CLIMATE CHANGE
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Interim Report

Integration of Landfills into the EU-ETS 1

An option to prevent possible waste diversion from municipal waste incineration?

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Abstract: Integration of Landfills into the EU-ETS 1

This exploratory study assesses whether the potential integration of landfills into the EU-ETS 1 could be a viable strategy to prevent waste streams from being diverted from municipal waste incineration (MWI) to landfills, a diversion that could result from the potential and currently discussed inclusion of MWI in the EU-ETS 1, leading to additional methane emissions. To this end, the study briefly reviews the existing legal framework, provides an overview of existing data and statistics on relevant waste streams, and assesses factors related to the risk of diversion. After this, the study sketches a potential landfill integration design and discusses its advantages and disadvantages. The study concludes with an outline of further research needs.

Key findings of the study include:

- Given the current shortcomings of the implementation of the EU Landfill Directive, the isolated inclusion of MWI in the EU-ETS 1 carries the risk that waste — particularly fossil waste and as a byproduct biodegradable organic fractions — may increasingly be diverted to landfills leading to additional methane emissions. This could potentially lead to an overall negative climate effect due to methane's high global warming potential. A deep assessment of the magnitude of this risk was not part of the study.
- A parallel integration of landfills as a complementing measure to current regulation could prevent such negative climate effects and would generally have a positive climate impact by establishing a consistent carbon pricing signal and inducing incentives to reduce emissions in the waste sector within the EU. Due to methane's high global warming potential and the high share of biodegradable organic fractions in municipal waste in the EU (Giavini & Favoino, 2024), the inclusion should also have a positive effect on the efforts to reduce landfilled municipal waste.
- The integration of landfills could also help promote investment in modern waste infrastructure in the medium term, and support the transition to a circular economy in the long term — provided it is implemented within a coherent, EU-wide, harmonised and research-informed regulatory framework.
- However, since the measure proposed in this study for the integration of landfills does not price fossil waste fractions directly, a risk remains that waste with low biodegradable organic shares and high fossil shares could be shifted to landfills. Furthermore, the reduction of landfilling will depend, among other factors, on CO_2-prices, the opportunity to pass on carbon costs to the polluter in the value chain, the availability and costs of other treatment options as well as potential perverse incentives to landfill. Such undesired incentives could arise if landfill gas recovery were to be awarded under the EU-ETS 1, which in connection with the incentive to use landfill gas for energy generation, carries the risk that further deposits of biodegradable waste in landfills would become attractive and thus could not be curbed in the long term. A thorough assessment of these influences and risks was not part of the study.
- Like other regulations in the waste sector the inclusion of landfills in the EU ETS 1 involves a risk of additional illegal dumping, especially to third countries. Efforts to estimate this risk and reduce illegal dumping should therefore be increased.
- Implementation of an integration in the EU-ETS 1 requires a differentiated approach to cover particular characteristics of landfills. The proposed concept includes emissions of newly landfilled municipal waste which would be priced ex-ante based on estimated life-time emissions. Due to measurement difficulties and potential perverse incentives to

increase landfilling, gas capture systems are not taken into account. The model thereby sets a strong signal to prevent landfilling of biodegradable organic waste. Other complementary policies could help mitigate emissions from historically landfilled waste.

The findings in this study are to be understood as indicative due to different limitations like the limited data availability and the selective focus on landfills and climate effects. A final evaluation of the necessity and appropriateness of a landfill integration should address these limitations and provide an answer to key research gaps identified in this study, such as the refinement of emission factors and the advancement of measurement methodologies and governance along the waste chain.

Furthermore, the study does not assess other alternative policies such as a tightening of landfill regulation and ongoing regulatory developments like the Best Available Technology Reference Documents process (Landfill BREF). These should be considered as well for a conclusive assessment and a coordinated policy approach should be aimed for.

Kurzbeschreibung: Integration von Deponien in das EU-ETS 1

Diese explorative Studie untersucht, ob die mögliche Einbeziehung von Deponien in das EU-Emissionshandelssystem (EU-ETS 1) eine tragfähige Strategie sein könnte, um zu verhindern, dass Abfallströme von kommunalen Abfallverbrennungsanlagen (MWI) auf Deponien umgeleitet werden – eine Umleitung, die durch die potenzielle (und zurzeit diskutierte) Einbeziehung von MWI in das EU-ETS 1 entstehen könnte und zusätzliche Methanemissionen verursachen würde. Zu diesem Zweck gibt die Studie einen kurzen Überblick über den bestehenden Rechtsrahmen, bietet eine Übersicht über vorhandene Daten und Statistiken zu relevanten Abfallströmen und bewertet Faktoren, die mit dem Risiko einer Umleitung zusammenhängen. Anschließend skizziert die Studie ein mögliches Konzept für die Einbeziehung von Deponien in den EU-ETS 1 und erörtert dessen Vor- und Nachteile. Die Studie schließt mit einem Überblick über den weiteren Forschungsbedarf.

Zu den wichtigsten Ergebnissen der Studie gehören:

- Angesichts der derzeitigen Mängel bei der Umsetzung der EU-Deponierichtlinie birgt die isolierte Einbeziehung von MWI in den EU-ETS 1 das Risiko, dass Abfälle – insbesondere fossile Abfälle und als Nebenprodukt anfallende biologisch abbaubare organische Abfälle – zunehmend auf Deponien umgeleitet werden, was zu zusätzlichen Methanemissionen führt. Dies könnte aufgrund des hohen Treibhausgaspotenzials von Methan zu einer insgesamt negativen Auswirkung auf das Klima führen. Eine quantitative Bewertung des Ausmaßes dieses Risikos war nicht Teil der Studie.
- Eine parallele Einbeziehung von Deponien als ergänzende Maßnahme zur aktuellen Regelung könnte solche negativen Klimaauswirkungen verhindern und insgesamt positiv auf das Klima wirken, indem ein einheitliches Preissignal für Treibhausgasemissionen gesetzt und damit Anreize geschaffen werden, die Abfall-Emissionen in der EU zu senken. Aufgrund des hohen Treibhausgaspotenzials von Methan und des hohen Anteils biologisch abbaubarer organischer Fraktionen in Siedlungsabfällen in der EU (Giavini & Favoino, 2024), sollte sich die Einbeziehung auch positiv auf die Bemühungen zur Verringerung der Deponierung von Siedlungsabfällen insgesamt auswirken.
- Die Einbeziehung von Deponien könnte mittelfristig auch dazu beitragen, Investitionen in eine moderne Abfallinfrastruktur zu fördern und langfristig den Übergang zu einer Kreislaufwirtschaft zu unterstützen – vorausgesetzt, sie wird innerhalb eines kohärenten, EU-weiten, harmonisierten und forschungsgestützten Rechtsrahmens umgesetzt.
- Da die in dieser Studie vorgeschlagene Maßnahme zur Einbeziehung von Deponien jedoch keine direkte Bepreisung fossiler Abfallanteile vorsieht, besteht weiterhin das Risiko, dass Abfälle mit einem geringen Anteil an biologisch abbaubaren organischen Stoffen und einem hohen Anteil an fossilen Stoffen auf Deponien gelangen könnten. Darüber hinaus hängt die Verringerung der Deponierung unter anderem von den CO_2-Preisen, der Möglichkeit, die CO_2-Kosten an die Verursacher in der Wertschöpfungskette weiterzugeben, der Verfügbarkeit und den Kosten anderer Behandlungsoptionen sowie von potenziellen Fehlanreizen ab. Ein solcher Fehlanreiz könnte etwa entstehen, wenn die Deponiegasgewinnung im Rahmen des EU-ETS 1 honoriert werden würde, was in Verbindung mit dem Anreiz zur energetischen Nutzung von Deponiegas das Risiko birgt, dass weitere Ablagerungen biologisch abbaubarer Abfälle auf Deponien attraktiv werden und somit langfristig nicht eingedämmt werden könnten. Eine detaillierte Bewertung dieser Einflüsse und Risiken konnte im Rahmen dieser Studie nicht durchgeführt werden.

- Wie andere Vorschriften im Abfallsektor birgt auch die Einbeziehung von Deponien in den EU-ETS 1 das Risiko zusätzlicher illegaler Verlagerungen, insbesondere in Drittländern. Die Bemühungen zur Einschätzung dieses Risikos und zur Verringerung illegaler Verlagerungen sollten daher verstärkt werden.

- Die Umsetzung einer Integration in den EU-ETS 1 erfordert einen differenzierten Ansatz, um den besonderen Merkmalen von Deponien Rechnung zu tragen. Das vorgeschlagene Konzept umfasst Emissionen aus neu deponierten Siedlungsabfällen, die auf Grundlage der geschätzten Emissionen über die gesamte Lebensdauer im Voraus festgesetzt werden. Aufgrund von Messschwierigkeiten und potenziellen Fehlanreizen zur Erhöhung der Deponierung biologisch abbaubarer Abfälle werden Systeme zur Deponiegasrückgewinnung nicht berücksichtigt. Der Integrationsansatz setzt damit ein starkes Signal, um die Deponierung biologisch abbaubarer organischer Abfälle zu verhindern. Andere ergänzende Maßnahmen könnten dazu beitragen, die Emissionen aus historisch deponierten Abfällen zu verringern.

Die Ergebnisse dieser Studie sind aufgrund verschiedener Limitierungen wie begrenzter Datenverfügbarkeit und selektiver Fokussierung auf Deponien und Klimaauswirkungen als indikativ zu verstehen. Eine abschließende Bewertung der Notwendigkeit und Angemessenheit einer Deponieintegration in den EU-ETS 1 sollte diese Aspekte berücksichtigen und Antworten auf die in dieser Studie identifizierten wesentlichen Forschungslücken liefern, wie z. B. die Präzisierung der Emissionsfaktoren sowie die Weiterentwicklung von Messmethoden und Governance entlang der Wertschöpfungskette in der Abfallwirtschaft.

Die Studie berücksichtigt keine alternativen Maßnahmen, wie eine Verschärfung der Deponievorschriften sowie laufende regulatorische Entwicklungen, wie den Prozess zu den Best Available Techniques Reference Documents (BREF-Prozess) für Deponien. Entsprechende Ansätze sollten bei einer abschließenden Bewertung berücksichtigt werden. Grundsätzlich sollte ein koordinierter politischer Ansatz angestrebt werden.

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List of abbreviations

Abbreviation	Explanation
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalents
CH_4	Methane
COP	Conference of the Parties
DOC	Degradable Organic Carbon
$DDOC_m$	Disaggregated Decomposable Organic Carbon – methane fraction
EC	European Commission
ENV_WASGEN	Abbreviation referring to the Eurostat database titled "Generation of waste by waste category, hazardousness and NACE Rev. 2 activity"
ENV_WASMUN	Abbreviation referring to the Eurostat database titled "Municipal waste by waste management operations"
ENV_WASTRT	Abbreviation referring to the Eurostat database titled "Treatment of waste by waste category, hazardousness and waste management operations"
EPR	Extended Producer Responsibility
E-PRTR	European Pollutant Release and Transfer Register
ESR	Effort Sharing Regulation
EU	European Union
EU-ETS	EU Emissions Trading Scheme
EWC	European Waste Catalogue
EWSTAT	European Waste Statistics
FOD	First Order Decay
GWP100	Global Warming Potential over 100 years
IPCC	Intergovernmental Panel on Climate Change
KrWG	Kreislaufwirtschaftsgesetz (German Waste Management Act)
MBT	Mechanical-biological treatment
MPT	Mechanical-physical treatment
MRV	Monitoring, Reporting, Verification
MWI	Municipal waste incineration
N_2O	Nitrous oxide
PIC	Prior informed consent
RDF	Refuse-derived fuels
SI	Supplementary Information

Abbreviation	Explanation
SUP	Single-Use-Plastics
TOC	Total Organic Carbon
UNFCCC	United Nations Framework Convention on Climate Change
WEEE	Waste electrical and electronic equipment

Summary and Conclusion

The focus of this study is to analyse the potential need to include landfills in the EU Emissions Trading System 1 (EU-ETS 1), assuming that municipal waste incineration (MWI) will be integrated into the system. The aim is to identify risks associated with waste stream diversion between thermal treatment and landfilling with the focus on possible climate-effects, and to develop initial conceptual approaches for the possible inclusion of landfills in the EU-ETS 1.

A complementary analysis from the perspective of MWI is not part of this study. The inclusion of MWI is therefore treated here as a given assumption.

This study does not aim to identify or systematically assess all existing research on the inclusion of the waste sector in the EU-ETS 1. Instead, it highlights key questions and knowledge gaps that should be explored in further research. The next step will be to determine whether sufficient evidence already exists or whether new, targeted studies are needed.

Due to its limited scope and data availability, the analysis does not provide a comprehensive quantitative assessment of all technical, economic, or regulatory aspects. The findings should therefore be interpreted as indicative rather than conclusive, and within the context of the landfill perspective adopted here. In particular, the study does not assess other potential policies to prevent the risk of diversion and reduce overall methane emissions on landfills such as a tightening of EU-regulations for example in form of stricter pre-treatment requirements for landfilled waste. For an overall assessment of a landfill integration these alternatives as well as ongoing regulatory developments like the process for the Best Available Techniques Reference Document for Landfills (Landfill BREF) should be considered and a coordinated policy approach should be aimed for.

In 2022, EU Member States treated approximately 1.986 billion tonnes of waste, of which about 7% was thermally treated — mainly for energy recovery — while roughly 30% was landfilled, primarily mineral waste (Eurostat, 2025b). The most relevant landfilled waste types with significant biodegradable organic content were municipal waste and sorting residues. Biodegradable organic fractions in landfills generate methane, a greenhouse gas with a significantly higher global warming potential than CO_2, while they are considered climate-neutral when incinerated. Fossil fractions, on the other hand, contribute directly to greenhouse gas emissions (GHG emissions) during thermal treatment but not when they are landfilled.

Assuming the inclusion of MWI in the EU-ETS 1, our analysis focuses on municipal waste. In 2022, EU Member States treated approximately 225 million tonnes of municipal waste, of which 58 million tonnes (26%) were thermally treated and 52 million tonnes (23%) landfilled. These figures include both primary and secondary waste, such as outputs from mechanical-biological or mechanical-physical pre-treatment (Eurostat, 2026a).[1] According to the EEA, the waste sector (CRF 5) was responsible for 109 million tonnes of CO_2-equivalent emissions in 2023 in the EU Member States, mainly due to methane emissions from managed solid waste disposal (i.e. landfills), which account for 60 % of the sector's greenhouse gas emissions (EEA, 2025). Combustion-related emissions constitute only a minor share, as waste incineration with energy recovery is allocated to the energy sector rather than the waste sector. Emissions from Municipal Waste treatment are therefore accounted for in both the waste and the energy sector.[2]

[1] Data for 2022.

[2] Not all of the emissions from landfills and waste incineration can be attributed to municipal waste treatment since the numbers include emissions from other treated waste as well. A detailed analysis of the emissions from municipal waste treatment was beyond the scope of this study.

A key finding is that waste management plays a crucial role in both climate protection and resource efficiency. Consequently, a potential EU-ETS 1 integration must be specifically designed to reduce methane emissions from landfills and support the circular economy.

The EU has established a comprehensive regulatory framework to reduce landfilling, promote recycling, and advance circular economy objectives. Key instruments include the Waste Framework Directive, the Landfill Directive, directives on Waste Electrical and Electronic Equipment (WEEE), packaging, and single-use plastics, and the Circular Economy Action Plan. These regulations define recycling targets, pre-treatment requirements, and energy recovery standards.

However, implementation varies significantly across Member States. Some countries do not fully meet pre-treatment and landfill reduction targets or recycling quotas. National measures such as landfill bans or taxes differ widely in scope, enforcement, and impact. As a result, the inclusion of MWI in the EU-ETS 1 would entail a risk of undesirable waste diversion to landfills resulting in methane emissions due to the biodegradable organic fractions. Without simultaneously implementing complementary policies to address this risk, MWI integration could thus lead to an overall negative climate effect due to methane's high global warming potential.

Against this background this study finds that including landfills in the EU-ETS 1 could be a viable option to avoid such effects and ensure fair competition in the waste sector.

Integrating both MWI and landfills in the EU-ETS 1 would help internalise climate costs and send a consistent price signal thereby enabling an efficient mitigation in the sector by incentivizing the most climate friendly treatment routes. Pricing methane on landfills would generally make landfilling waste containing biodegradable organic fractions economically unattractive due to methane's high global warming potential compared to CO_2-emissions resulting from MWI-treatment. This could not only address climate risks from diversion but also help to reduce landfilled municipal waste incentivising other treatment options like recycling and waste incineration. Furthermore, such price signals would promote innovation and infrastructure investments in climate friendly treatment routes which in the long run could facilitate the transition to a circular economy. Including landfills in the EU-ETS 1 could thus make a significant contribution to reducing GHG emissions from the waste sector. The magnitude of these effects was not assessed in this study and depends, among other factors, on CO_2-price levels, the ability of landfill operators to pass on carbon costs to other actors, the availability and costs of other treatment options (like recycling and MWI) as well as potential perverse incentives despite the costs implied by the EU-ETS 1. This could for example be the case if revenues from gas capture for the purpose of energy generation make it economically attractive to maintain or increase landfilling.

Although, given the typically significant biodegradable organic shares in municipal waste, diversion to landfills should generally be relatively more expensive, a risk remains that waste with high fossil and low biodegradable organic fractions could be diverted to landfills if resulting methane emissions are lower than emissions from the incineration of the same waste. Potentially fossil fractions might also be separated from mixed waste for the purpose of landfilling these fractions to avoid emission pricing. While from a pure climate policy perspective this is not problematic, such diversions violate the waste hierarchy and should be avoided for ecological reasons. A tightening of current regulation could help mitigate such detrimental effects. This risk, has however not been assessed in this study.

Despite existing international agreements and stricter EU regulations, a high risk remains that substantial quantities of waste are illegally shipped to third countries. Like other regulations in the waste sector that induce additional costs to waste treatment in the EU, the inclusion of landfills could increase incentives for illegal exports. Efforts to assess this risk and prevent illegal diversions should therefore be increased.

Furthermore, it is important to note that additional policies to reduce emissions on landfills if effective, could lead to a so-called "waterbed effect", meaning that emission reductions would allow other sectors in the EU-ETS 1 to emit more. If the cap is not designed or adjusted accordingly, emissions would thus simply be shifted. In light of ongoing regulatory efforts to reduce landfill emissions measures should be taken to avoid this effect.

A timely or parallel inclusion of landfills in the EU ETS 1 requires a pragmatic approach that builds on existing structures. The conceptual framework should, where possible, align with the approach currently under discussion for MWI integration to ensure comparable conditions.

Key design questions include which waste types should be covered. A focus on municipal waste, as defined under the extended definition, appears appropriate since, on the one hand, it is the most climate relevant waste stream due to its high biodegradable organic shares and on the other hand, municipal waste is the scope of the potential MWI inclusion. Only active landfills and waste deposited after a defined cut-off date should be considered; historical deposits should be excluded since emissions from these are very hard to measure and there is only a limited possibility for mitigation. The focus should therefore be on emissions from future waste streams which can be actively influenced through pre-treatment, redirection of organic waste, and improved waste management practices.

Exact monitoring, reporting, and verification (MRV) of methane emissions of landfilled waste is hardly possible because of the diffuse, long-term, and site-specific nature of methane emissions. Therefore, two possible options for an MRV system are proposed to estimate life-time-emissions of newly landfilled waste. For the estimation and pricing of emissions an ex-ante approach is suggested such that the liability to surrender certificates would arise at the time of landfilling. To avoid excessive costs the liability could be spread over several years. Due to measurement difficulties and potential undesired incentives to increase the landfilling of biodegradable organic waste, mitigation effects of gas capture systems are not taken into account. The integration of landfills into the EU-ETS 1 would lead to additional revenues if based on auctioning which could be used to ensure that upstream waste management processes also benefit.

Complementary policies e.g. via regulations or subsidies could help reduce methane emissions from historically landfilled waste since these are not addressed in the proposed integration model.

The analysis identifies several risks and research needs. The use of standardised emission factors can for example lead to over- and underestimations of factual emissions. Therefore, MRV methodologies should be advanced. Key research gaps include among others the determination of national DOC default values (e.g. for mixed waste) which are needed for the estimation of default emission factors, classifying waste fractions, understanding interactions with pre-treatment processes and defining governance structures. These issues should be addressed before implementation to avoid unintended consequences.

