1	6
Norway	1	3			4
Poland	1	2		3	
Portugal	3	1	1	2	3
Romania	11		4	13	2
Slovakia		4		3	1
Slovenia	1	5		6	
Spain	7	1	1	8	1
Sweden	4	2	2	6	2
Switzerland		2			2

1 3 6.7 23

Around 78 % of the solid waste PaMs were reported as linked to EU policy. Table 2 presents the specific EU legislation identified as linked to the reported PaMs. Unsurprisingly, a significant number of PaMs are linked to the WFD and the Landfill Directive as measures within those directives are anticipated to reduce GHG emissions, even if GHG emission reductions are not the sole or primary driver for the policy.

Table 2 Number of PaMs reporting links with EU policy

EU Policy	Number of PaMs
Waste Framework Directive	65
Landfill Directive	24
Waste Directive[20]	4
Industrial Emissions Directive and its associated Best Available Technique Reference Documents	3
Waste Incineration Directive	2
Biofuels directive	1
Other[21]	75
Not related to EU Policy	45

Figure 3 shows the policy instruments reported for the waste PaMs. Unsurprisingly, this shows the most common measure is "regulatory", reflecting the regulatory requirements to be met by countries within EU waste legislation. A significant number of PaMs were also / alternatively reported with "economic" and "planning" (measures which direct the development of the subject on a specific direction for example a waste management plan[22]) for implementation. When comparing the waste sector PaMs with the full PaMs data set the top three policy instruments are the same (regulatory, economic and planning). However, in the full data set economic is the most common policy instrument followed by regulatory and then planning.

Table 3 shows that almost all the waste PaMs reported were national measures. Only one was reported as a local measure and only nine measures were reported as regional. In fact, in many countries waste is not managed at the national level, and more usually at the regional or local level. This suggests that more specific local and/or regional measures may be missing from the national level PaMs reporting. However, it is particularly difficult to ascertain whether local actions would be unique from, or duplicating any impacts that trickle down from EU or national policy.

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20 Directive 2006/12/EC: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0009:0021:en:PDF

21 Other EU legislation and strategies include: Common Agricultural Policy, Directive 218/2001 on promoting RES, ETS Directive, Effort Sharing Decision, Effort Sharing Regulation, Energy Efficiency Directive, European Structural and Investment Funds, Governance Regulation, LULUCF Decision 529/2013, LULUCF Regulation 2018/841, NEC Directive, Nitrate Directive 1991/676, Renewable Energy Directive, Water Framework Directive, Biofuels Directive

22 https://www.eionet.europa.eu/reportnet/docs/govreg/policies-and-measures/2021_reporting-guidelines-ghg-pams_govregart18_v1.pdf/view

Figure 3 Policy Instruments reported for waste PaMs

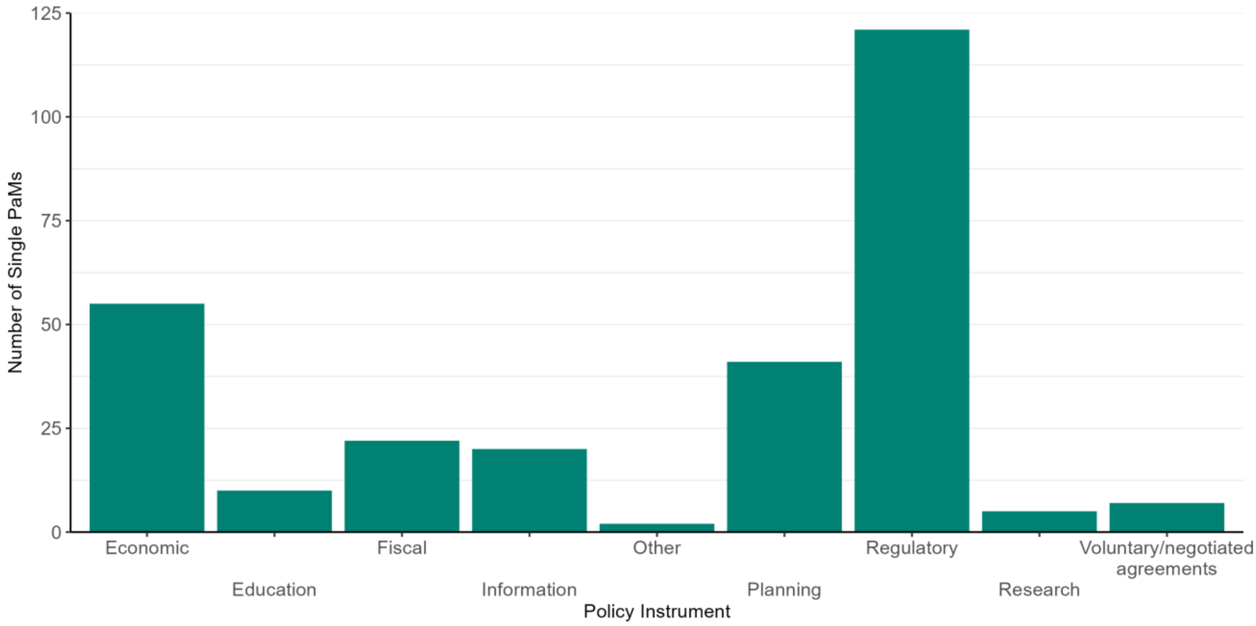
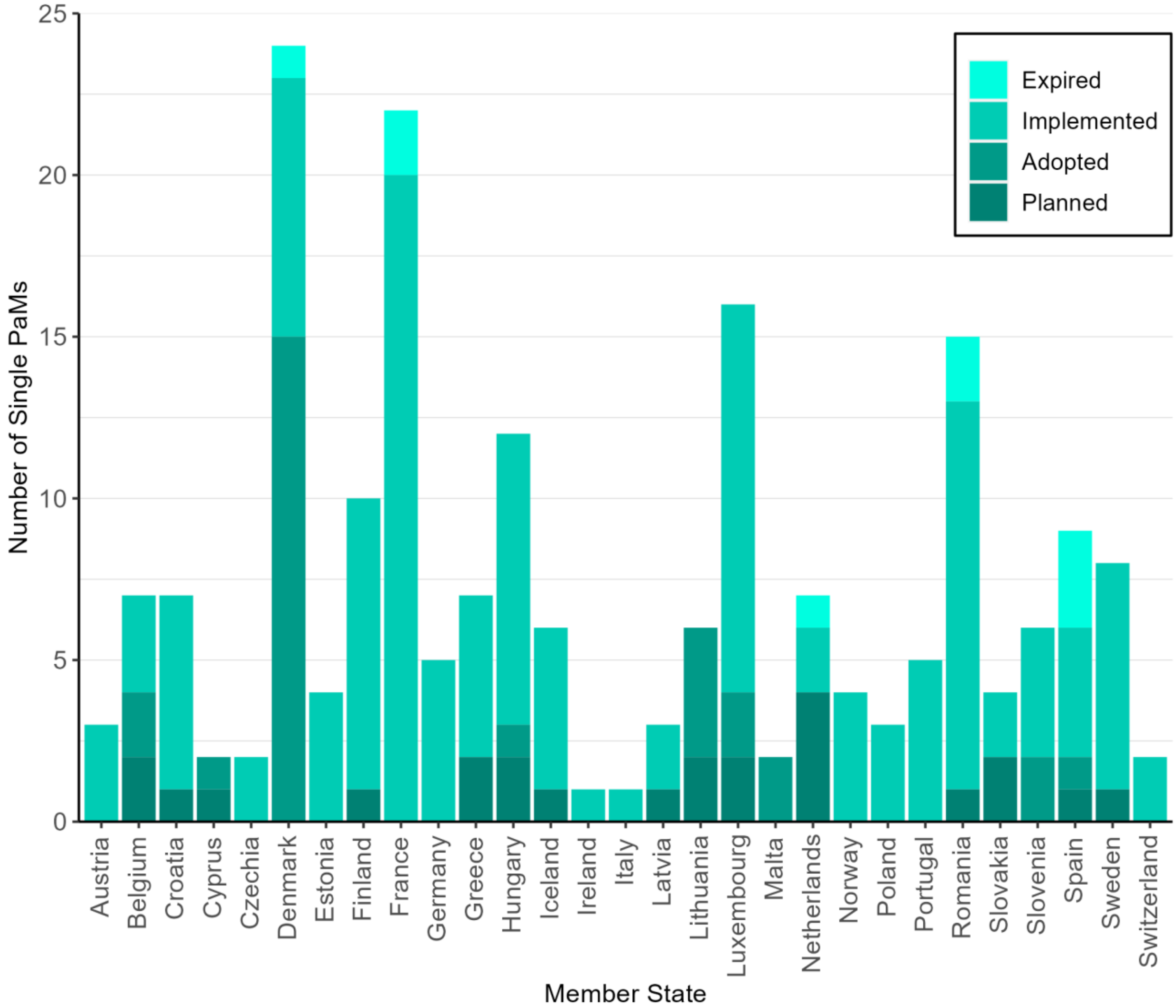


Table 3 Geographical coverage reported for waste PaMs

Geographical coverage of measure	Number of PaMs
Local	1
Regional	9
National	193

The majority of PaMs reported have already been implemented and a high proportion of these were currently in effect, or "Implemented" as opposed to "Expired" at time of reporting (Figure 4). 15 countries reported PaMs that are still in the "Planned" stage.

Figure 4 Number of PaMs by country and implementation status



2.1.2 PaMs by waste type

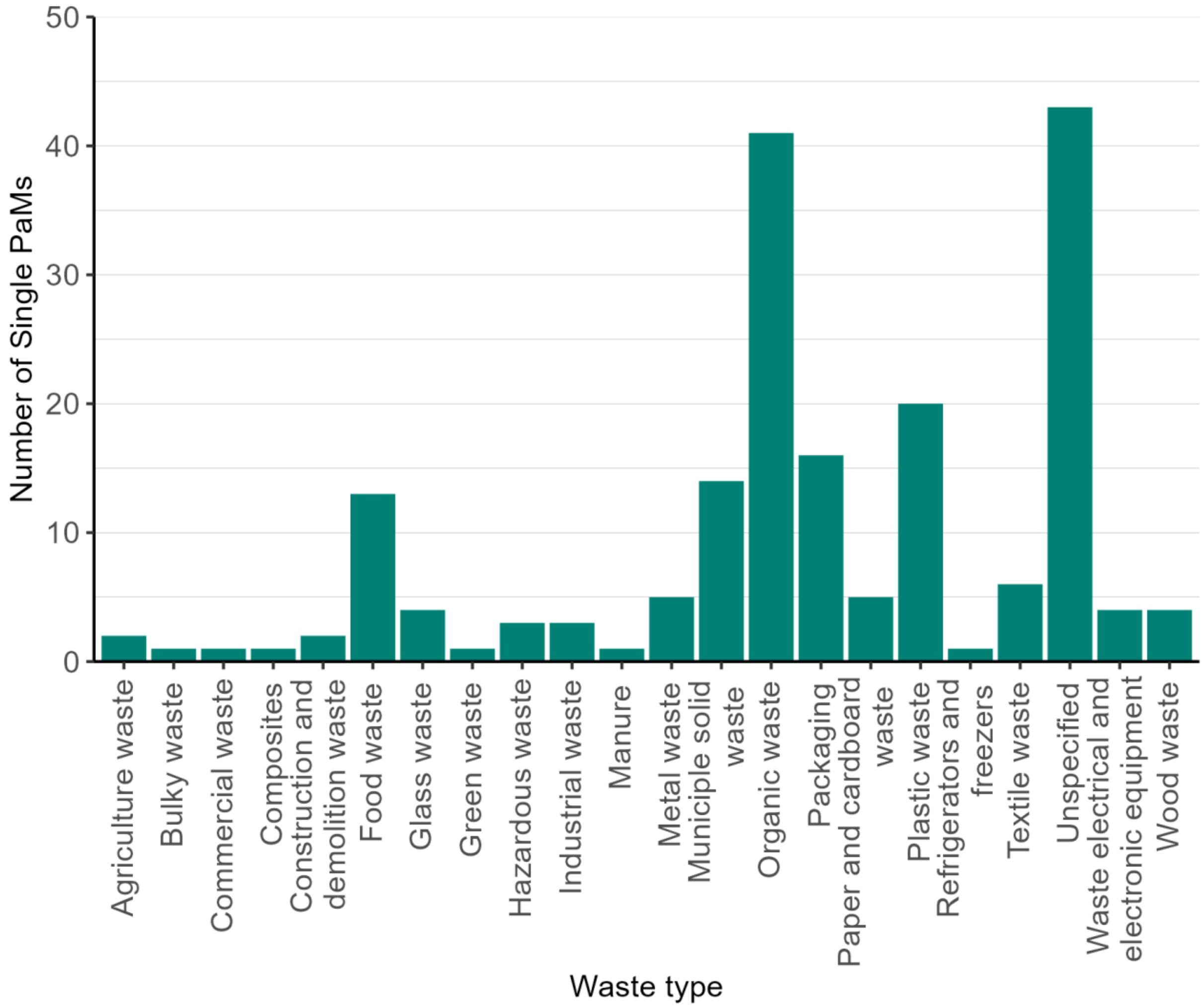
The majority of PaMs (e.g. through its description or title) did not specify which waste "type" they were related to (Figure 5). Of those PaMs that did specify a waste type the majority targeted organic waste, with 23 countries reporting one or more PaMs targeting this waste type. Reducing the amount of organic waste disposed of in landfill was the aim of 16 PaMs, with some countries such as Denmark having entirely banned the disposal of combustible (including organic) waste in landfill sites. Alternative treatment pathways proposed include Energy from Waste (EfW), anaerobic digestion and composting. It is important to note that all the PaMs targeting organic waste were likely to reduce the amount of waste disposed in landfill even if this was not specified. In addition to moving to more desirable stages in the waste hierarchy, reducing the amount of biodegradable waste disposed in landfill will reduce the amount of waste decomposing anaerobically without capture and use of the resulting CH_4, leading to reduced GHG emissions (in CO_2e) over time.

In addition to organic waste, some PaMs specified food waste, which could be seen as a sub-category of organic waste. Eleven countries reported PaMs targeting food waste. These are also likely to reduce the amount of organic waste sent to landfill, although only one PaM identified that as a stated aim. Ten PaMs did not target improved waste treatment and instead aimed at preventing food waste generation.

MSW (municipal solid waste) was targeted by 8 countries. This also usually contains a high share of organic waste. Many of these PaMs targeting MSW specify their aim to reduce waste to landfill, although many of the PaMs targeting MSW may well result in this even if it was not a specified aim. Some of these PaMs specified that it was the organic fraction (of MSW) to be diverted, whilst some aimed at reducing the total quantity of MSW landfilled. Several of the PaMs targeting MSW aimed at improving separate collection of waste or increasing waste sorting and two of the PaMs introduced charges for the amount of waste disposed. As with the organic waste PaMs these will both reduce waste disposal, helping to achieve the goals of the WFD; and reduce the amount of CH_4 emissions from biodegradable waste.

Nine countries reported PaMs targeting plastic waste, two of which specified the introduction of charges for plastic bags. France went further with a PaM banning certain single-use plastic bags, in place since 2016. The majority of PaMs targeting plastic however were related to re-use and recycling. Most plastic waste is not currently biodegradable outside of compostable or biodegradable packaging which has a small market share. Therefore, these PaMs won't necessarily reduce GHG emissions in the waste sector from reducing disposal in landfill, although emissions could be reduced if the plastic waste was diverted from incineration and from other sectors if virgin plastics are replaced with recycled. More broadly, emissions from preventing and treating plastics waste will mainly be accounted for in the chemical industry sector (plastics production and substituting virgin with secondary plastics) and in the energy sector (when incinerated with energy recovery), or cement industry (when used as refuse-derived fuel in cement production).

Figure 5 Number of waste PaMs by waste type



2.1.3 PaMs by waste hierarchy

The majority of PaMs are related to recycling and recovery, representing 67 and 51 of the single PaMs respectively (Figure 6). Recycling and recovery PaMs are reported by 23 countries and 71% of these PaMs can be further disaggregated by waste type. Excluding where the waste type was not specified, PaMs related to recycling targeted organic waste the most, closely followed by plastic waste and packaging. PaMs aiming to increase recycling of organic waste often also involved increasing composting and anaerobic digestion. The PaMs targeting recycling of packaging waste were more varied, including measures such as specifying the markings on packaging and implementing extended producer responsibility for packaging waste. Increasing recycling of more inert waste types would not necessarily lead to the reduction of GHG emissions from the waste sector, however it could reduce emissions within other sectors, for example in production and extraction.

The PaMs relating to recovery most targeted organic waste. Almost all of these were related to energy from waste (EfW), composting and anaerobic digestion, leading to the organic waste being diverted from landfill. Treating organic waste through EfW or anaerobic digestion would likely lead to reduced overall GHG emissions even if the profile of relevant gases changes (from primarily CH_4 emissions in landfilling to CO_2, CH_4 and N_2O from alternative pathways).

A significant proportion of PaMs were also related to prevention, with 19 countries reporting PaMs relating to prevention. PaMs related to prevention had a fairly even split between waste types, however the majority of the PaMs targeting food waste were also classified as waste prevention. These measures included changing behaviours through social campaigns and requiring supermarkets and distributors to make agreements with charities to donate unsold foodstuffs. This is likely to be driven by the fact that the Sustainable Development Goals (SDGs) include a target to halve food waste generated by 2030, and that food waste is a priority in the Waste Framework Directive as amended in 2018. The European Commission has proposed a set of binding food waste targets in the proposed targeted amendment of the WFD, adopted in July 2023[23]. Such PaMs may become more prevalent in future years. However, countries are likely to pursue many more measures to reduce food waste - the EEA has identified 89 policy instruments related to food waste prevention in the 27 EU Member States' waste prevention programmes[24].

The GHG impact of prevention is harder to determine depending on the waste type. The prevention of more biodegradable waste types, such as food waste, will likely lead to GHG emission reductions in the waste sector as well as in the sectors that produce the related products. The prevention of other waste types, especially inert wastes such as metals and plastics, is unlikely to have much GHG reduction effects in the waste sector but mainly contributes to potentially reduce GHG emissions in other sectors due to substituting virgin materials (potential cross-sectoral impacts).

Preparation for re-use and disposal were the least mentioned waste hierarchy categories across the reported PaMs. Plastic waste and packaging are the waste types most targeted by preparation for re-use PaMs and were often coupled with recycling. One interesting measure from Denmark was to have a spot at municipal recycling stations where citizens could hand in objects that could be re-used. The objects would then be made available to voluntary organisations and other citizens as a priority.

[23] Proposal for a targeted revision of the Waste Framework Directive (europa.eu)

[24] EEA, 2023, Tracking waste prevention progress — A narrative-based waste prevention monitoring framework at the EU level, **EEA Report No 2/2023**, Tracking waste prevention progress — European Environment Agency (europa.eu)

Figure 6 Number of PaMs by waste hierarchy and waste type

	Waste hierarchy					
Waste type	**Prevention**	**Preperation for re-use**	**Recycling**	**Recovery**	**Disposal**	**Total**
Agriculture waste			1	2		2
Bulky waste		1	1			1
Commercial waste			1			1
Composites			1			1
Construction and demolition waste	1					2
Construction and deomiltion waste			1	1		1
Food waste	10	2	4	2		13
Glass waste	1	1	3	3		4
Green waste				1		1
Hazardous waste			1			2
Industrial waste	1	1	2	1		2
Manure				1		1
Metal waste	1	1	5	3		5
Municiple solid waste	3	4	7	2	3	13
Organic waste	1	3	18	25	9	40
Packaging	9	5	9	2		15
Paper and cardboard waste	1	1	5	4	1	5
Plastic waste	10	5	12	3		20
Refrigerators and freezers			1			1
Textile waste		2	3	1		6
Unspecified	11	5	17	15	16	43
Waste electrical and electronic equipment	2	1	1	1		3
Wood waste			3	4	1	4
Total	45	26	67	51	27	203

1 1.3 3 25

Note: A PaM can be applicable to more than one waste hierarchy and waste type so the sum of the columns/rows can be higher than the totals presented.

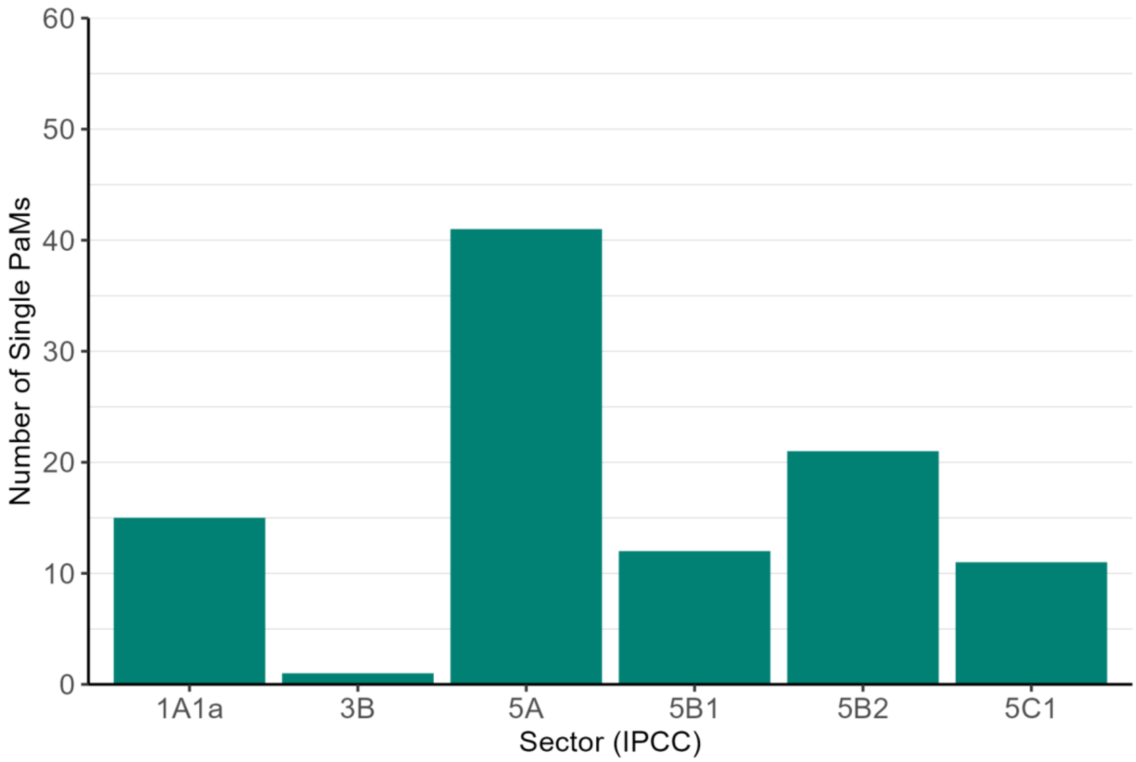
2.1.4 PaMs by IPCC sector

When classifying PaMs by IPCC reporting sector (Figure 7), many fall outside of the direct scope of those specific solid waste sectors. For example, those covering recycling or prevention may have links to diversion of waste from solid waste disposal sites (CRF 5A). However, where such links could not be determined from the PaM name and description, PaMs were not allocated to a specific IPCC sector (144). Additionally, 23 PaMs were attributed to more than one IPCC sector. It is also important to note that PaMs related to recycling, prevention and/or preparing for re-use are likely to reduce emissions in those sectors where the recycled materials will be used as secondary raw material, or where the PaM leads to reducing production due to a lower demand for products. Even when exploring such policies in depth it would be difficult to disaggregate which specific products and materials are being targeted to accurately assign the emissions savings to an appropriate (non-waste) inventory sector.

Of the PaMs that it was possible to classify with an IPCC code, the most common was 5A solid waste disposal on land, with 22 countries reporting PaMs relating to this sector. Almost all these PaMs involved diverting waste from landfill or better management of the landfills, in particular capture and combustion of the resulting landfill gas (with or without energy recovery). Other landfill management improvement measures include mechanical biological treatment (MBT) of waste ahead of landfilling and improved coverage materials. As previously stated, diverting biodegradable waste from landfill to other treatment methods is known to reduce overall GHG emissions. The landfill management measures would also reduce GHGs although these would not help to move towards more desirable waste management options higher in the waste hierarchy. Measures such as MBT or improved coverage materials reduce the amount of waste decomposing anaerobically, reducing CH_4 emissions (whilst increasing the biogenic CO_2 emissions). MBT often includes separating some materials from the waste that are then sent to energy recovery or recycling processes. While flaring landfill gases will reduce CH_4 emissions, these measures are less preferable than capturing the landfill gas and combusting it for energy in keeping with the desire for a circular economy model. Additional GHG reduction benefits may occur if the burning of landfill gas for energy reduces the demand for energy from fossil fuels.

PaMs relating to EfW (1A1a) were reported by 11 countries, often as one of the proposed treatment methods for waste diverted from landfill. It was often hard to determine whether a PaM was related to EfW or incineration without recovery. Incineration without recovery is becoming much less prevalent across Europe and as such, many of the PaMs classified as ‘5C1’ are also classified as ‘1A1a’. Incinerating, with or without energy recovery, reduces the CH_4 emissions from the treatment of waste whilst increasing emissions of both biogenic and non-biogenic CO_2 (depending on waste type). This will reduce the overall GHG emissions from treatment of waste, however EfW has the potential to further reduce GHG emissions by replacing the combustion of fossil fuels in energy production. It is also preferable over landfilling in terms of the waste hierarchy (‘recovery’ compared to ‘disposal’). Measures relating to anaerobic digestion were also widely reported with 18 countries reporting measures relating to this treatment path. As for EfW measures many involve diversion of waste from landfill to this treatment method, reducing overall GHG emissions and contributing to the move away from waste disposal.

Figure 7 **Number of PaMs by IPCC sector**



2.2 PaMs quantification

Of the 203 single (solid) waste sector PaMs, a total of 21 included quantified, projected emissions savings, representing only 10% of total PaMs. A further 32 PaMs were quantified as part of group PaMs, meaning that while the total projected reduction estimate for the group was known, the proportion of this reduction associated with each individual PaM was not. Out of the 29 reporting countries, 16 attempted any form of quantification. The analysis in the following section includes these additional PaMs, where there was shown to be no duplication amongst the reported quantified single PaMs and the single PaMs included within the group PaMs.

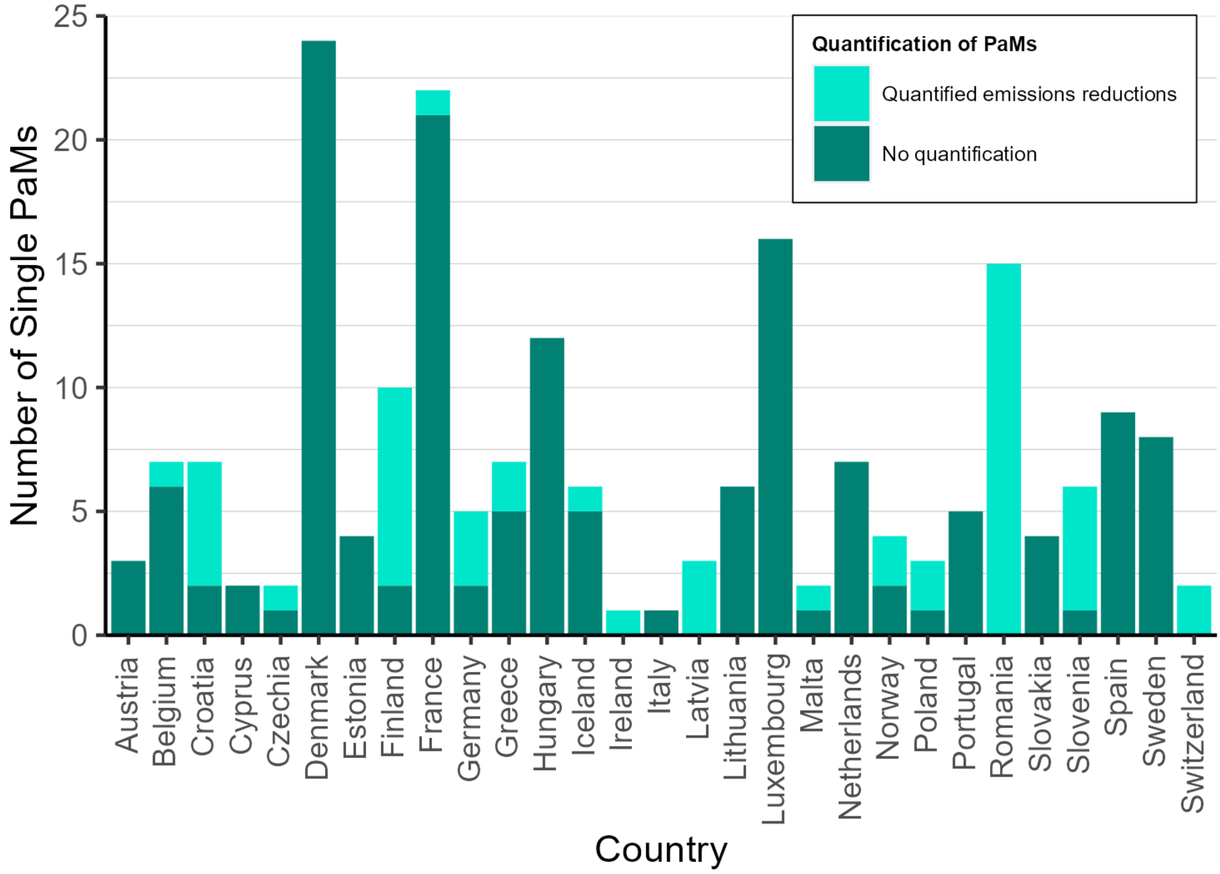
Of the 53 single quantified PaMs, 11 were categorised under an unspecified waste type, with the same number of PaMs being classified under organic waste. This shows a distinct lack of quantification across PaMs referring to defined waste types. Figure 8 provides a visual overview of the quantification of waste PaMs by country. Most countries have a disproportionately high number of unquantified PaMs as opposed to quantified PaMs. Moreover, since only 14 of the 53 quantified PaMs came accompanied by average ex-post reduction estimates, it is difficult to draw conclusions about the effectiveness of currently implemented PaMs towards their projected reduction estimates. Waste related PaMs can also be interrelated. For instance, preventing waste from being generated in the first place leaves less waste to be managed.

Annex 2 presents further analysis of the ex-post reduction estimates and how this data (if complete) could be compared and verified against national emissions projections.

A common theme amongst the quantified waste sector PaMs was of ambiguous or elaborate descriptions which did not lend to a well-defined metric from which to measure and assess progress. This may have been the reason why a large proportion of quantified PaMs were assigned to an unspecified waste type.

Accordingly, the PaMs would benefit from further disaggregation in order to create a more focused and actionable set of targets to work towards.

Figure 8 Number of single waste PaMs with and without quantified emission reductions by country (includes PaMs classified as ex-post and ex-ante, and those quantified as part of groups)



From Figure 8, in some cases, demographically smaller countries such as Croatia, Latvia and Slovenia appear to have quantified a greater number of their PaMs than demographically larger countries such as France and Spain. However, it is important to assess the combined impact of a country's quantified PaMs on its national emissions total for the waste sector, as the impact of a single waste PaM from a large country could vastly outweigh the impact of multiple PaMs from smaller countries. In addition, there are instances of single PaMs being quantified only as part of a broader group PaM (e.g. Romania). In such cases it is difficult to determine the individual contribution of single PaMs to the reported GHG savings. This may also have implications for the *quality* of any quantifications submitted but that conclusion would need to be supported by more specific and in-depth analysis of reported group PaMs. **Annex 1** provides a more detailed analysis of the potential impact of the quantified PaMs in relation to the national waste sector emissions totals.

A full list of the quantified PaMs is presented in **Error! Reference source not found.** below.

Table 4 The IDs and names of each quantified waste PaM by countries (includes single and group PaMs)

Country	PaM ID	PaM Name	Projected PaM emission reduction by future year (kt) 2025	2030	2035	2040
Belgium	62	Long-term waste treatment strategy		380.00	380.00	380.00
Croatia	110	MWM-6: Waste (group PaM, including PaMs: 50, 51, 52, 53, 54)	74.22	514.21	827.31	1052.48
Croatia	50	MWM-1: Preventing the generation and reducing the amount of solid waste				
Croatia	51	MWM-2: Increasing the amount of separately collected and recycled solid waste				
Croatia	52	MWM-3: Ensuring the system of treatment and use of landfill gas				
Croatia	53	MWM-4: Reducing the amount of disposed biodegradable waste				
Croatia	54	MWM-5: Use of biogas for biomethane production and electricity and heat generation				
Czechia	26	Waste management plan 2015-2024	330.00	330.00	330.00	330.00
Finland	165	Aggregated all implemented PAMs/WASTE (group PaM, including PaMs: 33, 36, 85, 127, 128, 130, 131)	4287.00	4568.00	4760.00	
Finland	33	Government decree on packaging and packaging waste 962/1997, 1025/2000, 987/2004, 817/2005, 2014/518, 1029/2021				
Finland	36	Government decree on Landfills (861/1997) revised 2013 (331/2013), revised in 2021 (1030/2021), Biowaste strategy 2004.				
Finland	85	Updated National Waste Plan 2027				
Finland	127	Biowaste strategy 2004				
Finland	128	Waste tax act (1126/2010)				
Finland	130	Decree on waste (978/2021)				
Finland	131	Waste Act (646/2011)				
Finland	6	Promoting biogas in electricity and heat production	130.00	137.00	156.00	156.00
France	158	Obligation to sort waste from economic activities (for materials paper, cardboard, plastic, metals, wood, glass, mineral waste and plaster)	3600.00	4000.00	4200.00	
Germany	98	Funding of landfill aeration (Waste Management)	211.10	637.27	1022.12	1180.50
Germany	99	Promotion of technologies for the optimised capture of landfill gases in municipal waste (Waste Management)	149.10	270.00	270.00	270.00
Germany	101	Reduction of food waste (Waste Management)	51.65	84.04	83.89	83.74
Greece	11	Recovery of organic waste	875.00	1250.00		
Greece	12	Recovery of biogas	960.00	750.00		

Country	PaM ID	PaM Name	Projected PaM emission reduction by future year (kt)			
			2025	2030	2035	2040
Iceland	504	Gas and compost plant	23.00	77.00	110.00	134.00
Ireland	24	Landfill Directive (1999/31/EC)	730.11	801.20	848.46	921.26
Latvia	39	Increase of waste preparation for treatment (group PaM, including PaMs: 36, 38)				
Latvia	36	Increase biological waste preparation for treatment to 210 000 t per year		4.00	4.00	
Latvia	38	Increase biological waste treatment to 110 000 t per year				
Latvia	37	Increase preparation of Refused derived fuel to 130 000 t per year		2.00	2.00	
Malta	25	Waste Management Plan 2020 - 2030	97.37	117.18		
Norway	68	Requirement to collect landfill gas	133.00	105.00		
Norway	69	Ban on depositing biodegradable waste in landfills	666.00	783.00		
Poland	47	Development of agricultural biogas plants	749.00	1002.00		
Poland	53	Rational waste management	5588.00	8269.00	9739.00	10759.00
Romania	96	Waste WEM (with existing measures) (group PaM, including PaMs: 1, 2, 3, 5, 10, 11, 80, 81, 82, 83, 84, 85, 86, 87, 88)				
Romania	1	GD no. 739/2016 approving the National Climate Change and Low Carbon Green Growth Strategy for period 2016 - 2030 and the National Action Plan for implementation of the National Climate Change and Low Carbon Green Growth Strategy for period 2016-2020				
Romania	2	GD no. 877/2018 approving Romania's Sustainable Development Strategy 2030				
Romania	3	Law no. 278/2013 on industrial emissions, including Decisions establishing best available techniques (BAT) conclusions under Directive 2010/75/EU	4283.46	5978.92	6644.56	7358.29
Romania	5	Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement				
Romania	10	Romania's National Recovery and Resilience Plan (PNRR)				
Romania	11	National programs for local and regional development				
Romania	80	Law no. 211/2011 regarding waste management, with subsequent amendments				
Romania	81	GEO no. 92/2021 regarding waste management, approved by Law no. 17/2023				
Romania	82	GD no. 942/2017 approving the National Waste Management Plan				

Country	PaM ID	PaM Name	Projected PaM emission reduction by future year (kt) 2025	2030	2035	2040
Romania	83	Law no. 249/2015 regarding the method of managing packaging and packaging waste, with subsequent amendments				
Romania	84	GEO no. 5/2015 regarding waste from electric and electronic equipment				
Romania	85	GD no. 349/2005 on landfill of waste, amended and supplemented by GD no. 201/2007 and GD no. 1292/2010				
Romania	86	GEO no. 2/2021 on landfill of waste				
Romania	87	Law no. 181/2020 regarding the management of compostable non-hazardous waste				
Romania	88[a]	GD no. 188/2002 for the approval of certain norms concerning the conditions of discharging the wastewater into aquatic environment, with subsequent amendments				
Romania	103	Waste WAM (with additional measures) (group PaM, including one single PaM 89)	633.99	89.86	125.03	154.56
Romania	89	Improving solid waste management				
Slovenia	75	Reduction of landfilled biodegradable waste (group PaM, including PaMs: 70, 71, 72, 73)	237.00	448.00	607.00	716.00
Slovenia	70	Changes in environmental taxation of waste management				
Slovenia	71	Improving the system of packaging waste collection				
Slovenia	72	Implementation of pay as you throw concept				
Slovenia	73	Change of rules for use of compost on agricultural land				
Slovenia	74	Collection of landfilled gas and its energy use	229.00	172.00	132.00	103.00
Switzerland	29	Ban on landfilling of combustible waste	145.00			
Switzerland	38	Ordinance on the Avoidance and Management of Waste	28.00			

Notes: a: PaM 88 for Romania relates to wastewater treatment and discharge. It is included in this table due to its contribution to the reported group savings of Romania PaM 96. It is excluded from the analysis of solid waste PaMs found elsewhere in this report.

2.3 Discussion

At the EU level there are a small number of PaMs for every waste type, sector and waste hierarchy. However, there are significant differences in the coverage, for example there are 40 PaMs involving the recovery of organic waste, with further PaMs that will also target organics as part of other waste types, such as MSW and food waste. This highlights how countries likely see the recovery of organic waste as the most important target in addressing GHG reductions from the waste sector. WEEE and other non-organic wastes that currently receive less coverage in the reporting of waste sector PaMs may not directly contribute to GHG emissions in the same way as organics. However, they may reduce GHG emissions in other sectors due to their role in replacing virgin materials. This is explored further in **Section 5**. All countries have measures for WEEE management, following the requirements of the WEEE directive, so absence of PaMs on this waste type cannot be interpreted as a “true” gap in handling of WEEE and its knock-on impacts (potentially in other GHG reporting sectors) across countries.

The analysis has also shown that many of the PaMs are very broad or general, listing waste management or climate plans/programmes. Descriptions are often not detailed enough to determine the applicable (IPCC) sectors or waste type. These broader PaMs will potentially have a more significant impact, containing many individual measures, if quantified. However, to identify the full extent of these PaMs requires additional analysis of the plans and programmes which is beyond the scope of this preliminary research.

The analysis also shows that the majority of the PaMs reported are already active. Not many are PaMs which have not yet been implemented, i.e., those that are “Planned” or “Adopted”. It can be expected that new PaMs will be added, given that the new, more ambitious targets for recycling and reducing landfilling of waste as introduced in the revised Waste Framework Directive and Landfill Directive adopted in 2018, will have to be implemented. For example, the majority of Member States have plans in place to increase the coverage of the population with separate collection systems for bio-waste or to improve the effectiveness of collection systems already in place[25].

The geographical scope of the policies shows that very few of the reported PaMs are local or regional, which as previously stated is not usually how waste is managed within a country. It is however important to note that local/regional policies may be implementing national policies and therefore the reporting of all local/regional policies may lead to some double counting. Due to the low number of reported local/regional PaMs it is not possible to determine the comparative impact of these against those that derive from national (and often EU) level legislation.

It is clear that there are limitations and potential barriers to quantification of the waste sector PaMs that are being reported. In Section 3, we explore historical emissions trends that have been achieved across the reporting countries for the waste sector along with the currently reported projections data. This should give greater context to the scale of emission reductions already achieved at national and EU-level, and hence give an indication of what future reductions may be feasible as an alternative viewpoint to the PaMs submissions.

25 EEA, 2023, Briefing No. 29/2022 Economic instruments and separate collection systems — key strategies to increase recycling — European Environment Agency (europa.eu); and EEA, 2023, Briefing no. 28/2022, Many EU Member States not on track to meet recycling targets for municipal waste and packaging waste — European Environment Agency (europa.eu)

3 Waste sector emissions reporting

Key Messages

- The waste sector, as defined in the IPCC reporting guidelines, is responsible for 3.2% of the EU's greenhouse gas emissions in 2021, and about 70% of waste sector emissions is methane emitted by landfills. Waste sector emissions have declined in 2021 by 41% since 1990 and are projected to decrease further to 68% below 1990 levels, by 2050 under WEM and WAM scenarios. It is noted that emissions from incineration (5C) under the waste sector exclude incineration with energy recovery which are reported under the energy sector (1A1) – the activity for which has increased across the observed timeframe.
- Per capita analysis shows improvements across the majority of EU countries, with 13 countries showing per capita emission reductions of more than a third between 2000 and 2021. These have been achieved through measures such as reducing the number of operational landfills and improving technical measures at landfills that are retained (including methane recovery). Increased recycling and targeted landfill bans are also identified as contributing factors.
- In contrast, eight countries show an increase in per capita waste sector emissions across the same timeframe, despite the regulatory framework in place. This may be a result of socio-economic waste generation and waste management trends, or an artefact of poor (particularly historical) waste data.

3.1 Historical waste sector trends and projections

Having identified the most commonly reported (and quantified) waste PaMs, it is useful to seek clarity from historically submitted emissions data on what has been achieved by EU countries to date. In this section, we present historical waste sector emissions and projections at EU level before using per capita emissions analysis as an indicator of how the GHG intensity and profile of waste sector emissions appears to have changed across Europe since the turn of the century.

From 2023, historical GHG emissions and future projections scenarios are reported by countries under the Governance Regulation EU 2018/1999[26]. Previous submissions have been made through the MMR (EU 525/2013). This section includes a brief overview of the reported historical emission trends and projections from the waste sector. It should be noted that under these national reporting obligations, emissions are compiled by *sector* e.g. 'waste' and *category* e.g. 'incineration without energy recovery', rather than e.g. by waste *type*. It is therefore common to present and define trends in GHG emissions by the category or associated activity rather than by attributing emissions to a specific waste type/composition.

After initially increasing between 1990-1993 emissions from the waste sector have been reducing up to 2021 (Figure 9). This equates to an overall reduction of 41 % between 1990 and 2021. The waste sector contributes 3.3% of EU total GHG emissions in 2021[27]. The most significant source of emissions in the waste sector throughout the historical timeseries is CH_4 from landfill, making up a little over 70 % of emissions throughout. The strong decrease of emissions from the waste sector between 1990 and 2021 is mainly influenced by a strong decline of emissions in the waste sector from Germany, the Netherlands and Poland. Reductions from category 5.A solid waste disposal make up about 55 % of the observed reductions across the same time period. In contrast, emissions from biological treatment of waste have been increasing across the timeseries, supporting the analysis above which showed a high proportion of MS reporting PaMs to increase the amount of composting and anaerobic digestion. This increase is however, obscured by the reductions in emissions from solid waste disposal. The trend in emissions from

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26 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0001.01.ENG

27 EU NIR, 2023, available: https://unfccc.int/documents/627851

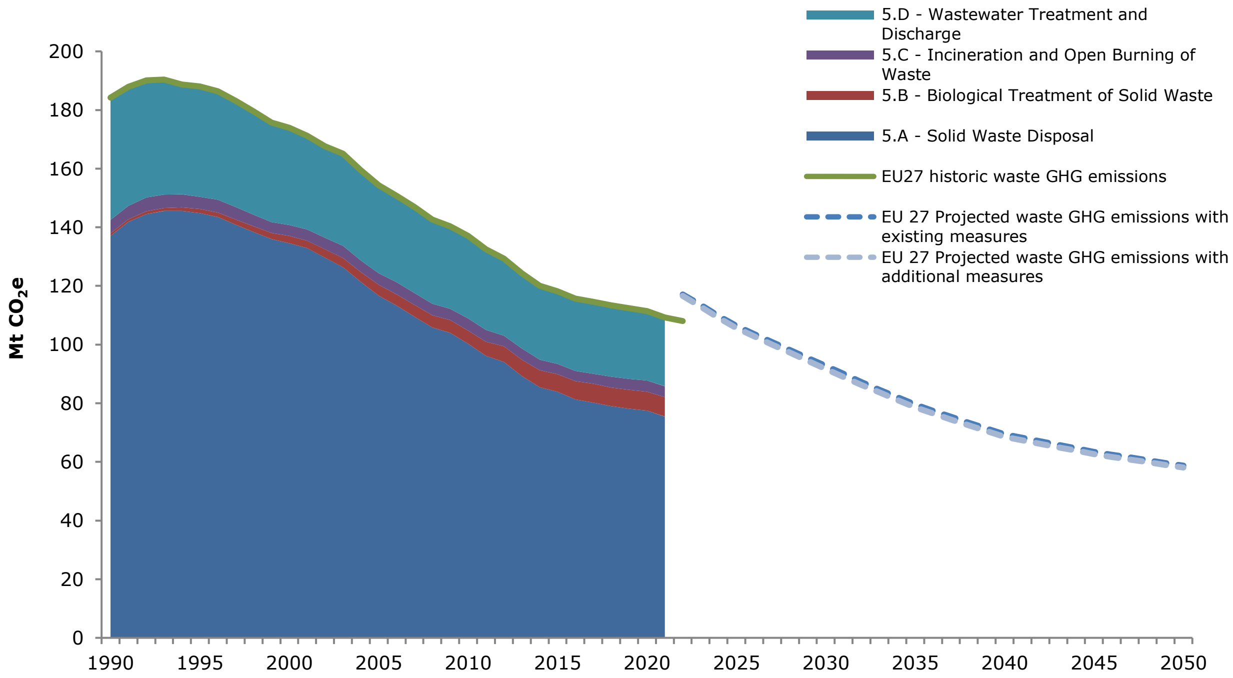
incineration and open burning has also increased since 1990 but has been relatively stable over the most recent years. However, emissions from incineration (5C) under the waste sector exclude incineration with energy recovery which are reported under the energy sector (1A1) – the activity for which has increased across the observed timeframe. Eurostat data[28] shows that only 7.6% of waste incinerated in Europe is characterized as 'incinerated without energy recovery', see also Figure 10.