In conclusion, the study demonstrates that the inclusion of MWI in the EU-ETS 1 requires accompanying measures to prevent unwanted negative climate effects. A parallel inclusion of landfills could not only prevent diversion effects but also provide a consistent economic incentive to reduce emissions in the waste sector, thereby having an overall positive climate effect. An integrated consideration of municipal waste incineration and landfilling can thereby make an essential contribution to achieving the EU's climate goals and also strengthening the circular economy. A general assessment, whether including the whole waste sector in the EU-ETS 1 makes sense overall was, however, not part of this study and requires further dedicated research.

Furthermore, other policy options and ongoing regulatory developments, which have not been included in this study should be taken into account as well for a conclusive assessment of the necessity and appropriateness of a landfill integration. A coordinated policy approach should be aimed for to effectively prevent undesirable diversions, reduce emissions and support the creation of a circular economy.

For a practical and timely start of a landfill integration into the EU-ETS 1, the following starting points could be considered:

Scope
(landfill types, waste, GHG emissions)

- Only landfills accepting municipal waste
- Only emissions from newly landfilled municipal waste
- Only methane

Scope could be expanded in the future

Determination of the Cap-Adjustment

- Cap-adjustment starts in the first year of surrender obligation
- Adjustment could be based on the expected life-cycle-methane emissions of the (newly) landfilled waste in a year, split up over several years according to MRV rules

MRV obligations

One of the two following MRV methods could be applied:

Method 1:
Determination of emission factors according to IPCC-guidelines

- Phase-in: MRV obligation may start with reporting of only municipal waste amounts accepted at the landfill, related waste composition for the determination of default values and information about whether and how waste has been pretreated
- After phase-in complete MRV could start with country specific default values; landfill specific values could be determined optionally in the beginning and possibly become obligatory after a transition phase.

Method 2:
Determination of emission factors based on laboratory analysis

- Municipal waste amounts accepted at the landfill have to be reported as well as the results of representative sample analysis;
- Samples of individual waste are analysed by accredited laboratories to determine emission factors of individual waste streams
- Test methods: gas formation rate (GB21), respiratory activity (AT4) or performance of similar tests to directly measure gas formation (see German Landfill Ordinance for further details). For the EU-ETS 1, it is expedient to present the result as the amount of methane formed (in kg) per amount of waste (in Mg wet mass). Depending on the measurement method selected (GB21 or similar), it may therefore be necessary to convert the laboratory result. If, for example, the total amount of gas formed is measured, only the methane content should be reported. The laboratory values may also need to be adjusted by a correction factor to reflect long-term degradation behavior.

- Alternatively, samples of municipal waste could be analysed at the landfill level to determine default emission factors for each individual landfill.

Determination of default values

Method 1:

- Use phase-in-period to determine DOC default values for mixed waste. Representative waste analyses would be necessary to determine the composition of waste and thus the proportions of biodegradable fractions.
- Different default values should be determined for pretreated and not pretreated waste.
- Values should be calculated separately for Member states taking into account country-specific waste compositions and pretreatment requirements

Method 2:

- If default values for emission factors of individual landfills are used these should be determined in the phase-in-period.
- Calculation based on analysis of random samples of waste for each landfill. Values should be updated regularly.

Determination of surrendering obligation

Ex-ante approach:

- Liability at the time of landfilling based on calculated estimate of future methane generation possibly split up over several years

Timeline

- Start with 2-years mandatory reporting and tests to determine default values.
- Smooth phase-in of surrendering obligation (e.g. comparable to maritime sector)

Zusammenfassung und Fazit

Der Schwerpunkt der vorliegenden Kurzstudie liegt auf der Analyse der potenziellen Notwendigkeit, Deponien in das EU-Emissionshandelssystem 1 (EU-ETS 1) einzubeziehen – unter der Annahme, dass Siedlungsabfallverbrennungsanlagen (MWI) in das System integriert werden. Ziel ist es, die mit der Umlenkung von Abfallströmen zwischen thermischer Behandlung und Deponierung verbundenen Risiken mit Schwerpunkt auf möglichen Klimaauswirkungen zu identifizieren und erste konzeptionelle Ansätze für die mögliche Einbeziehung von Deponien in das EU-ETS 1 zu entwickeln.

Eine ergänzende Analyse aus der Perspektive der MWI ist nicht Teil dieser Studie. Die Einbeziehung der MWI ist daher Prämisse in der vorliegenden Studie.

Diese Studie zielt nicht darauf ab, alle vorhandenen Forschungsarbeiten zur Einbeziehung des Abfallsektors in das EU-ETS 1 zu identifizieren oder systematisch zu bewerten. Stattdessen werden zentrale Fragen und Wissenslücken identifiziert, die in weiteren Forschungsarbeiten untersucht werden sollten. Der nächste Schritt wird darin bestehen, zu überprüfen, ob bereits ausreichende Evidenz vorliegt oder ob neue, zielgerichtete Studien erforderlich sind.

Aufgrund ihres begrenzten Umfangs und der nur eingeschränkt verfügbaren Daten liefert die Analyse keine umfassende quantitative Bewertung aller technischen, wirtschaftlichen oder regulatorischen Aspekte. Die Ergebnisse sind daher als indikativ und nicht als abschließend zu interpretieren - und gelten im Kontext der hier eingenommenen Deponieperspektive. Insbesondere bewertet die Studie keine anderen potenziellen Politikinstrumente zur Vermeidung des Umlenkungsrisikos und zur Reduktion der Methanemissionen auf Deponien, wie etwa eine Verschärfung der EU-Vorgaben in Form strengerer Vorbehandlungsanforderungen für deponierte Abfälle. Für eine Gesamtbewertung der Deponieintegration sollten diese Alternativen sowie laufende regulatorische Entwicklungen wie der Prozess zum BVT- Referenzdokument für Deponien berücksichtigt werden; zudem ist eine koordinierte politische Vorgehensweise anzustreben.

Im Jahr 2022 behandelten die EU-Mitgliedstaaten etwa 1,986 Milliarden Tonnen Abfall, von denen etwa 7 % thermisch verwertet bzw. beseitigt wurden – hauptsächlich zur Energierückgewinnung –, während etwa 30 % deponiert wurden, vorwiegend mineralische Abfälle (Eurostat, 2025b).[3] Die relevantesten deponierten Abfallarten mit signifikantem biologisch abbaubarem organischem Anteil waren Siedlungsabfälle und Sortierrückstände. Biologisch abbaubare organische Fraktionen erzeugen auf Deponien Methan, ein Treibhausgas mit deutlich höherem Treibhauspotenzial als CO_2, während sie bei der Verbrennung als klimaneutral gelten. Fossile Fraktionen hingegen tragen bei der thermischen Behandlung direkt zu Treibhausgasemissionen (THG-Emissionen) bei, nicht jedoch, wenn sie deponiert werden.

Unter der Annahme der Einbeziehung der MWI in das EU-Emissionshandelssystem konzentriert sich die Analyse auf Siedlungsabfälle. Im Jahr 2022 behandelten die EU-Mitgliedstaaten etwa 225 Millionen Tonnen Siedlungsabfälle, von denen 58 Millionen Tonnen (26 %) thermisch verwertet und 52 Millionen Tonnen (23 %) deponiert wurden (Eurostat, 2026a).[4] Diese Zahlen umfassen sowohl Primär- als auch Sekundärabfälle wie z. B. Outputfraktionen aus der mechanisch-biologischen oder mechanisch-physikalischen Vorbehandlung. Nach Angaben der EEA war der Abfallsektor (CRF 5) im Jahr 2023 in den EUMitgliedstaaten für 109 Millionen Tonnen -CO_2Äquivalente verantwortlich, hauptsächlich aufgrund von Methanemissionen aus kontrollierter Ablagerung fester Abfälle-, die 60 % der Treibhausgasemissionen dieses Sektors

[3] Data for 2022.

[4] Data for 2022.

ausmachen (EEA, 2025). Verbrennungsbedingte Emissionen spielen hingegen nur eine untergeordnete Rolle, da Abfallverbrennung mit Energierückgewinnung dem Energiesektor und nicht dem Abfallsektor zugeordnet wird. Emissionen aus der kommunalen Abfallbehandlung entfallen damit sowohl auf den Abfall- als auch den Energiesektor.[5]

Ein zentrales Ergebnis ist, dass die Abfallwirtschaft sowohl für den Klimaschutz als auch für die Ressourceneffizienz eine entscheidende Rolle spielt. Daher muss die potenzielle EU-ETS 1-Integration gezielt darauf ausgerichtet sein, Methanemissionen aus Deponien zu reduzieren und die Kreislaufwirtschaft zu unterstützen.

Die EU hat einen umfassenden Rechtsrahmen geschaffen, um die Deponierung zu verringern, das Recycling zu fördern und die Ziele der Kreislaufwirtschaft voranzubringen. Zu den wichtigsten Instrumenten gehören die Abfallrahmenrichtlinie, die Deponierichtlinie, die Richtlinien über Elektro- und Elektronikaltgeräte (WEEE), Verpackungen und Einwegkunststoffe sowie der Aktionsplan für die Kreislaufwirtschaft. Diese Regelwerke definieren Recyclingziele, Vorbehandlungsanforderungen sowie Standards für die Energierückgewinnung.

Die Umsetzung variiert jedoch erheblich zwischen den Mitgliedstaaten. Einige Länder erfüllen die Ziele zur Vorbehandlung und Deponiereduktion oder die Recyclingquoten nicht vollständig. Nationale Maßnahmen wie Deponieverbote oder -abgaben unterscheiden sich hinsichtlich Reichweite, Durchsetzung und Wirkung stark voneinander. Infolgedessen würde die Einbeziehung der MWI in das EU-ETS 1 das Risiko einer unerwünschten Umleitung von Abfällen auf Deponien mit sich bringen, was aufgrund der biologisch abbaubaren organischen Fraktionen zu Methanemissionen führen kann. Ohne gleichzeitig ergänzende Maßnahmen zur Adressierung dieses Risikos umzusetzen, könnte die Integration der MWI angesichts des hohen Treibhauspotenzials von Methan daher zu einem insgesamt negativen Klimaeffekt führen.

Vor diesem Hintergrund kommt diese Studie zu dem Schluss, dass die Einbeziehung von Deponien in das EU-ETS 1 – bei Einbeziehung der MWI – eine praktikable Option sein könnte, um solche Auswirkungen zu vermeiden und einen fairen Wettbewerb im Abfallsektor zu gewährleisten.

Die gemeinsame Integration von MWI und Deponien in das EU-ETS 1 könnte helfen, Klimakosten zu internalisieren und ein konsistentes Preissignal zu senden. Dadurch ließe sich eine effiziente THG-Minderung im Abfallsektor erreichen, indem die klimafreundlichsten Behandlungswege angereizt werden. Eine Bepreisung von Methan auf Deponien würde die Deponierung von Abfällen mit biologisch abbaubaren organischen Fraktionen im Allgemeinen wirtschaftlich unattraktiv machen – aufgrund des im Vergleich zu CO_2-Emissionen aus MWI-Behandlung deutlich höheren Treibhauspotenzials von Methan. Dies könnte nicht nur Klimarisiken durch eine Umlenkung auf Deponien adressieren, sondern auch dazu beitragen, die deponierte Menge an Siedlungsabfällen generell zu verringern, indem andere Behandlungsoptionen wie Recycling und Abfallverbrennung angereizt werden. Darüber hinaus würden solche Preissignale Innovationen und Infrastrukturausbau in klimafreundliche Behandlungswege fördern, was langfristig den Übergang zu einer Kreislaufwirtschaft erleichtern könnte. Die Einbeziehung von Deponien in das EU-ETS 1 könnte somit einen bedeutenden Beitrag zur Reduktion der THG-Emissionen im Abfallsektor leisten. Das Ausmaß dieser Effekte wurde in dieser Studie nicht bewertet und hängt unter anderem vom Niveau der CO_2-Preise, der Fähigkeit der Deponiebetreiber ab, CO_2-Zertifikatskosten an die Verursacher weiterzugeben, der

[5] Nicht alle Emissionen aus Deponien und Abfallverbrennungsanlagen lassen sich der kommunalen Abfallbehandlung zuordnen, da die Zahlen auch Emissionen aus anderen behandelten Abfällen enthalten. Eine detaillierte Analyse der Emissionen aus der kommunalen Abfallbehandlung würde den Rahmen dieser Studie sprengen.

Verfügbarkeit und den Kosten anderer Behandlungsoptionen (wie Recycling und MWI) sowie potenziellen Fehlanreizen ab. Dies könnte beispielsweise dann der Fall sein, wenn Erlöse aus der Gasfassung zur Energieerzeugung es wirtschaftlich attraktiv machen, die Deponierung beizubehalten oder zu erhöhen.

Obwohl die typischerweise signifikanten biologisch abbaubaren organischen Anteile in Siedlungsabfällen eine Deponierung teurer machen sollten, besteht das Risiko, dass Abfälle mit hohem fossilem und niedrigem biologisch abbaubarem organischem Anteil auf Deponien umgeleitet werden, sofern die daraus resultierenden Methanemissionen geringer sind als die Emissionen aus der Verbrennung derselben Abfälle. Fossile Fraktionen könnten auch aus gemischten Abfällen separiert werden, um sie zur Deponierung zuzuführen und so eine Bepreisung von Emissionen zu vermeiden. Aus rein klimapolitischer Sicht ist dies nicht problematisch; solche Umleitungen verstoßen jedoch gegen die Abfallhierarchie und sollten aus ökologischen Gründen vermieden werden. Eine Verschärfung der derzeitigen Regulierung könnte helfen, derartige nachteilige Effekte zu mindern. Dieses Risiko wurde in dieser Studie jedoch nicht bewertet.

Trotz bestehender internationaler Abkommen und verschärfter EU-Regelungen besteht ein hohes Risiko, dass erhebliche Mengen an Abfällen illegal in Drittländer verbracht werden. Wie andere Regularien im Abfallsektor, die zusätzliche Kosten für die Abfallbehandlung in der EU verursachen, könnte die Einbeziehung von Deponien die Anreize für illegale Ausfuhren erhöhen. Anstrengungen zur Bewertung dieses Risikos und zur Verhinderung illegaler Umleitungen sollten daher verstärkt werden.

Ferner ist zu beachten, dass zusätzliche Politiken zur Emissionsminderung auf Deponien – sofern wirksam – zu einem sogenannten „Wasserbett-Effekt“ führen könnten. Das bedeutet, dass Emissionsminderungen in anderen Sektoren im EU-ETS 1 höhere Emissionen zulassen würden. Wenn das Cap nicht entsprechend gestaltet oder angepasst wird, würden Emissionen lediglich verlagert. Angesichts laufender regulatorischer Bemühungen zur Reduktion von Deponieemissionen sollten Maßnahmen ergriffen werden, um diesen Effekt zu vermeiden.

Eine zeitnahe oder parallele Einbeziehung von Deponien erfordert einen pragmatischen Ansatz, der auf bestehenden Strukturen aufbaut. Das konzeptionelle Rahmenwerk sollte, soweit möglich, an den derzeit für die MWI diskutierten Ansatz anschließen, um vergleichbare Bedingungen sicherzustellen.

Zentrale Ausgestaltungsfragen betreffen die abzudeckenden Abfallarten. Ein Fokus auf Siedlungsabfälle (gemäß erweiterter Definition) erscheint sinnvoll, da sie einerseits aufgrund hoher biologisch abbaubarer organischer Anteile der klimarelevanteste Abfallstrom sind und andererseits der Geltungsbereich der potenziellen MWI-Einbeziehung ebenfalls Siedlungsabfälle umfasst. Es sollten nur aktive Deponien und Abfälle berücksichtigt werden, die nach einem definierten Stichtag abgelagert werden; historische Ablagerungen sollten ausgeschlossen werden, da deren Emissionen sehr schwer messbar sind und es nur begrenzte Minderungspotenziale gibt. Der Fokus sollte daher auf Emissionen aus künftigen Abfallströmen liegen, die durch Vorbehandlung, Umleitung organischer Abfälle und verbesserte Abfallbewirtschaftungspraktiken aktiv beeinflusst werden können.

Eine exakte Überwachung, Berichterstattung und Verifizierung (MRV) der Methanemissionen deponierter Abfälle ist aufgrund der diffusen, langfristigen und standortspezifischen Natur der Emissionen kaum möglich. Deshalb werden zwei Optionen für ein MRV-System vorgeschlagen, um die Lebenszeit-Emissionen neu deponierter Abfälle zu schätzen. Für die Schätzung und Bepreisung der Emissionen wird ein ex-ante-Ansatz empfohlen, sodass die Pflicht zur Abgabe von Zertifikaten zum Zeitpunkt der Ablagerung entsteht. Um übermäßige Kosten zu vermeiden, könnte die Abgabepflicht über mehrere Jahre verteilt werden. Aufgrund der Messschwierigkeiten und potenziell unerwünschter Anreize zur verstärkten Deponierung biologisch abbaubarer organischer Abfälle werden die Minderungswirkungen von Gasfassungssystemen nicht berücksichtigt. Die Integration von Deponien in das EU-ETS 1 würde – bei Auktionierung als Basis – zu zusätzlichen Einnahmen führen, die genutzt werden könnten, um sicherzustellen, dass vorgelagerte Abfallbewirtschaftungsprozesse ebenfalls profitieren.

Komplementäre Politiken, z. B. über Regulierung oder Förderinstrumente, könnten helfen, Methanemissionen aus historisch deponierten Abfällen zu reduzieren, da diese im vorgeschlagenen Integrationsmodell nicht adressiert werden.

Die Analyse identifiziert mehrere Risiken und Forschungsbedarfe. Die Verwendung standardisierter Emissionsfaktoren kann beispielsweise zu Über- und Unterschätzungen tatsächlicher Emissionen führen. Daher sollten MRV-Methodiken weiterentwickelt werden. Zentrale Forschungslücken umfassen unter anderem die Bestimmung nationaler DOC-Default-Werte (z. B. für gemischte Abfälle), die für die Ableitung von Default-Emissionsfaktoren benötigt werden, die Klassifizierung von Abfallfraktionen, das Verständnis der Wechselwirkungen mit Vorbehandlungsprozessen sowie die Definition von Governance-Strukturen. Diese Themen sollten vor der Umsetzung adressiert werden, um unbeabsichtigte Nebenwirkungen zu vermeiden.

Fazit: Die Studie zeigt, dass die Einbeziehung der MWI in den EU-ETS 1 begleitende Maßnahmen erfordert, um unerwünschte negative Klimaeffekte zu verhindern. Eine parallele Einbeziehung von Deponien könnte nicht nur Umlenkungseffekte vermeiden, sondern auch allgemein ein konsistentes ökonomisches Signal für die Emissionsminderung im Abfallsektor setzen und damit einen insgesamt positiven Klimaeffekt haben. Eine integrierte Betrachtung von kommunaler Abfallverbrennung und Deponierung kann so einen wesentlichen Beitrag zur Erreichung der EU-Klimaziele leisten und zugleich die Kreislaufwirtschaft stärken. Eine Bewertung, ob die Einbeziehung des gesamten Abfallsektors in das EU-ETS 1 sinnvoll ist, war jedoch nicht Bestandteil dieser Studie und erfordert weitere spezifische Forschung.

Darüber hinaus sind für eine abschließende Bewertung der Notwendigkeit und Angemessenheit einer Deponie-Integration auch andere Politikoptionen sowie laufende regulatorische Entwicklungen zu berücksichtigten, die in dieser Studie nicht enthalten sind. Es sollte eine koordinierte politische Vorgehensweise angestrebt werden, um unerwünschte Umleitungen wirksam zu verhindern, Emissionen zu reduzieren und den Aufbau einer Kreislaufwirtschaft zu unterstützen.

Für einen praktischen und zeitnahen Start der Einbindung von Deponien in das EU-Emissionshandelssystem könnten folgende Ansatzpunkte in Betracht gezogen werden:

Geltungsbereich (Deponieklassen, Abfälle, THG Emissionen)

- Nur Deponien, die Siedlungsabfälle annehmen
- Nur Emissionen aus neu deponierten Siedlungsabfällen
- Nur Methan

Der Geltungsbereich könnte in Zukunft erweitert werden.

Festlegung des Caps

- Die Anpassung des Caps beginnt im ersten Jahr der Abgabepflicht.
- Die Anpassung könnte auf den erwarteten lebenszyklusbasierten Methanemissionen der (neu) abgelagerten Abfälle in einem Jahr beruhen, aufgeteilt über mehrere Jahre gemäß den MRV-Vorgaben.