Despite the reduction in emissions, data (Figure 10) shows that waste generation has been on average increasing between 2004 and 2018 with a sharp decline in 2020, driven by the COVID-19 pandemic and the ensuing economic slow-down. The amount of waste disposed in landfill has reduced since 2004, also with a sharp decline between 2018 and 2020, while recycling and EfW have been increasing. This divergence of activity (waste generation) against emissions is likely showing the impact of EU legislation and national PaMs as countries started diverting waste from landfill to other, less GHG intensive treatment pathways. In addition, a large quantity of generated waste is inert mineral waste that will not directly contribute to methane emissions.

The projections show further reductions up to 2050 in the 'with existing measures' (WEM) and 'with additional measures' (WAM) scenarios of 68 % below 1990 levels under both scenarios. These reductions however will not be enough to meet the EU's net-zero target by 2050. This does not necessarily show that the implemented and planned PaMs are ineffective, however it suggests that i) the implementation or ambition of existing measures could be enhanced; ii) not all relevant measures are reported, and/or iii) further measures could be introduced. The following sections will further explore the effectiveness of national PaMs as well as highlighting any gaps that could further contribute to GHG reductions.

[28] Tables ENV_WASGEN and ENV_WASTRT accessed 29/11/2022

Figure 9 EU 27 historical emissions and projections for the waste sector



Note 1: Latest projections data covers the period 2021-2050, hence the overlap year. 2021 is the current end point for the reported historical dataset which is submitted based on current year (2023) minus 2. The EU historic waste GHG emissions trend is continued to 2022 based on the EU approximated inventory[29].

Note 2: The most recent projections data of seven countries include a base year derived from the 2022 inventory with a further country reporting projections with a base year derived from the 2021 inventory. These base year discrepancies cause the disconnect between the historical and projected timeseries as visible in the above figure.

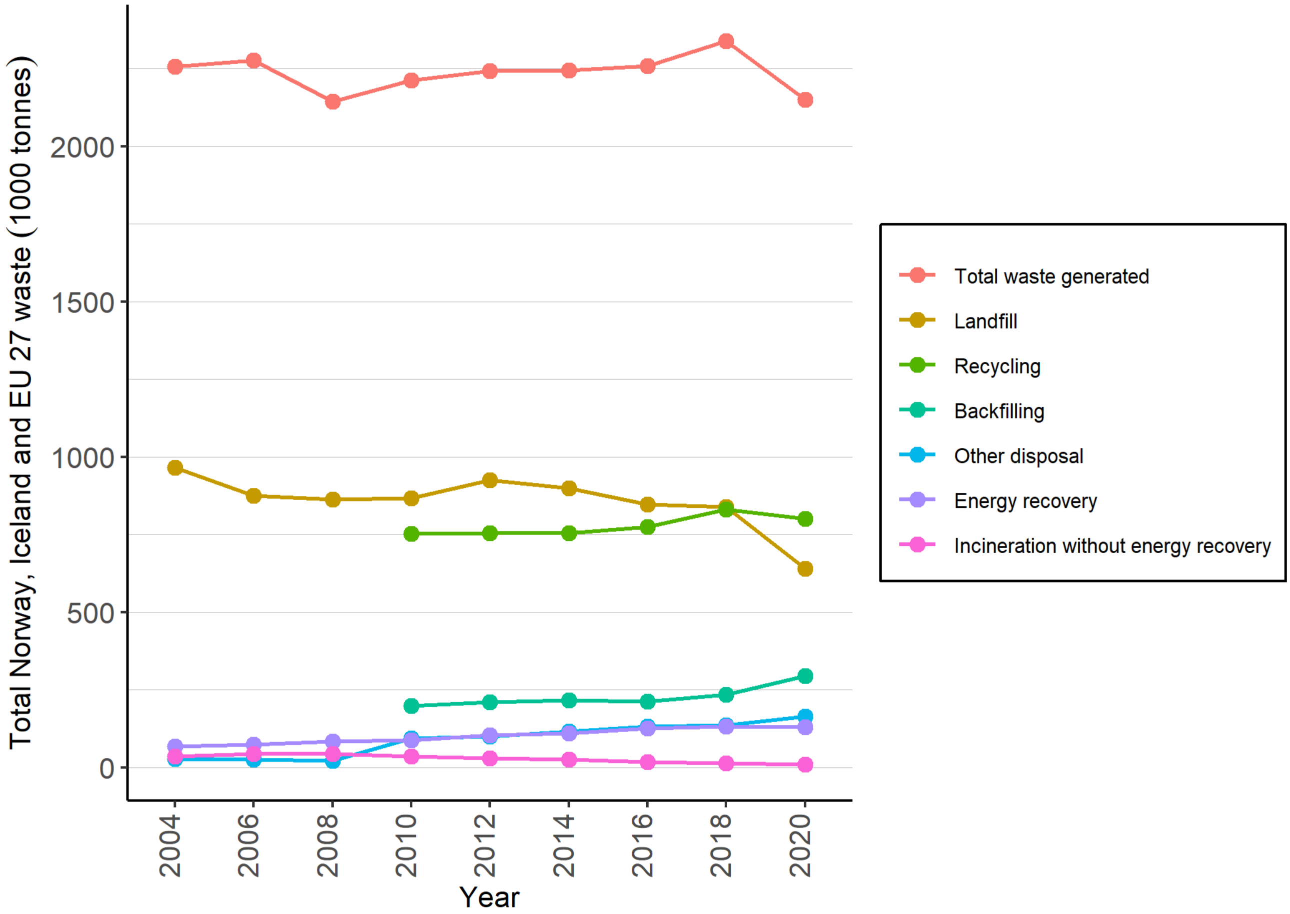
Note 3: The EEA's projections dataset is gap filled, where countries do not yet report a WaM scenario the WEM scenario is used. This is the case for 14 Member States.

Note 4: Projections data was not available for CH, NO and IS for the full projections timeseries.

Source: EEA, final GHG inventory submission 2023 (version 15/04/2023), final GHG projection submission 2023 (version 24/10/2023)

[29] EU (2023) Approximated estimates for greenhouse gas emissions, 2022, available: https://sdi.eea.europa.eu/data/f86e5d0e-fb08-46ae-9cb9-e5338a2174dc

Figure 10 **EU 27 Waste generation and treatment in 1000 tonnes**



Note: No data was available from Switzerland

Source: Eurostat[28]

3.2 Per capita emissions analysis

In addition to looking at the historical trends, variations in per capita emissions from the waste sector may give further indication of progress in waste sector regulation over time across the EU. This indicator also allows for a consistent basis of comparison across the countries included in this analysis, where overall populations and waste production levels significantly skew the presentation of country-level data in terms of total activity and/or emissions.

Figure 11 presents per capita GHG emissions from the waste sector by country. It shows progress that has been achieved in the sector when looking at the period from 2000 to 2021. Most countries show a decrease in emissions per capita. 13 countries have shown per capita emission reductions of more than a third over the assessed timeframe. However, eight of the presented country profiles show an increase in per capita emissions across the same period.

Figure 12 presents this information in more detail by considering the contribution of each solid waste disposal category to the per capita emissions. Generally, the contribution of unmanaged /uncategorized landfill appears greater in 2000, with managed landfills becoming present in all reporting countries by 2021. It should be noted that many countries still report emissions from unmanaged landfills even though many such sites have closed. This is due to the gradual decay of biological material and resultant methane emissions that occurs for many years after solid waste is first disposed of in a landfill.

Almost all countries that show a significant decrease in waste sector emissions per capita have achieved this by making their landfills less GHG intensive on a per capita basis. This implies that for many countries:

- Biodegradable solid waste is being diverted away from landfills to other management pathways, or subjected to pre-treatment operations reducing biodegradability;
- the biodegradable content of waste being landfilled is lower than it was in 2000; and/or
- technical landfill gas control measures are more prevalent in 2021 than in 2000.

The increased role of biological treatment is visible for several countries in 2021 compared to 2000 when the practice was minimal. In some instances, the uptake in treatment pathways such as composting and anaerobic digestion could be at least a partial cause in the decline in per capita emissions associated with landfilling. This is in line with the doubling of municipal waste reported as composted or anaerobically digested over the same period[30].

The influence of waste incineration pathways on per capita emissions is less visible in this analysis. However, that influence may well be hidden, as emissions associated with energy recovery / energy from waste facilities would be attributed to the energy sector within national inventories. This is supported by waste statistics[31] that show the decline in waste that is incinerated without energy recovery, from 35% in 2004 to 7% in 2020. In absolute numbers, the amounts of waste incinerated without energy recovery fell from 36 million tonnes to 10 million tonnes across the same period, with the amount of waste sent to energy recovery increasing from 66 million to 129 million tonnes. The potential impacts of this topic are discussed further in **Section 5**.

Some reporting countries stand out when viewing the per capita data – most obviously being those that show an increase in per capita emissions between 2000 and 2021, and alternatively those countries that have achieved the greatest per capita reductions across the same timeframe. The below examples present trend descriptions identified through a review of the National Inventory Reports (NIRs) as a means to identifying the reasons for the variance observed in per capita waste emission trends.

3.2.1 Examples of increasing per capita emissions

Cyprus had relatively high per capita waste sector emissions in 2000 in comparison to the other reporting countries, and this rose further in 2021 owing to increased population, consumption and tourism[32,33]. The split of waste treatment in Cyprus changed between 2000 and 2021. In 2000 waste was disposed solely in unmanaged landfill sites, but in 2006 the first managed waste disposal site started operating, and the second site followed in 2010. Also operating until 2010 were 113 sites of unmanaged household and solid waste disposal sites, many of which were not compliant with the EU Landfill Directive. While a lot of these have since closed, only 46% of the closed landfill sites have been rehabilitated, hence they still contribute to the country's methane emissions, and the largest sites remained open until February 2019. In 2021, the government of Cyprus decided on major changes to the waste system[34] which could be expected to decrease the per capita emissions.

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30 Eurostat database ENV_WASMUN, available: https://ec.europa.eu/eurostat/databrowser//product/ view/ENV_WASMUN

31 Extracted from Eurostat database ENV-WASTRT for total waste, EU-27.

32 Cyprus NIR, 2023, available: https://unfccc.int/documents/627714

33 Methods and data used for estimating GHG emissions have been improving over time. E.g. more accurate emission factors, waste data have improved, through better waste composition analysis, installation of weighing bridges at landfills, and closing of dumpsites. Countries report information about the methods used in calculation of GHG emissions in National Inventory Documents (NIR)

34 EEA and ETC CE, Cyprus country profile, 2023, available: https://www.eea.europa.eu/publications/many-eu-member-states/cyprus/view.

Malta also highlights the influence of tourism on its sectoral emissions. Consistently increasing tourist numbers (evidenced by a 5.9% increase between 2018 and 2019) are cited as key factor in Malta's waste generation trend, and hence per capita emissions that rank third highest amongst EU MS in 2021[35].

In Romania, the GHG emissions trend from solid waste disposal increased significantly in 2021 (+192%) when compared with 2000. This significant rise is attributed to the increasing trend of waste deposited in managed landfills, which is attributed to increased population and material consumption[36].

A similar trend is true of Croatia, where generation of MSW per capita and associated waste emissions experienced a significant increasing trend until 2009, also due to increased population and material consumption[37]. Thereafter, there was a slight decrease in waste and emissions generated, chiefly as a result of the economic crisis but also other factors such as the wider adoption of measures to prevent, reduce and recycle waste. However, these measures are still not sufficiently applied.

Interestingly, both Romania and Croatia present comparatively low per capita emissions from the sector in comparison to the other reporting countries for 2000. Both countries reported very low levels of municipal waste generated in 2000. Data on waste generation and content of biodegradable components used for estimating GHG emissions for that time might be less reliable. However, the reporting of (municipal) waste data has improved over the past few years and is expected to improve further due to recent harmonisation of reporting requirements.

3.2.2 Examples of decreasing per capita emissions

Iceland has managed to reduce its comparatively high per capita emissions in the waste sector between 2000 and 2021. A significant factor influencing this trend is increased recycling rates, rising more than tenfold across the time period[38], while still significantly below the EU average. Methane recovery has also increased in Iceland across the timeseries. In 2000 only 500t was recovered, while in 2019 the amount peaked at around 3000t, resulting from increased collection of landfill gas at Iceland's largest landfill site, Álfsnes. The high tourist population in Iceland could at least partly explain the comparatively high per capita emissions from the sector that are observed in 2021 despite the reductions achieved.

In Finland, the significant reduction in per capita waste emissions between 2000 and 2021 coincides with a >50% reduction in total CH_4 emissions from solid waste disposal sites[39]. Following the implementation of the Waste Act (2011) and the EU Landfill Directive (1999/31/EC) and the ban of organic waste to landfills since 2016 (Government Decree 2013), the country has been able to minimize waste sent to landfill, whilst increasing the recycling of waste material, landfill gas recovery and transferring waste to alternative treatment methods. Nevertheless, Finland can further improve by moving more waste from its energy recovery facilities towards recycling[40].

In the Netherlands, per capita emission reductions are attributable to there being only 19 operational landfill sites in 2021, whereas historically waste was landfilled on a few thousand sites[41]. Many of these

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35 Malta NIR, 2023, available: https://unfccc.int/documents/627693

36 Romania NIR, 2023, available: https://unfccc.int/documents/627662

37 Croatia NIR, 2023, available: https://unfccc.int/documents/627738

38 Iceland NIR, 2023, available: https://unfccc.int/documents/627842

39 Finland NIR, 2023, available: https://unfccc.int/documents/627718

40 EEA and ETC CE, Finland country profile, 2023, available: https://www.eea.europa.eu/publications/many-eu-member-states/finland/view

41 Netherlands NIR, 2023, available: https://unfccc.int/documents/627759

still contribute to emissions of methane but this is reducing over time. The reducing trend is also partly due to increased CH_4 recovery, occurring at 53 sites currently in the Netherlands. Netherlands report that CH_4 recovery rates have increased from around 4% in 1990 to 13% in 2021.

Figure 11 Per capita emissions change by country, 2000 – 2021

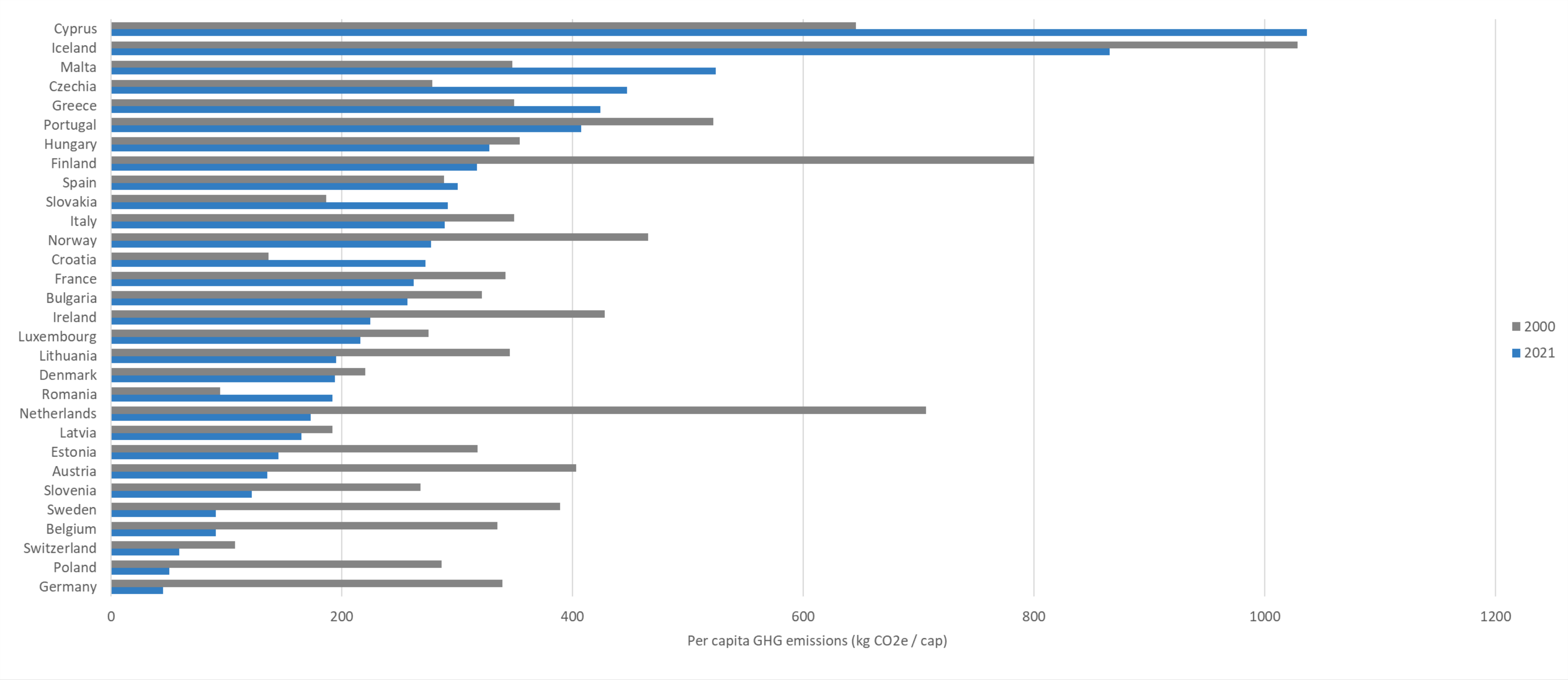
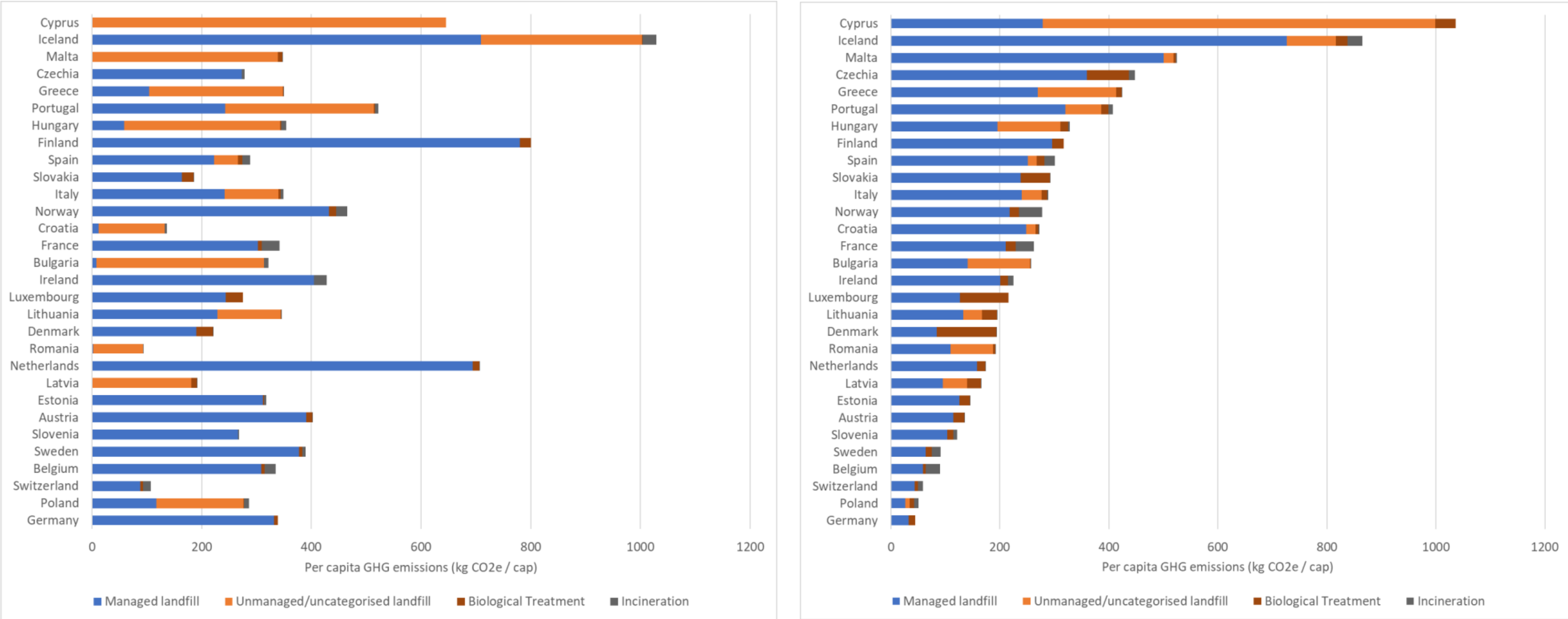


Figure 12 Per capita emissions by solid waste treatment category and country, 2000 (left) and 2021 (right)



Note: 'Incineration' includes only incineration without energy recovery, as reported under the waste CRF category 5.C.

3.3 Discussion

It becomes evident when looking at the EU-level historical emissions trends for the waste sector that consistent progress has been made in terms of emission reductions. The projections continue this trend over the coming decades. However, there is not a pronounced difference between the WEM and WAM projection scenarios when viewed at EU-level. This supports the findings from the analysis of PaMs reporting (**Section 2**) – specifically that there appear to be limitations or barriers affecting reporting countries from being able to quantify emission reductions from their identified waste sector PaMs.

The analysis of national level per capita emissions trends highlights the variance between countries in terms of progress (and lack of progress) that has been achieved across Europe when looking at 2021 data compared to a 2000 baseline. Overall, many countries have achieved significant reductions in per capita emissions, largely through the changing emissions profile from solid waste disposal and landfills. Examples such as Iceland, Finland and the Netherlands show changes of waste management at the national level that have reduced per capita emissions. These include:

- Reductions in the number of operational landfills.
- Improved technical measures at retained / new landfills, including methane recovery.
- Banning specific waste types from entering landfills.
- Diversion of waste from landfills to alternative pathways including significant increases to national recycling rates.

However, data from a number of reporting countries show that solid waste management remains a significant challenge. This appears to be at 'activity' level – i.e. that national circumstances of growing populations and increased material consumption have led to increased solid waste generation on a per capita basis. In countries such as Cyprus and Croatia – measures appear to be in place to mitigate the impact of increased waste generation, but those measures require effective implementation. It will take time before such mitigation measures translate into a decrease in per capita emissions, especially where poorly managed, or unmanaged landfills remain operational, or have remained operational until more recent years. It is also noted that in some cases, early waste data (as reported in national inventories) may be poor, or of lower quality which makes the data less reliable for drawing robust conclusions.

In **Section 4**, we explore key elements of EU-level waste legislation in more detail and consider how reporting countries have responded to that legislation. That analysis will give greater context to the variance observed in national progress against broader waste sector mitigation efforts, and hence the resulting sectoral emissions and PaMs data being reported.

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4 Analysis of key EU-level waste policy and national implementation

Key Messages

- GHG reductions from landfill are brought about by two factors: reducing biodegradable waste sent to landfill; and technical measures to reduce the emissions of methane from landfills. The Landfill Directive (1999, revised 2018) has been a driver for action at the national level.
- Some of the strongest early responses to the LD included the introduction of landfill bans – particularly those focused on specific biodegradable waste streams. The introduction of such landfill bans in specific countries appears well correlated to achievements in waste sector emission reductions, as a national total and on a per capita basis (e.g. Germany, Belgium, Sweden).
- A wide variety of additional measures have been introduced by countries in response to the LD. Reductions in the generation of specific waste types, increased re-use and recycling can also have knock-on impacts in terms of GHG savings, however the impacts do not appear to be as strong for these measures in terms of GHG savings in comparison to specific landfill bans.
- Despite this, Ireland is highlighted as a country that has achieved strong waste sector emission reductions despite not having a specific landfill ban in place. Instead, a relatively high landfill tax along with targeted waste management measures show success, including the uptake on energy recovery facilities. It is noted that a small proportion of Ireland's reported emission reductions are likely achieved through the export of waste materials. In situations where waste exports are involved, it may be beneficial in terms of net GHG emissions depending on the capacity of the waste generating country to treat waste via less carbon intensive treatment pathways.
- The ability of countries to meet their LD obligations may continue to be limited where they are reliant on softer waste management PaMs, as shown by the review of Latvia's national waste legislation. This may in turn result in comparatively weak GHG reductions in waste sector reporting from some countries. However, it is noted that many waste management measures may have hidden benefits in terms of GHG savings due to their influence on e.g. energy mix and energy/material/product demand. The GHG impact of these influences would only become visible if the emissions are calculated and reported (in terms of PaMs) across waste and non-waste sectors of IPCC reporting. This topic is discussed further in Section 5.
- With all measures, particularly those such as landfill taxes, it is evident that their effectiveness is closely linked to how they are designed, implemented and enforced based on the ability of policy makers and practitioners to apply them.

From our analysis in Sections 2 and 3 of this report, it is evident that solid waste disposal and landfills have played a critical role in determining historical emissions trends and variance between reporting countries. In addition, it is evident that identified PaMs being reported by countries have strong links to European legislation that impacts on the pathways of solid waste disposal. In this section, we assess the role of key EU-level waste sector legislation and reflect on how countries have reacted to, and implemented measures in response to such legislation across the most recent decades.

4.1 Implementation of the Landfill Directive

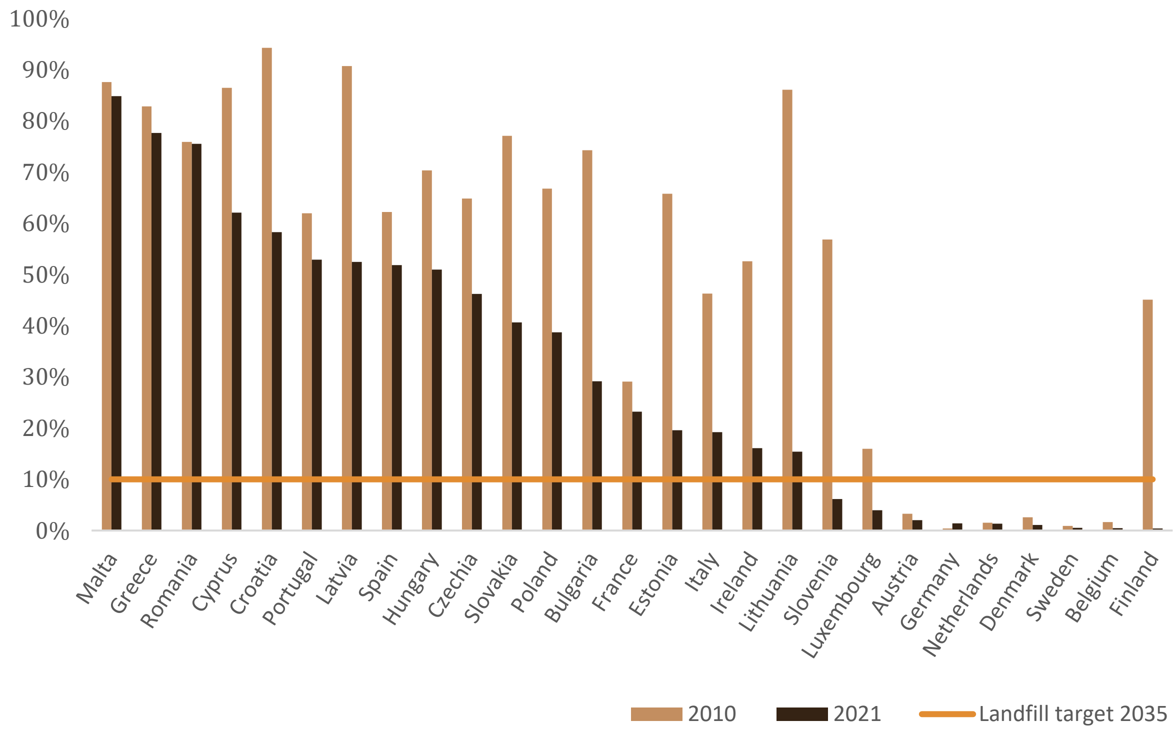
A key legislation for waste management and reducing GHG emissions from the waste sector across the EU is the Landfill Directive (LD). The LD was adopted in 1999 and had to be incorporated into national law by 2001. This legislation was also revised in 2018 to be incorporated into national law by 2020. A key aspect of the LD that would impact GHG emissions was to reduce the amount of biodegradable waste and MSW sent to landfill with the targets set out previously in Box 0.3. The first target, if derogations were not applied for, was for 2006, to reduce biodegradable municipal waste landfilled to 75% of the biodegradable municipal waste generated in 1995, increasing to 50% in 2009 and 35% in 2013. The 2018 revision of the Landfill Directive sets a new target to reduce landfilling of all municipal waste to a maximum of 10% of the generated municipal waste in the same year by 2035. This assessment of the implementation of the LD therefore focusses on this.

It is important to note that GHG reductions from landfill are brought about by two factors: reducing biodegradable waste sent to landfill; and technical measures to reduce the emissions of methane from landfills. Biodegradable waste in landfills emits methane for decades after being landfilled, so reducing landfilled amounts is not immediately translated into GHG emission reductions of the same magnitude.

In 2023 the EEA and European Topic Centre on Circular Economy (ETC/CE) published early warning assessments related to the 2025 targets for municipal waste and packaging waste, including the new LD target to reduce landfilling to a maximum of 10% of the generated municipal waste by 2035[8]. Figure 13 presents the percentage of municipal waste landfilled in 2010 and 2020 for EU countries and shows that numerous countries appear to be already meeting the 2035 target. Interestingly, Slovenia is a country that shows strong progress against the 2035 LD target whilst also indicating fairly significant further emission reductions from their waste sector PaMs (Annex I, Figure A1.1). Low reporting of PaMs quantification may mean that other countries are also expecting significant further reductions.

The synergy between historical reductions of GHG emissions with the diversion of biogenic waste from landfill achieved across countries suggests that the LD has been a hugely effective measure in reducing GHG emissions from waste. An interesting exception is Denmark, who has seen more modest overall sector GHG reductions of 17 % since 2000 despite showing strong progress against the LD, with approximately 1% of municipal waste landfilled in 2020. This is likely to be due to Denmark implementing measures before 2000 such as the diversion of waste away from landfill to energy recovery starting already before 2000. In addition, while emissions from landfill in Denmark have decreased, the emissions from anaerobic digestion and composting have increased notably (as a percentage of the emission reductions from landfill) in comparison to totals for other countries, which may also contribute to explaining this feature.

Figure 13 Landfill rates[a] for countries against revised landfill directive target



Notes: a Data for 2011 is shown instead of 2010 for Denmark. Data for 2019 is shown instead of 2021 for Greece. Data for 2020 is shown instead of 2021 for Ireland. The reported landfill rates do not yet fully respond to the calculation rules related to the target as laid down in the Commission Implementing Decision (EU) 2019/1885.

Source: Figure 2 EEA, 2024[42]

Bans on Landfilling Waste

Figure 14 shows a timeline of landfill bans introduced across EU countries. Many countries meeting the targets under the LD early had introduced measures banning or limiting the amount of biodegradable waste disposed in landfill before or within a few years of adoption of the LD. Germany introduced the earliest ban on landfilling certain waste types, limiting the biodegradable content of landfilled waste to 3% total organic carbon (TOC) in 1993. This is followed in 1995 by a ban on landfilling combustible and biodegradable waste in the Netherlands, and subsequently in 1997 by a ban on landfilling recyclable and combustible waste in Demark. Belgium introduced a ban on landfilling of untreated waste, including biodegradable waste, in 2007 for all regions. However, the Flanders region had introduced a ban on landfill of unsorted and separately collected waste in 1998, which was expanded in 2000 to ban landfill of combustible waste. The Wallonia region had introduced a landfill ban of combustible waste in 2004.

Landfill bans have been shown to be hugely effective in reducing the amount of waste sent to landfill. Six years after the introduction of the landfill bans in Sweden and Germany the amount of municipal waste disposed in landfill had reduced from 23% to 4% and 27% to 1% respectively[43]. Figure 9 shows that Germany and Belgium have reduced their emissions from the waste sector by a significant amount since 2000. Further analysis of reductions in GHG emissions show Austria, Belgium, Germany, The Netherlands and Sweden to have the highest reductions of waste sector GHG emissions in Europe with countries such as Finland, Estonia and Slovenia close behind. Austria, Belgium, Germany, The Netherlands, Sweden and

42 https://www.eea.europa.eu/ims/diversion-of-waste-from-landfill

43 https://www.dcceew.gov.au/sites/default/files/documents/landfill-ban.pdf

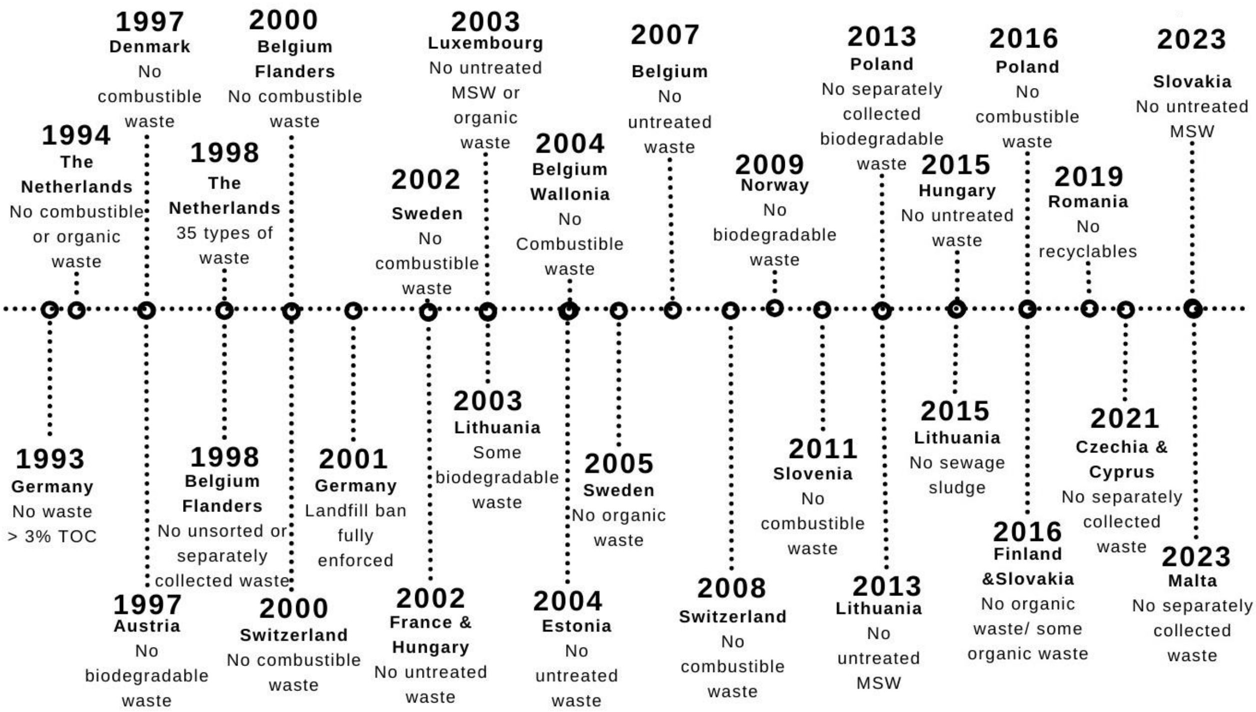
Finland are also countries which rely strongly on energy recovery of waste, and emissions from this operation are not included in the waste sector emissions.

Lithuania also introduced various landfill bans, although later in the timeline than those discussed above. Poland also had a late start to introducing measures to implement the LD, as the responsibility for waste management was held by private companies up until 2013, making implementation difficult. Poland banned the landfill of separately collected biodegradable waste in 2013 and all combustible waste in 2016. The full effects of the latter on the amount of biodegradable waste disposed in and GHG emissions from landfill are yet to be seen. Both France and Hungary also banned the landfill of untreated waste in 2002, which has likely contributed to the meeting of their targets for biodegradable municipal waste under the LD, however this has been shown to not reduce GHG emissions as much as more vigorous bans on all combustible waste for example.

Of the countries who have not met their LD targets for biodegradable municipal waste and are also not on track to meet the revised targets (Bulgaria, Croatia, Cyprus, Greece, Latvia, Malta, Portugal, Romania, Slovakia) only Cyprus, Romania, Slovakia and Malta have introduced landfill bans. In Cyprus and Malta this ban is limited to separately collected waste, and in Romania the ban covers recyclable waste. In Slovakia the ban is on landfilling biodegradable and untreated mixed municipal waste[44].

[44] EEA, 2023, Technical note accompanying the EEA briefing 'Economic instruments and separate collection – key instruments to increase recycling'

Figure 14 Landfill bans introduced by EU countries up to 2023



Note: Compiled by authors based upon a summary of landfill bans produced by CEWEP[45] supplemented by information from the Technical note accompanying EEA briefing 'Economic instruments and separate collection – key instruments to increase recycling'[44] and Country profiles on the management of municipal waste[46]

Separate bio-waste collection

Another common measure is separate collection. Figure 15 shows the proportion of bio-waste that is separately collected (out of the total bio-waste generated). Most of the countries who met their LD targets have a higher separate collection rate than the average.

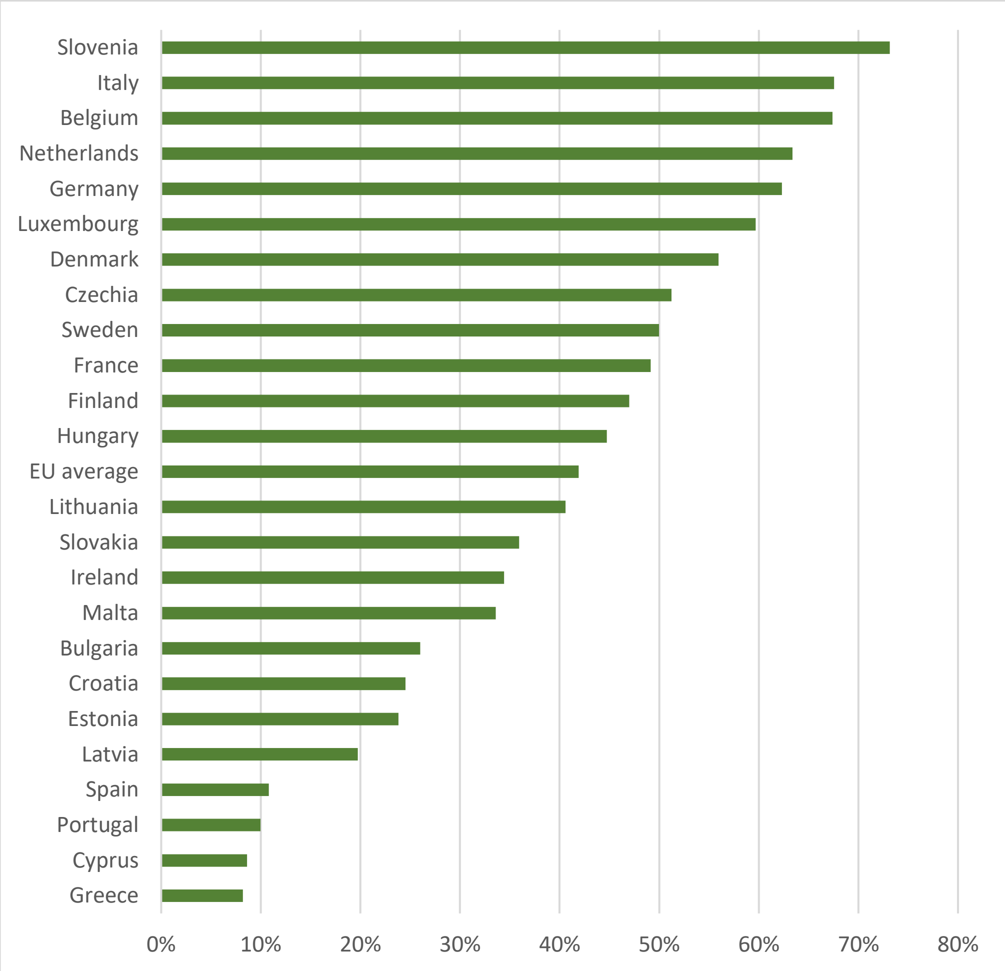
MS who met most of their LD targets on biodegradable municipal waste and are potentially on track to meet the 2035 LD target do not necessarily have a high bio-waste collection rate, because the targets on diversion of biodegradable municipal waste from landfill can also be me by pre-treatment of municipal waste in MBT plants or by sending this waste to incineration. However, many do have some separate collection measures. Lithuania introduced separate collection for biodegradable waste in cities with over 50,000 inhabitants for both households and non-households (2019) and Hungary introduced measures such as encouraging separate collection of biowaste (made mandatory for green waste in 2015), increasing green waste recycling, home composting and commercial composting. France has legislated that major bio-waste producers have to sort and prepare waste for recycling. In Ireland there is particular focus on food waste; in 2006 a measure to increase kerbside organic waste collection was introduced although success was limited by the fractured waste collection system. Additionally, segregation of food waste was introduced in the 2009 Food Waste Regulations and this was replaced in 2015 by two regulations targeting

45 https://www.cewep.eu/wp-content/uploads/2021/10/Landfill-taxes-and-restrictions-overview.pdf

46 Country profiles on the management of municipal waste: https://www.eionet.europa.eu/etcs/etc-ce/products/country-profiles-on-the-management-of-municipal-waste

commercial and household food waste, the latter making kerbside organic waste collection mandatory. Nevertheless, in 2022 only 48% of the Irish population was serviced by separate collection bins for biowaste[47]. These measures make Ireland an interesting case study, as a country who has met the LD targets for biodegradable municipal waste without introducing restrictions on landfill of waste. This is explored further in Section 4.2.2.

Figure 15 Proportion of bio-waste collected separately



Note: Poland, Romania, Norway, Iceland n/a. Data refer to 2020 or earlier depending on data availability.

Source: compiled by EEA based on EEA, 2023[48]

Landfill Tax

Most countries have also introduced a tax on landfilling waste, with mixed results. Currently 22 EU MS in addition to Switzerland have a tax on landfill, within at least one region. Croatia, Cyprus, Germany, Luxembourg, Malta and Norway do not have a landfill tax. Norway previously implemented one and repealed it in 2015[49]. Germany and Luxembourg are the only countries meeting their targets for biodegradable municipal waste under the LD who have never implemented a landfill tax. However, the implementation of a landfill tax alone, and the level of those taxes applied, do not automatically result in

47 EEA and ETC CE (2023), [EEA early warning assessments related to the 2025 targets for municipal waste and packaging waste]

48 EEA and ETC CE (2023), [EEA early warning assessments related to the 2025 targets for municipal waste and packaging waste]

49 https://www.cewep.eu/wp-content/uploads/2021/10/Landfill-taxes-and-restrictions-overview.pdf

policy success in terms of reducing the amount of (bio-)waste sent to landfill. In fact, landfill and incineration tax levels vary widely between Member States. An EEA Briefing on economic instruments and separate collection systems (2023) identified that the effectiveness of these taxes depends not only on their level but also on how they are designed, implemented and enforced[50]. In many countries, the use of landfill taxes in conjunction with application of landfill bans is thought to have been an effective approach to significantly reduce the landfilling of (primarily organic) waste streams.

4.2 Country Case Studies

4.2.1 Belgium

Earlier policies and measures

Belgium has achieved GHG emission reductions of 70% between 2000 and 2023[51] across its entire waste sector. In addition, earlier analysis in this report identified Belgium as making significant reductions in its per capita solid waste sector emissions across the same time period (Figure 11) to a point where it now ranks in the lowest five countries in Europe using this metric. Belgium has only quantified one of its seven reported waste sector PaMs in its most recent PaMs reporting (Figure 8). It is therefore interesting to research deeper into the practices and legislation that underpin its success.

In Belgium, waste management and prevention responsibilities are devolved to each of the three regions: the Brussels Capital Region (BCR), Flanders and Wallonia. Belgium has one of the highest landfill taxes and landfill tax rate increases in the EU, in conjunction with a selective landfill ban on biodegradable waste, which has been in place since 2007[52]. The landfill tax also applies to waste that is exported from Belgium for landfilling in other countries, and on waste that is imported from other countries for landfilling in Belgium. Restrictions on landfilling have been stringently adopted in Flanders and Wallonia, while the BCR has no landfill capacity owing to high urbanisation and population density. As such, it depends heavily on the waste management systems and policies of Flanders and Wallonia[52].

In Flanders, the separate collection of bio-waste and garden waste was introduced in 1991, while a landfill ban and an incineration ban of selected waste streams have been implemented since 1998. In Wallonia, a landfill ban for various waste types including combustible waste was implemented in 2004, and the landfill tax rose significantly from EUR 25 per tonne in 2008 to EUR 65 per tonne in 2010[52]. The increase in the Wallonian landfill tax, paired with the longstanding application of landfill tax in Flanders, have had by far the greatest impact in successfully diverting waste from landfill to incineration or recycling. This is evidenced by a drastic decrease in national landfilling levels, from 11 % of MSW in 2001 to 0.9 % in 2020[52]. Belgium has already met all of the diversion targets for biodegradable municipal waste of the EU Landfill Directive, and recycled 51% of its municipal waste in 2020.

Aside from landfill bans and taxes, various other initiatives have been taken to push waste management further up the waste hierarchy, with emphasis on prevention and material recovery. These include but are not limited to[52]:

- Regularly updated waste management plans
- Systematic installation of civic amenity sites, in Flanders and Wallonia
- Obligatory waste separation with fines of up to EUR 625 for non-compliance since 2010, in BCR
- High levels of separate waste collection, via kerbside and bring banks, in Flanders and Wallonia

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50 EEA 2023, [Briefing - Economic instruments and separate collection systems — key strategies to increase recycling]

51 Belgium NIR, available: https://unfccc.int/documents/627709

52 EEA/ETC (2023) [Circular economy country profile – Belgium]

Recent policies and measures

A total of seven PaMs were reported by Belgium: two each for Flanders and BCR, and three for Wallonia. These are summarised below. The only quantified PaM reported by Belgium was the Flemish long-term waste strategy, estimated to reduce GHG emissions by 380 kt CO_2e by 2040.

- BCR
  - Biomethanisation - recover all or part of locally collected biowaste and green waste in a biogas plant.
  - Establish a long-term calendar for the adaptation/optimisation of the regional incinerator.
- Flanders
  - Separate collection and recycling of waste streams to limit emissions from incineration and primary plastic production, with government incentives for reusable packaging.
  - Long-term waste strategy aiming to reduce the least efficient waste combustion capacity.
- Wallonia
  - Develop tools and support for professionals to implement energy-efficient solutions (systems, materials and processes).
  - Supervision of the use of biomass through the Biomass Transversal Committee and development of a biomass energy strategy
  - Management of biomethanisation using co-products from crops for non-energy purposes or based on waste treatment.