MRV Pflichten

Es könnten zwei MRV-Methoden angewendet werden:

Methode 1:

Bestimmung der Emissionsfaktoren nach IPCC-Leitlinien

- Phase-in: Die MRV-Pflicht kann zunächst mit der Meldung der akzeptierten Siedlungsabfallmengen, der entsprechenden Abfallzusammensetzung zur Bestimmung von Default-Werten sowie Informationen zur Vorbehandlung beginnen.
- Nach Abschluss der Phase-in-Periode kann MRV mit mitgliedstaatenspezifischen Default-Werten starten; deponiespezifische Werte könnten zunächst optional und nach einer Übergangsphase ggf. verpflichtend werden.

Methode 2:

Bestimmung der Emissionsfaktoren mittels Laboranalysen

- Die angenommenen Siedlungsabfallmengen sowie die Ergebnisse **repräsentativer Probenanalysen** müssen gemeldet werden.
- Proben einzelner Abfallströme werden in **akkreditierten Laboren** analysiert, um die Emissionsfaktoren der jeweiligen Abfälle zu bestimmen.
- **Testmethoden**: Gasbildungsrate (GB21), Atmungsaktivität (AT4) oder vergleichbare Verfahren zur direkten Messung der Gasbildung (siehe deutsche Deponieverordnung für weitere Details). Für den EU-ETS 1 ist es zielführend, das Ergebnis als Menge an gebildetem Methan (in kg) pro Abfallmenge (in Mg Feuchtmasse) darzustellen. Je nach gewählter Messmethode (GB21 o.ä.) ist daher eine Umrechnung des Laborergebnisses erforderlich. Wird bspw. die gesamte gebildete Gasmenge gemessen, so ist nur der Methananteil anzugeben. Die Laborwerte müssen zudem ggf. durch einen Korrekturfaktor angepasst werden, um das langfristige Abbauverhalten abzubilden.

- Alternativ könnten **deponiespezifische Default-Faktoren** bestimmt werden, basierend auf vor Ort analysierten Proben des Siedlungsabfalls.

Festlegung von Standardwerten

Methode 1:

- Die Phase-in-Periode sollte genutzt werden, um **DOC-Default- Werte für gemischte Abfälle** zu bestimmen. Dafür sind repräsentative Abfallanalysen nötig, um die Zusammensetzung und den Anteil biologisch abbaubarer Fraktionen zu bestimmen.
- Es sollten unterschiedliche Default-Werte für vorbehandelte und nicht vorbehandelte Abfälle festgelegt werden.
- Die Werte sollten **mitgliedstaatenspezifisch** berechnet werden, basierend auf nationalen Abfallzusammensetzungen und Vorbehandlungsanforderungen.

Methode 2:

- Falls deponiespezifische Default-Werte genutzt werden, sollten diese bereits in der Phase-in-Periode bestimmt werden.
- Die Berechnung erfolgt anhand zufällig gezogener Proben je Deponie. Die Werte sollten regelmäßig aktualisiert werden.

Feststellung der Abgabepflicht

Ex-ante-Ansatz:

- Die Abgabepflicht für Zertifikate entsteht zum Zeitpunkt der Ablagerung, basierend auf einer berechneten Prognose der zukünftigen Methanbildung, die ggf. über mehrere Jahre verteilt wird.

Zeitplan

- Beginn mit zwei Jahren verpflichtender Berichterstattung und Tests, um Default-Werte festzulegen.
- Gleitender Einstieg in die Abgabepflicht (analog zum maritimen Sektor).

1 Background

As part of the European Green Deal, the regulation of greenhouse gas emissions from the waste management sector is increasingly taking centre stage. Thermal treatment plants that generate energy from waste play a key role here: they reduce waste volumes and contribute to resource utilisation, but also produce CO_2 emissions. Against this background the European Commission will provide by 31 July 2026 an impact assessment and a subsequent legislative proposal on the potential integration of municipal waste incineration plants (MWIs) into the European Emissions Trading System (EU-ETS 1) from 2028 onwards and how to avoid possible redirection effects to landfills or abroad.

Given the possible inclusion of MWI into the EU-ETS 1, this study examines **whether** and **to what extent a parallel inclusion of landfills into the EU-ETS 1** would be **appropriate** and **necessary**. To this end the analysis focuses on the **risks of possible waste diversion from** thermal waste treatment installations to landfills, and on **initial conceptual considerations for a potential integration of** landfills in the EU-ETS 1. It does however not include a conclusive assessment of all the benefits and drawbacks of a landfill integration. Instead, the study serves as a basis for **discussion,** outlining key questions, critical interdependencies, and areas requiring further research.

The study begins with a short overview of relevant **background information**, including waste generation, treatment routes, and the role of the circular economy. Subsequently the EU-ETS 1's relevance for the waste sector and how it fits into the broader regulatory framework is discussed. This is followed by a qualitative assessment of factors driving the **risk of waste redirection** to landfills and overarching considerations for landfill inclusion. Thereafter, an **initial conceptual approach** for integrating landfills into the EU-ETS 1 is presented, with a brief assessment of its potential advantages and drawbacks. Finally outstanding issues that cannot be fully addressed are identified as **topics for further research**.

1.1 Waste generation, disposal routes and GHG emissions

In the EU member states, a total of nearly 1,986 million tonnes of waste were treated in 2022.[6] The share of hazardous waste in the total waste treated was almost 100 million tonnes (5%).[7]

The total amount of **waste thermally treated** was almost 136 million tonnes (corresponding to 7 % of the total amount of waste treated), with incineration (disposal) accounting for 8.4 million tonnes and energy recovery for 127 million tonnes in 2022.[8] The share of hazardous waste that was incinerated was 10.6 million tonnes (Eurostat, 2025b).[9] In total, almost 47 million tonnes (34%) were accounted for by household and similar waste, 37 million tonnes (27%) by sorting residues,[10] and nearly 22 million tonnes (16%) by wood waste (Eurostat, 2025b).[11]

[6] Please refer to supplementary information in the Annexe, SI 1: European Waste Statistics.

[7] Please refer to supplementary information in the Annexe, SI 2: Waste amounts treated in the EU member states in 2022.

[8] Please refer to supplementary information in the Annexe, SI 3: Classification of thermal treatment of waste.

[9] Data for 2022. The abbreviation ENV_WASTRT refers to Eurostat database titled "Treatment of waste by waste category, hazardousness and waste management operations"

[10] For additional information please refer to the Annexe, SI 4: EWSTAT category „Sorting residues"

[11] Data for 2022.

The share of **landfilled waste** was 591 million tonnes, corresponding to 30 % of total treated waste; of these, nearly 41 million tonnes (7 % of the total landfilled amount) were hazardous waste (Eurostat, 2025b).[12] Mineral waste accounted for the largest share of landfilled waste (together, almost 514 million tonnes, corresponding to 87%) (Eurostat, 2025b).[13] Household and similar wastes[14] accounted for 6% of the landfilled waste volume (28 million tonnes), and sorting residues accounted for 6% (36 million tonnes) (Eurostat, 2025b).[15]

According to the EEA, the waste sector (CRF 5) was responsible for 109 million tonnes of CO_2-equivalent emissions in 2023 in the EU Member States, mainly due to methane emissions from managed solid waste disposal (i.e. landfills), which account for 60 % of the sector's greenhouse gas emissions (EEA, 2025). Combustion-related emissions constitute only a minor share, as waste incineration with energy recovery is allocated to the energy sector rather than the waste sector. Emissions from Municipal Waste treatment are therefore accounted for in both the waste and the energy sector.[16] Recycling activities, by contrast, are generally attributed to the industrial processes and product use sector rather than to the waste sector.

Supplementary information in the Annexe: Waste treatment by category

A detailed overview of waste thermally treated or landfilled in EU Member States in 2022 is provided as supplementary information (SI) - SI 2: Waste amounts treated in the EU member states in 2022 in the Annexe. The data covers total waste treated across the 27 EU Member States, including the share incinerated or landfilled, broken down by main waste categories according to the EWC-Stat classification. A distinction is made between hazardous and non-hazardous waste.

For this short study, waste categories were identified that include, at least in part, waste codes for municipal and similar waste (e.g., household and comparable sources). Categories containing biodegradable waste were also identified, as landfilling such waste is considered climate-relevant.

Due to limited data availability at the waste code level in most Member States, a robust quantitative assessment was not feasible within the scope of this project.

To assess the climate relevance of disposal routes, it is not only the quantity of waste treated that is decisive, but above all its **material composition**. A distinction must primarily be made between organic and fossil waste components. During landfilling, the microbial decomposition of organic materials, particularly, produces considerable quantities of methane, a greenhouse gas that is particularly harmful to the climate. Although fossil waste is essentially inert in landfill sites and does not lead to GHG emissions, it contributes to long-term environmental pollution. By contrast, while organic waste, such as wood, paper, or organic residues, is considered climate-neutral when incinerated, as the CO_2 released was previously bound by plants, fossil waste—such as plastics—leads to non-zero-rated greenhouse gas emissions when incinerated.

Organic content is generally not reported separately in European Waste Statistics (EWSTAT). However, specific waste codes are known to be either wholly or partly biogenic and can be assigned to EWSTAT categories. Direct shares cannot be derived from these codes, except for fully biogenic ones, because the biogenic fraction varies across waste streams and countries. For

[12] Data for 2022.

[13] Data for 2022.

[14] For additional information please refer to the Annexe, SI 5: EWSTAT category "Household and similar waste".

[15] Data for 2022.

[16] Not all of the emissions from landfills and waste incineration can be attributed to municipal waste treatment since the numbers include emissions from other treated waste as well. A detailed analysis of the emissions from municipal waste treatment was beyond the scope of this study.

initial orientation, the waste fractions containing a biogenic component are highlighted in Annexe, SI 2: Waste amounts treated in the EU member states in 2022.

Regarding the indicative classification of waste types containing organic fractions, it is evident that around 11% (66.5 million tonnes) of landfilled waste may include organic components—16% (93.5 million tonnes) if smaller shares in industrial sludges and mineral wastes are also considered.

The largest share of landfilled waste fractions with partial organic content is made up of household and similar wastes, as well as sorting residues, which together account for 64.2 million tonnes (97%) of the landfilled waste containing organic fractions within the EU. Since household and similar wastes are typically mixed waste streams, the separation of fossil and organic components can often not fully be achieved.

For sorting residues, a more differentiated assessment is necessary because organic content in sorting residues can vary significantly depending on their origin and the processing method used. Sorting residues from mechanical-biological treatment plants (MBT) typically contain higher shares of organic substances, as they originate from mixed municipal waste that is mechanically separated before biological treatment. Organic-rich components often remain in the residual fractions; the proportion depends on the MBT plant's technology.

In contrast, sorting residues from plastic sorting facilities usually have a significantly lower organic content, as these facilities specialise in separating packaging plastics from relatively clean input materials such as those from the Yellow Bag system. Nevertheless, organic contamination can still occur here—for example, due to improperly disposed food waste or dirty packaging.

1.2 Waste management as part of the circular economy

Waste management is a central component of modern environmental and resource systems. It encompasses the collection, treatment, recycling, and disposal of waste to minimise environmental pollution, conserve resources, and protect public health. Waste can be categorised according to its origin and composition, for example, as municipal waste, commercial and industrial waste, construction and demolition waste or special waste such as hazardous substances, sewage sludge and refuse-derived fuels (RDF). The treatment options range from material recovery and recycling through mechanical-biological processes to thermal treatment and landfilling. Legal requirements and EU directives seek to promote environmentally friendly collection, treatment and storage.

Sustainability and the circular economy are becoming increasingly crucial for conserving resources, reducing emissions, and minimising the environmental impact of waste streams. The waste management industry is gradually transforming itself from a pure "waste disposal company" to a resource manager that simultaneously ensures the safe handling of non-recyclable waste and recovers valuable secondary raw materials.[17]

This transformation in waste management is closely linked to the objectives of the European Green Deal which forms the basis for a macroeconomic shift towards a circular economy within the EU. The aim is to decouple economic growth from resource consumption and achieve climate neutrality in Europe by 2050. Waste management in the EU is thereby evolving from a reactive “end-of-pipe” system to a proactive enabler of resource security, secondary raw material provision, and climate neutrality.

[17] For additional information, please refer to the Annexe, SI 7: Transformation of Waste Management.

Political instruments, such as recycling quotas, directly affect the design of waste composition streams and plant technologies and thus the amount of waste available for thermal treatment or landfilling, as well as the resulting emissions. This creates a dynamic interplay among the regulatory framework, technical infrastructure, and ecological goals.

The **Waste Framework Directive** (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives (Text with EEA Relevance), 2008) (WFD, last amended by 2018/851) sets out the framework for EU waste management. It defines key terms, establishes the five-stage waste hierarchy, requires separate collection and promotes resource efficiency. It also introduces the extended producer responsibility (EPR)[18] and requires member states to adopt national waste strategies for sustainable waste management. It establishes the framework for all subsequent EU waste directives, including the **Waste Incineration Directive** (Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the Incineration of Waste, 2000) which sets emission limit values for the thermal treatment of waste. This directive was later integrated into the **Industrial Emissions Directive** (Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial Emissions (Integrated Pollution Prevention and Control) (Recast) (Text with EEA Relevance), 2010) to ensure harmonised environmental and energy efficiency standards. The **Landfill Directive** (Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste, 1999) regulates the landfilling of waste and sets requirements for landfill construction, leachate, the reduction of biodegradable waste and landfill gas treatment.

1.3 EU Emission Trading System and Waste Management

In addition, to environmental standards, greenhouse gas emissions from waste management are becoming increasingly important. The **EU-ETS 1** uses carbon pricing to incentivize emissions reductions and the broad adoption of climate-friendly technologies. Until now, according to the Monitoring and Reporting Regulation (MRR) emissions from MWI must only be reported and no certificates need to be surrendered while landfill operators are not required to monitor emissions.

The aim of a possible EU-ETS 1 inclusion of MWI is to price CO_2 emissions from thermal treatment, incentivising reductions in emissions, recycling, and waste avoidance, while ensuring a level playing field across different sectors in the EU. This measure could complement existing waste legislation.

On the basis of the gathered data, the European Commission will by 31 July 2026 provide an impact assessment and a subsequent legislative proposal on the potential integration of municipal waste incineration plants from 2028 onwards. The evaluation will also analyse whether a transition period is necessary and how redirection effects to landfills or abroad can be avoided.

The ETS Directive lays out a list of key criteria for the assessment (*Delivering the European Green Deal: On the Path to a Climate-Neutral Europe by 2050*, n.d.):

- Fair competition: Ensuring a level playing field for Member States and companies.
- Avoidance of waste redirection: No redirection to landfills or abroad to avoid ETS costs.
- Environmental integrity: No compliance gaps for climate protection targets.

[18] For additional information, please refer to the Annexe, SI 9: Extended Producer Responsibility (EPR).

- Compatibility with the Waste Framework Directive: Compliance with the waste hierarchy and circular economy objectives
- Data reliability (MRV): Precise recording and separation of fossil and organic CO_2 emissions.

Against this background, this study will focus on the potential **risks of municipal waste being redirected from MWI to landfills due to induced CO_2-costs in case of an MWI-integration into the EU-ETS 1**. Initial considerations on the necessity and possible options for including landfills in the EU-ETS 1 will be derived from this.

2 Risk of waste redirection

If **MWI** will be integrated in the EU-ETS 1, there is a risk that actors in the waste sector could shift fossil and mixed **waste streams** to **landfills**, in order to avoid the carbon price. This diversion would lead to increased methane emissions from landfills, with significant climate consequences, while also undermining ecological goals by allowing fossil carbon to accumulate in landfills. To assess this risk, it is essential to consider the **legal framework** for landfill disposal in the EU as well as international waste legislation, including **economic and regulatory incentives**, the risk of **illegal transboundary waste shipments** and the **capacities and availability of alternative disposal routes.**

Key factors include the **relevant plants and waste types**, the effects of **carbon pricing**, differences in regulations across Member States, the **capacities and availability of alternative disposal routes**, and compliance with national and international **waste legislation**. While these aspects are critical for understanding potential **waste redirections**, they are outlined only briefly in this study; a detailed evaluation would require further analysis. Another important factor which was beyond the scope of this study is the capability of MWI operators to pass on carbon costs.

2.1 Legal Framework to restrict landfilling of waste

This chapter outlines the EU-level directives, national implementations, and transboundary shipment regulations that influence redirection risks.

2.1.1 EU Legal Framework

The European Union has laid down, which types of waste may not be deposited in landfills (direct landfill ban) and which may only be deposited to a minimal extent or not at all (indirect landfill restriction).

The **Landfill Directive** (Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste, 1999) explicitly excludes certain types of waste from landfilling, including for instance oxidising and (highly) flammable substances and untreated waste (Council Directive 91/689/EEC of 12 December 1991 on Hazardous Waste, 1991; Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste, 1999). Moreover, it also obliges member states to reduce the landfilling of biodegradable municipal waste drastically and requires that waste be pre-treated before landfilling (article 6(a)) to minimise environmental impacts. Until 2020, no more than 35% of the biodegradable waste generated in 1995 could be landfilled. The current target is to reach a maximum of 10% municipal waste by 2035, with an extension to 2040 possible under certain conditions, referring to the amounts landfilled in the respective year (Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018 Amending Directive 1999/31/EC on the Landfill of Waste (Text with EEA Relevance), 2018). From 2030, recyclable or recoverable waste may no longer be landfilled - unless landfilling is the most environmentally friendly option (Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018 Amending Directive 1999/31/EC on the Landfill of Waste (Text with EEA Relevance), 2018).

However, the EU Commission's report from 2023 shows considerable implementation deficits:

- 15 Member states[19] do not fully implement the pre-treatment obligation. The municipal waste landfilled by these Member States amounted to 37.1 million tonnes in 2022,

[19] Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, Spain

representing 71% of the municipal waste landfilled across all EU Member States (Eurostat, 2026a).

- 13 Member states[20] are a long way from achieving the 10 % target for 2035 (European Commission, 2023).

In addition to the Landfill Directive the **Waste Framework Directive (WFD)** (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives (Text with EEA Relevance), 2008) defines the basic principles of waste management and aims to minimise environmental impact and promote the circular economy. A central element is the **five-step waste hierarchy**.[21] When applied consistently, the hierarchy implies that all combustible waste — including mixed municipal waste and residues from mechanical-biological treatment (MBT) or mechanical-physical treatment (MPT)—should primarily be subject to energy recovery, with landfilling being the last option in the waste hierarchy.

The directive also stipulates the separate collection of paper, glass, plastics, metals and biowaste and sets binding recycling quotas for municipal waste. In addition, there are **sectoral requirements**, such as the Packaging Ordinance (Regulation (EU) 2025/40 of the European Parliament and of the Council of 19 December 2024 on Packaging and Packaging Waste, Amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and Repealing Directive 94/62/EC (Text with EEA Relevance), 2024), the Directive on waste electrical and electronic equipment (WEEE Directive), and the Single-Use-Plastics (SUP) Directive (Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the Reduction of the Impact of Certain Plastic Products on the Environment (Text with EEA Relevance), 2019), which address specific material flows and further reduce landfill pressure. The **Circular Economy Action Plan** (*Circular Economy: The EU Aims to Transition to a Circular Economy for a Cleaner and More Competitive Europe*, n.d.) also promotes material recycling and a product design-oriented approach to minimise the use of non-recyclable materials.

The waste streams "non-pretreated waste" and "other waste types" are particularly relevant for assessing possible redirection risks, as they could be preferentially diverted to landfills due to CO_2 pricing of MWI. The regulations on landfill restrictions for biodegradable waste are particularly relevant from a climate perspective as biodegradable organic fractions in landfills are responsible for methane formation, leading to significant greenhouse gas emissions.

Unfortunately, many requirements under the Waste Framework and Landfill Directives are set to only take effect in the medium term. While the inclusion of waste incineration plants in the EU-ETS 1 is proposed to take effect from 2028 (subject to political approval), the 10 % landfill cap target and further recycling targets will not be fully implemented until 2035. The legal framework, therefore, has a limited impact in the short term but, if fully implemented, could enable effective prevention of redirection in the medium and long term.