In addition to the reported PaMs, Belgium has the circular economy at the forefront of its future ambitions and has put in place committed targets towards it. Each of the three Belgian regions have developed separate waste management plans which have mutual aims including the transition to circular economy by linking waste to resources[46]. The BCR adopted the Plan de Gestion des Ressources et des Déchets (PGRD) in 2018. Some overarching aims of the PGRD are to promote the transformation towards more sustainable and circular consumer practices, maximise resource local conservation and valorisation, and lead the economic sector towards circular practices[52]. The plan defines key quantitative waste sector objectives, several of which are not covered in the PaMs database, such as:

- Reducing household and non-household per capita waste by:
  - 5% by 2023
  - 20% by 2030
- Increasing by 50% the amount (weight) of WEEE reported and collected in Brussels (versus 2017)
- Increasing by 50% the amount (weight) of household WEEE collected to be treated as waste, or prepared for repair or reuse (versus 2017)
- Doubling the amount of biowaste that is being recycled
- Increasing by 50% the rate of plastic packaging collection (versus 2016)

Flanders launched the Circular Flanders programme in 2017, aiming to reduce the Flemish material footprint by 30 % by 2030 and establish Flanders as circular trendsetter in Europe. It forms a partnership of governments, companies and civil society towards collaborative action and is structured around six strategic agendas which are aligned with the priorities of the EU Green Deal:

- Circular construction
- Chemistry and plastics
- Water cycles
- Bio-economy
- Food chain
- Manufacturing

The Walloon waste plan, Plan Wallon des Déchets-Ressources (PWD-R), was adopted in 2018. It includes 157 specially developed measures of which 93 seek to facilitate the most efficient implementation of the principles of the CE and waste management hierarchy. The PWD-R comprises of six major strands:

- Strand 1: the strategic framework of the Plan, which includes a programme of structural measures relating to data management (capture, use, traceability and simplification), issues of taxation, and the fight against environmental violations (inspection and penalties).
- Strand 2: the programme for prevention and the reuse of waste, which covers both industrial and household waste.
- Strand 3: the specific management plan for household waste.
- Strand 4: the specific management plan for industrial waste.
- Strand 5: the plan for public cleanliness and the fight against litter and fly tipping.
- Strand 6: surveys environmental and socio-economic impacts.

The inclusion of numerical objectives in the PWD-R varies from one strand to another, depending on various factors, which make it particularly difficult to quantify progress in terms of projected GHG emission reductions. As a general summary, the non-technical summary document for the PWD-R highlights that many of the proposed actions are expected to have an indirect effect on the improvement of prevention, management, or public cleanliness. Accordingly, in most cases the assessment of the anticipated effects can only be qualitative[53]. Despite this, there is an observed lack of PaMs relating to each of the strands of the PWD-R amongst those reported.

4.2.2 Ireland

Figure 11 shows that Ireland was in the top half of countries in terms of achieved GHG emission reductions on a per capita basis. However, the impact of their reported policy/measure is also expected to be significant (Annex I), despite only reporting one. In addition, Ireland was one of the countries who has not implemented a landfill ban. As such, Ireland’s context is explored in greater detail.

Earlier policies and measures

Ireland chose to apply for the derogations to the LD for 2006, 2009, and 2016. Ireland has met these three targets of reducing biodegradable municipal waste going to landfill. However, it was thought that the meeting of the targets was in some part due to the economic crisis reducing MSW generation. However, despite increases in GDP from 2013 the waste generation did not increase[54]. Policies such as the landfill tax levy (introduced in 2007) and obligations on food waste (Section 4) were also thought to contribute. To achieve this, Ireland moved from being almost completely reliant on landfill to recovering a significant portion of recyclable materials and incinerating with energy recovery, both waste derived fuel and municipal solid waste. However, the analysis noted that Ireland also relied on exporting waste for treatment due to a lack of recycling facilities. According to the Irish EPA[55], 'Of the waste exported, most went for recycling (57 per cent) or energy recovery (33 per cent) while 8 per cent went for composting or anaerobic digestion'. These activities only generate minor GHG emissions in the waste sector as defined by the IPCC. This means that if the same waste would have been treated in Ireland, it is possible that resultant GHG emissions would have been higher unless Ireland had the capacity to treat the waste in-country via treatment pathways of similar carbon intensity. Ireland aims to reduce its dependency on

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[53] http://environnement.wallonie.be/dechetsressources/docs/WWRP-NTS-EN.pdf

[54] https://www.eea.europa.eu/themes/waste/waste-prevention/countries/ireland-waste-prevention-country-profile-2021.pdf/view

[55] https://www.epa.ie/our-services/monitoring--assessment/waste/national-waste-statistics/municipal/

exporting waste by building up own processing capacity but expects to further rely on exports for recycling given the limited market for recyclables in the country[56].

Recent policies and measures

Ireland reported one policy under the Governance Regulation, to implement the Landfill directive. This was expected to reduce emissions by 730 kt a year by 2025 and 921 kt a year by 2040 with implementation starting in 1999. Further to the policy reported, Ireland has a national waste prevention programme[57], this includes a number of waste prevention measures:

- Training to upcycle textiles provided by the Roscommon Women's Network
- Producer responsibility initiative which emphasises prevention during the design phase
- A network of repair and re-use organisations as well as a tool to connect repair businesses with consumers
- Funding for innovation, "Green Enterprise", for reducing priority wastes
- The TREE tool, which helps companies improve their resource use efficiencies
- A research project in Irish manufacturing to measure GHG and waste generation performance
- Assessments of on-farm resource efficiencies to identify potential savings
- Publicity campaigns around food waste in particular for example the "stopfoodwaste" campaign which aims to raise awareness with the public on food waste but also to increase local prevention measures
- The "Rezero" project - a pilot for a deposit return scheme for food retailers
- A project to demonstrate the remolding of single-use plastics into pallets
- A project to convert waste into protein for animal and aquaculture feed
- A project to use waste bread for beer brewing and waste from brewing for bread making

A move towards the circular economy is a high priority for Ireland. The Circular Economy Country Profile[58] indicates that the climate action plan (2021) includes a number of key objectives for waste:

- Strengthening the regulatory and enforcement frameworks for waste management and collection, maximizing circular economy principles
- Development of a bioeconomy action plan
- Increasing food waste separation, collection and treatment
- Developing new levies to reduce resource consumption and increase recycling and re-use

In addition, Ireland has produced a Waste Action Plan for a Circular Economy[55], published in 2022. This outlines a significant number of measures targeting waste including actions to meet the revised targets under the LD and WFD. The measures include:

- A policy framework that discourages wasting resources and rewards circularity.
- Producer responsibility for the environmental impact of their products
- Measures that support sustainable economic models
- Using the influence of all sectors including the voluntary sector, R&D, manufacturers, regulatory bodies and civic society

The national waste prevention programme identified food waste as a priority area and the climate action plan and waste action plan both support this. Ireland generates around 1 million tonnes of food waste a

56 Waste Action Plan for a Circular Economy, available: https://assets.gov.ie/86647/dcf554a4-0fb7-4d9c-9714-0b1fbe7dbc1a.pdf

57 https://www.eea.europa.eu/themes/waste/waste-prevention/countries/ireland-waste-prevention-country-profile-2021.pdf/view

58 EEA/ETC (2023) Circular economy country profile – Ireland

year, excluding food waste from agriculture, with 60 % coming from households and the remaining from food processing. In 2019, only 48% of households had access to separate bio-waste collection bins, and Ireland is considered at risk for not meeting the recycling target of municipal solid waste in 2025[59]. There are several measures to prevent food waste throughout the supply chain, from agriculture to consumers. It is also proposed to further support the donation of food and investigate prohibition of destruction of edible food before its "use by date". For waste that could not be prevented increased anaerobic digestion and composting is proposed as is analysis on the removal of the bio-waste exemption on the landfill levy.

There is no quantification of how these policies impact on GHG emissions but while many of these policies could be considered an implementation of the landfill directive (and therefore be included within their reported PaM) the data reported under the Governance Regulation looks to be a small portion of Ireland's waste policies and GHG reductions could be more than reported.

4.2.3 Latvia

Figure 11 shows Latvia has relatively low GHG emissions from solid waste sectors on a per capita basis. However, it has not made much progress in further reducing emissions on this basis between 2000 and 2021. The expected impact of their reported PaMs is also comparatively low (Annex I). Therefore, it was thought to be interesting to look closer at both historically implemented and current PaMs to identify if any are missing from the reporting and their potential impact.

Earlier policies and measures

Latvia applied for the derogations under the LD and met the target for 2010. However, significant effort was going to be required to meet the 2013 and 2020 targets. Figure 13 shows that the amount of municipal waste sent to landfill in Latvia has decreased significantly between 2010 and 2020 but also that significant effort is required in order to meet the new target by 2035.

Some earlier policies that Latvia had implemented were[60]:

- A landfill tax initially introduced in 1991 which had been periodically revised. This was identified as being quite low compared to other countries.
- A ban on landfilling waste from food and timber industry & liquid waste / sludge from wastewater treatment plants if the water content is above 80%.
- Limited producer responsibility, covering a few waste streams.
- Legally binding targets from the European legislation.
- Information campaigns around waste collection and packaging labels.

Analysis in 2011[60] stated that Latvia had made significant efforts to close all landfill sites which did not meet the requirements of the landfill directive; this was supposed to be completed in the next few years. Latvia also intended not to build any additional landfill sites, and only expand their current ones, until they reached capacity. All the landfill sites for disposal of household waste have gas collection systems and for many sites, this landfill gas is used for energy production[61]. The report also detailed that recycling infrastructure was in place, except for glass for which there was no recycling capacity – only separation and re-use. For bio-degradable waste there were five large scale composting facilities, which increased to 11 by 2014, and one anaerobic digestion plant. Composting is additionally carried out at landfilling sites, with the resulting compost being used in the landfill (e.g. for coverage material). Mechanical biological treatment (MBT) was also in place, with one facility starting operation in 2014 and plans for nine more[60].

59 EEA (2023) [Results of the EEA's Early warning assessment related to the 2025 targets for municipal waste and packaging waste — European Environment Agency (europa.eu)]

60 https://ec.europa.eu/environment/pdf/waste/framework/LV%20factsheet_FINAL.pdf

61 Waste management Plan 2021-2028

Waste incineration (with or without energy recovery) is not widely practiced in Latvia. Waste is collected separately in many areas, through for example sorting areas located in apartment blocks, and there are also 36 facilities for separation of both sorted and unsorted waste[61].

However, the early warning report published in 2018[62] suggested that at this point Latvia:

- Was not effectively carrying out separate collection of recyclables (including bio-waste).
- Lacked economic incentives for households to separate waste.
- Did not have extended producer responsibility schemes that covered the cost of separate collection.
- Required further investment in projects higher up the waste hierarchy.

Recent policies and measures

Latvia reported three PaMs (from their waste management plan):

- Increase biological waste preparation for treatment. Implementation of separate collection of biological waste.
- Increase preparation of refuse-derived fuel (RDF). Develop installations for RDF production.
- Increase biological waste treatment capacity.

All three policies aimed to reduce landfilling of waste, expecting to divert between 110 000 t and 210 000 t of waste from landfill annually. However, these PaMs were only reported to reduce emissions by 4 kt CO_2e/year combined. As Latvia reported 575 kt CO_2 from the waste sector in 2020 the impact of these policies is expected to be minimal.

The separate collection of biological waste would be through additional bins at waste collection points located at the sources of this waste. Food waste would also be collected from commercial activities such as food wholesale businesses, markets, production companies and supermarkets. Three EfW facilities are proposed with a total required capacity of 150 000 t per year. Biological waste treatment would include processing biodegradable waste (especially commercial food waste) into fuel for transport, through anaerobic digestion. Additional infrastructure for the purification of landfill gas to fuel grade methane is also proposed. Additional infrastructure for pre-processing biodegradable waste in landfill sites, including sewage sludge is also proposed.

Latvia's waste management plan (2021-2028) was published in 2021. Implementation of the plan is expected to reduce GHG emissions to 401 kt CO_2e by 2024 and 373 kt CO_2e by 2028[63]. The plan includes some measures not listed in the PaMs data:

- Increasing the waste management fees.
- Regions must develop a regional waste management plan for approval by 30th December 2022.
- Regions must establish a commercial company for ensuring waste processing, regeneration and disposal. These companies must be permitted.
- Extension of extended producer responsibility systems to comply with the 2008 WFD directive if the system started operation before 1st August 2020 and with the 2018 WFD if started operation after this date.
- The resource tax will be mandatory for all packaging from 2022. This will be created for single-use plastics and from 2023 also for textiles. It will also be applied to furniture and a higher fee for WEEE investigated.
- Expansion of the separate collection infrastructure including adding additional collection areas, ensuring recycling bins are provided in addition to municipal waste bins.

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62 Commission staff working document, The early warning report for Latvia (2018)

63 https://www.varam.gov.lv/lv/media/6191/download?attachment (translated using google translate)

- Expanding the waste management system for the separate collection of textiles including adding collection points for textiles and establishing textile waste sorting centers.
- A pilot project for the collection, repairing and preparation of used goods for re-use.
- Supporting the creation of new recycling facilities.
- The measures around new separate collection would be supported by public awareness campaigns.

Additionally, in 2021 Latvia increased its landfill tax for municipal waste to 95 Euro per tonne[64], the highest landfill tax in Europe after Belgium. The landfill tax also applies to MBT outputs that are sent to landfill for final disposal.

Not all of these PaMs will necessarily reduce emissions from the waste sector (in a GHG inventory sense) although may reduce GHG emissions when looking at GHG emissions as a whole, for example increasing recycling from inert waste such as glass, plastics and metals which do not decompose in a landfill. The measures to increase textile recycling, diverting this waste stream from landfill, would be anticipated to reduce GHG emissions as would increasing waste management fees if these fees prevented waste generation, or encouraged increased recycling.

In addition, under the WFD all countries are required to have plans to reduce food waste[65]. Some of the measures discussed above will reduce GHG emissions from food waste produced but the waste prevention plan includes some measures to prevent food waste including:

- Increasing food donation by improving the donation system and promotion.
- Preventing food waste at the production stage with updated guidance and increasing awareness.
- Awareness raising with consumers.

As part of the early warning report published in 2023[66], the European Commission identified key policy recommendations:

- Support preparing for re-use of municipal waste and re-use systems for packaging.
- Improve performance in the separate collection of waste, as a large share of the population lacks access to high-convenience collection services (especially for biowaste). The combination of different collection modes with different collection areas (according to types of housing) and different types of waste stream should be taken into consideration when seeking to improve performance in this area.
- Prioritise projects higher up in the waste hierarchy. It should channel the available funding into extending the treatment capacity for biowaste and supporting home composting.
- Latvia should implement a pay-as-you-throw system to further incentivise the public to separate waste at source.

4.3 Discussion

This section has brought into greater focus the role of EU-level waste legislation in influencing waste sector emissions trends across reporting countries. The LD has been a key component of this since its introduction in 1999.

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64 EEA (2023) Technical note accompanying the EEA briefing 'Economic instruments and separate collection – key instruments to increase recycling' and 'Economic instruments and separate collection systems — key strategies to increase recycling — European Environment Agency (europa.eu)'

65 https://www.eea.europa.eu/themes/waste/waste-prevention/countries/latvia-waste-prevention-country-profile-2021.pdf/view

66 European Commission (2023) COMMISSION STAFF WORKING DOCUMENT, The early warning report for Latvia, SWD(2023) 187.

By marrying up the analysis of overall sector, and per capita emissions trends (**Section 3**) with the review presented in this Section, it becomes visible that early adopters / implementers of measures in response to the Directive correlates with countries that have achieved the greatest GHG reductions at sector level, or in terms of the GHG intensity of the sector on a per capita basis. Germany, Belgium and Sweden are clear examples where the early adoption of measures to the LD, most notably landfill bans, has led to them reporting relatively low per capita emissions at a national level (Figure 11) as well as a significant per capita emissions trend decrease for 2000-2021 (Figure 12), in comparison to other reporting countries.

Many of the countries that report comparatively high per capita emissions from the waste sector are those that have made least progress collecting bio-waste separately for recycling, thereby diverting it from landfill (Figure 15).

The diversion of biodegradable waste away from landfills appears to be most effectively associated with stringent landfill bans. Wider waste sector mitigation, circular economy and waste management programmes can also play an important role but are likely to be less effective in terms of diversion of biodegradable waste. Ireland is identified as a reporting country that has notably reduced its total and per capita waste sector emissions without the introduction of a landfill ban. However, it is noted that a small portion of this impact may also be due to the role of waste exports.

Where landfill taxes are applied, the taxation rate alone is not identified as a factor that has a major impact on the reduction of waste sector emissions. Instead, the effectiveness of these taxes depends not only on their level but also on how they are designed, implemented and enforced. The review of Latvia's policy implementation provides an example of how the incorporation of multiple "softer" measures in response to the updated LD (2018) leaves a number of challenges in countries meeting their LD targets in future years.

It is important to note that the above policy discussion has focused on the emissions impact achieved under the IPCC waste sector 5 reporting. In many cases, waste PaMs also influence national energy mix and energy/material/product demand. Additional GHG impacts would potentially be hidden when taking a siloed view of the waste sector as reported under IPCC Sector 5. The following **Section 5** therefore explores the potential linkages of waste sector PaMs to emissions that would be calculated and reported under other, non-waste sectors of national inventories, projections and PaMs data.

5 Cross-sectoral analysis of waste PaMs

Key Messages

- It is possible to identify cross-sectoral impacts associated with almost all waste management policies.
- It may be necessary for emissions compilers and those quantifying impacts of waste PaMs to think about how national waste policies of each stage in the waste hierarchy can result in the diversion or prevention of waste entering specific treatment pathways. Table 5 presents an overview of these cross-sectoral impacts and the interconnectedness of waste treatment pathways with waste hierarchy stages and emissions reporting sectors.
- A review of different waste management stages has been conducted to present the potential impacts and implications of such measures on emissions outcomes. Associations between waste PaMs and cross-sectoral emissions outcome are identified for remanufacturing (exemplifying waste prevention), recycling, (energy) recovery, carbon capture and storage (CCS), cement production and waste disposal measures such as MBT and wider technical measures at landfill.
- We conclude that achieving complete understanding and analysis of the emissions savings that can be achieved through implementation of waste PaMs relies upon developing a cross-sectoral approach. This will require greater collaboration between national experts and sectoral representatives. An example from Switzerland (see sections 5.2.3.2 and Discussion section 5.3) provides a potential model that can be explored by national compilers as a means to quantify the impact of waste PaMs beyond the boundaries of IPCC sectoral reporting.
- Analysing the emissions impact of waste PaMs across sectors may also identify cross-border impacts due to the influence of such PaMs on the trade and supply of materials, products and energy.
- In reference to energy and heat production, there is a risk of over-reliance on EfW facilities as a means for managing solid waste. Planning the capacity need of such installations alongside projected future waste generation and prevention effects is essential to avoid unintended outcomes such as demand-driven waste imports either within, or across national borders.

5.1 Overview of waste treatment processes and cross-sectoral impacts

As identified in earlier parts of this report, it is evident that the reporting of waste PaMs is often not reflective of the true progress and activity that has been achieved historically and/or will be achieved due to future waste related actions across reporting countries. Specifically, Sections 3 and 4 of this report have highlighted that in its silo (as IPCC sector 5) the impact of the Landfill Directive and associated landfill bans provide the strongest cause of national waste sector emission reductions, as national totals, and on a per capita basis.

However, it is quite possible that additional emissions impacts and savings are being hidden from national level reporting due to the upstream and downstream impacts that waste prevention, treatment and diversion measures have on other economic sectors.

For example, CO_2 emissions from the incineration of non-hazardous waste in waste incineration installations with and without energy recovery, as reported to the E-PRTR (covering only larger installations with a capacity of 3 tonnes of waste per hour), have more than doubled in the period 2007-2020 for the EU-27, Iceland, Norway and Switzerland[67]. A large portion of these emissions will not be allocated under the waste sector of national GHG inventories (CRF 5) but included within energy sector reporting, making it more difficult to trace the impacts of changing waste practices on the resultant emissions.

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[67] Air releases (europa.eu)

Waste is also being used in cement production. In some cases, for example the recovery of dry sewage sludge, waste can be recovered as material and energy: While the biomass portion replaces standard fuels such as coal, the ash portion of the dry sewage sludge is incorporated into the clinker minerals. In the case of substitute fuels with marginal ash content (e.g. waste oil, solvents, plastics), however, one can no longer speak of material-energy recovery, but only of energy recovery. However, there are also competing forms of primarily material recovery, for example the recycling of phosphorous from sludge waste. Emissions associated with the cement industry are reported in national GHG inventories under both energy and industrial processes and product use (IPPU) sectors (splitting out emissions associated with energy use and process emissions respectively).

Emissions impacts from waste PaMs may be realised at national level, between European countries, or even outside of Europe where those upstream and downstream impacts influence exports, imports and hence production e.g. of virgin products, materials and/or energy supply.

For compilers of national GHG emissions, projections and PaMs data, this means that effective analysis and estimation of PaMs that are derived for the purpose of waste management also need to consider potential GHG impacts (savings) that will only be represented in national level reporting under non-waste sectors at CRF level. Table 5 below provides a summary of different waste treatment pathways and the interlinkages that may result with other GHG reporting sectors.

Table 5 Summary of potential cross-sectoral links for waste treatment pathways

Primary pathways	Waste sector CRF	Sub-pathways	Waste hierarchy options	Other sectors impacted
Landfill	5A	Landfilled biodegradable waste generates methane and CO_2 through degradation, and for many years after it has been landfilled. The biogenic CO_2 does not count towards national GHG totals so methane is the main focus within GHG inventories. Landfills are classed as managed (5A1) or unmanaged (5A2). Landfilled inert waste does not generate GHG emissions.	Prevention: Measures to reduce waste generation. Recycling: Improved sorting, diversion after sorting. Recovery: Technical measures in the landfill itself e.g. methane capture. Recovery/Disposal: Plans and infrastructure for landfill gas management systems Disposal: Divert waste from landfill to other pathways, pre-treatment of waste so it is much less bioactive, closing and remediation of landfills.	Increased recycling may impact on waste transfer routes (*transport*), *energy* consumption and replacement of virgin materials (*industrial processes and product use (IPPU) / energy*). Methane captured from landfills can be used for *energy* recovery. Pre-treatment usually only reduces landfill emissions without positive substitution effects. Downstream impacts of diversion to other pathways (see below).
Incineration	5C	With energy recovery (not reported under waste sector 5C). Without energy recovery (5C1).	Recovery: Optimisation of energy recovery, increases to efficiency of process. Recovery: Plans and infrastructure for CCS. Recycling: Optimise extraction of recyclables before or after incineration. Recycling: Extract some recyclables from the incineration slag.	Energy recovery through incineration and/or CCS leads to new / replacement activity data for *energy* generation. Incineration slags can be treated and replace some virgin (mineral) materials (*IPPU / energy*). Metals extracted from slags can replace some virgin metals – metals sector (*IPPU / energy*).
Biological treatment	5B	Composting (5B1) and anaerobic digestion (5B2) contribute methane and nitrous oxide emissions. Mechanical-biological treatment is not specifically allocated to its own waste category, but its component processes e.g. sorting (energy use) and anaerobic digestion should be accounted for in the correct category.	Recovery/Recycling: Use biological and MBT processes to recover energy from waste. Biological treatment of bio-waste is a recycling process. Reduce methane leakage during processing.	Clean compost/digestate can substitute mineral fertilisers/soil improvers (*IPPU / agriculture*). However, output of MBT is too contaminated to be used as fertilizer on land. Methane from anaerobic digestion can be used as a fuel for *energy* production, replacing alternative fuels.