2.1.2 National landfill bans/restrictions and taxes

Many EU member states have enacted comprehensive bans or restrictions on landfilling for specific types of waste. The basis is the EU Landfill Directive, which makes provisions for both organic and inorganic substances, including Total Organic Carbon (TOC).[22] An exception applies to **municipal waste**, where **compliance with TOC values is not mandatory if the waste has**

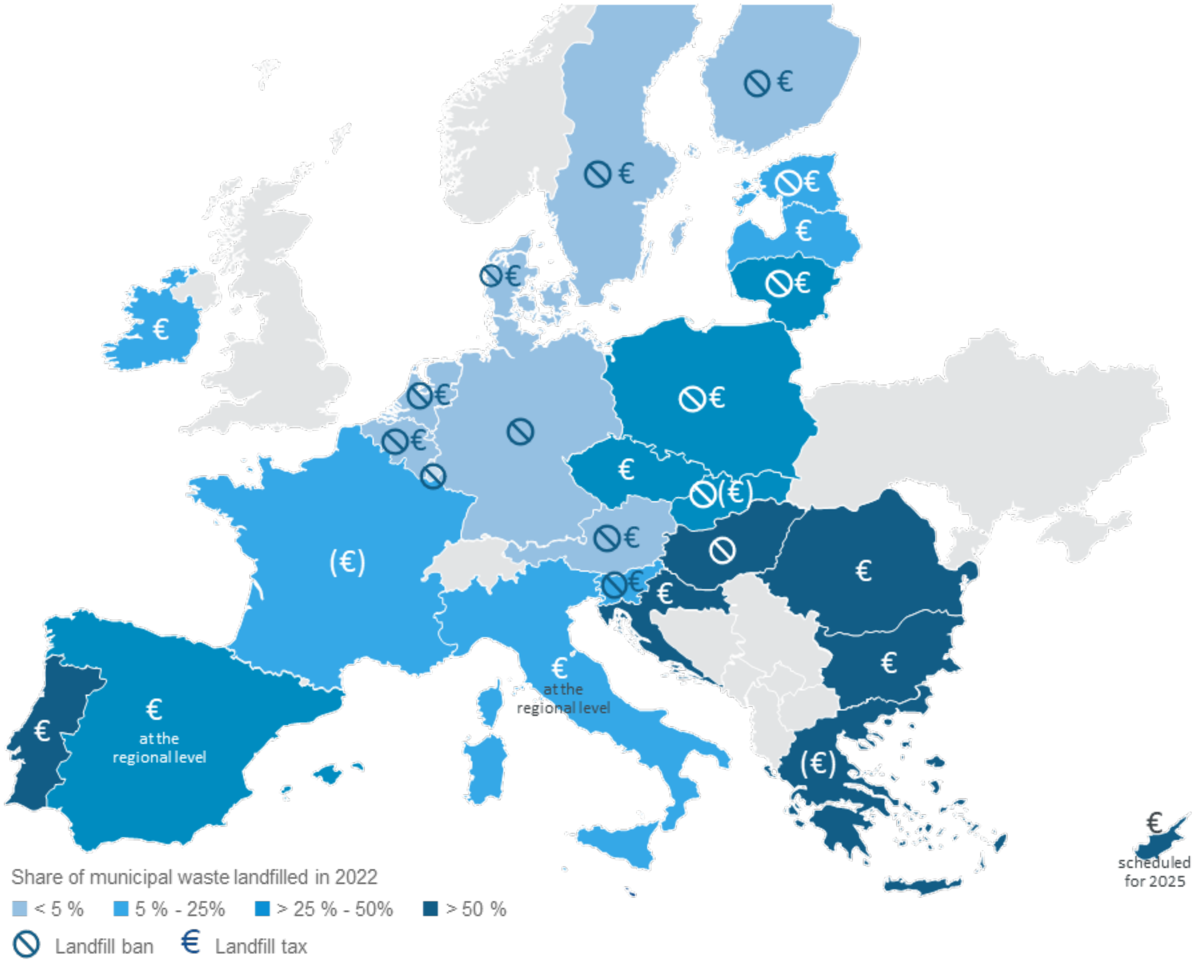
[20] Bulgaria, Croatia, Cyprus, Czech Republic, Greece, Hungary, Latvia, Malta, Poland, Portugal, Romania, Slovakia, Spain.

[21] For additional information, please refer to the Annexe, SI 11: The five-step waste hierarchy.

[22] For additional information, please refer to the Annexe, SI 13: Total Organic Carbon (TOC)

undergone appropriate treatment before landfilling, as specified in Council Decision 2003. The exemption for municipal waste allows for higher methane emissions, which must be critically assessed from an environmental perspective.

Figure 1: Landfill ban and taxes in place compared to the share of municipal waste landfilled in 2022



‚Regional level' refers to the fact that landfill taxes were introduced in specific regions only, not nationwide.
Source: CEWEP, 2021; EEA, 2023; Eurostat, 2026 (data for 2022), additional research and own illustration, Prognos AG 2025.

The implementation of the EU Landfill Directive varied considerably among the member states, both in terms of timeframe, level of ambition, and specificities (CEWEP, 2021; EEA, 2023). While countries such as Germany, Austria, Scandinavia and the Benelux countries have introduced comprehensive **landfill bans** based on TOC limits or for certain types of waste, other countries have only partial bans (e.g. Poland for combustible waste, Slovenia for wood waste).

The landfill bans can be roughly divided into three categories:

- Primarily biodegradable waste (e.g. Croatia, Luxembourg - partly not implemented)
- Organic and fossil waste (e.g. Austria, Belgium, Denmark, Germany, France, from 2025 also for recyclable fractions)
- Non-organic waste only (e.g. Hungary, Lithuania, Poland).

However, some countries have not imposed any additional bans beyond the EU minimum. Restrictive landfill bans are lacking in Ireland, Bulgaria, Greece, Latvia, Malta, Cyprus, Romania, Italy, Spain (except in some regions for organic waste), and Portugal. Particularly in Spain and Italy, there are significant regional differences, as no nationwide regulation is in place (CEWEP, 2021; EEA, 2023). In the Czech Republic, a ban originally planned for 2024 has been postponed to 2030 (MŽP, 2020).

In most EU member states, **landfill taxes** have been introduced, but their amounts vary significantly across the region. These taxes aim to make all landfilling unattractive, not just the prohibited types of waste. They are typically paid by the landfill operators, who may pass the costs on to waste producers or municipalities. Usually, a flat rate per tonne is applied, regardless of the type of waste. Some countries use differentiated rates to specifically control specific fractions, such as higher charges for combustible or recyclable waste in Austria, Belgium, the Czech Republic, Latvia, Lithuania, Slovakia, and Spain. There are no landfill taxes in Croatia, Cyprus, Germany, and Malta. In Germany, a comprehensive ban on landfills is in effect.

Comparatively high taxes of more than € 100/t have been introduced in Belgium (Wallonia for mixed waste, Flanders for combustible waste), France, Sweden, Ireland, and Finland. Particularly in Eastern Europe, however, the tax rates are often significantly lower (CEWEP, 2021).

Despite a dense network of bans and financial steering instruments, considerable implementation gaps remain. This is evident in the persistently high landfill rates in selected member states and is also reflected in the early warning reports issued by the EU Commission (*Early Warning Assessment Related to the 2025 Targets for Municipal Waste and Packaging Waste*, n.d.; European Commission. Directorate General for the Environment. et al., 2017). The 2023 report found that Member States are not currently utilising the full range of economic measures to reduce landfilling and incineration (such as landfill and incineration taxes).[23]

The main reasons for implementation gaps include, in particular:

1. **Lack of infrastructure**: without sufficient capacity for recycling, composting or thermal utilisation, bans and taxes only have a limited effect.
2. **Insufficient economic incentives**: low fees reduce the control effect and favour evasion or illegal disposal.
3. **Weak control and enforcement**: laws often only exist on paper (e.g. numerous illegal landfills in Romania) (Court of Justice of the European Union, 2023).
4. **Socio-economic and political factors:** financial bottlenecks, low administrative capacities, lack of prioritisation and lack of acceptance hinder implementation.

Without effective complementary measures - such as landfill bans, high landfill taxes or targeted promotion of alternative recycling routes - the risk of redirection increases, particularly in countries with low or no landfill taxes and/or weak control and enforcement, **Moreover, the regulatory and implementation deficits mean that the necessary build-up of thermal waste treatment capacities for non-recyclable waste and medium- and high-calorific fractions from MBT are not being built up, or only after a very long delay.**

Mechanically and biologically pre-treated waste (MBT-stabilised waste) deposited in landfills has a reduced, but not negligible methane formation potential, which is even higher in CO_2-equivalent terms than the direct thermal utilisation of this fraction, which also generates energy.

[23] Best-practice examples include Austria, the Netherlands, Germany, and Slovenia. These countries combine high landfill taxes or bans with effective separate collection systems, pay-as-you-throw schemes, and strong regulatory frameworks to minimise landfilling and promote recycling and recovery.

2.1.3 Regulations for transboundary shipment of waste

With the Regulation on transboundary shipment of waste (Regulation (EU) 2024/1157 of the European Parliament and of the Council of 11 April 2024 on Shipments of Waste, Amending Regulations (EU) No 1257/2013 and (EU) 2020/1056 and Repealing Regulation (EC) No 1013/2006 (Text with EEA Relevance), 2024), which will be gradually applied from May 2026, the EU is tightening its rules on the export of waste - both within the EU and to countries outside the EU. For exports to non-EU countries, particularly non-OECD states, stricter conditions apply: such exports are only permitted if the receiving country can demonstrate its ability and willingness to manage the waste in an environmentally sound manner. Even for OECD countries, enhanced monitoring and verification requirements, such as independent audits, are introduced to ensure compliance. The aim is to curb illegal waste flows, prevent the export of waste that cannot be treated in an environmentally friendly manner and strengthen the European circular economy.

In doing so, the EU is going beyond of the **Basel Convention** of 1989 (*Basel Convention - Home Page*, n.d.), which serves as the global foundation for managing the shipment of waste. It obliges the signatory states to authorise the transboundary transport of hazardous and other waste, including municipal waste, only with the prior informed consent (PIC) of the states concerned and to ensure environmentally sound disposal. Amendments to the agreement, particularly in 2019, also extended the strict controls to plastic waste. At the same time, an OECD decision from 2001 (Decision of Council Concerning the Revision of Decision C(92)39/FINAL on the Control of Transboundary Movements of Wastes Destined for Recovery Operations, 2004) regulates the shipment of waste among industrialised countries. A simplified procedure applies to "green"-listed waste for recycling, while "amber"-listed materials are monitored more strictly. The aim is to achieve a functioning recycling trade within the OECD.

The **new EU regulation** not only implements these international standards, but also significantly tightens them. From May 2026, the export of waste for disposal will be generally prohibited. It will only be permitted in minimal exceptional cases if no suitable treatment is possible in the country of origin and all authorities involved agree, including the competent authorities of dispatch, transit, and destination, both within the EU and in third countries. The PIC procedure will apply to plastic waste from the same date, with a complete export ban to non-OECD countries from November 2026 for an initial period of 2.5 years. As of May 2027, all receiving facilities abroad must undergo independent audits to ensure environmentally sound recycling practices. For other non-hazardous municipal waste, an export ban to non-OECD countries will also take effect from May 2027. Only if these countries comply and prove that they can treat waste in accordance with EU standards will they be placed on a regularly updated positive list.

The EU is thus adopting key elements of the Basel Convention - the precautionary principle, PIC mechanism and environmentally sound disposal - but is going a decisive step further: while Basel and the OECD are creating uniform minimum standards, the EU is effectively establishing an export ban on municipal and plastic waste to many third countries. It also relies on digitalisation (for example, through the future Digital Waste Shipment System) as well as strict controls and sanctions to create transparency regarding waste flows.

Risks and compliance gaps despite stricter regulations

Despite the ambitious requirements, there remains a risk that waste will be exported to third countries under the guise of "recovery" and not treated in an environmentally friendly manner. In practice, there are several potential compliance gaps:

1. **Unclear distinction between recycling and disposal**: In the past, waste streams were already formally labelled as recycling, even though they were actually landfilled or incinerated in open facilities. In the future, waste could also be minimally sorted or treated to legally classify it as recyclable, even though its environmental impact is equivalent to that of disposal (Directorate-General for Environment, 2024).
2. **Circumvention via OECD countries**: Although exports to non-OECD countries will be prohibited mainly in future, waste can first be exported to an OECD member and then forwarded from there. Such "hub models" are challenging to monitor, especially in countries with large processing and transit capacities (Directorate-General for Environment, 2024).
3. **Misdeclaration of waste**: Mixed loads or contaminated municipal waste could be passed off as "green"-listed recyclables or unmixed fractions. The declaration as a "product" or "secondary raw material"—for example, in the form of plastic granulate—can also be used to circumvent stricter waste regulations.[24]
4. **Dubious audits**: From 2027, all treatment facilities in third countries must be independently audited. However, the quality and independence of such audits cannot always be guaranteed. Sham audits or certifications with low standards could only formally document compliance with the regulations (Directorate-General for Environment, 2024).
5. **Limited inspection capacities**: The practical inspection of thousands of containers at European ports and borders is hardly possible without gaps. There is, therefore, a risk that incorrectly declared or mixed waste streams will remain undetected despite the new regulations (Commission Staff Working Paper Impact Assessment: Accompanying Document to a Legislative Proposal and Additional Non-Legislative Measures Strengthening the Inspections and Enforcement of Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on Shipments of Waste, 2013).

To summarise, the EU regulation sets much stricter standards than the Basel Convention and the OECD rules. However, its actual impact depends largely on consistent enforcement. Only if declarations are carefully checked, audits are independently monitored, and illegal exports are consistently sanctioned can compliance gaps be closed and sham utilisation effectively prevented.

2.2 Risk of Redirection for municipal waste

According to the EU-ETS 1 Directive installations for the **incineration of municipal waste** with a total rated thermal input exceeding 20 megawatts (MW) are already included in the scope of the EU-ETS 1 for the purpose of monitoring emissions since 2024. However, they **are not yet obliged to surrender certificates**. This includes facilities that treat household waste and comparable commercial waste, as defined in the **extended municipal waste definition.**[25] The 20 MW threshold aligns with the general ETS threshold for combustion plants. **Installations**

[24] This aspect is particularly relevant because fossil-based waste is likely to be affected by a diversion risk, while organic waste in MWI is assessed as climate-neutral. However, as the present analyses focus primarily on the diversion risk towards landfill, this point could not be examined in detail.

[25] For the definition of municipal waste, please refer to the Annexe, SI 14: Definition of Municipal Waste.

that incinerate industrial waste are already required to surrender certificates while hazardous waste incineration plants are completely excluded from the EU-ETS 1.

The inclusion criterion for the EU-ETS 1 is based on the **type of plant** (municipal waste incineration), not on the specific waste types. Whether a plant qualifies as an MWI and is therefore covered by the EU-ETS 1 is determined according to the predominant share of waste treated. Not only traditional municipal waste incinerators but also RDF power plants can be covered, which, by virtue of their permits or operational practices, either accept municipal waste directly or treat sorting and pre-treatment residues derived from municipal waste streams, such as those from MBT of mixed municipal waste. Once a plant qualifies as a municipal waste incineration facility, **all emissions must be reported**, regardless of whether industrial waste or sewage sludge is also thermally treated. The outlined criterion would also apply in case of a possible full integration of MWI in the EU-ETS 1 (including the obligation to submit certificates) such that only installations that qualify as hazardous waste incineration plants would be excluded. Based on the data gathered in the Monitoring phase (2024 to 2026) the EU will assess the feasibility of full MWI-inclusion in the EU-ETS 1.

For the sake of completeness, it is worth noting that in some EU Member States – including Germany, the Netherlands, and Sweden – municipal waste incineration plants are already subject to CO_2-pricing in the EU-ETS 1 or a national pricing scheme.

The data availability needed to assess covered waste streams poses some challenges. Eurostat statistics do not differentiate between plant types. Instead, Eurostat only categorises data by disposal (D-codes) or recovery (R-codes) methods (e.g., all thermal treatment plants (R1 – energy recovery and D10 – incineration without energy recovery, WFD) are grouped), making it challenging to isolate municipal waste incineration by plant type. For this reason, this study's further analyses are carried out from a waste-stream perspective.

For further analysis of potential redirection from MWI to landfill, the focus will be on municipal waste, as it is the defining waste stream for inclusion in the EU-ETS 1. Other waste types are relevant only to the extent that they are also thermally treated in these plants. In the Waste Treatment Statistics (WASTRT), municipal waste is not recorded as a standalone category. Instead, it is allocated to different waste categories based on composition and origin. National statistics partially utilise the 6-digit codes outlined in the European Waste Catalogue (EWC), which are then grouped differently for Eurostat reporting purposes.[26] This leads to **fragmented, non-transparent data, complicating the** precise demarcation of municipal waste volumes.[27]

To assess the share of municipal waste still being landfilled, this study uses EWSTAT Municipal Waste statistics (WASMUN) (Commission Implementing Decision (EU) 2019/1885 of 6 November 2019 Laying down Rules for the Calculation, Verification and Reporting of Data on Landfill of Municipal Waste in Accordance with Council Directive 1999/31/EC and Repealing Commission Decision 2000/738/EC (Notified under Document C(2019) 7874), 2019; European Commission, 2023). These include all waste collected by municipalities and private waste management companies, but do not differentiate further by type of waste.

By imposing a cost on fossil CO_2 emissions, the EU-ETS 1 inclusion of MWI would increase the absolute price of thermal treatment for municipal waste, particularly for non-recyclable (fossil) fractions (emissions from organic fractions would not be priced since biogenic emissions from

[26] For example, paper and cardboard (EWC 200101) and paper and cardboard packaging (EWC 150101) can be found in the EWSTAT group W072 - Paper and cardboard waste, biodegradable waste [EWC 200201] is assigned to the group W092 Vegetable waste. In the EWSTAT groups, they are then partially combined with corresponding types of waste from the commercial and industrial origin area.

[27] Please refer to the Annexe, SI 2: Waste amounts treated in the EU member states in 2022.

waste are zero-rated under the ETS). This higher cost reduces the economic advantage of incineration relative to other disposal or recovery routes. It could incentivise more sorting and recycling, but also a shift of waste toward landfilling, despite its lower position in the waste hierarchy. Such potential shifts illustrate the broader system of interlinked incentives and constraints that determine the risk of waste redirection.

Conceptually, such redirection risks arise whenever:

- a regulatory or economic intervention increases the cost of one treatment option (e.g. thermal treatment),
- alternative options remain available and less costly (e.g. landfilling), and
- Enforcement mechanisms are insufficient to prevent substitution.

In this sense, the inclusion of MWI in the EU-ETS 1 represents a potential "pressure point" within the waste hierarchy — intended to drive decarbonisation, but that may generate unintended redirection effects if other policy instruments are not aligned.

Three main domains shape these redirection dynamics:

- **Regulatory conditions**:
  The strength of landfill bans, the intensity of enforcement, and waste shipment rules determine whether redirection is legally and practically feasible.
- **Economic incentives**:
  The interplay of CO_2 prices, landfill fees, and transport costs determines whether redirection is financially attractive.
- **Structural and market factors**:
  The availability of waste incineration and landfill capacities, regional infrastructure, and control mechanisms affects whether redirection can actually take place in practice.

These domains interact and influence each other: inclusion in the EU-ETS 1 increases the operational costs of incineration, altering the cost hierarchy among treatment routes. Where regulatory or economic barriers are weak, this may lead to the undesired redirection of waste to cheaper, but environmentally inferior, options such as landfilling. The following chapters build on this conceptual framework by quantifying affected waste streams, assessing exposure across Member States, and analysing the key incentives and risk factors that determine the likelihood and scale of redirection risks.

2.2.1 Quantities and Regional Differences of Municipal Waste Treatment

Besides an increased potential of redirection of waste from MWI to landfilling in case of an MWI inclusion in the EU-ETS 1 it is important to acknowledge that a tightening of regulatory restrictions (like stricter methane emission controls) which works against this risk might lead to an overall net shift of organic waste from landfill to thermal treatment. The opposing effects would make it generally difficult to measure diversion effects of an MWI integration. Although this aspect is not analysed in detail here, it should be considered in a broader policy context to fully assess the reform's environmental and economic implications.

Moreover, waste is rarely generated as pure fractions; in practice, most waste streams—especially residual municipal waste and MBT and/or mechanical treatment (MPT) outputs—are complex mixtures of fossil and biogenic materials. This heterogeneity complicates the assessment of redirection risks and requires a nuanced analysis of how different components within mixed waste streams may respond to changing economic incentives.

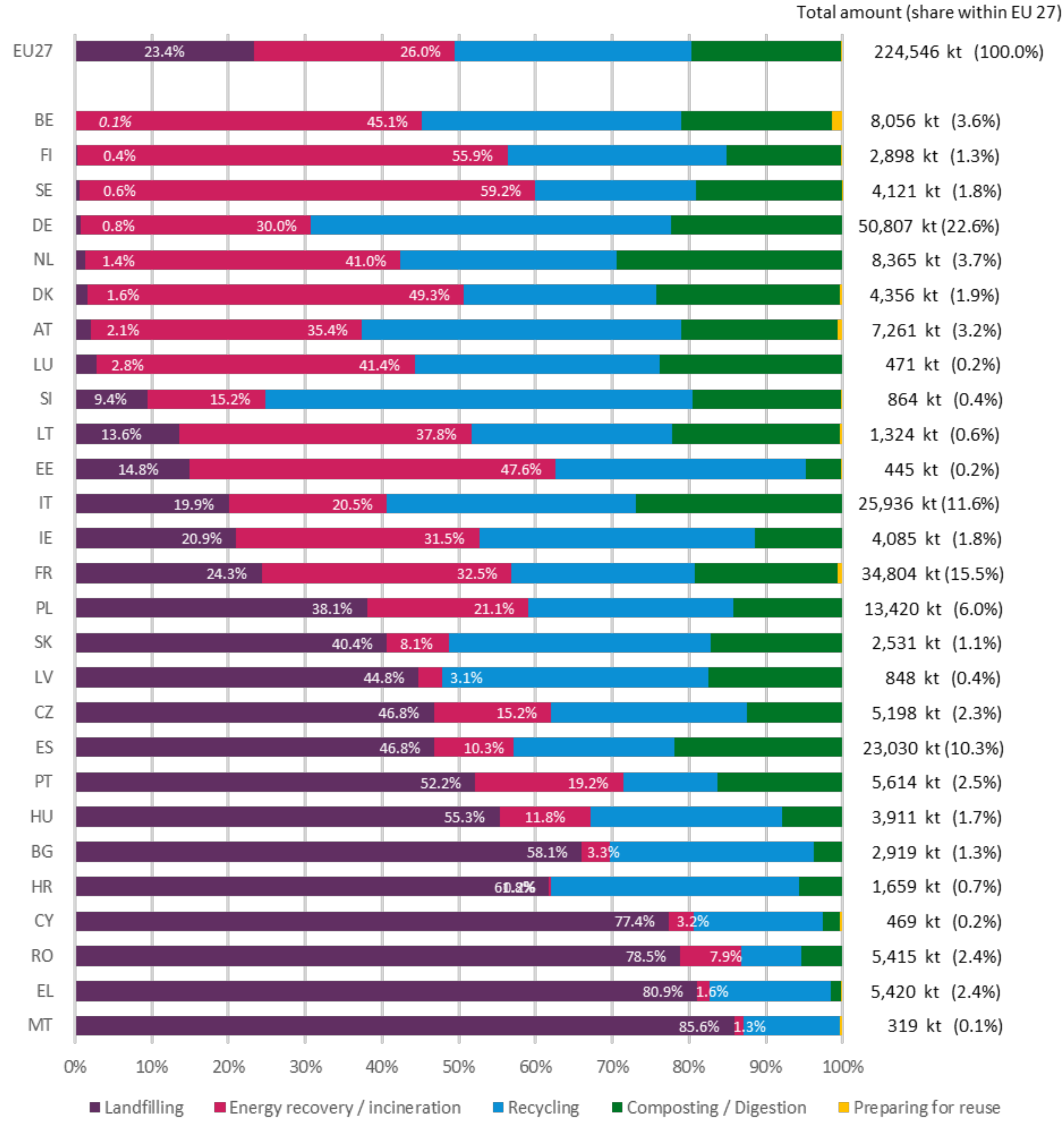
To assess potential redirection risks from integrating MWI into the EU-ETS 1, it is necessary to analyse the volumes of municipal waste currently sent to thermal treatment. This reveals the scale of affected waste streams and shows, by their distribution across Member States, which countries are most exposed based on the importance of incineration as a disposal route. The following section draws on WASMUN statistics to provide an overview of the relevant quantities and treatment routes. In 2022, approximately **225 million tonnes of municipal waste** were treated across EU Member States[28] of which **58 million tonnes** (26% of the total treated municipal waste) were **subject to thermal treatment**,[29] and **52 million tonnes** (23 %) were **deposited at landfills.**[30]

[28] Data is already available for 2023; for reasons of comparison with the ENV_WASTRT statistics, 2022 was selected as the reference year.

[29] Mainly with energy recovery (R1).

[30] Mainly with energy recovery (R1).

Figure 2: Municipal waste treatment, by EU member state (2022)[31]



Source: Eurostat, 2026 (data for 2022), own illustration (Prognos AG, 2025).

These averages mask significant disparities between Member States: while countries in Northern and Western Europe (e.g. Germany, Austria, Benelux) report minimal landfill shares, landfilling remains the dominant disposal route in parts of Southern and Eastern Europe, with shares exceeding **50%** in countries such as Portugal, Hungary, Bulgaria, and Romania, and even **above 80%** in Greece and Malta (Eurostat, 2026a).[32] In this context, countries such as France, Spain, Poland, Italy, Romania, and Greece, each with high absolute quantities of deposited municipal waste ranging from 4 million tonnes to almost 11 million tonnes, must be considered.

[31] For the detailed figures please refer to the Annexe, SI 15: Municipal waste amounts and treatment routes 2022.

[32] Data for 2022.

It is important to note that landfill data does not solely refer to the direct disposal of untreated mixed municipal waste, but that it covers both waste disposed of at the site of generation and waste sent to public landfills, whether domestically or abroad.

Crucially, this also includes residual waste from pre-treatment processes, such as sorting or MBT/MPT) (Eurostat, 2026a).[33] These secondary wastes must still be counted in national landfill statistics, even though they are no longer classified as primary municipal waste. There is currently no separate Eurostat data on MBT/MPT residues. The corresponding quantities are reported only in Eurostat in aggregated form under "non-recyclable municipal waste" or "waste for energy recovery", making it impossible to separate specific MBT residues at the EU level. This is particularly relevant in the context of the EU-ETS 1, given its association with fossil CO_2 emissions.

The potential diversion of municipal waste to landfills would be particularly problematic for climate policy, as landfills emit methane—a greenhouse gas with a global warming potential approximately 28 times that of CO_2 (over a 100-year horizon). While organic CO_2 from waste incineration plants is classified as climate-neutral, the same material flows have an incomparably higher climate impact when landfilled.

A recent analysis (Birnstengel et al., 2026) has shown that municipal waste deposited at landfills in EU Member States in 2022 alone—amounting to at least 52 million tonnes—could lead to methane emissions equivalent to 45 million tonnes of CO_2e by 2130 (based on GWP100). Even under a strict implementation of the Waste Framework Directive, assuming the 10% landfill target for municipal waste is achieved by 2035 (or 2040 for selected Member States assumed to make use of the derogation option) and maintained then at the 10%-level until 2050, methane emissions from newly deposited waste starting from 2022 would still amount to 622 million tonnes of CO_2e (GWP100) by 2130. This scenario assumes constant municipal waste generation and a linear reduction of landfilled waste until 2030. For Greece, Romania, Bulgaria, Cyprus, Croatia, Malta, and Slovakia, the use of the derogation option until 2040 was assumed. This could reduce emissions by 53% compared to continuing current trends.

It is essential to highlight that methane emissions persist for many years after municipal waste is deposited in landfills. In this estimated scenario, 27% (corresponding to 189 million tonnes CO_2e (GWP 100)) of total emissions would be released after 2050. Notably, the analysis only considers new deposits from 2022 onward; emissions from historical waste deposits are not included.

The calculations are based on EU-27 aggregate values, not a country-by-country aggregation, as the study conducted a detailed analysis only for selected countries. A methane recovery rate of 34% (2023 average across EU Member States) was assumed, based on information provided in the National Inventory Report for the EU 27 member states (EEA, 2025).

From a policy perspective, assessing redirection risk requires understanding not only the total volume of thermally treated waste but also its composition. The higher the share of fossil-rich waste, the stronger the potential economic incentive to divert to cheaper, non-EU-ETS 1 disposal routes, especially where landfill fees are low or enforcement is weak.

However, when considering not only the integration of MWI into the EU-ETS 1 but also a possible future integration of landfills, this fossil-focused view would be insufficient. In the case of an integration of landfills, especially when assessing the climate impact, as discussed above.

[33] Data for 2022.

Thus, while fossil components are central to evaluating redirection risks from incineration to landfills, the organic components are key to assessing the climate relevance of said redirection. Both dimensions must be considered separately but in conjunction when determining the regulatory scope and environmental impact of waste treatment pathways.

The share of thermally treated municipal waste across EU Member States provides only a partial indication of potential exposure to redirection risk. To structure the analysis, EU Member States are grouped based on their waste management systems and exposure to potential redirection:

1. **Countries with a high proportion of thermal treatment**, such as Germany, the Netherlands, Sweden and Denmark, where landfilling plays only a minor role. Here, the redirection risk is limited by the low availability of landfill alternatives, and functional landfill regulation further reduces national redirection risk. However, export risks, particularly for fossil-based waste streams such as plastics, synthetic textiles, and composite, may still arise (CEWEP, 2022), as operators could seek destinations with lower treatment costs or less stringent regulation. The cost impact of ETS inclusion is also most immediate for operators. Even though these fossil materials are associated with high CO_2 emissions during incineration the overall volume of such waste remains limited relative to the total municipal waste thermally treated. Effective enforcement of existing legal provisions, especially regarding (illegal) waste exports or sham recovery can help mitigate these risks.
2. **Countries with mixed waste treatment systems,** featuring moderate or still expanding thermal capacities and a still relevant proportion of landfilled municipal waste. These countries are **potentially most sensitive to redirection effects**, **as both options coexist**, and economic incentives can directly influence the choice. The overall risk is considered higher due to the continued availability of national alternatives within the waste infrastructure. There is also a risk that organic waste may be landfilled via mixed waste streams, undermining climate and resource protection goals.
3. **Countries with low or no thermal capacities,** where landfilling continues to dominate. In these regions, the introduction of the EU-ETS 1 for MWI could indirectly hinder the development of new thermal treatment infrastructure if costs rise disproportionately. The primary risk here lies in increased imports of waste from other countries. National redirection is less likely given the limited number of thermal treatment facilities. However, this situation could negatively impact climate and resource protection efforts by slowing down the expansion of necessary thermal treatment capacity. This aspect was not analysed in detail in the study due to its specific focus, but it warrants further investigation.

The likelihood and scale of these redirection effects depend on the interplay between waste composition, local treatment infrastructure, and the economic and regulatory framework. High fossil-content fractions, abundant low-cost landfill capacity, and weak enforcement create the highest risk of undesired redirection. Conversely, stringent landfill bans, effective monitoring, and limited alternative disposal routes reduce the practical feasibility of such shifts.

For completeness, it should be noted that redirection risks are also **linked to the availability of free landfill capacity**. However, the data on remaining landfill capacity in the European Union is very limited. While Eurostat publishes comprehensive statistics on the annual amounts of waste sent to landfills, it does not provide EU-wide data on the remaining volumes or available landfill capacity in the Member States. Such information, where it exists, is only available at the national or regional level, for example, through site registers or environmental reports of individual countries. A comparable, consolidated European data set that would allow robust statements on the availability or exhaustion of landfill space is currently unavailable.

2.2.2 Legal, Economic and Structural Drivers of Redirection Risk

The likelihood and extent of waste redirection to landfill depend on a combination of legal, economic, and structural factors.

1. Legal Framework

Landfill bans, regulations on cross-border shipments, and their enforcement critically influence redirection risks:

- In Member States with strict landfill bans and effective enforcement, options for redirection are limited. Conversely, weak implementation or tolerance for specific waste types increases the potential for redirection.
- Cross-border shipment rules under the EU Waste Shipment Regulation define the legal feasibility of redirection. While intra-EU transfers are allowed under reporting obligations, insufficient enforcement may enable redirection to countries with lower fees or weaker controls.
- The design of the EU-ETS 1 itself affects legal risk: reporting, compliance provisions, and exemptions determine whether operators comply or seek alternative disposal routes.

2. Economic Drivers

The potential inclusion of MWI in the EU-ETS 1 introduces direct cost signals that may alter disposal choices:

- Landfill gate fees: Low fees make redirection financially attractive.
- Transport costs: Logistical feasibility determines whether domestic or cross-border redirection is viable.
- Revenue from energy recovery or recyclable fractions: High energy or recycling value can counteract redirection incentives; low returns may reinforce them.

Redirection becomes likely when the combined cost of EU-ETS 1-compliant incineration exceeds the sum of landfill, transport, and compliance costs.

3. Structural and Market Conditions:

Physical and institutional conditions determine whether redirection is practically possible.

- Landfill capacity: Abundant, low-cost capacity facilitates redirection; scarcity constrains it.
- Thermal treatment infrastructure: Countries with high incineration capacity face direct EU-ETS 1 impacts, whereas regions with limited infrastructure may experience indirect effects, such as delayed development of new plants.
- Enforcement and governance: Strong monitoring and reporting systems reduce the risk of illegal disposal; weak controls increase uncertainty and potential for non-compliance.

The intersection of three domains determines the risk of undesired redirection from MWI to landfill:

- Legal constraints (bans, shipment rules, enforcement)
- Economic incentives (CO_2 pricing, gate fees, transport costs, revenues from energy/materials)

- **Structural and market conditions** (capacity, infrastructure, governance)

For example, abundant landfill capacity in a country with weak enforcement creates the highest risk, particularly for fossil-rich waste fractions subject to CO_2 costs.

2.2.3 Potential Redirection Effects in the Case of Including MWI

Building on the legal, economic, and structural drivers, the potential inclusion of MWI in the EU-ETS 1 could create new financial incentives that reshape waste flows. Depending on national frameworks, infrastructure, and enforcement, this can lead to both desired and undesired redirection effects. Three principal pathways can be distinguished:

1. **Desired redirection to material recycling**, where EU-ETS 1 pricing and policy measures make recycling economically preferable. This supports resource efficiency and fossil fuel substitution, representing the intended outcome of a well-aligned waste management system.
2. **Undesired redirection to landfills,** domestically or cross-border, where landfill fees are low, capacity is available, and enforcement of landfill bans or shipment restrictions is weak. Redirection to third countries may also occur under certain conditions.
3. **Illegal disposal,** particularly in regions with weak governance, limited monitoring, or low detection probability.

These pathways are shaped by the same legal, economic, and structural conditions identified above. The risk of undesired redirection is thus not uniform across the EU but context-specific, influenced by two main dimensions:

1. **Geographical:** redirection may occur within the same country, across EU borders, or to third countries, depending on logistics, regulatory constraints, and available landfill capacity.
2. **Waste composition**: Fossil-rich fractions (e.g. plastics, MBT/MPP residues) are most exposed to EU-ETS 1-related costs and hence most prone to redirection; organic fractions, though relevant for methane emissions, are not sensitive to EU-ETS 1 price signals as biogenic emissions from waste are zero-rated under the ETS.

To mitigate unwanted redirection, **complementary measures are essential**:

- Aligning landfill fees with EU-ETS 1 costs to reduce economic incentives for redirection.
- Ensuring robust enforcement of landfill bans and cross-border shipment regulations.
- Monitoring waste composition and cross-border flows, particularly fossil-rich fractions.
- Strengthen recycling and material recovery infrastructure as viable alternatives to landfill disposal.

While complementary measures such as aligned landfill fees, robust enforcement, and strengthened recycling infrastructure can mitigate undesired redirection, certain risks remain difficult to control—most notably illegal disposal. The following section examines this risk in greater detail, highlighting the mechanisms, scale, and consequences of illicit waste shipments both within and beyond the EU.

2.3 Risks of illegal disposal in cross-border waste transport

In addition to compliance gaps in sham recycling, illegal disposal is one of the most significant risks in the international waste trade. Despite existing international agreements and stricter EU regulations, the risk remains high that substantial quantities of waste are shipped to third countries in violation of legal procedures and are improperly treated there. Landfill inclusion like other waste regulations that make waste treatment more expensive within the EU could further increase that risk.

According to information from the Council of the European Union (Consilium) and other sources, it is estimated that between 15% and 30% of all waste shipments from the EU are illegal, meaning they are either uncontrolled or in breach of applicable regulations (Directorate-General for Environment, 2024; Igino Garruto & Grassin, 2024). Municipal waste, mixed plastics, waste electrical and electronic equipment and end-of-life vehicles are particularly affected. The forms range from deliberate misdeclaration to illegal shipping and transit via third countries. Waste is often labelled "green" even when it is contaminated or mixed. The declaration of a secondary raw material or product is also used to circumvent stricter regulations.

There is also hidden mixing: Shipments of recyclable materials often contain large quantities of non-recyclable fractions, which are disposed of or incinerated at lower cost in the destination country, a practice the EU's new Waste Shipment Regulation seeks to curb through tighter controls, digital traceability and stronger cross-border enforcement (*Waste Shipments*, n.d.).

The consequences are severe: illegal landfills, open incineration, and massive environmental pollution are created in the destination countries, while Europe loses valuable raw materials that could support the circular economy. There are also considerable reputational and legal risks associated with exporting. Interpol and Europol have been pointing out the close links between the illegal waste trade and organised crime for years.

Overall, although the new EU regulation establishes a strict set of rules, its effectiveness depends crucially on practical enforcement. Without a significant increase in control and inspection rates, stronger cooperation between authorities across Europe, and consistent sanctions against illegal exports, there is a risk that substantial quantities of waste will continue to be disposed of illegally. Given the need for additional measures to reduce emissions in the waste sector, which could increase incentives for illegal dumping, efforts to prevent this should be stepped up even further.

2.4 Summary

Summary

The risk of waste redirection from MWI to landfills exists, but the extent of this redirection will vary across countries. A comprehensive assessment must consider various parameters related to the aspects of "ability," "permission," and "willingness", which are interdependent (Pohl et al., 2022):

- **Ability ("Can"):** This refers to whether sufficient landfill capacity is available and whether redirection is economically feasible.
- **Permission ("May"):** This concerns whether legal regulations allow such redirection and whether effective enforcement mechanisms are in place.

- **Willingness ("Want"):** This relates to whether market participants might take countermeasures. For example, integrating thermal waste treatment into the energy supply system requires continuous fuel input. However, this aspect cannot be explored further within the scope of this study.

Redirection is more likely to be initiated by waste producers rather than plant operators.

Regardless of the specific circumstances, redirection effects are expected to occur, although the extent cannot be quantified within this study.

The inclusion of thermal treatment of municipal waste in the EU-ETS 1 results in varying redirection risks across country groups.

In **Group 1** (countries with low or no landfilling), there is a potential risk of redirection, particularly of **fossil-rich and potentially mixed waste**, to other countries, as national MWI may lose competitiveness due to EU-ETS 1-related costs. This is likely to concern **secondary waste streams**, such as sorting and processing residues, rather than **primary waste** directly from households or businesses, because these flows are typically more transferable across facilities and borders.

In **Group 2** (countries with partially available landfill capacity and a higher share of thermal treatment), there is an increased risk of **redirections within the country** – especially for **mixed and fossil-rich waste**, if landfilling is not equally regulated.

Group 3 (countries with high landfill rates) shows limited potential for redirections within the country due to a lack of MWI capacities but is vulnerable to **imports of fossil-rich waste**.

The distinction between **primary waste** (directly from households or businesses) and **secondary waste** (e.g., sorting residues, refuse-derived fuels) is relevant for assessing whether accompanying targets and measures are needed – such as requirements for the organic content of output fractions from MBT/MPT and corresponding **technological minimum standards**.

To avoid misaligned incentives, **solutions for the entire waste value chain need to** be developed that assign responsibility throughout the chain. This is subject to further research and not part of this study.

3 General Implications of CO_2 Pricing for Landfills

Although the primary focus of this study is not on the broader systemic implications of waste redirection, an analysis of potential shifts from MWI to landfilling inevitably requires engagement with related questions. It also highlights the need to place these issues into a broader policy and environmental context. The authors consider this perspective essential and offer the following reflections as an initial impulse—particularly from the viewpoint of landfills—to encourage a more integrated consideration of the circular economy.

A comprehensive understanding of waste and climate policy must recognise that both thermal treatment and landfilling contribute significantly to greenhouse gas emissions. Incineration plants release fossil-based CO_2, while landfills emit methane. Despite existing EU legislation, such as the Landfill Directive and the Waste Framework Directive, which set requirements for the redirection of organic waste and landfill management, substantial methane emissions persist. This is especially true in Member States that rely heavily on landfilling and have limited enforcement capacity.

Extending CO_2 pricing to landfills could help internalise the climate costs of methane emissions, provide **consistent economic signals** across waste treatment **options, reinforce the waste hierarchy**, and support **the transition to a circular economy**.