Processing and recycling	NA	Residues from sorting processes are usually either landfilled (5A) or incinerated (5C1).	Recycling: Optimisation of sorting and processing to reduce impacts.	Emissions due to fuel/energy needed for the recycling process accounted for in *energy* sector. Where recycled materials replace the need for virgin materials this will lead to reduced production of virgin materials and related emissions from manufacturing and industry (*IPPU / energy*).
Cement production	NA		Recovery: Plans and infrastructure of CCS. Recovery: Phosphorous recovery of sewage sludge.	Emissions due to fuel/energy needed for cement production accounted for in *energy* sector. Where recovered materials replace the need for virgin materials this will lead to reduced production of virgin materials and affect cement process emissions (*IPPU / energy*).
Waste transport	NA		Optimisation of waste transport and collection systems.	PaMs related to waste treatment pathways may have a knock-on impact on transport of waste, goods and materials. Transport emissions are accounted for in the *transport (energy)* sector. Emissions are mostly disaggregated by vehicle type/technology rather than by type of use. Therefore waste-transport emissions are not identifiable in emissions inventories. Impacts could be separately assessed and modelled.

5.2 Detailed examples of cross-sectoral impacts within the waste hierarchy

Given the realization that waste sector PaMs may have numerous impacts on GHG savings across GHG reporting sectors, it may be necessary, or an improvement for compilers of national data sets and reporting to consider alternative ways to estimate the impact of waste PaMs. This approach would likely follow an approach more in line with lifecycle analysis (LCA) and would require successful collaboration across national (sector-based) inventory compilers and stakeholder groups. A possible approach would be to consider waste PaMs estimation more closely with the waste hierarchy to create a better link between GHG reporting and waste policy and legislation in the real world. The sections below are not meant to be exhaustive, but illustrative of the alignment between some practical waste management steps and their place within the waste hierarchy.

5.2.1 Prevention - Remanufacturing

Electrical and electronic equipment (EEE), including computers, laptops, mobile phones, is an ideal contender for remanufacturing, a waste prevention process in which certain components are replaced with newer versions. This restoration of products extends lifespan while maintaining or exceeding the original performance specifications. Remanufacturing of EEE is important because electronics tend to contain a wide range of materials, the separate recycling of which is complex and requires advanced technology. Moreover, since most energy is invested during the manufacturing stage of the device, remanufacturing offers a far greater ecological payback than recycling[68]. For instance, it helps to preserve metallic and mineral resources, thereby preventing the loss of such resources through recycling. Dependence on international electronics trade is also reduced, because low-carbon domestic remanufacturing prevents the need for overseas mining operations, production processes, and large-scale material or product imports, which are much more polluting. EEE represented 8% of total imported goods by EU countries in 2018, with 70% coming from China[69], so there is strong potential to localise supply while continuing to satisfy demand by extending the lifecycle of electronics. The remanufacturing industry does present some negative impacts however, such as the manufacture of replacement parts requiring virgin materials as inputs.

The drivers for remanufacturing are typically associated with cost benefits and job creation. The production cost of remanufactured products is 40-65% less than that of brand-new products[70] and they are generally sold at lower prices, making them more accessible to consumers. Remanufacturing may have a positive impact on job creation by creating skilled work opportunities in the country of product demand – whereas virgin products are often manufactured in countries with low labor costs leading to an increased import market. Through reverse engineering, remanufacturing companies can harvest a more in-depth knowledge of product imperfections, in turn helping contribute to more robust product design and function.

To evaluate the PaMs impact of waste remanufacturing, national teams will likely need to prioritise understanding of national trends and projections for materials and product imports. The associated emissions will be evaluated under the energy and IPPU sectors of the national GHG inventory where remanufacturing leads to new or increased fuel combustion and/or process emissions. Emission

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68 Williams, E.D.; Sasaki, Y. Energy analysis of end-of-life options for personal computers: Resell, upgrade, recycle. In Proceedings of the IEEE International Symposium on Electronics and the Environment, Boston, MA, USA, 19–22 May 2003; pp. 187–192

69 https://ec.europa.eu/eurostat/web/international-trade-in-goods/database

70 Giutini, Ron & Gaudette, Kevin. (2003). Remanufacturing: The next great opportunity for boosting US productivity. Business Horizons. 46. 41-48. 10.1016/S0007-6813(03)00087-9.

reductions may not be realized in the implementing country, but across borders where there is a reduced need for the production of virgin materials and goods. The transport sector (national and international) may also be impacted due to the changing role of imports and exports.

5.2.2 Recycling – Metals recycling

Metals are a waste stream for which recycling represents a key contributor to circular economy and climate policy because unlike other raw materials, metals are highly recyclable, and most maintain their intrinsic properties during the process. However, some material can be lost during the collection process and some metals, such as aluminium, may degrade when recycled repeatedly which can affect the quality of material. Metal recycling holds particular importance in the EU, which only produces around 3% of the primary raw materials necessary to meet the growing demand for metals[71]. The metal recycling value chain is therefore integral to combating the EU's reliance on imported materials. Producing metals from secondary raw materials massively reduces emissions compared to primary production through the mining sector, abating the impacts of land degradation and water pollution by 80% and 76% respectively. Recycling metals also provides an efficient way of reintroducing metals back into the supply chain, saving between 60% and 95% of energy compared to extraction from ores, while preserving quality. Reducing the landfilling of metals is another positive impact, which would otherwise cause a loss of raw materials and environmental impacts such as metals leaching into water bodies.

Of the common metals, steel is the most widely used in the world, being present in many small- and large-scale products such as cars, railways, bridges and domestic equipment. Steel recycling in the EU is already widely practiced, and to great effect. 90% of end-of-life stainless steel is currently collected and recycled into new products, which outweighs the demand for scrap steel in the EU, meaning there is no shortage of scrap steel in the EU. Based on data for 2018[71], the annual savings on environmental costs by using steel scrap in the EU can reach up to €20 billion. The secondary production of steel saves 72% of the energy needed for primary production (4,697 kWh per tonne) and reduces the reliance on metal imports which would otherwise cause international transport sector emissions to be greater. Around 157 million tonnes of CO_2 were saved in the EU by recycling 94 million tonnes of scrap in 2018.

Fuel combustion and process emissions from the production of metals are accounted for in the energy and IPPU sectors of national GHG inventories respectively. To fully evaluate the impact of metals recycling PaMs on future emission reductions, estimates and projections should include inventory categories 1.A.2 (fuel combustion in manufacturing industries and construction) and 2.C (process emissions from metal industry).

5.2.3 Recovery

Energy from Waste (EfW)

EfW facilities (also known as waste-to-energy) offer an opportunity to divert combustible waste away from landfill as a means to generate heat and electricity. This practice has significantly lowered dependency on landfills in Europe and can contribute towards carbon neutrality through combined heat and power production. However, efforts to move further up the waste hierarchy towards prevention, reuse and recycling are generally preferable in terms of maximizing progress towards broader sustainability and climate goals.

In Denmark, incineration accounts for around 20% of heat production and 5% of electricity generation[72]. Many of the newer waste incinerators have energy recovery efficiency rates of above 90%. Following the

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71 EuRIC (2020) Metal Recycling Factsheet

72 IEA Bioenergy (2021) Implementation of bioenergy in Denmark – 2021 update

combustion process, residues in the form of recyclable metals are recovered from the waste, while bottom ashes are collected and used in the industrial sector for construction purposes, such as base layers in roads, car parks and embankments. This has the impact of reducing demand for extraction or importation of natural aggregates such as sand and gravel, while also contributing to the circular economy.

However, EfW may also be a barrier to circular economy as there is a constant need for waste supply in order to maximise efficiency. The capacity for energy recovery of MSW for energy production exceeds the available waste in Denmark. As a result, large amounts of waste are imported from other countries to supply the excess capacity at its plants, which has the impact of increasing emissions generated through the transit of waste. 975,000 tonnes were imported in 2018, with 53% coming from Germany and the UK alone[73]. Denmark has therefore sought to gradually reduce energy recovery of waste and advance up the waste hierarchy by further increasing recycling rates. The Action Plan for Circular Economy, released in 2021, aims to reduce the amount of incinerated Danish plastic waste by 80%, relative to 2020, by 2030[74].

This example shows how quantified analysis of EfW PaMs will need to consider the potential for cross-sectoral impacts as well as transboundary impacts. EfW facilities will likely divert waste away from landfills (waste sector 5.A). However, historically landfilled waste will continue to degrade over a decadal timeframe and a complete evaluation of emissions trends and savings may also need to be considered over that timeframe.

Emissions from EfW facilities will be included under the energy sector, and data required to quantify emissions will normally become available through national energy balances once operations have been implemented. Emissions impacts may also occur in IPPU sector where material is recovered from the process. Transport and transfer of materials may be affected. Emission reductions may not be realized in the implementing country, but across borders in cases where the EfW facilities lead to an increase in waste imports from neighboring countries.

Carbon capture and storage (CCS)

CCS has a high potential to reduce emissions in industrial EfW facilities, be it municipal waste incineration or cement plants (see e.g. Wipächtiger et al. 2023[75]).

In Switzerland, an agreement between the Federal Department for the Environment, Transport, Energy and Communication (DETEC) and the Association of Plant Managers of Swiss Waste Treatment Installations (VBSA) aims to reduce emissions from waste incineration. The agreement signed in March 2022[76] also aims to drive forward the introduction of technologies for the capture of CO_2 at Swiss waste treatment installations and its storage.

In its long-term climate strategy, the Federal Council states that the use of such technologies is imperative to offset emissions that are difficult to avoid and to reduce greenhouse gas emissions to net zero by 2050. The strategy concludes that pilot projects and the industrial application of negative-emissions technologies (NETs) and CCS plants are needed. As a result, the agreement obliges operators of waste treatment installations to put at least one CO_2 capture plant into operation by 2030. The plant is to have a minimum nominal capacity of 100,000 tonnes of CO_2 per year and capture as much CO_2 as the transport, storage and use conditions permit. At the same time, the operators of waste treatment installations must lay the

73 MST (2018) Waste Statistics

74 Ministry of Environment of Denmark (2021) Action Plan for Circular Economy

75 Available: https://onlinelibrary.wiley.com/doi/10.1111/jiec.13364

76 https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/reduction-measures/sector-agreements/agreement-waste-treatment.html

foundations for CO_2 capture and storage to be used on a large scale in the medium to longer term. The agreement sets annual interim targets for this.

5.2.4 Disposal

Mechanical Biological Treatment (MBT)

Broadly, the aim of waste pre-treatment is to reduce the amount of waste sent to landfill or reduce the impact of waste that cannot be diverted from landfill. Mechanical Biological Treatment (MBT) is a pre-treatment process that combines mechanical and biological processes to recover materials and energy from waste. These can then feed into other parts of the waste hierarchy such as materials extracted for recycling, recovery and prepared for disposal. In treating organics through bio-stabilisation, MBT may also produce compost-like outputs. However, the general poor quality of the output lends only to application as a source of organic matter to improve certain low-quality soils, such as brown field sites or landfill cover, or it is landfilled. The most common recoverable output is refuse-derived fuel which can be used for example in cement kilns. Recyclables obtained from MBT process are usually of lower quality, most commonly metals and glass, which consequently have lower potential market value. Therefore, the Waste Framework Directive has established a clear preference for separate collection, reflected in legal requirements for sorting at source for a range of materials (bio-waste, paper, cardboard, plastics, metals, glass, textiles).

Despite the lower grade materials, MBT can to some degree help enhance overall recycling rates in case additional sorting steps are applied, for example to extract plastics, but MBT operations cannot replace the separate collection of recyclables. Investment in MBT capacity needs proper planning in order to avoid over-capacity competing with separate collection and waste prevention. MBT technologies were mostly developed in Germany but are in practice across the EU. According to German waste disposal firm Nehlsen, there are some 60 MBT plants operating in Germany with an overall capacity of 5.7 million tonnes of waste per year[77]. In early 2017, Europe had approximately 570 active MBT plants with a treatment capacity of 55 million tonnes, and the commission of another 120 facilities with a combined capacity of around 10 million annual tonnes was projected by 2025[78].

MBT systems often have many components at each of the stages of the process: waste preparation; waste separation; and biological treatment. Waste preparation is the first stage, occurring before both the biological treatment and sorting. This can involve processes that remove bulky waste, split open bags, and shred and homogenize waste. Waste separation or sorting is required if not all of the waste is being pre-treated for landfill disposal, so is key for feeding into higher stages of the waste hierarchy. The separation for different end uses mostly relies on different properties of materials such as size and shape, density, weight, magnetism, and electrical conductivity. Biological treatment is another stage that can occur before or after mechanical separation depending on the end use as described above. There are aerobic processes such as bio-drying or bio-stabilization that result in the partial composting of all the waste. Another aerobic biological treatment is in-vessel composting that can bio-stabilize waste and process a segregated organic rich fraction. Anaerobic digestion is another biological treatment that processes a segregated organic rich fraction.

PaMs to implement or increase the implementation of MBT processes on a national scale are therefore likely to have numerous cross-sectoral linkages, encompassing all of those discussed for the preceding examples for remanufacturing, recycling and energy recovery. Links to emissions reporting under both energy and IPPU sectors are evident.

[77] https://en.nehlsen.com/technology/mbs-plant

[78] ecoprog GmbH (2017) The Market for Mechanical Biological Waste Treatment in Europe

Technical strategies at landfills

Technical strategies at landfills to reduce methane emissions aim to reduce the production of methane emissions and treat landfill gas directly to reduce emissions, some of which are compulsory under the Landfill Directive[17]. Optimizing containment and waste placement can reduce methane emissions by increasing the oxygen that reaches the waste to encourage aerobic decomposition, which is less methane intensive than anaerobic decomposition. The landfill lining needs to be considered to protect groundwater and, along with capping methods, increase oxygen concentrations and prevent the conditions for the generation of landfill gas. Waste placement involves evenly spreading out and compacting the waste to maximise the contact between the waste and the liner to effectively increase oxygen levels.

Landfill gas management systems involve strategies for effective gas collection, and treatment, utilisation and flaring. When landfill gas is being used as a fuel primary treatment and supplementary processing are necessary, especially where there may be potentially corrosive trace contaminants. The utilisation of landfill gas allows for energy recovery and is classified as recovery in the waste hierarchy. However, if energy recovery is not possible, flaring can still reduce methane emissions through the breakdown of landfill gas during thermal oxidation. For both utilisation and flaring, strategies to control the combustion air are required to minimise NOx emissions.

There are other technical solutions such as methane oxidation where microbial populations oxidise methane. As this requires specific conditions to maximise the rate of oxidation, this is only viable in specific circumstances where there are lower levels of emissions near the end of a landfills gassing life (when collecting gas for flaring becomes very inefficient), the soil is well aerated, and the soil is regularly inspected to ensure no cracks and good soil structure.

PaMs that include improved technical strategies at landfills are most likely to require cross-sectoral evaluation with the energy sector where landfill gas recovery is practiced. As with EfW facilities, such data may become available through national energy balances once implemented. Minor emissions impacts may also occur due to increased activity at the landfill site, such as the operation of mobile / stationary machinery (included under CRF category 1.A.4).

5.3 Discussion

The analysis in this section supports the implication from Section 2 of this report that the complexities and cross-sectoral nature of waste management policy is a barrier to quantification of GHG savings from waste PaMs. In addition, it supports the findings from Sections 3 and 4 that analysing and calculating emissions trends, projections and PaMs savings in the silo of IPCC sector 5 may not present the “true” impact of such PaMs on total GHG reductions achieved at national level. Of particular importance are emissions from EfW facilities, where emissions are reported under the energy sector 1A1 in national reporting. This management option introduces complex interactions between waste and energy supply/demand. Linked technologies such as CCS and comparison of effectiveness against waste management measures that are higher in the waste hierarchy make impact assessment particularly challenging for these PaMs.

Ideally, national experts and emissions compilers would work within a wider stakeholder network to consider the holistic GHG savings that may occur from national waste PaMs. There may be barriers to this because of historical working practices of national teams that tend to focus on sectoral expertise and calculation of emissions-related data. In addition, the aggregation level of national statistics and activity data for non-waste sectors may not immediately allow for the separation of waste-related impacts and outcomes. An example of this would be the analysis of avoided emissions that may result from the remanufacturing of goods and/or recycling of materials due to waste management approaches. Determining the impact of such activities on national energy and production balances may be challenging and require primary research as opposed to relying on commonly available annual statistics to provide this information.

We also find examples of cross-border impacts as a result of several common waste PaMs. Introduction of EfW facilities may increase waste imports from neighboring countries that will see a decline to their own waste treatment needs and resultant emissions. Many stages higher in the waste hierarchy are designed with circular economy benefits in mind. These PaMs will impact on the need for production of virgin materials and products, much of which may lie outside of the implementing country/region. Where remanufacturing is implemented, this may increase activity and emissions sources within the implementing country despite bringing intended circular economy benefits.

The above section on CCS references a study by Wiprächtiger et al. (2023)[75] which provides an assessment of the potential GHG benefits that could be realized when moving to higher levels of the waste hierarchy. The analysis, based on policy options for Switzerland, illustrates the cross-sectoral impacts and provides quantification estimates, analysing eight (industry) sectors and more than 30 scenarios in depth. The study identifies CCS from waste incineration, biogas and cement production, food waste prevention in households, hospitality and production, and the increased recycling of plastics as having the highest mitigation potential. The review and harmonization of such cross-sectoral approaches against the needs of sectoral national reporting obligations could provide national teams with approaches that achieve the best outcome for effective policy making and impact analysis.

6 Conclusions

6.1 Status of waste PaMs reporting and potential reporting gaps

This analysis highlights that the style and detail of reporting by countries is varied in nature. In addition, there are several ‘group’ and/or cross-sectoral PaMs being reported (largely unquantified) where it is very difficult to determine the true waste sector apportionment of those PaMs. This may in part be an artefact of the reporting structure in use. The waste sector, and its associated policy context has ties to many different emission generating sectors, notably energy use. In addition, the drive towards circular economy, and increased recycling of goods may have downstream impacts on virgin materials through substitution effects, and subsequent GHG impacts that are not easily extracted when using strict sectoral reporting structures. Overall, quantification levels for the reported waste PaMs is low and it is difficult to ascertain the potential impact of existing and planned PaMs on expected EU-wide GHG emissions savings.

The analysis of PaMs reporting (**Section 2.1**) identified specific types of waste PaMs that are more prevalent than others. The majority of reported PaMs are focused on the recycling and recovery stages of the waste hierarchy. The focus on landfills and the diversion of biodegradable wastes away from landfill, leads to a greater number of PaMs that relate to biodegradable e.g. food wastes in comparison to PaMs targeting inert wastes. This is likely to be because the emissions (and PaMs savings) associated with the waste sector as CRF Sector 5 are mostly associated with the degradation and decomposition of the biogenic content of waste. The reporting of waste PaMs that impact on inert wastes is less prevalent. Resultant GHG savings from such PaMs are likely to be associated with non-waste reporting sectors.

PaMs with quantified GHG reductions are most common for biodegradable wastes and landfills, so additional and/or hidden GHG savings from other waste categories and through cross-sectoral impacts could be causing incompleteness in the PaMs data at EU level. Table 6 below presents an overview of frequently reported waste PaMs and suggests potential gaps in PaMs reporting that could enhance the completeness of PaMs reporting and quantification at national and EU-level. In addition, it is considered very likely that further PaMs will be reported once the revisions of the WFD and Landfill Directive are fully implemented in national legislation and strategies such as national, regional and local waste management plans.

Table 6 Overview of existing waste measures and gaps in waste policies and measures

Focus area	Most frequently reported PaMs	'Gaps' in reported PaMs
Prevention	Prevention and reduction of food waste through social campaigns and schemes targeting supermarkets and distributors.	Prevention schemes targeting non-food wastes. For inert wastes (plastics, metals), cross sectoral impacts may occur due to the reduced demand for virgin goods/materials.
Preparation for reuse	Very few PaMs reported. Small number related to re-use of plastic goods.	Preparation for reuse measures and cross-sectoral impacts of reduced energy use in manufacturing of virgin goods.
Recycling	Landfill bans and landfill taxes (diversion of recyclables). Measures to increase recycling of plastics through improved packaging and labelling.	Metals and other materials recycling schemes appear under reported compared to plastics. Cross-sectoral impacts of reduced energy use in manufacturing of virgin materials.
Recovery	Landfill bans and landfill taxes (diversion of biodegradable waste). Energy from waste (EfW), anaerobic digestion and composting.	Quantification of cross-sectoral (waste and energy sector) impacts. Consideration of complex interactions when introducing EfW facilities e.g. cross-sectoral, cross-border, waste/energy supply/demand.
Disposal	Few PaMs reported.	Technical landfill measures including MBT and improved coverage materials.

6.2 Achieving further reductions in emissions from EU waste prevention and management

This analysis indicates that there will not be a singular action towards achieving further emission reductions in the waste sector. However, it is logical that countries who have not already achieved strong emission reductions from the sector (Section 3.1) or those that show comparatively high per capita emissions from the sector (Section 3.2), are also those that may have the greatest potential to achieve future emission reductions. There appears to be a consistent finding across the analysis that those countries with the strongest implementation and response to the existing EU regulatory framework are those that have achieved the greatest in terms of historical emissions trends and per capita emissions.

A theoretical exercise has been carried out (Table 7) by imagining the scale of future EU-wide emission reductions depending on the capacity of reporting countries to reduce their per capita solid waste emissions in line with other countries (Section 3.2). It is important to acknowledge that national circumstances are extremely important in determining the ability to reduce per capita emissions as well as political or legislative ambition. Such factors may include:

- Socio-economic pressures e.g. population change and consumption growth.
- Tourist numbers, which will increase national emissions when presented on a per capita basis.
- Feasibility of waste management options based on climate, land resources and other geographical and economic factors.
- Vested interests, overcapacity and lock-ins to certain waste management paths.

As such, it is not realistic to assume that all countries are equally able to achieve the same emissions per capita from the sector and the hypothetical values presented below should be treated with caution and as indicative only.

Table 7 Indicative potential waste sector emission reductions for EU 27 + Norway, Switzerland and Iceland based on assumptions of future solid waste per capita emission reductions

Scenario	Maximum per capita solid waste emissions to be achieved under the scenario (kg CO_2e / capita)[b]	Total emissions (thousand Gg CO_2e) and hypothetical % reduction from current 2021 emissions total[c]
Current 2021 reported total waste sector emissions	NA	112.1
Current 2021 reported wastewater emissions	NA	24.5
Current 2021 reported solid waste sector emissions	NA	87.6
Current WEM projections by 2040[a]	NA	69.6 (-38%)
Current WAM projections by 2040[a]	NA	68.7 (-39%)
GHG emissions if all countries meet at least the average per capita solid waste emissions benchmark set by the 10 best performing countries[b]	107.5	65.9 (-41%)
GHG emissions if all countries meet at least the average per capita solid waste emissions benchmark set by the 5 best performing countries[b]	67.1	52.9 (-53%)
GHG emissions if all countries meet the per capita solid waste emissions benchmark set by the best performing country[b]	44.9	45.2 (-60%)

Note: a See Figure 9,

b see Figure 11,

c data compiled by project authors based upon national GHG inventory reporting and Eurostat population data. Assumes that wastewater emissions remain at 2021 levels.

The above hypothetical analysis indicates that there is the potential for greater future achievement at EU-level in terms of GHG savings from the waste sector that could go beyond what is currently being reported under national WEM and WAM scenario projections. The current projections by 2040 align most closely with the indicative scenario where each reporting country achieves at least the per capita solid waste emissions benchmark set by the ten best performing countries. Should countries widely (and successfully) adopt more stringent waste PaMs, particularly in response to their regulatory waste management targets, it could be possible for more significant emission reductions to be achieved. For example, a scenario where all countries achieve at least the average per capita solid waste emissions benchmark set by the five best performing countries would see overall waste sector emissions reduce by 53% from 2021 levels. Any additional emissions savings from the wastewater category would further increase the potential sector level savings.