The following considerations outline potential economic, technological, environmental, and regulatory implications of including landfills in the EU-ETS 1. These reflections are not exhaustive and do not aim to provide a detailed quantitative or policy impact analysis. Instead, they are intended to illustrate the complexity and interdependencies of the relevant factors and to encourage further discussion of integrating landfills—and the circular economy more broadly—into climate policy frameworks.

3.1 Economic Aspects

Integrating landfills into the EU-ETS 1 would internalise external environmental costs and create financial incentives to shift waste flows toward more sustainable treatment options. As landfill operators would need to purchase emission certificates, especially for methane, landfilling becomes more costly, thereby strengthening the EU waste hierarchy and promoting innovation in waste management.

Opportunities include strengthening the circular economy, as higher landfill costs make recycling and pre-treatment comparatively more attractive, leading to higher recycling rates and reduced landfilling. This transition could also stimulate job creation in recycling and sorting industries (European Commission, 2025), increase the availability of secondary raw materials (Eurostat, 2026a),[34] and foster innovation in circular technologies (Regulation (EU) 2024/1157 of the European Parliament and of the Council of 11 April 2024 on Shipments of Waste, Amending Regulations (EU) No 1257/2013 and (EU) 2020/1056 and Repealing Regulation (EC) No 1013/2006 (Text with EEA Relevance), 2024). A harmonised inclusion of all EU landfills would establish fair competitive conditions. Furthermore, technical upgrades could enable energy recovery from landfill gas, generating new revenue streams (Kjeldsen et al., 2023).

[34] Data for 2022.

Challenges arise from the potential social and economic burden of higher disposal costs (EEA, 2024),[35] which may disproportionately affect low-income households and municipalities. Direct incentives for landfill operators to invest in technical improvements might be limited unless complemented by regulatory measures or subsidies. Implementation is complex, as accurate methane measurement and verification are technically demanding and administratively intensive. Moreover, immediate emission reductions are constrained, as much of the methane originates from previously deposited waste; the steering effect would thus mainly apply to future waste streams.

3.2 Technological Aspects

Including landfill emissions in the EU-ETS 1 could stimulate technological innovation and efficiency improvements in landfill operations. By attaching a price to methane emissions, investments in gas capture systems, methane oxidation layers, or waste inertisation processes could be supported (Environment Agency, 2026).

Opportunities include creating targeted incentives to reduce emissions across the waste value chain (Seymer, 2025). Waste generators and municipalities could improve their separate collection systems, while landfill operators could improve their gas collection systems (Seymer, 2025). Emissions trading would also accelerate technological progress by rewarding innovation, as each tonne of avoided CO_2 translates into cost savings or potential revenues (Fageda & Teixidó, 2025). Upgrades such as gas wells or oxidation layers will mitigate greenhouse gases.

Challenges include the high upfront investment and profitability risks for smaller or soon-to-close landfills, technical uncertainties regarding the maturity and reliability of some mitigation technologies, and delayed effects due to the long planning and implementation timelines of technical measures. Methane from existing waste deposits will continue to be emitted, even with optimised technologies. Besides incentives to improve gas collection systems and other technologies that reduce emissions of historically landfilled waste depends on the integration model. Due to measurement difficulties and fairness reasons (landfill operators would be facing emission costs from waste that was already deposited in the past and for which they only have a limited possibility to mitigate emissions) historical emissions might better be addressed with complementary policies (see 4.1).

3.3 Regulatory Aspects

Incorporating landfills into the EU-ETS 1 would enhance regulatory coherence, aligning climate policy instruments across waste treatment methods and Member States. It would close an existing regulatory gap, ensuring that all major emitters are covered under a unified framework.

Opportunities include improving policy coherence by treating landfills and incinerators under the same system. A harmonised EU-wide ETS framework would reduce fragmentation caused by differing national landfill taxes and regulations, ensuring comparability.

Challenges relate to differing national interests and starting points. Member States still reliant on landfilling would face significant financial and administrative burdens, potentially affecting infrastructure planning (Warringa, 2021; “Waste No Time,” n.d.). Establishing the necessary regulatory framework requires standardised MRV systems for methane emissions, clear

[35] In contrast, waste incineration plants operate in a more competitive environment. They rely on a steady input of waste to generate energy. Some of them are integrated into municipal heating networks. Here, investments in more efficient technology or lower-emission processes can create a competitive advantage, helping operators position themselves as climate-conscious service providers. Thus, while cost pass-through is also possible in incineration, the market dynamics offer stronger incentives for innovation and efficiency (PwC2024).

definitions of covered waste streams, and capacity-building measures for operators and authorities.

3.4 Competitive Aspects

While some waste-to-energy facilities already bear CO_2 costs (notably cement plants and other combustion plants co-incinerating waste), the inclusion of all MWI into the EU-ETS 1 will be examined as part of the ETS 1 review. If MWI will be included and methane emissions from landfills remain largely unpriced, this will make landfilling artificially cheaper despite its higher climate impact. National landfill taxes only partially compensate for this imbalance and differ widely in design and effectiveness.

Opportunities include establishing a level playing field across the EU by aligning CO_2 costs for both MWI and landfills. A uniform price signal would reduce the incentive to redirect waste to cheaper, more climate-damaging options and strengthen the waste hierarchy.

Challenges involve the administrative burden of integrating all landfills—especially smaller ones—into the EU-ETS 1, as well as potential transition issues or leakage effects if cost differences persist.

3.5 Data Quality and Monitoring

The current limited availability of differentiated methane emission data hampers accurate climate impact assessments of landfilled waste, particularly in distinguishing between untreated municipal waste and MBT/MPT residues. While IPCC guidelines, such as the First Order Decay (FOD) model,[36] provide methodological frameworks for refined emission estimates based on waste composition and treatment history, many national inventories still rely on default values that do not adequately reflect the reduced methane potential of stabilised MBT/MPT residues. Eurostat's WASMUN statistics classify MBT/MPT residues under the general category of landfilled waste, while WASTRT statistics list them as "sorting residues," without systematically differentiating methane-relevant organic content.

Opportunities include improving the currently limited, estimation-based data on landfill emissions. Establishing comprehensive MRV systems could enhance data quality, transparency, and harmonisation across Member States. Site-level data and country-specific assumptions could yield more accurate emission estimates than default values, enabling better cross-country comparisons.

Challenges include the diffuse, long-term, and site-specific nature of methane emissions. Methane is released gradually over decades as organic waste decomposes under anaerobic conditions, making direct measurement difficult. Unlike CO_2 emissions from incineration, which are immediately measurable, methane estimates rely on models that incorporate waste composition, degradation rates, and local landfill management practices (Ioannidis et al., 2026). Many national inventories continue to use default values, and methodologies are not harmonised, leading to substantial uncertainties in both quantification and temporal allocation of emissions. Also, the European Commission's guidance on uncertainty assessment under the EU-ETS 1 confirms that calculation-based approaches carry significant uncertainty, especially when measurement systems are not under the operator's control (European Commission, 2021). It therefore points to the **need for a plausible and manageable method based on standard**

[36] First-order decay describes a process where the rate of decay of a substance is directly proportional to its current amount. This means that the quantity decreases exponentially over time, with a constant fraction lost per unit of time. It is commonly used in modelling the degradation of organic waste, radioactive materials, and other natural decay processes.

values, such as those outlined in the Guidance Document on biomass (European Commission, 2025).

Eurostat and WASTRT statistics do not systematically differentiate methane-relevant organic content, further complicating reporting and climate impact assessments. Additional challenges include ongoing measurement uncertainties, potential discrepancies in data interpretation (e.g., oxidation factors), and the financial and administrative burden of implementing comprehensive MRV systems for operators and authorities, particularly during the transition phase.

To summarise:

Integration of landfills into the EU-ETS 1 offers substantial opportunities: it internalises environmental costs, incentivises recycling and pre-treatment, stimulates technological innovation, enhances regulatory coherence, and mitigates climate-relevant methane emissions.

At the same time, it entails risks, including higher disposal costs for municipalities and households, measurement and MRV uncertainties, implementation challenges, and potential redirection to unregulated routes.

CO_2 pricing can complement existing waste legislation and reduce the risks of redirection in case of MWI integration in the EU-ETS 1. It promotes sustainable waste management, supports circular-economy practices, and strengthens technological capacities.

4 Starting points for integrating landfills into the EU-ETS 1

The potential inclusion of landfills in the EU-ETS 1 assumes that MWI will be covered. As outlined in chapter 2 regulating only MWI without addressing landfills would create regulatory gaps and distortions in the waste management sector potentially leading to redirection effects, resulting in waste being sent to landfills. The goal of a landfill inclusion is to establish a level playing field in the waste sector and thereby prevent distortions and the risk of unwanted redirection effects. The regulatory framework should be designed such that the inclusion is climate-effective, and economically efficient. However, the exact design and scope of MWI's integration into the EU-ETS 1 remain unclear at this stage. Consequently, the following considerations are primarily made from the perspective of landfills.

A targeted focus on municipal waste, rather than all waste streams, is justified for several reasons:

- **Comparability and Fair Competition**: The potential inclusion of MWI in the EU-ETS 1 would primarily cover emissions from the incineration of municipal waste. Extending the system to landfills handling the same type of waste ensures consistent treatment of emission sources and prevents competitive distortions between different treatment routes. This creates a level playing field for MWI and landfill operators.
- **Climate Relevance of municipal waste**: Based on the statistical analysis of waste fractions landfilled within the EU-27 member states municipal waste contains the highest proportion of biogenic material, which is the primary driver of methane emissions in landfills. Given methane's high global warming potential, focusing on this waste fraction ensures that the EU-ETS 1 targets the most significant sources of landfill-related greenhouse gases. Including all waste streams (including the mineral fractions)—many of which have low organic content—would dilute the system's climate effectiveness and increase complexity without proportional benefits.
- **Practicality and Implementability**: Data availability, MRV procedures are far more established for municipal waste. Focusing on MSW, therefore, enables efficient implementation of the EU-ETS 1 in the waste sector while still capturing the majority of climate-relevant landfill emissions.

In summary **focusing on landfills handling municipal waste** ensures **comparability with MWI, targets the most climate-relevant emissions, and facilitates practical MRV**. The approach would focus on newly landfilled waste and organic fractions, prioritising methane emissions while leaving room for future expansion as data quality and sector practices improve.

Importantly, this conceptual approach should be seen as a **starting point** rather than a final design. Further research is needed to develop concrete implementation details, including:

- Assessing the social and economic impacts of certificate costs at the national level, particularly in Member States with limited MWI capacity;
- Evaluating redirection effects in detail to ensure that unintended shifts in waste flows do not offset emissions reductions;
- Refining MRV methodologies for methane and other relevant gases;
- Considering potential inclusion of other gases or waste fractions as data quality improves;

- Exploring complementary measures for historical deposits and long-term emissions mitigation.

4.1 Potential Scope of application and delimitation

1. Waste Types

The inclusion of landfills in the EU-ETS 1 should focus on municipal waste, as defined under the extended EU definition. This scope ensures consistency with the potential inclusion of MWI and would in particular cover organic waste and organic waste fractions in mixed waste streams, the main drivers of methane emissions in landfills. Other waste types contribute only marginally to methane emissions and could be considered based on a quantity threshold, for instance, if the amount exceeds a certain annual level.

Given that the share of municipal waste deposited in landfills varies significantly between Member States, the application of an **integration-threshold** in order to limit administrative burden should be assessed. The threshold could for example be based on the country's share of total municipal waste landfilled within the EU or the share of deposited municipal waste in the country's total municipal waste (e.g., ≤ 2% of all municipal waste). For such small quantities, existing legal requirements would generally still apply. Additionally, there is an incentive for sorting and processing residues to be directed to higher-value recovery options due to their energy content.

Thresholds for individual landfills could also be introduced based on for example the amount of municipal waste deposited or the landfill's share of total municipal waste in a given country. In cases with many small landfills, standardised national default values could be applied to further simplify implementation. These measures require however further evaluation.

Focusing on municipal waste also enables the use of existing data for MRV, facilitating efficient and reliable implementation of the EU-ETS 1. This approach ensures the system targets the most climate-relevant emissions while remaining practical, enforceable, and compatible with the broader MWI framework.

2. Landfill Types

Only active landfills that are still accepting municipal waste should be considered, as defined at the beginning. This ensures that the included sites are those whose emissions can be influenced by waste producers or other stakeholders, as they make active decisions about the disposal of current waste, similar to municipal waste incineration facilities. Historical or closed sites, where no such influence is possible, would therefore be excluded. Landfills for hazardous waste, inert material landfills and underground landfills should also be excluded, as these either do not cause any relevant methane emissions or are already regulated by other sectoral requirements

According to Eurostat, 2,342 landfills for non-hazardous waste were reported in 2022, of which 933 were considered closed. These closed sites still had a residual capacity of 1,370 million cubic meters. However, the regional data contain numerous gaps and are often not fully verifiable, and it is unknown how many of these sites accept municipal waste (Eurostat, 2025a).[37]

[37] Data for 2022.

3. **Emission Types**

From the perspective of this study, which primarily considers the risks of waste redirection associated with MWI, but also from a climate policy perspective the focus should be on **landfill methane emissions**, as they are the most climate-relevant emissions. Pricing methane would therefore set a strong incentive against waste diversion to landfills if MWI are included in the EU-ETS 1.

However, from a broader waste management and climate perspective, other emissions—such as nitrous oxide (N_2O) and additional greenhouse gases—may also be relevant. Due to limitations in data availability, these additional emissions could not be assessed within the scope of this study. The inclusion of additional GHGs may be discussed as a second step of MWI- and landfill-integration.

4. **Temporal Scope**

The EU-ETS 1 obligation should apply only to **waste deposited in landfills after the regulation takes effect**. This approach ensures legal certainty for operators and prevents them from being confronted with emission costs (and potentially high financial risks) from historical waste that they cannot pass on retroactively to the polluter and for which they have only limited mitigation options. By focusing on current and future waste streams, emissions can be actively influenced through pre-treatment, redirection of organic waste, and improved waste management practices. In other words, the steering effect of CO_2 pricing primarily applies to emissions from waste whose disposal routes can still be actively managed. Besides methane emissions on landfills are hard to measure due to their diffuse and delayed nature which makes it more viable to estimate emissions from newly landfilled waste (see 5.).

Therefore, although historically landfilled waste continues to generate emissions, it is not recommended to address them by inclusion into the EU-ETS 1. Instead, they can be mitigated through complementary measures such as voluntary compensation and regulatory requirements or subsidies for enhanced gas collection, or improved sealing. Emissions from old deposits remain part of the IPCC-defined monitoring system, and no separate EU-ETS 1 requirement is needed; however, a clear link should be established to ensure consistency. Complementary measures to promote mitigation of emission from historically landfilled waste should be designed such that undesired incentives for additional landfilling are avoided.

From a broader waste management perspective, including emissions from historically landfilled waste could be relevant for stimulating investments in improved methane recovery technologies - which are already obliged by the Landfill Directive - but whose real-world effectiveness often remains limited due to fugitive emissions, early-phase methane release and varying operational performance. This may also support the deployment of alternative monitoring methods, such as satellite-based measurements, which capture the full spectrum of emissions. However, this falls outside the scope of the current study and should be considered in future assessments if a more comprehensive integration of the waste sector into the EU-ETS 1 is pursued.

5. **Monitoring, Reporting, Verification (MRV)**

As stated above (Temporal Scope), only methane emissions, that result from newly deposited waste should be taken into account for the EU-ETS 1. Since methane emissions from landfills are diffuse, delayed and difficult to measure and emissions from newly and historically deposited waste could hardly be separated from each other, a method is **needed**

to determine the methane formation potential of waste ex-ante. The total amount of methane that is generated during the biodegradation process of waste, which takes several years or even decades in a landfill, is to be estimated.

Emission reductions by gas capture systems or other mitigation technologies at landfills are not taken into account because they can hardly be measured accurately since this would require measurement of methane emissions on landfills. Furthermore, an inclusion of these technologies can lead to undesired incentives for landfilling. Captured landfill gas can already be used to generate energy, which creates a revenue stream for landfill operators. While using landfill gas from deposited waste for energy purposes is good for the climate, there is a risk that the revenue incentivises additional landfilling. Gas capture systems can however capture only a part of the methane emissions on landfills which is why the focus of climate protection efforts ultimately needs to be on avoiding landfilling of MSW altogether. The integration model should be designed in such a way that it does avoid additional incentives to landfill MSW, which is why mitigation effects from gas capture systems should not be taken into account.

While this approach leaves out an incentive for emission mitigation on landfills for waste already being deposited it sets a strong stimulus to avoid the deposition of municipal waste altogether and is therefore in line with the goal of the EU Landfill Directive to reduce the share of landfilled municipal waste. Besides gas capture systems are already mandatory under the EU-landfill directive, which limits the steering effect for additional mitigation of emissions from historically deposited waste.

To ensure that pricing reflects actual waste deposition, calculations should **be performed at the landfill level, based on actual waste quantities**. The use of **default values** (country- or landfill-specific) could be allowed (e.g. in a transition-phase) to avoid excessive measurement and reporting burden.

There are different methods available to derive the methane formation potential:

Method 1

Calculation based on IPCC → please see equation 3.2 and 3.3 in 2006 IPCC Guidelines for National Greenhouse Gas Inventories; In a nutshell this method would use the mass of waste to be deposited to calculate the mass of decomposable degradable organic carbon (DDOCm), which is ultimately responsible for the methane formation. The DDOCm can then be used to calculate potential life cycle methane formation. For the determination of the DDOCm, values of the share of degradable organic carbon (DOC) and the fraction of degradable organic carbon that decomposes under anaerobic conditions (DOCf) which causes methane formation, are multiplied with the mass of waste. Both the DOC and the DOCf depend on the composition of waste. Ideally waste composition would be determined for individual waste streams for more accurate emission factors, but default values are also available for different waste types like food waste, garden and park waste, nappies or paper/cardboard. **National DOC-default values for mixed waste are not provided and would have to be determined before the implementation.**[38] The same applies to default values for **waste, that has been mechanically-biologically pretreated** which are not yet provided neither. A different default value for pretreated waste is important for reasons of fairness and to create

[38] The IPCC guidelines offer the use of regional default values for bulk waste (e.g. for eastern, western, northern and southern Europe) for the estimation from MSW if national waste composition data are not available (Tier 1). These default values are however less precise since they do neither differentiate between countries within a region nor between pretreated and non-pretreated waste. Preliminary results of a recent study (Prognos/ifeu 2026) have also shown that an update is required since the average IPCC-default value for the EU-27-regions is underestimated and likely to be 0.20 instead of 0.15. The use of regional default values is therefore not recommended.

the right mitigation incentives because pretreatment significantly reduces methane formation. Default values should be differentiated between Member States since waste composition and national requirements for pretreatment can differ substantially between countries. They could also be introduced at the landfill level.

Method 2

Determination of the gas formation rate (GB21) or respiratory activity (AT4) or performance of similar tests on a representative waste sample of the waste in a laboratory: The sample is fermented and the amount of gas produced over a certain period of time is directly measured. The result of the test is then used to determine the methane formation potential of the whole waste ready to be deposited. These tests are already applied in Germany according to the national landfill ordinance (Deponieverordnung – DepV). Instead of indirectly calculating emissions according to the biodegradable content using DOC-default values in this case the emissions of a sample are measured directly. These methods could also be used to calculate default values for the emission factors of individual landfills using random samples of waste, which would reduce measurement and reporting efforts.

Neither method would be immediately ready for use for the intended purpose (the determination of emission factors and the subsequent calculation of potential methane emissions), but would first need to be further developed. For example, as stated above, if method 1 is applied, default values for mixed waste would have to be determined, which would require waste analyses to examine the composition of waste in each single case and thus obtain, for example, the proportions of food and other biodegradable fractions. The measurement results from the laboratory may need to be multiplied by a correction factor, as the tests can only be carried out for a few days or a maximum of weeks and therefore cannot reliably reflect the long-term behaviour of the waste in a landfill.

According to the IPCC guidelines, the DOC and DOCf (fraction of DOC that can decompose) values can be determined in different ways, depending on the chosen methodological approach. If country-specific values are used instead of the IPCC default vales, this must be explained or substantiated with scientific research results. As an alternative to the two methods described above for methane emission calculations, the Total Organic Carbon (TOC) approach is often discussed. TOC represents the entire organic carbon content of the waste. While TOC measurements are relatively straightforward and can provide a complete carbon inventory, they do not directly indicate the fraction of carbon that is biologically available for methane production. To avoid an overestimation of potential emissions additional assumptions or conversion factors to estimate the degradable portion are therefore required.