6.3 Reflections on effectiveness of previous EU policies and future development

This report consistently finds strong correlation between the effective implementation of PaMs in response to EU legislation on waste management, and the resultant GHG emissions trends achieved at EU-level in the most recent decades. It is also concluded that there may be additional hidden, or cross-sectoral benefits that occur as a result of existing legislation. These benefits will be realised in the emissions reporting of non-waste sectors, although the identification and separation of those emissions savings poses a significant challenge to national teams, particularly for the quantification of PaMs in national reporting under the EU Regulation on the Governance of the Energy Union and Climate Action.

Section 4 details how countries have responded to and continue to implement the Landfill Directive. There is a strong link for many countries in terms of the strength of their implementation of the Directive, particularly through landfill bans, and the historical emissions savings that have been achieved. Ireland is identified as an outlier that has achieved its LD targets without a specific landfill ban, by implementing a comparatively high landfill tax and targeting specific waste streams as part of its national waste prevention programme, although it should also be noted that some of this achievement is likely due to the increased export of waste. This may be an effective instrument / example to follow for other countries that have so far struggled, potentially for political and administrative reasons, to effectively introduce significant measures in response to the Landfill Directive.

For countries such as Czechia, there may be large potential emissions savings to come due to their intention to restrict the landfilling of recyclable, recoverable and mixed municipal waste in 2025. For remaining countries that have failed to meet their LD targets, it is important to understand why significant national legislation has lagged. Assuming these countries will at some stage respond more forcefully to the amended directive, this should be reflected in the PaMs reporting and quantification attempts of those countries as they plan out their national policy response. This will increase the accuracy of information about policies and measures and give an indication of the likely timelines for future emissions savings that may be achieved triggered by existing measures at the EU level.

6.4 Avoiding trade-offs with other important outcomes

It is important to acknowledge (as highlighted in Section 1.4) that historical legislation in the waste sector has not always been typically, or directly targeted at reducing GHG emissions. In fact, broader environmental benefits are the primary reason why legislation such as the Waste Framework Directive was first introduced. Going further back, waste treatment options, such as controlled landfilling and waste incineration, were initially brought in as a practical response to waste generation amongst growing, often urban populations. Their effective supervision enabled societies to manage and dispose of large waste quantities in a controlled environment where the impacts to land and water resources could be minimised.

However, in most European economies there is an ever-increasing policy move towards circular economy. This means that policies more and more address waste prevention next to managing that waste which is generated. There are also established opportunities and technologies to remanufacture and recycle goods, reducing the need for upstream virgin materials, and to generate and/or capture energy from remaining waste streams. Energy recovery facilities, composting and anaerobic digestion of organic waste are all options for the current and future management of waste that does remain in increasingly circular-based systems. From a GHG perspective, there may be options that appear preferable. However, trade-offs may remain, for example the generation of GHG emissions and air pollutants from combustion-related activities. For example, the recycling of materials within the implementing country may create new, localized emissions source(s).

A trade-off that has been identified when viewing waste PaMs from the perspective of the waste hierarchy (Section 5) is the potential for emissions to be transferred and impacted across borders. International trade and the supply/demand of materials and goods is extremely complex and is unlikely to be fully evaluated by national GHG inventory teams and data compilers as part of their PaMs reporting. However, it may be beneficial for national compilers to consider unintended or potential consequences of their PaMs across national borders particularly where changes to imports and exports of energy, waste materials and virgin materials and products are expected.

6.5 Future outlook

To fully determine and evidence the impact of EU and national implementation of waste strategy and regulation – it is increasingly important for emissions experts and those assessing policy impact, to consider such impacts at a lifecycle and/or cross-sectoral level. It is evident that the analysis of PaMs reporting and its quantification within the bounds of IPCC report (CRF 5) is not sufficient as we move towards a push for circular economy and carbon neutrality from the sector. Waste-related emissions from energy industries (EfW, reported under sector 1A1 Energy) are likely to be an important consideration for many countries due to the complex interactions introduced e.g. for the supply/demand of waste materials and energy. The position of this management option in the 'recovery' level of the waste hierarchy means that alternative measures may be favorable from a circular economy and climate change mitigation perspective, however opportunities such as integration of CCS technologies could lead to this option playing an increasingly important role at the European level. Emissions from wastewater treatment and discharge (reported under sector 5D) also need to be considered when looking holistically at the waste sector, although the related PaMs are very separate to the management of generated solid waste and as such, have not been considered within this report.

Circular economy policies, including waste policies, have been very dynamic over the past years. Several new binding targets and requirements have been introduced recently, and many of them are still awaiting full implementation on national and sub-national levels. For example, binding recycling targets for municipal waste to be met by 2025, 2030 and 2035, obligatory separate collection of bio-waste by 2023 and a reduction target for landfilling of municipal waste by 2035. In many countries, the new targets and requirements will lead to major changes in the waste management system which can be expected to further reduce greenhouse gas emissions both in the waste sector and beyond.

Beyond that, circular economy policies addressing circularity beyond the waste sector, such as the proposed Ecodesign for Sustainable Products Regulation[79], the Batteries Regulation ((EU) 2023/1542), the proposed Construction Products Regulation and the EU Textiles strategy, aim to influence the design of products towards extending their lifetimes through repair, re-use, remanufacturing as well as improving recyclability and the use of recycled content in new products. In the longer term, these requirements should help to reduce the amount of (new) materials needed in the economy, and thereby reduce the amount of greenhouse gas emissions in the sectors producing such products and the energy sector.

79 https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en

List of abbreviations

Abbreviation	Name	Reference
BAT	Best Available Techniques	
CCS	Carbon Capture and Storage	
CEWEP	Confederation of European Waste-to-Energy Plants	https://www.cewep.eu/
CRF	Common Reporting Format	
EC	European Commission	https://commission.europa.eu/index_en
EEA	European Environment Agency	www.eea.europa.eu
EEE	Electrical and Electronic Equipment	
EfW	Energy From Waste	
EIONET	European Environment Information and Observation Network	https://www.eionet.europa.eu/
ESD	Effort Sharing Decision	
ESR	Effort Sharing Regulation	
ETC	European Topic Centre	https://www.eionet.europa.eu/etcs
EU	European Union	
GDP	Gross Domestic Product	
GHG	Greenhouse Gas	
IED	Industrial Emissions Directive	https://environment.ec.europa.eu/topics/industrial-emissions-and-safety/industrial-emissions-directive_en
IPCC	Intergovernmental Panel on Climate Change	https://www.ipcc.ch/
IPPU	Industrial Processes and Product Use	
LCA	Lifecycle Analysis	
LD	Landfill Directive	https://environment.ec.europa.eu/topics/waste-and-recycling/landfill-waste_en
LULUCF	Land Use, Land Use Change and Forestry	
MBT	Mechanical Biological Treatment	
MMR	Monitoring Mechanism Regulation	https://www.eea.europa.eu/policy-documents/monitoring-mechanism-regulation-525-2013
MS	Member State	
MSW	Municipal Solid Waste	
PaMs	Policies and Measures	
PRTR	Pollutant Release and Transfer Register	https://environment.ec.europa.eu/topics/industrial-emissions-and-safety/european-pollutant-release-and-transfer-register-e-prtr_en
RDF	Refuse-derived Fuel	
TOC	Total Organic Carbon	

TREE	EPA Tool for Resource Efficiency	https://www.epa.ie/our-services/monitoring--assessment/circular-economy/circular-and-sustainable-sectors/tree-online-tool/

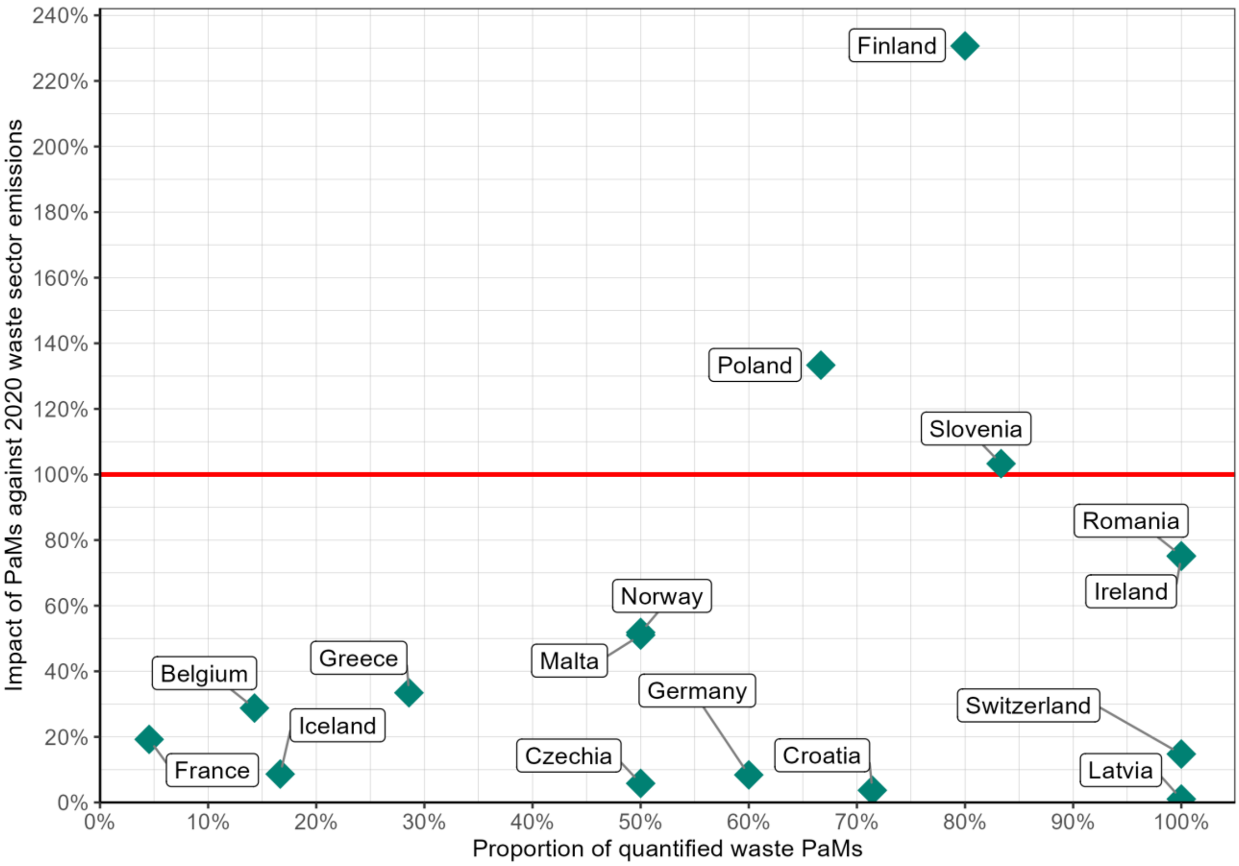
Annex 1 PaMs impact analysis and indicators

An indicator has been developed to show potential “impact” (in terms of GHG savings) of the quantified PaMs. The sum of the earliest projected emission reductions (typically in 2025, with the exception of Latvia where 2030 was earliest) for the PaMs of each country was compared against the latest national emissions sector totals for 2020, reported under the Governance Regulation. These impact indicators (as calculated percentages) were then plotted against the proportion of quantified PaMs for each country, also expressed as a percentage, to consider any correlation. The results can be seen in Figure A1.1.

It is important to note that the impact calculated for Finland, Poland and Slovenia is greater than 100%. This appears to be caused by the quantification of a group of PaMs in the case of Finland and Slovenia, and the large future reductions being reported for PaM 53 (Rational waste management) in the case of Poland. However, it is not immediately clear in the reported information whether these expected savings are genuine or an artefact of the reporting itself as emissions data for 2020 were used as a benchmark to compare against projected reductions for 2025 as these are the most recent data available.

There may be other genuine reasons for the reported emissions savings to appear high using this method of analysis. For example, PaMs relating to biogas and/or energy recovery practices may include quantification of both waste and energy crops. This would explain the quantified emission reductions appearing high when plotted against total emissions reported for the waste sector in 2020. It is also important to note that for Romania one of their reported PaMs was related to a number of group PaMs, with reported reductions, not specifically related to the waste sector. These have been excluded from the analysis.

Figure A1.1 Impact of waste PaMs on the 2020 sector emissions total against the proportion of quantified PaMs by country



Notes: Data has not been reviewed or altered in any cases where varied global warming potentials (GWPs) are used by countries in their reporting. In some cases, there may be discrepancies between the data reported by countries between their historical GHG inventory and projected datasets (see also section 3 and Figure 9 footnotes). As such, the data should be reviewed with caution and is presented for indicative purposes only.

Sources: PaMs quantifications and 2020 emissions data as submitted by countries under the Governance Regulation[1,26].

A key observation is that, in addition to the high impact of Finland's quantified PaMs, the single quantified PaM reported by Ireland accounts for around an 80% reduction of the country's national waste sector total for 2020. Furthermore, despite having quantified 100% of their waste PaMs, the projected reductions for Latvia account for a very small percentage of their respective 2020 national sector totals, so it can be concluded that these PaMs will not be very effective in terms of GHG emissions savings. The lack of correlation shown across countries in Figure A1.1 indicates that there is no clear link between the ability of a country to make multiple PaMs quantifications (by number) and the overall magnitude of their associated impacts.

For the countries with the highest calculated impact of their PaMs, all are linked to implementation of the Landfill directive. The precise measures are not always specified, for example the PaM from Ireland is the implementation of the Landfill Directive and the PaM from Poland is their national Waste Management Plan, however the directive includes targets for reducing the amount of biodegradable waste disposed in landfill as well as the more recent targets from the 2018 amendments on reducing the total amount of municipal waste disposed in landfill. Many of the most reported measures, highlighted in Figure 6, relate to the increased recycling and recovery of MSW which are also likely implementing the Landfill Directive.

Table A.1 highlights the PaMs classifiers from Step 1 that are most relevant for the countries indicated as having high impact PaMs in Figure A1.1. The table highlights consistency across these countries, being that further implementation of the landfill directive is still a major force in terms of potential emissions savings from the waste sector at EU level. The key cross-sectoral issue identified in this table is the use of waste in energy and electricity generation (IPCC sector 1A1a). This would also tie in with the wider circular economy model. Organic wastes and MSW are likely to be the most impactful waste streams targeted in terms of achieving GHG emission reductions. These policies tend to cover a broad range of the waste hierarchy classifiers.

Table A.1 PaMs classifiers for countries with the highest impact of their quantified PaMs

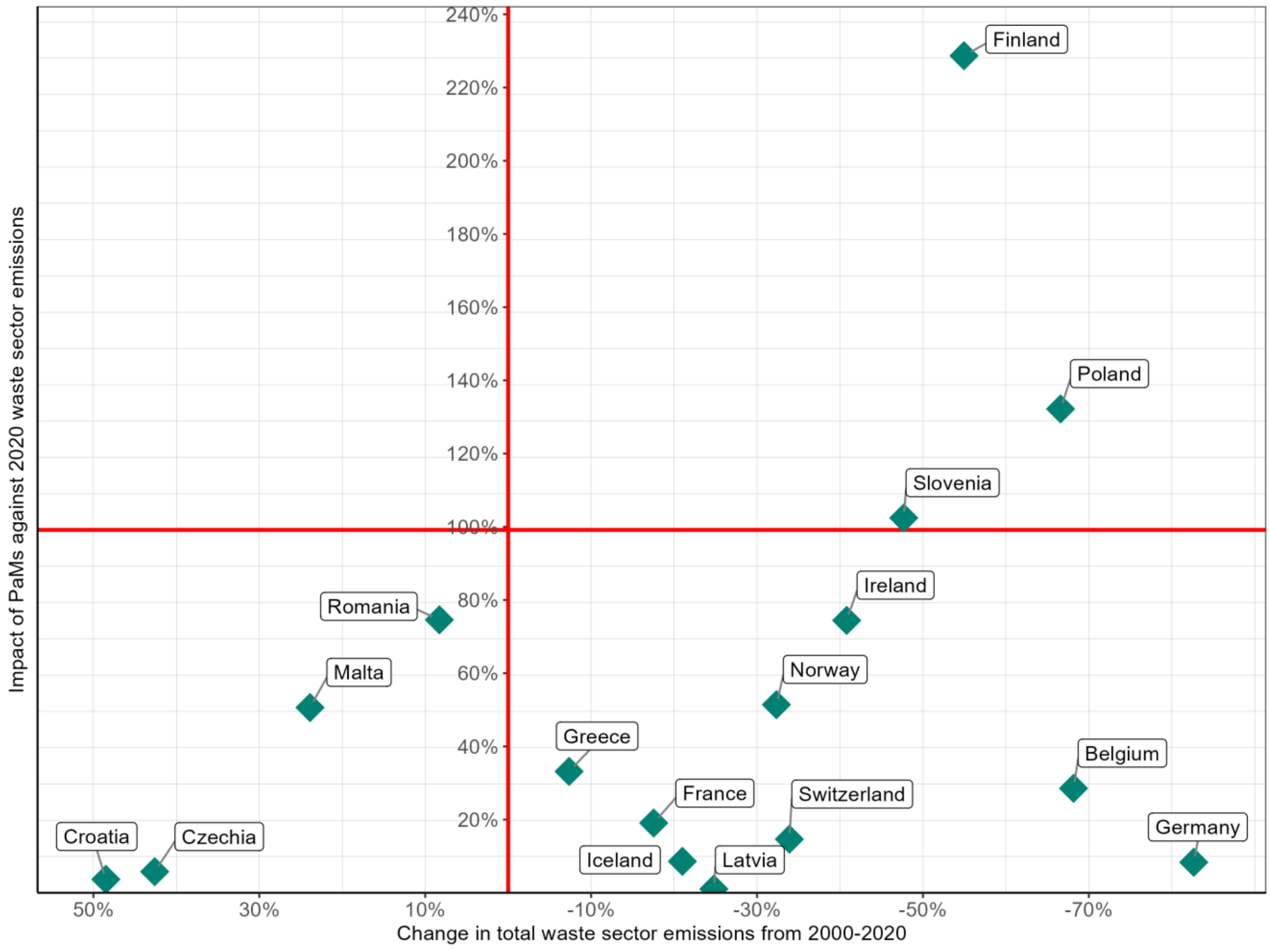
Country	Applicable EU Policy	IPCC sector code	Waste type	Waste hierarchy
Malta	Waste Management Framework Directive			
Norway		5A	Unspecified; Organic waste	Disposal; Recycling
Romania	Renewable Energy Directive; European Structural and Investment Funds; Effort Sharing Regulation; Waste Management Framework Directive; Waste Directive; Landfill Directive	5A; 5B1; 5B2	Paper and cardboard waste; Metal waste; Plastic waste; Glass waste; Packaging; WEEE; Organic Waste; Unspecified	Re-use; Recovery; Recycling; Disposal; Prevention
Ireland	Landfill Directive	5A	Unspecified	Disposal
Finland	Renewable Energy Directive	5B2; 5A	Organic waste; Packaging; Unspecified	Recovery; Disposal
Slovenia	Waste Management Framework Directive; Landfill Directive	5B1; 5B2; 5A; 1A1a	Packaging; MSW; Organic waste; Unspecified	Prevention; Recycling; Recovery; Disposal
Poland	Waste Management Framework Directive; Waste Directive; Waste incineration Directive; Landfill Directive	5B2	Agriculture waste	Recovery

Building upon Figure A1.1, it is also possible to compare the impact indicator of reported PaMs to the historical trend in emissions across the 2000-2020 timeseries for each country. This analysis identifies whether there is a link between the historical trend (typically emissions decreases) that have been achieved in a country and the remaining ambition of its waste sector PaMs.

From the results in Figure A1.2, it can be deduced that Belgium and Germany have each experienced large reductions in their waste sector emissions since 2000, and the impact of their PaMs is smaller in turn. Norway and Ireland have each achieved respectable reductions in their emissions but are still forecasting meaningful reductions in their PaMs. Conversely, Croatia and Czechia have seen considerable increases in their waste sector emissions since 2000, but are also presenting low impact within their PaMs reporting. Malta and Romania have also experienced increases in emissions over the timeseries, but their PaMs are predicted to have a sizeable impact going forward. The data presented for Slovenia, Finland and Poland also indicates significant PaMs savings against strong historical reductions – however as indicated in the discussion of Figure A1.1, additional context is required to interpret and understand the magnitude of those savings (>100% of the 2020 sectoral emissions).

The literature reviews undertaken in Sections 4 and 5 seek to understand and confirm why certain countries, at both ends of the waste emission reductions spectrum, are reporting limited scope for improvement amongst their current PaMs. Conversely, it will be important to determine how certain countries appear to have relatively high ambition in their PaMs data despite already achieving substantial historical emission reductions from the waste sector.

Figure A1.2 Impact of waste PaMs against trend in waste sector emissions from 2000-2020



Notes: Data has not been reviewed or altered in any cases where varied global warming potentials (GWPs) are used by countries in their reporting. In some cases, there may be discrepancies between the data reported by countries between their historical GHG inventory and projected datasets (see also section 3 and Figure 9 footnotes). As such, the data should be reviewed with caution and is presented for indicative purposes only.

Sources: PaMs quantifications and 2020 emissions data as submitted by countries under the Governance Regulation[1,26].

Annex 2 Comparison of quantified PaMs submissions with projection scenarios

The below analysis has been conducted to evaluate how complete and consistent emissions reductions data is, as reported by European countries across reporting requirements. The EU, its Member States and other European countries regularly prepare and report on historic GHG emissions and removals, projections of future GHG emissions, information on national policies and accompanying measures, descriptions and setups of the national systems for GHG projections and policies and measures. GHG projections are estimates based on modelling exercises that show how GHG emissions could develop in the future. These estimates depend on a number of assumptions affecting these emissions, for example demographic and economic growth, fuel prices and the anticipated effects of PaMs. Different projection scenarios can be used to represent different sets of assumptions, for example by considering, or not, the expected effects of new policies. National information on GHG emissions and PaMs are regularly updated, officially reported by European countries under the EU's Governance of the Energy Union and Climate Action regulation ((EU) 2018/1999) and quality checked and disseminated by the EEA, for example through the 'Climate and energy in the EU' website.

Each country has to report GHG projected emissions under the with existing measures (WEM) scenario, however with additional measures (WAM) scenario as well as available quantitative estimates (ex-ante and ex-post) of the effects on emissions shall be reported where available. It should be noted that across the majority of reporting countries, there are currently gaps when it comes to WAM projection scenario and quantification of PaMs. As such, **the comparative analysis in this Annex should be treated with caution and as indicative only**. However, it is useful to consider the value of this analysis, particularly in a future situation where national reporting of PaMs quantifications (including ex-post reduction estimates) and projection scenarios become more complete. It would then be possible to evaluate how much each PaM contributes towards sectoral targets (Table A2.1) and to transparently identify inconsistencies between PaM quantifications and nationally submitted projection scenarios (Table A2.2).

As mentioned in Section 2.2, 14 of the 53 quantified PaMs included average ex-post reduction estimates, which provide an indication of progress towards the associated future reduction estimates. For each of these PaMs, a comparison was therefore made between the ex-post reduction estimates and the projected emission reductions the country has estimated for each of the future years, which are presented in Table A2.1. For most PaMs, the country has reported to be behind each of its reduction estimates, and more so in later years when the projected reduction is generally higher. An exception is that Greece's PaM referring to the recovery of biogas (ID 12) is indicated to be 17% behind the 2025 reduction estimate, but 7% ahead of the 2030 estimate. This reflects the fact that the reduction estimate is lower for the later year. Poland was the only country to submit multiple ex-post estimates, in 2015, 2018, and 2020 for their PaMs (ID 47 and 53). The reported figures indicate Poland to have made substantial progress towards their 2025 reduction estimate, particularly for PaM 53, relating to rational waste management, between 2015 and 2020. The country was only 13% away from reaching the projected reduction estimate in 2020. It therefore follows that Poland is on course to have achieved this target by 2025.