TOC is, however, commonly applied in the EU in regulatory contexts such as waste acceptance criteria, stability assessments, and landfill classification (e.g., Council Decision 2003/33/EC), where it serves as a proxy for organic content or waste stability rather than methane production.

One **important caveat** for the methods above is that the use of **default values** while leading to a reduction of complexity and administrative burden, carries the risk of inaccuracies and false incentives. This is because the outlined default values rely on the composition of historically deposited waste. After all, with the use of these values the emission factor applied within a country (or landfill) is equal regardless of the real waste composition and hence the real emissions of newly deposited waste. This hampers the incentive to reduce organic fractions in deposited municipal waste. Additionally, this could lead to diversions from countries (or landfills) with higher default values to countries (or landfills) with lower default values, which means that the average organic share (and hence emission factors) of the latter would be higher than historical data suggest. These diversions could be more pronounced for landfill specific default values because of the lower distances between landfills within a country.

One way to address these unintended redirection incentives would be to apply **default values according to the country of origin** instead of the destination country of waste.

A **sample analysis** of individual waste streams **according to method 2** would also avoid this effect, since the results would best reflect real methane formation potential and thereby set a differentiated price signal for individual waste streams independent of the country or landfill in which the waste is deposited. The experience with the German Landfill Ordinance shows that this is a viable option. It would however require more MRV and administrative efforts. A thorough evaluation of these considerations was beyond the scope of this study.

6. **Regional Scope**

The regulation should apply throughout the European Economic Area (EEA)/jurisdictions covered by EU-ETS 1, and be mandatory, despite significant differences in initial conditions across Member States. In countries with a landfill ban on untreated organic waste (e.g., Germany, Austria), the effect would be minimal. In contrast, Member States with a high landfill rate (e.g., Romania, Greece, Bulgaria) would need to make considerable adjustments.

To account for differences across Member States, **threshold values for deposited waste quantities could be implemented**.

7. **Determination of the surrendering obligation and adjusting the cap**

The transfer of the existing ETS mechanism based on annual retrospective billing appears problematic for landfills, as emissions occur with a significant time lag between waste deposition and the actual release of methane. In contrast, an **ex-ante approach** appears more practicable and better suited to the specific characteristics of landfill emissions. Under such a system, the **liability** to surrender certificates would **arise at the time of landfilling**, based on the total potential life-cycle-methane generation. The liability could be spread over several years, e.g. five years, to be more consistent with the annual cap setting under the EU-ETS 1 and to avoid excessive costs in the year of landfilling. Similarly, the adjustment of the cap to account for landfill emissions in the EU-ETS 1, could be based on this ex-ante assessment, split up over several years.

The main advantage of such an ex-ante system lies in its administrative simplicity and early cost certainty. It avoids the need for complex, long-term emission monitoring while ensuring operators face a clear, immediate carbon cost signal which could also yield broader environmental benefits than a purely ex post system. Furthermore, it would be compatible with the existing ETS structure, requiring only limited adjustments to account for the specificities of landfill processes.

Nevertheless, several limitations and risks would need to be carefully addressed. Since the approach relies on standardised emission factors, there is a risk that site-specific conditions or variations in waste composition are not adequately captured, potentially leading to over- or underestimation of emissions. The methodology for defining emission factors would therefore need to be robust, transparent and regularly reviewed. Before a final decision on implementation, several aspects would merit further technical and regulatory assessment. These include the accuracy and representativeness of the emission factors across different waste types and climatic conditions as well as the coherence of the proposed mechanism with other EU waste and climate legislation, such as the Landfill Directive and the Waste

Framework Directive. It would also be essential to examine potential market effects, for instance, whether the introduction of such a system might unintentionally encourage landfilling in certain cases.

In the long term, an ex-ante mechanism could evolve into a hybrid model that integrates real performance data as measurement technologies advance. Such a transition could enable the gradual inclusion of ex-post verification elements, allowing actual mitigation outcomes to be more directly reflected in certificate obligations, particularly if other legal instruments limiting the landfilling of biodegradable waste are not yet fully enforced.

8. **Funding of emission-reducing measures through EU-ETS 1 Revenues**

Member States are obliged to use 100% of EU-ETS 1 revenues, or their financial equivalent, for climate-related purposes. Article 10(6) of the ETS Directive (2003/87/EC) further specifies the types of measures that qualify as climate-related, providing a non-exhaustive list (Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and Amending Council Directive 96/61/EC (Text with EEA Relevance), 2003).

Although waste management and circular economy measures are not explicitly mentioned in the directive, they may be eligible for funding if they demonstrably contribute to reducing greenhouse gas emissions. Examples of potentially eligible projects include the implementation of carbon capture technologies at municipal waste incineration plants (MWIPs), the reduction of methane emissions from landfills, the energy-efficient optimisation of waste treatment processes, and the development of innovative recycling technologies with measurable climate benefits. Several waste-to-energy projects have already been awarded grants from the Innovation Fund, which is funded by ETS revenues (*Innovation Fund Projects*, n.d.).

In summary, while there is no obligation to allocate auction revenues specifically to waste or circular economy measures, the directive allows for their inclusion within national climate funding strategies, provided they align with the overarching climate objectives of the EU-ETS 1. The European Commission monitors compliance to ensure that all revenues are genuinely spent for these purposes (*How Do Member States Use ETS Revenues?*, n.d.).

4.2 Actors

1. **Obligated Actors**

Landfill operators are classified as "facility operators" and are responsible for emission detection, monitoring, reporting and emissions trading. The duties of landfill operators particularly include

- **Monitoring**: Use of validated measurement methods or models
- **Reporting**: Annual reporting according to EU-ETS 1 requirements
- **Certificate obligation**: Purchase and submission of appropriate emission rights

In the event of a change of ownership, the emission rights and obligations must be transferred to the new owner.

2. Other Actors involved

The involved actors include **national environmental and emissions trading authorities**. They are responsible for supervising, approving, and examining reports as enforcement bodies, similar to those in other industrial sectors under the EU-ETS 1.

In addition, **accredited verifiers** must be involved, who check the compliance with the MRV requirements and confirm the accuracy of the emission data. In case of MRV method 2 accredited laboratories would have to analyse representative waste samples. The extent to which additional stakeholders should be involved, either directly or indirectly (for example, through complementary measures), **cannot be conclusively determined within the scope of this study**.

4.3 Summary of possible starting points

For a practical and timely start of a landfill integration into the EU-ETS 1, the following starting points could be considered:

Scope (landfill types, waste, GHG emissions)

- Only landfills accepting municipal waste
- Only emissions from newly landfilled municipal waste
- Only methane

Scope could be expanded in the future

Determination of the Cap-Adjustment

- Cap-adjustment starts in the first year of surrender obligation
- Adjustment could be based on the expected life-cycle-methane emissions of the (newly) landfilled waste in a year, split up over several years according to MRV rules

MRV obligations

One of the two following methods could be applied:

Method 1:
Determination of emission factors according to IPCC-guidelines

- Phase-in: MRV obligation may start with reporting of only municipal waste amounts accepted at the landfill, related waste composition for the determination of default values and information about whether and how waste has been pretreated
- After phase-in complete MRV could start with country specific default values; landfill specific values could be determined optionally in the beginning and possibly become obligatory after a transition phase.

Method 2:
Determination of emission factors based on laboratory analysis

- Municipal waste amounts accepted at the landfill have to be reported as well as the results of representative sample analysis;
- Samples of individual waste are analysed by accredited laboratories to determine emission factors of individual waste streams

- Test methods: gas formation rate (GB21), respiratory activity (AT4) or performance of similar tests to directly measure gas formation (see German Landfill Ordinance for further details). For the EU-ETS 1, it is expedient to present the result as the amount of methane formed (in kg) per amount of waste (in Mg wet mass). Depending on the measurement method selected (GB21 or similar), it may therefore be necessary to convert the laboratory result. If, for example, the total amount of gas formed is measured, only the methane content should be reported. The laboratory values may also need to be adjusted by a correction factor to reflect long-term degradation behavior.
- Alternatively, samples of municipal waste could be analysed at the landfill level to determine default emission factors for each individual landfill.

Determination of default values

Method 1:

- Use phase-in-period to determine DOC default values for mixed waste. Representative waste analyses would be necessary to determine the composition of waste and thus the proportions of biodegradable fractions.
- Different default values should be determined for pretreated and not pretreated waste.
- Values should be calculated separately for Member states taking into account country-specific waste compositions and pretreatment requirements

Method 2:

- If default values for emission factors of individual landfills are used these should be determined in the phase-in-period.
- Calculation based on analysis of random samples of waste for each landfill. Values should be updated regularly.

Determination of surrendering obligation:

Ex-ante approach:

- Liability at the time of landfilling based on calculated estimate of future methane generation possibly split up over several years

Timeline

- Start with 2-years mandatory reporting and tests to determine default values.
- Smooth phase-in of surrendering obligation (e.g. comparable to maritime sector)

4.4 Strengths, Weaknesses and Risks

The initial concept of including municipal waste landfills in the EU-ETS 1 presents both strengths and weaknesses, as well as specific risks. Among its main strengths is the **direct climate impact through methane pricing** which sets a strong price signal against waste diversion from MWI to landfills even if MWI are included in the EU-ETS 1 as well. This is due to methane's high global warming potential compared to CO_2-emissions resulting from MWI-treatment. Thus, depositing Municipal waste should generally become economically unattractive. This depends however on the waste's share of biodegradable organic fractions. Although MSW usually contains significant shares of biodegradable waste this might not always be the case and there remains a risk that waste with small organic fractions (and high fossil fractions) might be diverted to landfills. This diversion would be detrimental to the waste hierarchy and should be prevented. A thorough analysis of (organic) waste fractions in municipal waste and related diversion risks was beyond the scope of this study. It should be noted however, that given a parallel landfill and MWI integration, any diversion to landfills should (all else equal) have a positive climate impact since it should (all else equal) only be economically attractive if resulting emissions from landfilling are lower than those from incinerating the same waste. This is because the parallel landfill inclusion would set a consistent price signal in the waste sector (for municipal waste). In addition to preventing climate damaging diversions to landfills, a parallel landfill integration would thereby generally incentivise emission reductions and the use of the most climate friendly waste treatment routes. It should be noted that the use of default values could compromise this effect and potentially lead to unwanted side effects since the associated emission factors for landfilled waste would not always reflect real values of individual waste streams (see discussion on default values in chapter 4.1). A thorough analysis of this distortion was beyond the scope of this study.

Another advantage of the proposed concept is its focus on municipal waste for landfill because it is compatible with the potential MWI inclusion.

Furthermore, the concept is **compatible with existing MRV systems**. By leveraging available data and standardised calculation methods, the measure is feasible and enables reliable monitoring and reporting, though it should be noted that the calculation methods are not as detailed as needed and further improvements are required.

While there are good reasons for the proposed focus on emissions from newly landfilled waste (see 4.3), **the exclusion of ongoing methane emissions from historical deposits** can be seen as another drawback**.** These emissions need to be addressed through complementary measures.

Implementation challenges arise from variability in landfill practices across Member States, gaps in data, and the diffuse nature of methane emissions, which make MRV more difficult. Additionally, in countries with high landfill shares and a lack of alternative treatment options, incentives to invest in higher-value pre-treatment or necessary thermal treatment may be hampered if **investments in alternative treatment infrastructure are delayed**.

Despite these limitations and risks, **the concept was chosen because it maximises climate relevance while remaining practical and timely**. Pricing methane emissions discourages the redirection of organic waste and its overall landfilling. The focus on organic fractions and existing MRV systems can help accelerate implementation. A transition phase would however be needed to achieve further necessary development regarding e.g. the build-up of laboratories (if method 2 is applied) and the determination of lacking default values.

5 Further Research Needs

Within the specific scope of this study, the potential risks of redirecting waste to landfills arising from the possible inclusion of MWI in the EU-ETS 1 were analysed. In this case, including landfills in the EU-ETS 1 can ensure a level playing field and comparable regulatory conditions in the short term. The analysis focused on a pragmatic implementation based on existing data and methods. However, the authors acknowledge that this represents only one perspective and that the broader question is considerably more complex. A more comprehensive assessment requires examining both whether and under what conditions the inclusion of MWI and landfills in the EU-ETS 1 would be appropriate – and, if so, how such a system could be effectively designed.

The following section summarises the resulting research needs on two analytical levels.

5.1 Level 1: Broader assessment of the effectiveness, socio-economic impacts and compatibility with overall waste and climate policy

Broader assessments are required to determine whether including landfills and MWI in the EU-ETS 1 would be environmentally effective, economically proportionate, and compatible with broader waste and climate policy objectives.

Key areas of inquiry include:

- **Compatibility with EU circular economy strategy goals**: The question arises whether inclusion in the EU-ETS 1 supports or potentially conflicts with the goals of the waste hierarchy and the broader circular economy policy framework.
- **Policy Alternatives and compatibility with ongoing regulatory developments**: The focus of this paper was on the inclusion of landfills. Other policy options to prevent diversion to landfills and generally reduce methane emissions on landfills such as a tightening of regulations e.g. in form of stricter pretreatment requirements for landfilled waste should however be assessed as well. After all a coordinated efficient policy approach which avoids undesirable side-effects should be developed.
- **Proportionality of administrative cost and climate benefit**: The recommended approach should enable a practicable and timely start. Nevertheless, administrative cost should be analysed more thoroughly, and the proposed concept should be reviewed to determine whether implementation deficits such as those in the Landfill Directive can be avoided.
- **Incentive structure and socio-economic implications**: For the incentives of an EU-ETS 1 integration to work it is essential that actors who choose to deposit MSW on landfills are faced with the corresponding CO_2-cost. It is therefore important to assess cost structures and fee systems in Member States to better understand how and to what extend landfill operators would pass on costs to the polluter and where changes in the systems are required. An analysis in this regard should also include social and economic impacts across Member States. A comparison of the overall treatment cost in MWIs and landfills including carbon cost is necessary to determine to what extent carbon pricing can avoid diversion of waste from MWI to landfills.

This level serves as an evidence base to determine whether integrating the landfill and MWI sectors into the EU-ETS 1 would make a meaningful and proportionate contribution to the EU's climate objectives—or whether alternative instruments, such as targeted CO_2 and methane regulation or minimum performance standards, would be more appropriate.

5.2 Level 2: Developing and Designing a Potential Inclusion

Suppose inclusion is found to be justified and effective in principle. In that case, a second level of research is needed to understand **how such a system could be designed** to ensure practicability, efficiency, and fairness. It should be noted, that not all of the research areas laid out here are necessary to start the EU-ETS 1 inclusion. Unless stated otherwise, they are intended as research for the purpose of further developing and improving the system after its implementation.

Priority areas of research/assessment of already existing studies include:

- **Methodological and technical foundations**: Targeted empirical studies are needed to address current uncertainties in and partly lacking data needed for the calculation of emission factors. Particularly DOC values for landfills (mixed waste and pretreated waste) have to be determined before a possible start of full EU-ETS 1 integration if method 1 is applied. Therefore, regional variations in waste composition and methane generation across Member States should be captured. Harmonisation and refinement of MRV methodologies must be prioritised.
- **Advancement of methane quantification methodologies**: Further research should evaluate alternative approaches which could potentially be integrated in a second step to further improve methane measurement. These include, e.g., satellite-based measures. A comprehensive assessment of their feasibility should be undertaken.
- **Broadening the scope of greenhouse gas coverage**: In the event of inclusion of landfills under the EU-ETS 1 based on a broader context than only about redirection risks, further research should assess whether the focus on methane emissions alone is sufficient. Other climate-relevant gases may also be relevant, as considered in the European Pollutant Release and Transfer Register (E-PRTR).[39] These could be included in a second step.
- **Inclusion of previously deposited waste in active landfill sites**: Further research is needed to determine whether and how emissions from waste deposited in earlier years—yet still contributing to methane generation in currently active landfill sites—should be accounted for under the EU-ETS 1 This research should take into account the risk of undesired incentives to landfill waste e.g. for the purpose of capturing gas for energy use.
- **Interactions with upstream treatment stages**: Given the interlinkages between landfills and MWI processes, interactions with upstream treatment stages should be systematically examined. Further research should assess whether complementary measures (e.g., enhanced separate collection or technical upgrades, such as MBT/MPT) are necessary to meet overall mitigation objectives.
- **Leakage and waste flow displacement risks**: Quantitative modelling is required to assess potential shifts between treatment routes or across Member States. Research should also examine whether EU-ETS 1 coverage might inadvertently delay the development of thermal treatment capacity due to the higher operating cost.
- **Governance and allocation of responsibility**: Clear allocation of responsibility along complex waste chains—especially for secondary waste streams—must be established.

[39] Please refer to supplementary information in the Annexe, SI 17: Landfills as part of the E-PRTR .

Further investigation is needed to ensure alignment with the polluter-pays principle and administrative feasibility.

This level thus shifts the focus from the fundamental question of ‘whether’ to the operational question of ‘how’—ensuring that any inclusion is methodologically sound, administratively feasible, and economically balanced. The identified research gaps highlight the need for further targeted analysis to support both strategic decision-making and practical system design.

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Annexe: Supplementary information

SI 1: European Waste Statistics

Eurostat's waste statistics are based on the EU Waste Statistics Regulation (and provide comprehensive data every two years on waste generation (WASGEN) and waste treatment (WASTRT) in the Member States. **WASGEN** refers to the amount of waste generated within a country by households and economic activities.

WASTRT, on the other hand, describes the amount of waste treated within the Member State, taking into account **imports** but excluding **exports.** It is not directly comparable with WASGEN. Particularly when analysing at the individual country level, larger import/export effects may need to be considered

Waste is classified according to the **material-oriented statistical waste nomenclature (EWSTAT)** into various categories. This classification enables differentiated analysis of waste streams, such as chemical waste, plant-based waste, and combustion residues.

Mapping EWC codes (European Waste Codes) as defined in the European Waste Catalogue (EWC/AVV) to EWSTAT categories is possible using **correspondence tables**. However, **quantitative evaluations based solely on EWC codes are not feasible**.