Table A2.1 Comparison of reported ex-post emission reductions against projected reduction estimates for future years

						Comparison of reported ex-post emission reductions against projected reduction estimates for future years			
Country	**PaM ID**	**PaM Title**	**PaM Start Year**	**Ex-post Reduction (kt)**	**Ex-post Year**	**2025**	**2030**	**2035**	**2040**
Finland	6	Promoting biogas in electricity and heat production	1997	116	2019	89%	85%	74%	74%
Greece	11	Recovery of organic waste	2002	550	2015	63%	44%	NA	NA
Greece	12	Recovery of biogas	2002	800	2015	83%	107%	NA	NA
Ireland	24	Landfill Directive (1999/31/EC)	1999	625	2020	86%	78%	74%	68%
Norway	68	Requirement to collect landfill gas	2002	171	2020	129%	163%	169%	NA
Norway	69	Ban on depositing biodegradable waste in landfills	2002	516	2020	77%	66%	59%	NA
Poland	47	Development of agricultural biogas plants	2010	319	2015	43%	32%	NA	NA
Poland	53	Rational waste management	2002	3035	2015	54%	37%	31%	28%
Poland	47	Development of agricultural biogas plants	2010	476	2018	64%	48%	NA	NA
Poland	53	Rational waste management	2002	4085	2018	73%	49%	42%	38%
Poland	47	Development of agricultural biogas plants	2010	513	2020	68%	51%	NA	NA
Poland	53	Rational waste management	2002	4840	2020	87%	59%	50%	45%
Switzerland	29	Ban on landfilling of combustible waste	2000	173	2020	119%	NA	NA	NA
Switzerland	38	Ordinance on the Avoidance and Management of Waste	2016	28	2020	100%	NA	NA	NA

Note: A percentage of 100 or higher signifies that the ex-post savings being reported from a given PaM surpass the projected reduction estimates for the waste sector in the associated reporting country. Please note that this analysis should be viewed as indicative only – it does not imply that values closer to (or exceeding) 100% imply success. In fact, the return of high percentages in the table could imply a greater disconnect between national reporting of PaMs savings and sectoral projections.

Poland reported ex-post reductions for its PaMs (IDs 47 and 53) across multiple years, hence there are multiple rows for these PaMs in the table.

As a verification exercise, and to highlight potential reporting gaps, the quantification reported for the waste sector PaMs was then compared to the reductions reported under projections in 2023 (Table A2.2). Emission reductions between the without measures (WOM) and WEM scenarios were calculated for those countries that reported a WOM scenario. This was then compared to the quantified PaMs in the WEM scenario and the difference calculated. Due to the lack of both reported WOM scenarios and quantified PaMs this gap analysis was only possible to be undertaken for two countries, Romania and Slovenia. Slovenia and Romania show a significant gap in the reductions reported in the PaMs data compared to those expected from their projections. In both cases this suggests some disconnect in the quantification of PaMs and projections reporting.

A similar exercise was undertaken but for comparing the WEM and WAM scenarios (Table A2.3). This analysis is of more interest as it could be used to identify where additional PaMs would be required to meet the reductions expected in the projections. The analysis implies that 22 countries are not expecting further reductions for their waste sector in the WAM scenario compared to the WEM scenario. Of these countries, 21 had no quantified WAM scenario PaMs and as such it could be said that there was therefore no gap in the quantification of PaMs compared to the projections. However, it does suggest that additional PaMs could be considered to reduce emissions from the waste sector further as no country was found to be approaching zero emissions from the waste sector, although for countries where high reductions have already been achieved since 2000 additional reductions may be more modest.

Malta's projections show no decrease in emissions between the WEM and WAM scenarios, however within the PaMs database it reported WAM scenario PaMs with reductions of a maximum of 117 Gg CO_2e a year. Belgium reported no difference between WEM and WAM scenarios in 2025 and an increase in emissions between the WAM and WEM scenarios in 2035 and 2040 for their projections, but reductions of 380 Gg CO2e in those years for the WAM scenario PaMs. This suggests some disconnection between the projections calculations and the quantification reported in the PaMs for these MS.

Czechia, Spain, Luxembourg (in 2035 and 2040), Lithuania and Slovakia show reductions between their WEM and WAM projections scenarios but report no quantification for their PaMs under the WAM scenario and Czechia and Spain do not report any PaMs for the WAM scenario. As such the analysis shows a significant gap between the projections and quantification of the PaMs, although whether this implies that additional PaMs would be required to be implemented or there are just gaps in the reporting cannot be commented on at this stage.

Finally, Latvia and Romania reports both reductions between the WEM and WAM scenarios in their projections and quantified WAM scenario PaMs. For Latvia only quantification for their WAM scenario PaMs for 2030 and 2035 were reported. As there are estimated to be no savings between their WEM and WAM scenarios in 2025 there is no gap between their PaMs reporting and projections for this year. However, for 2030 and 2035 their WAM scenario PaMs are estimated to reduce emissions by 2 Gg CO_2e. However, their projections show reductions of 3.3 and 6.4 kt CO_2e respectively. It is unclear therefore how these additional reductions would be achieved. Romania reports higher reductions associated with their WAM scenario PaMs than projections in 2025 and reductions less than the projections for 2030-2040, with a maximum gap of 266 kt CO_2e in 2030. As for the MS above, it cannot be commented on whether these gaps are due to gaps in the reporting or a requirement for additional PaMs.

Table A2.2 Analysis of gap between projected emission reductions and reductions reported for climate PaMs in waste sector, WEM scenario

Country	Projected reductions $ktCO_2e/yr$				Reductions reported for PaMs $ktCO_2e/yr$				Gap in projected emission reductions and reductions reported for PaMs			
	2025	2030	2035	2040	2025	2030	2035	2040	2025	2030	2035	2040
Romania	5847	6015	6111	6167	0	0	0	0	-5847	-6015	-6111	-6167
Slovenia	858	1030	1119	1180	466	620	739	819	391.5	409.8	379.5	361

Table A2.3 Analysis of gap between projected emission reductions and reductions reported for climate PaMs in waste sector, WAM scenario

Country	Projected reductions $ktCO_2e/yr$				Reductions reported for PaMs $ktCO_2e/yr$				Gap in projected emission reductions and reductions reported for PaMs			
	2025	2030	2035	2040	2025	2030	2035	2040	2025	2030	2035	2040
Austria	0	0	0	0								
Belgium	0	0	-111	-106	0	380	380	380	0	-380	-491	-486
Bulgaria	0	0	0	0								
Croatia	0	0	0	0								
Cyprus	0	0	0	0								
Czechia	18	96	114	115					18	96	114	115
Denmark	0	0	0	0								
Estonia	0	0	0	0								
Finland	0	0	0	0								
France	0	0	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0								
Hungary	0	0	0	0								
Iceland	0	0	0	0								
Ireland	0	0	0	0								
Italy	0	0	0	0								
Latvia	0.0	3.3	6.4	26.6	0.0	2.0	2.0	0.0	0.0	1.3	4.4	26.6
Lithuania	6.0	5.1	5.1	5.1	0.0	0.0	0.0	0.0	6.0	5.1	5.1	5.1
Luxembourg	-1.4	-2.8	0.5	10.6					-1.4	-2.8	0.5	10.6
Malta	0	0	0	0	97	117	100	0	-97	-117	-100	0
Netherlands	0	0	0	0								
Norway	0	0	0									
Poland	0	0	0	0								
Portugal	0	0	0	0								
Romania	277	356	355	322	634	90	125	155	-357	266	230	167
Slovakia	170	339	332	338	0	0	0	0	170	339	332	338

Country	Projected reductions $ktCO_2e/yr$				Reductions reported for PaMs $ktCO_2e/yr$				Gap in projected emission reductions and reductions reported for PaMs			
	2025	**2030**	**2035**	**2040**	**2025**	**2030**	**2035**	**2040**	**2025**	**2030**	**2035**	**2040**
Slovenia	0	0	0	0								
Spain	0.2	0.5	0.6	-0.4								
Sweden	0	0	0	0								
Switzerland	0	0	0									
Austria	0	0	0	0								

Note: Zero values presented in the table mean there is no difference in WEM and WAM scenarios for the country. Missing / blank values mean no information was reported.

Annex 3 Full list of single waste PaMs identified for this analysis

Country	PaM ID	PaM Name
Austria	16	Reduce emissions from landfill sites
Austria	17	Strengthen waste prevention & increase recycling
Austria	18	Reduce emissions from biological treatment by implementing best available techniques (BAT) in the waste treatment process
Belgium	61	Actions to keep more recyclable waste out of residual waste
Belgium	62	Long-term waste treatment strategy
Belgium	76	Develop and deploy tools allowing the evaluation of the durability of renovation projects
Belgium	122	Biomass energy strategy
Belgium	123	Biomethanisation strategy
Belgium	155	Biomethanisation
Belgium	205	Optimize incineration of wastes
Croatia	50	MWM-1: Preventing the generation and reducing the amount of solid waste
Croatia	51	MWM-2: Increasing the amount of separately collected and recycled solid waste
Croatia	52	MWM-3: Ensuring the system of treatment and use of landfill gas
Croatia	53	MWM-4: Reducing the amount of disposed biodegradable waste
Croatia	54	MWM-5: Use of biogas for biomethane production and electricity and heat generation
Croatia	87	MCC-11: Foundation of the Platform for Circular Economy
Croatia	88	MCC-12: Foundation of the Platform for Bioeconomy
Cyprus	55	Efficient district heating and cooling
Cyprus	56	Energy efficiency in water sector
Cyprus	84	Waste (National Municipal Waste Management Strategy)
Czechia	26	Waste management plan 2015-2024
Czechia	63	Circular Economy Package (CEP)
Denmark	16	1-TD-16: Low registration tax on zero- and lowemission cars (as of 2021) [changes to 1-TD-07 og 1-TD-10]
Denmark	24	2-EN-07: Adjustment of waste incineration capacity
Denmark	33	3-BU-11: The Danish Green Investment Fund (DGIF)
Denmark	88	9-WA-01: A ban of landfill of combustible waste.
Denmark	89	9-WA-02: The waste tax
Denmark	90	9-WA-03: Weight-and-volume-based packaging taxes
Denmark	91	9-WA-04 (expired): Subsidy programme – Enterprise Scheme (special scheme for businesses)
Denmark	92	9-WA-06: Implementation of the EU landfill directive
Denmark	93	9-WA-09: Subsidy programme for biocovers on landfills
Denmark	94	9-WA-10: Prohibition of free plastic bags and thin plastic bags
Denmark	95	9-WA-11: Triple the tax on carrier bags and disposable tableware

Country	PaM ID	PaM Name
Denmark	96	9-WA-12: Requirements for the possibility of direct recycling at municipal recycling stations
Denmark	97	9-WA-13: Streamlining the sorting and collection of business household-like waste
Denmark	98	9-WA-14: Streamlining and mandatory collection schemes for household waste
Denmark	99	9-WA-15: Streamlining with mandatory collection scheme for household textile waste
Denmark	100	9-WA-16: Waste sorting in the public space
Denmark	101	9-WA-17: Requirements for the municipalities on tenders for bulky waste schemes with re-sorting with regard to higher real recycling and reuse
Denmark	102	9-WA-18: Demand for smaller losses in recycling plastic
Denmark	103	9-WA-19: Target of 50% reduction of certain plastic takeaway packaging by 2026
Denmark	104	9-WA-20: National implementation of extended producer responsibility for packaging
Denmark	105	9-WA-21: Target of 50% sorting of plastic for recycling in the agricultural sector
Denmark	106	9-WA-22: Target of 50% sorting of plastic for recycling in the construction sector
Denmark	107	9-WA-23: New model for waste management to ensure increased recycling
Denmark	108	9-WA-24: Productivity gain on increased recycling of plastics through the synergy effect between a clear framework for the sector, the market gaining access to both household and acquired waste and the increase and streamlining of waste streams
Denmark	109	9-WA-25: Ceiling over nitrous oxide emissions from large treatment plants
Estonia	89	Limiting the percentage of biodegradable waste going to landfill and increasing the preparing for reuse and recycling of waste materials
Estonia	90	Promoting the prevention and reduction of waste generated, including the environmentally sound management of waste
Estonia	91	Reducing environmental risks arising from waste, improvement of monitoring and supervision
Estonia	92	Circular material use rate
Finland	6	Promoting biogas in electricity and heat production
Finland	33	Government decree on packaging and packaging waste 962/1997, 1025/2000, 987/2004, 817/2005, 2014/518, 1029/2021
Finland	36	Government decree on Landfills (861/1997) revised 2013 (331/2013), revised in 2021 (1030/2021), Biowaste strategy 2004.
Finland	85	Updated National Waste Plan 2027
Finland	127	Biowaste strategy 2004
Finland	128	Waste tax act (1126/2010)
Finland	129	Waste tax act amendment
Finland	130	Decree on waste (978/2021)
Finland	131	Waste Act (646/2011)
Finland	136	Food loss and food waste
France	1	La Stratégie nationale bas-carbone révisée
France	16	Droit à l'injection (biométhane)

Country	PaM ID	PaM Name
France	17	Les tarifs d'achat pour le biométhane injecté dans les réseaux de gaz, en guichet ouvert
France	23	Volet agricole de la feuille de route économie circulaire
France	157	Filières à responsabilité élargie du producteur
France	158	Obligation de tri des déchets des activités économiques (pour les matériaux papier, carton, plastique, métaux, bois, verre, déchets minéraux et plâtre)
France	159	Collecte séparée des déchets ménagers
France	160	Obligation de tri des biodéchets
France	161	Extension des consignes de tri des emballages ménagers à l'ensemble des emballages en plastique d'ici 2022
France	162	Plans régionaux de prévention et de gestion des déchets
France	163	Interdiction des sacs plastiques et de nombreux autres produits en plastique à usage unique
France	164	Lutte contre le gaspillage alimentaire
France	165	Pénalisation de l'obsolescence programmée
France	166	Déploiement de la tarification incitative pour l'enlèvement des déchets ménagers et assimilés
France	167	Extension des consignes de tri des emballages ménagers à l'ensemble des emballages en plastique d'ici 2022
France	169	Composante déchets de la taxe générale sur les activités polluantes
France	170	Feuille de route économie circulaire
France	171	La loi anti-gaspillage pour une économie circulaire
France	173	Planification régionale sur le climat
France	186	Services publics eco-responsables
France	213	Augmentation du fonds économie circulaire
France	214	Stratégie d'accélération recyclabilité, recyclage et réincorporation des matériaux et plan d'investissement sur le recyclage des plastiques
Germany	96	Ordinance on landfill (LULUCF)
Germany	97	Separate collection of biological waste (Waste Management)
Germany	98	Funding of landfill aeration (Waste Management)
Germany	99	Promotion of technologies for the optimised capture of landfill gases in municipal waste (Waste Management)
Germany	100	Promotion of climate-friendly wastewater treatment (Waste Management)
Germany	101	Reduction of food waste (Waste Management)
Greece	11	Recovery of organic waste
Greece	12	Recovery of biogas
Greece	23	Implementation of horizontal measures for improving the conditions for conducting research
Greece	24	Promotion of entrepreneurship through research and innovation actions which are embedded in market functions
Greece	25	Optimising support framework and schemes for promoting investment with a view to strengthening competitiveness
Greece	26	Strengthening competitiveness through the establishment and operation of Special Target Funds
Greece	27	Promoting innovative circular economy technologies
Hungary	1	Law on Climate Protection
Hungary	39	Act on waste

Country	PaM ID	PaM Name
Hungary	40	National Waste Management Plan 2021-2027
Hungary	41	The National Waste Management Public Service Plan (2022)
Hungary	42	Reduction of the share of landfilling in the management of municipal solid waste
Hungary	43	National Water Strategy - Kvassay Jeno Plan
Hungary	44	National Municipal Wastewater Disposal and Treatment Implementation Programme
Hungary	45	Sludge Treatment and Recovery Strategy
Hungary	46	Second National Climate Change Strategy
Hungary	48	National Clean Development Strategy
Hungary	49	Environment and Energy Operational Programme (KEHOP) Priority Axis 5
Hungary	67	The introduction of separate collection of textiles
Hungary	68	The introduction of separate collection of bio-waste
Hungary	86	Circular economic systems and sustainability (KEHOP Plus - Priority 2.)
Hungary	162	Environment and Energy Efficiency Operational Programme (EEEOP), Axis 3
Iceland	501	Ban on landfilling of organic waste
Iceland	502	Landfill tax
Iceland	503	Reduction in food waste
Iceland	504	Gas and compost plant
Iceland	505	Pay-as-you-throw system
Iceland	506	Extended manufacturer's warranty
Ireland	24	Landfill Directive (1999/31/EC)
Italy	121	Agevolazioni a sostegno di progetti di ricerca e sviluppo per la riconversione dei processi produttivi nell'ambito dell'economia circolare
Latvia	36	Increase biological waste preperation for treatment to 210 000 t per year
Latvia	37	Increase preperation of Refused derived fuel to 130 000 t per year
Latvia	38	Increase biological waste treatment to 110 000 t per year
Lithuania	100	Waste management
Lithuania	101	Development of waste collection measures
Lithuania	102	Waste water management
Lithuania	103	Waste sorting
Lithuania	104	Food waste prevention
Lithuania	105	Circularity in public procurement
Lithuania	106	Household composting
Luxembourg	511	"Pacte climat pour les entreprises (PME)
(Klimapakt fir Betriber)"		
Luxembourg	512	Régime d'aides en faveur des entreprises - protection de l'environnement
Luxembourg	513	Fit4Sustainability
Luxembourg	514	SME Packages Sustainability
Luxembourg	515	Régime d'aides en faveur des entreprises - protection de l'environnement (Révision)
Luxembourg	521	Stratégie économie circulaire "Kreeslafwirtschaft Lëtzebuerg"
Luxembourg	601	Lois Déchets et PNGDR
Luxembourg	602	Soutien à une économie circulaire "Null Offall Lëtzebuerg"

Country	PaM ID	PaM Name
Luxembourg	603	Stratégie économie circulaire "Kreeslafwirtschaft Lëtzebuerg"
Luxembourg	604	Incinération des déchets
Luxembourg	605	Systèmes de récupération du méthane
Luxembourg	606	Valorisation des déchets de verdure
Luxembourg	607	Valorisation des déchets organiques
Luxembourg	608	Réduction des matériaux à l'usage unique
Luxembourg	609	Décharge
Luxembourg	610	Décharge inertes
Luxembourg	611	Gestion des eaux usées
Luxembourg	612	Épuration des eaux usées
Luxembourg	613	Épuration des eaux usées
Luxembourg	614	Stratégie de valorisation des boues d'épuration
Malta	24	Development of a Waste to Energy Facility
Malta	25	Waste Management Plan 2020 - 2030
Netherlands	74	Subsidy scheme Circular Economy Projects (SCK)
Netherlands	78	Clean Air Agreement
Netherlands	116	Stimulating the development and upscaling of recycling
Netherlands	117	Mandatory percentage of recycled materials in construction
Netherlands	118	Subsidies for exchanging old refrigerators and freezers
Netherlands	119	Extended producer responsibility for textiles
Netherlands	159	National Programme for a Circular Economy (NPCE)
Norway	2	Tax on waste incineration
Norway	68	Requirement to collect landfill gas
Norway	69	Ban on depositing biodegradable waste in landfills
Norway	70	Other measures in the waste sector
Poland	47	Development of agricultural biogas plants
Poland	48	Reduction of food losses
Poland	52	Development of water and wastewater management
Poland	53	Rational waste management
Portugal	2	Green tax implementation
Portugal	3	To promote the transition to a circular economy.
Portugal	4	Promote R&D projects that support the transition to a carbon neutral economy
Portugal	5	Reduction of waste production and of landfill disposal and promotion of recycling.
Portugal	27	To promote the production and consumption of renewable gases.
Romania	1	GD no. 739/2016 approving the National Climate Change and Low Carbon Green Growth Strategy for period 2016 – 2030 and the National Action Plan for implementation of the National Climate Change and Low Carbon Green Growth Strategy for period 2016 – 2020
Romania	2	GD no. 877/2018 aproving Romania's Sustainable Development Strategy 2030
Romania	3	Law no. 278/2013 on industrial emissions, including Decisions establishing best available techniques (BAT) conclusions under Directive 2010/75/EU
Romania	5	Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement

Country	PaM ID	PaM Name
Romania	10	Romania's National Recovery and Resilience Plan (PNRR)
Romania	11	National programs for local and regional development
Romania	80	Law no. 211/2011 regarding waste management, with subsequent amendments
Romania	81	GEO no. 92/2021 regarding waste management, approved by Law no. 17/2023
Romania	82	GD no. 942/2017 approving the National Waste Management Plan
Romania	83	Law no. 249/2015 regarding the method of managing packaging and packaging waste, with subsequent amendments
Romania	84	GEO no. 5/2015 regarding waste from electric and electronic equipment
Romania	85	GD no. 349/2005 on landfill of waste, amended and supplemented by GD no. 201/2007 and GD no. 1292/2010
Romania	86	GEO no. 2/2021 on landfill of waste
Romania	87	Law no. 181/2020 regarding the management of compostable non-hazardous waste
Romania	88	GD no. 188/2002 for the approval of certain norms concerning the conditions of discharging the waste water into aquatic environment, with subsequent amendments
Romania	89	Improving solid waste management
Slovakia	16	Collection of biodegradable municipal waste
Slovakia	17	Deposit return scheme for single-use containers
Slovakia	30	Biofiltration of methane from landfills.
Slovakia	31	Construction and operation of mechanical–biological treatment (MBT) plants.
Slovakia	32	Improving Municipal Wastewater Management
Slovenia	69	Reduction of amount of generated waste and promotion of reuse and recycling
Slovenia	70	Changes in environmental taxation of waste management
Slovenia	71	Improving the system of packaging waste collection
Slovenia	72	Implementation of pay as you throw concept
Slovenia	73	Change of rules for use of compost on agricultural land
Slovenia	74	Collection of landfilled gas and its energy use
Slovenia	79	Improvement of management of waste water
Spain	123	Hoja de Ruta del Biogás
Spain	202	Programa Estatal de Prevención de Residuos 2014-2020
Spain	203	Estrategia "Más alimento, menos desperdicio"
Spain	204	Plan estatal marco de residuos 2016-2022
Spain	205	Estrategia Española de Economía Circular España 2030
Spain	229	Real Decreto 646/2020 de eliminación de residuos en vertederos
Spain	231	Primer Plan de Acción de Economía Circular 2021-2023
Spain	232	Ley 7/2022 de Residuos y suelos contaminados para una economía circular
Spain	249	Proyecto de Ley de Prevención de las Pérdidas y el Desperdicio Alimentario
Sweden	3	The Environmental Code
Sweden	63	Landfill tax
Sweden	64	Ban on landfilling combustible and organic materials and methane collection
Sweden	65	Extended producer responsibility
Sweden	66	Municipal waste planning requirement

Country	PaM ID	PaM Name
Sweden	92	The energy research grant
Sweden	95	Fertilizer gas support
Sweden	104	Biowaste collection and treatment
Switzerland	29	Ban on landfilling of combustible waste
Switzerland	38	Ordinance on the Avoidance and Management of Waste

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