SI 2: Waste amounts treated in the EU member states in 2022

EWSTAT	Waste fraction	Amount treated			Amount thermally treated*		Amount landfilled		Includes partly municipal waste codes	Includes partly organic waste codes***
Code		Total	non-hazardous	hazardous	non-hazardous	hazardous	non-hazardous	hazardous		
		kt/2022	kt/2022	kt/2022	kt (%)/2022**	kt (%)/2022	kt (%)/2022	kt (%)/2022		
W011	Spent solvents	1,590	-	1,590	-	880 (55%)	-	-	x	
W012	Acid, alkaline or saline wastes	3,040	1,220	1,820	20 (2%)	90 (5%)	260 (21%)	130 (7%)	x	
W013	Used oils	2,270	-	2,270	-	300 (13%)	-	-	x	x
W02A	Chemical wastes	8,630	1,380	7,250	240 (17%)	2,820 (39%)	490 (36%)	1,110 (15%)	x	
W032	Industrial effluent sludges	6,210	4,790	1,420	1,760 (37%)	470 (33%)	1,440 (30%)	330 (23%)		(x)
W033	Sludges from waste treatment	2,840	1,870	970	50 (3%)	360 (37%)	850 (45%)	420 (43%)		
W05	Health care/biological wastes	1,360	680	680	600 (88%)	670 (99%)	70 (10%)	-		x
W061	Metal wastes, ferrous	63,740	63,740	-	130 (0%)	-	50 (0%)	-		
W062	Metal wastes, non-ferrous	8,330	8,330	-	-	-	10 (0%)	-		
W063	Metal wastes, mixed	4,120	4,120	-	-	-	-	-	x	
W071	Glass wastes	16,290	16,290	-	10 (0%)	-	140 (1%)	-	x	
W072	Paper and cardboard wastes	30,650	30,650	-	340 (1%)	-	10 (0%)	-	x	x
W073	Rubber wastes	2,570	2,570	-	810 (32%)	-	-	-		
W074	Plastic wastes	12,460	12,460	-	2,510 (20%)	-	580 (5%)	-	x	
W075	Wood wastes	41,400	39,600	1,800	19,790 (50%)	1,720 (96%)	60 (0%)	-	x	x
W076	Textile wastes	1,380	1,380	-	210 (15%)	-	160 (12%)	-	x	(x)
W077	Waste containing PCB	50	-	50	-	30 (60%)	-	-		
W081	Discarded vehicles	2,160	1,180	980	-	-	-	-		
W0841	Batteries and accumulators	1,490	70	1,420	-	-	-	30 (2%)	x	
W08A	Discarded equipment	2,840	1,470	1,370	10 (1%)	50 (4%)	10 (1%)	30 (2%)	x	
W091	Animal and mixed food waste	23,950	23,950	-	3,980 (17%)	-	1,140 (5%)	-	x	x
W092	Vegetal wastes	42,690	42,690	-	2,060 (5%)	-	550 (1%)	-	x	x
W093	Animal faeces, urine, manure	12,290	12,290	-	1,540 (13%)	-	20 (0%)	-		
W101	Household and similar wastes**	87,120	87,120	-	46,590 (53%)	-	28,160 (32%)	-	x	x
W102	Mixed/undifferentiated materials	22,900	22,750	150	5,310 (23%)	50 (33%)	5,170 (23%)	30 (20%)	x	
W103	Sorting residues	85,450	81,180	4,270	34,860 (43%)	1,880 (44%)	35,410 (44%)	590 (14%)	x	x

EWSTAT Code	Waste fraction	Amount treated			Amount thermally treated*		Amount landfilled		Includes partly municipal waste codes	Includes partly organic waste codes***
		Total kt/2022	non-hazardous kt/2022	hazardous kt/2022	non-hazardous kt (%)/2022**	hazardous kt (%)/2022	non-hazardous kt (%)/2022	hazardous kt (%)/2022		
W11	Common sludges	10,920	10,920	-	2,940 (27%)	-	490 (4%)	-		x
W121	Mineral waste from C&D	281,120	272,880	8,240	1,020 (0%)	490 (6%)	22,440 (8%)	2,700 (33%)		(x)
W124	Combustion wastes	84,560	81,690	2,870	320 (0%)	140 (5%)	47,980 (59%)	850 (30%)		
W126	Soils	463,790	457,740	6,050	35 (0%)	135 (2%)	94,520 (21%)	2,440 (40%)		
W127	Dredging spoils	56,980	56,280	700	30 (0%)	130 (19%)	3,390 (6%)	510 (73%)		
W128_13	Mineral wastes from treatment	59,040	53,730	5,310	20 (0%)	100 (2%)	7,560 (14%)	2,740 (52%)		
W12B	Other mineral wastes	541,280	490,690	50,590	40 (0%)	330 (1%)	299,640 (61%)	28,840 (57%)		
	Total	**1,985,510**	**1,885,710**	**99,800**	**125,225 (7%)**	**10,645 (11%)**	**550,600 (29%)**	**40,750 (41%)**		

* Includes R1 (thermal treatment with energy recovery and D10 (incineration without energy recovery)

** The percentages in brackets refer to the proportion of the total non-hazardous or hazardous waste.

*** Own assessment Prognos AG

Source: ENV_WASTRT (data for 2022)

The European waste statistics system WASTRT is based on the Waste Statistics Regulation (Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 November 2002 on Waste Statistics (Text with EEA Relevance), 2002). The regulation establishes a common framework for the systematic collection and reporting of data on waste generation, treatment, and disposal across EU Member States, thereby serving as a key instrument for implementing EU waste policy. It is based on a clearly defined legal framework and a methodologically harmonised classification system, ensuring consistent and comparable reporting by Member States. According to Article 3 of the regulation, Member States are required to collect and submit data to Eurostat using surveys, administrative sources, or statistical estimation methods. Reporting is conducted biannually and covers both hazardous and non-hazardous waste. Eurostat publishes data in standardised formats that serve as a basis for policy decisions and environmental assessments.

The use of EWC-Stat categories instead of 6-digit waste codes reflects a waste stream (material-based) focus rather than an origin-based focus.

SI 3: Classification of thermal treatment of waste

The incineration of waste can be classified as either a disposal operation (D10) or a recovery operation (R1), depending on the plant's energy efficiency and the purpose of the incineration.

According to Annexe II of Directive 2008/98/EC (Waste Framework Directive), D10 is defined as 'incineration on land' where no significant energy recovery takes place. In contrast, R1 is defined as 'use principally as a fuel or otherwise for energy recovery' and is only applicable if the plant achieves a defined energy efficiency threshold.

This threshold is calculated using the so-called R1 formula, which was introduced by Directive (EU) 2015/1127 (Commission Directive (EU) 2015/1127 of 10 July 2015 Amending Annex II to Directive 2008/98/EC of the European Parliament and of the Council on Waste and Repealing Certain Directives (Text with EEA Relevance), 2015). Only plants that reach this threshold may be classified as thermal recovery facilities, which is preferable from a legal and environmental policy perspective, as they help substitute for fossil fuels and are therefore ranked higher in the waste hierarchy than pure disposal (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives (Text with EEA Relevance), 2008).

SI 4: EWSTAT category „Sorting residues"

Sorting residues are included under the EWSTAT category W103, which covers waste generated from waste treatment operations (so-called secondary waste fractions). The term refers to waste generated by sorting operations, typically at material recovery facilities (MRFs), where mixed waste is separated into different fractions. These residues are the non-recyclable or rejected portions that remain after sorting and are usually sent for disposal (e.g. landfill or incineration).

This category is part of the European Waste Classification for Statistics (EWC-Stat Version 2), which is used as the basis for statistical reporting under Regulation (EC) No 2150/2002 on waste statistics.

Examples of sorting residues include rejects from mechanical sorting of municipal or industrial waste, non-compostable fractions from composting processes, unused portions of refuse-derived fuels (RDF), and contaminated or oversized materials screened out during recycling.

Sorting residues from municipal and similar waste is considered a subset of total sorting residues, as they specifically originate from the treatment of household-like waste streams within the broader category of secondary waste.

SI 5: EWSTAT category "Household and similar waste"

According EC 2002 the EWSTAT category W101 "Household and similar waste" in the WASGEN and WASTRT statistics is defined as "Household and similar waste refers to waste generated by households and waste that is similar in nature and composition, including waste from sources such as offices, small businesses, schools, and other institutions, provided it is collected and treated in the same way as household waste".

In EWSTAT statistics, two related but distinct categories are used, which should not be directly compared:

WASGEN / WASTRT: The category W101 "Household and similar waste" covers the primary mixed household and similar waste, which is not separately collected or treated. Separately collected fractions (e.g., paper, glass, metals, bio-waste) and bulky waste are excluded and assigned to other waste stream–specific categories. Sorting residues generated during treatment is also not included in this category but is reported separately under “Sorting residues.”

WASMUN: The WASMUN statistics, titled “Municipal waste by waste management operations”, represent the total managed municipal waste originating from households and similar entities. This includes the primary mixed household waste, the separately collected fractions, and the sorting residues produced during treatment (e.g., mechanical-biological pretreatment of mixed waste).

Data from these two statistics are not directly comparable.

SI 6: Refuse-Derived Fuel (RDF)

Refuse-Derived Fuel (RDF) is a combustible waste fraction that has been mechanically or mechanically-biologically treated to improve its calorific value and make it suitable for energy recovery in facilities such as cement kilns or waste-to-energy plants. RDF is mainly classified in the European Waste Catalogue (EWC) under 19 12 10 “Combustible waste (refuse-derived fuel)” and, for mixed fractions from mechanical treatment, under 19 12 12 “Other wastes from mechanical treatment of wastes”.

Sorting residues are the non-recyclable fractions remaining after sorting or mechanical-biological treatment. They are reported under EWC 19 12 12 and, in EWSTAT statistics, both RDF and sorting residues are generally aggregated under W103 “Sorting residues”. Some sorting residues may be further processed into RDF, but RDF is specifically treated and quality-controlled for fuel use. In practice, the two categories overlap because combustible parts of sorting residues are often reported as RDF.

SI 7: Transformation of Waste Management

Historically, waste management was focused on hazard prevention, designed to protect human health and the environment from the risks associated with uncontrolled disposal. Early legislation reflected this focus, such as the Waste Framework Directive, the Directive on toxic and dangerous waste, the Landfill Directive, and the Waste Incineration Directive, which aimed to minimise emissions and prevent risks, with waste understood predominantly as a substance to be safely eliminated.

From the 1990s onwards, EU waste legislation entered a second phase, characterised by waste stream-specific directives that introduced recovery and recycling obligations. These measures marked the first steps towards a resource-oriented perspective. Key examples include the Packaging and Packaging Waste Directive, the End-of-Life Vehicles Directive, the Waste Electrical and Electronic Equipment (WEEE) Directive, and the Batteries Directive. By setting explicit targets for reuse, recycling, and recovery, these legal acts established producer responsibility and began to position waste as a source of secondary raw materials rather than solely a disposal problem.

SI 8: German term ‘Kreislaufwirtschaft’ and the economic model of the circular economy

In German, the term 'Kreislaufwirtschaft' describes the management of waste. However, the term 'circular economy' is also often translated literally as 'Kreislaufwirtschaft'. However, the concept of the circular economy extends beyond the scope of waste management. This assertion is further corroborated by the EU Commission, which has emphasised this point in its 'Action Plan for the Circular Economy'.

In Germany, the term 'circular economy' is predominantly employed in the context of waste management as delineated in Section 3 of the German Waste Management Act (KrWG). This term encompasses a state or phase of waste management, encompassing the multifaceted areas of impact, objectives, and instruments associated with it. Until approximately the beginning of the 21st century, the prevailing approach to waste management was based on the aim of separating the collection of glass, paper, and metals.

The subsequent phase of development focused on implementing a recycling-oriented waste management strategy to recycle a significant volume of materials from municipal waste. This approach was underpinned by the linear economic model, incorporating a partial recycling process.

The concept of a circular economy, which was initiated around 2008, marks the beginning of a distinct economic model. The objective of the circular economy is to recycle pertinent raw materials derived from municipal, construction, and commercial waste. Additionally, it emphasises the more extensive utilisation and reuse of recycled raw materials.

The circular economy is conceived as a comprehensive model of circular economic organisation, to facilitate the recycling of raw materials at all stages of production and product utilisation. This renders the circular economy an integral component of the broader concept of closed-loop management, which is responsible for the final phase of the process mentioned above (Hoffmeister et al., 2024).

SI 9: Extended Producer Responsibility (EPR)

Extended Producer Responsibility (EPR) is a policy approach under which producers are made financially or organizationally responsible for the waste management of their products, including collection, sorting, and treatment, and may also be required to support waste prevention and product recyclability.

SI 10: Municipal waste incineration

Municipal waste incineration (MWI) refers specifically to the thermal treatment of household and similar waste in dedicated facilities. However, MWI represents only a subset of thermal waste treatment methods. The broader category includes industrial waste incineration, co-incineration in cement kilns or power plants, and other high-temperature processes used for hazardous or commercial waste. These differ in terms of input materials, regulatory frameworks, and emission profiles. The ETS already covers co-incineration in cement kilns and power plants.

SI 11: The five-step waste hierarchy

The five-step waste hierarchy prioritizes waste management strategies in the following order: (1) Prevention – avoiding waste generation; (2) Reuse – using products or materials again without significant processing; (3) Recycling – converting waste into new materials or products; (4) Recovery – extracting energy or materials from waste; and (5) Disposal – final treatment such as landfilling or incineration without energy recovery. This hierarchy is designed to minimise environmental impact and promote resource efficiency.

SI 12: Definition of stabilised mineral waste

Stabilised mineral waste is mineral waste (e.g. building rubble, slag, industrial or construction waste) that has been chemically or physically treated using technical processes to reduce its environmental risks and stabilise its storage or landfill properties. They are considered the last option in the waste hierarchy because they typically cannot be recycled, or their treatment would be too expensive/complex.

SI 13: Total Organic Carbon (TOC)

Total organic carbon (TOC) describes the amount of organically bound carbon in a material and therefore serves as an important indicator of the methane-forming potential. Put simply, the more organic carbon it contains and the more biodegradable it is, the more methane can be produced through microbial decomposition processes.

SI 14: Definition of Municipal Waste

Municipal waste is a central concept in European waste management. The precise definition of this waste category is crucial for meeting legal requirements (e.g., recycling quotas in the EU) and for ensuring the statistical comparability of waste data between Member States. In recent years, the official EU definition of "municipal waste" has been expanded and clarified to clarify the scope of application and ensure standardised data collection for Eurostat (Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 Amending Directive 2008/98/EC on Waste (Text with EEA Relevance), 2018).

In earlier EU regulations, for example, under the Landfill Directive 1999/31/EC, municipal waste was traditionally defined as household waste and similar types of waste. With the amendment of the Waste Framework Directive by Directive (EU) 2018/851, a clear legal definition of municipal waste was introduced (Art. 3 para. 2b). It includes mixed and separately collected waste from private households (e.g. paper, glass, plastic, biowaste, bulky waste, electrical appliances) as well as from other sectors such as retail, administration, education, healthcare, catering or services, provided that this waste corresponds in composition to household waste. Excluded is "waste from production, agriculture, forestry, fishing, septic tanks and sewage network and treatment, including sewage sludge, and construction and demolition waste" (Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 Amending Directive 2003/87/EC to Enhance Cost-Effective Emission Reductions and Low-Carbon Investments, and Decision (EU) 2015/1814 (Text with EEA Relevance.), 2018; Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 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 and Amending Regulation (EU) No 525/2013 (Text with EEA Relevance), 2018). The definition applies regardless of the collection's organisation (public or private) and is broader than previous definitions (Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 Amending Directive 2003/87/EC to Enhance Cost-Effective Emission Reductions and Low-Carbon Investments, and Decision (EU) 2015/1814 (Text with EEA Relevance.), 2018; Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 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 and Amending Regulation (EU) No 525/2013 (Text with EEA Relevance), 2018). Green waste from parks, street sweepings, or market waste is also included, while coarse mineral materials such as sand, stone, sludge, or dust are excluded.

The Waste Catalogue (EWC) (94/3/EC, 1993) lists waste types in chapters. Municipal waste is primarily located in Chapter 20, which explicitly includes "municipal waste (household waste and similar commercial, industrial and institutional waste, including separately collected fractions)" (Eurostat, 2026b). In addition, some household-related waste from Chapter 15, 01 (packaging waste), is also counted as municipal waste if it originates from households or similar sources. However, not all types of waste in Chapter 20 are included: Specifically, 20 02 02 (excavated soil), 20 03 04 (septic tank sludge) and 20 03 06 (screenings/sewer clearing material) are excluded from the EU definition.

Eurostat makes it clear in its specifications that the final treatment is always decisive for the statistics. This means that the output quantities from sorting or MBT plants that are ultimately landfilled or incinerated must be recorded in the corresponding categories (landfilling, incineration) - but not the additional input quantity for pre-treatment. Such sorting residues are often assigned an AVV code from Chapter 19 (waste from waste treatment plants) rather than from Chapter 20.

With the new legal definition, everyone is now obliged to report the same scope. Eurostat adopted two necessary implementing acts in 2019: Decision (EU) 2019/1004 (on the monitoring of recycling rates) (Commission Implementing Decision (EU) 2019/1004 of 7 June 2019 Laying down Rules for the Calculation, Verification and Reporting of Data on Waste in Accordance with Directive 2008/98/EC of the European Parliament and of the Council and Repealing Commission Implementing Decision C(2012) 2384 (Notified under Document C(2019) 4114) (Text with EEA Relevance.), 2019) and Decision (EU) 2019/1885 (on landfilling of municipal waste) (Commission Implementing Decision (EU) 2019/1885 of 6 November 2019 Laying down Rules for the Calculation, Verification and Reporting of Data on Landfill of Municipal Waste in Accordance with Council Directive 1999/31/EC and Repealing Commission Decision 2000/738/EC (Notified under Document C(2019) 7874), 2019). These set out standardised reporting tables and calculation rules based directly on the definition.

SI 15: Municipal waste amounts and treatment routes 2022

Country	Total amount treated		Landfilling		Recycling		Composting/ Digestion		Energy recovery/ Incineration		Preparing for reuse	
	kt	% of EU 27	kt	%	kt	%	kt	%	kt	%	kt	%
AT	7.261	3,2%	150	2,1%	3.022	41,6%	1.478	20,4%	2.567	35,4%	44	0,6%
BE	8.056	3,6%	12	0,1%	2.722	33,8%	1.578	19,6%	3.633	45,1%	110	1,4%
BG	2.919	1,3%	1.695	58,1%	682	23,4%	95	3,3%	96	3,3%	0	0,0%
CY	469	0,2%	363	77,4%	79	16,8%	10	2,1%	15	3,2%	2	0,4%
CZ	5.198	2,3%	2.433	46,8%	1.327	25,5%	647	12,5%	792	15,2%	0	0,0%
DE	50.807	22,6%	414	0,8%	23.788	46,8%	11.378	22,4%	15.226	30,0%	0	0,0%
DK	4.356	1,9%	71	1,6%	1.102	25,3%	1.045	24,0%	2.148	49,3%	15	0,3%
EE	445	0,2%	66	14,8%	145	32,6%	20	4,5%	212	47,6%	1	0,2%
EL	5.420	2,4%	4.386	80,9%	854	15,8%	75	1,4%	87	1,6%	8	0,1%
ES	23.030	10,3%	10.782	46,8%	4.839	21,0%	5.045	21,9%	2.363	10,3%	0	0,0%
FI	2.898	1,3%	11	0,4%	829	28,6%	428	14,8%	1.621	55,9%	8	0,3%
FR	34.804	15,5%	8.465	24,3%	8.298	23,8%	6.511	18,7%	11.320	32,5%	207	0,6%
HR	1.659	0,7%	1.025	61,8%	538	32,4%	93	5,6%	3	0,2%	0	0,0%
HU	3.911	1,7%	2.164	55,3%	973	24,9%	311	8,0%	463	11,8%	0	0,0%
IE	4.085	1,8%	853	20,9%	1.458	35,7%	466	11,4%	1.288	31,5%	0	0,0%
IT	25.936	11,6%	5.173	19,9%	8.330	32,1%	6.951	26,8%	5.307	20,5%	0	0,0%
LT	1.324	0,6%	180	13,6%	345	26,1%	288	21,8%	500	37,8%	4	0,3%
LU	471	0,2%	13	2,8%	150	31,8%	112	23,8%	195	41,4%	0	0,0%
LV	848	0,4%	380	44,8%	295	34,8%	148	17,5%	26	3,1%	0	0,0%
MT	319	0,1%	273	85,6%	40	12,5%	0	0,0%	4	1,3%	1	0,3%
NL	8.365	3,7%	118	1,4%	2.353	28,1%	2.463	29,4%	3.431	41,0%	0	0,0%
PL	13.420	6,0%	5.108	38,1%	3.585	26,7%	1.900	14,2%	2.827	21,1%	0	0,0%

Country	Total amount treated		Landfilling		Recycling		Composting/ Digestion		Energy recovery/ Incineration		Preparing for reuse	
	kt	% of EU 27	kt	%	kt	%	kt	%	kt	%	kt	%
PT	5.614	2,5%	2.929	52,2%	695	12,4%	911	16,2%	1.078	19,2%	0	0,0%
RO	5.415	2,4%	4.253	78,5%	420	7,8%	291	5,4%	429	7,9%	0	0,0%
SE	4.121	1,8%	25	0,6%	859	20,8%	782	19,0%	2.439	59,2%	4	0,1%
SI	864	0,4%	81	9,4%	477	55,2%	165	19,1%	131	15,2%	2	0,2%
SK	2.531	1,1%	1.022	40,4%	857	33,9%	430	17,0%	204	8,1%	0	0,0%
EU27	**224.546**	**100,0%**	**52.445**	**23,4%**	**69.062**	**30,8%**	**43.621**	**19,4%**	**58.405**	**26,0%**	**0**	**0,0%**

Source: ENV_WASMUN (data for 2022)

SI 16: Classification of landfill types according to the Landfill Directive

The Landfill Directive (Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste, 1999) distinguishes between three main types of landfills: hazardous waste landfills, non-hazardous waste landfills, and inert waste landfills. The latter includes materials such as uncontaminated building rubble that undergo no significant physical, chemical, or biological changes. Non-hazardous landfills receive most of the organic waste, including the organic components of household waste, provided that no pre-treatment is performed. In some Member States, further differentiations are also made, for example, by type of waste or technical equipment, to reflect national disposal strategies better.

SI 17: Landfills as part of the E-PRTR

Landfills are subject to reporting under the European Pollutant Release and Transfer Register (E-PRTR), as defined by Regulation (EC) No 166/2006, if they fall under the activities listed in Annex I—specifically, landfills receiving more than 10 tonnes of waste per day or with a total capacity exceeding 25,000 tonnes. Among the emissions to be reported, methane (CH_4) is particularly relevant due to its classification as a significant greenhouse gas in Annex II, with a reporting threshold of 100 tonnes per year. Emissions must be reported when this threshold is exceeded, regardless of whether they are measured, calculated, or estimated.