

POSITION PAPER ON THE GLOBAL METHANE STATUS REPORT

OMISSION REGARDING THE EFFECTIVE CAPACITY TO REDUCE METHANE EMISSIONS IN LANDFILLS

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ABOUT WtE+X Knowledge Alliance

The WtE+X Knowledge Alliance is a strategic partnership that brings together leading organizations in waste management, energy, academia, and sustainability ([CEWEP](#), [ESWET](#) and [WtERT](#)). The Alliance's mission is to advance and share science-based knowledge on Waste-to-Energy technologies, supporting their responsible adoption as part of integrated solutions to reduce reliance on landfilling.

EXECUTIVE SUMMARY

This position paper presents a critical analysis, of a technical-scientific nature and oriented towards public policy, on how the Global Methane Status Report 2025 (GMSR 2025) structured its approach to the waste sector and, in particular, on an analytical gap with normative implications: the absence of an explicit defined framework for waste-to-energy (WtE) as a structuring technology for methane mitigation by diverting waste from final disposal in landfills and dumps (UNEP, 2025). The GMSR 2025 is recognized for consolidating recommendations focused on prevention measures, segregation at source, treatment of the organic fraction (composting and anaerobic digestion), and capture/use of landfill gas (UNEP, 2025). However, this architecture, as presented, is incomplete for guiding rapid, measurable, and lasting reductions in methane because it does not clearly typify the infrastructure needed to treat the inevitable residual fraction of non-recyclable waste (IPCC, 2021; OECD, 2023; UNECE, 2022).

The gap is clearly evident in the wording and summary tables of the GMSR 2025. In the treatment of industrial solid waste, the report lists options such as "upgrade to managed landfills with gas recovery & utilization; anaerobic digestion with biogas recovery; composting; energy recovery," but without technically defining "energy recovery" and without differentiating between biological and thermal routes, and without recognizing WtE as definitive treatment infrastructure for waste (UNEP, 2025). In the chapter on waste, the report states that effective strategies "prevent the formation" of methane by reducing/diverting organics through segregation, composting, anaerobic digestion, and "thermal pre-treatment," or capture and use landfill gas (UNEP, 2025). The issue is that "thermal pre-treatment" appears as a peripheral mention, without conceptual development, environmental requirements, MRV (monitoring, reporting, and verification), or an explicit connection to WtE as a controlled final treatment route integrated into the waste hierarchy (UNEP, 2025; European Parliament, 2008; JRC, 2019).

This omission is not merely semantic. Global reports such as the GMSR, due to their reference nature, are often translated into public policy language adopted in NDCs, sectoral strategies, climate finance guidelines, and green taxonomies. When a solution is not named, defined, and qualified, it tends not to be incorporated with legal certainty and predictability by governments and financiers—especially in countries where the realistic alternative to the "perfect solution" is the continuation of poorly managed landfills

and dumps (World Bank, 2018; UNECE, 2022; UNEP/CCAC, 2021). The silence of WtE in the report may result in a policy focus on organics and gas capture, without addressing the residual non-recyclable fraction (IPCC, 2021; OECD, 2023).

The central argument is that a mitigation strategy in the waste sector needs to be anchored in the physical-chemical and operational dynamics by which landfills generate methane: anaerobic decomposition produces emissions over long periods and is sensitive to design, cover, moisture, operation, and infrastructure aging failures (UNEP, 2025). The report itself acknowledges that methane emissions from waste can persist for decades and that capture performance depends on operational and engineering conditions (UNEP, 2025). Additionally, its assessment bears a high degree of uncertainty. Based on this, it is argued that relying primarily on gas capture/use, even when economically attractive in medium and large landfills, is insufficient as a primary strategy because a significant portion of emissions occurs as fugitive emissions, including persistent point sources (Themelis & Bourtsalas, 2021; Cusworth et al., 2024).

This analysis is reinforced by empirical evidence. Recent studies show that actual emissions from landfills can be substantially higher than modeled estimates and those reported in inventories, even in jurisdictions with advanced regulation (Duren et al., 2019; Cusworth et al., 2024). For Example, the Science study cited above presents emissions from 250 landfills in 18 US states using airborne spectrometers found observed emissions on average 2.7 times higher than those reported, with persistent point sources detected at 52% of landfills, contributing disproportionately to total emissions, with long-term high emission events (Cusworth et al., 2024). Additional studies identified "super emitters" in California, through concentrated plume detection (Duren et al., 2019), and via satellite detection (Schuit et al., 2023).

In Brazil, two points stand out: (i) landfills as super-emitters in plume mapping and (ii) significant emissions even with biogas/biomethane capture. For instance, Carbon Mapper data for the Caieiras landfill indicate estimated fugitive emissions of 7.7 t/h (2023), equivalent to 67,400 t/year of methane; using GWP20 as a parameter, equivalent emissions of 5.8 million tCO₂e/year are reported (Carbon Mapper, n.d.; IPCC, 2014). This demonstrates that even with modern capture infrastructure, significant fugitive flows remain, reinforcing the need for strategies that structurally reduce waste sent to landfills (Themelis & Bourtsalas, 2021; Cusworth et al., 2024).

Methane has a high short-term global warming potential (GWP₂₀) making its immediate reduction is one of the most cost-effective measures to slow warming in the coming decades (IPCC, 2014; UNEP/CCAC, 2021).

At the global policy level, this position paper links this urgency to the Global Methane Pledge and the Global Methane Assessment, which attribute a significant portion of anthropogenic emissions to the waste sector and identify cost-effective mitigation opportunities, including closing landfills and implementing treatment solutions for non-recyclable waste (UNEP, 2021; UNEP/CCAC, 2021). If reports such as the GMSR 2025 recommend quantifying methane targets in the waste sector, it is methodologically necessary to present a technically complete portfolio, including WtE, to achieve them without leaving residual non-recyclable waste unaddressed (UNEP, 2025; IPCC, 2021).

Robust waste management systems—especially in developing countries—require a combination of: prevention/ reduction (including food waste), sorting/ recycling, treatment of the organics (composting/ anaerobic digestion), closure of dumps and improvement/capture in existing landfills, and final treatment via environmentally controlled thermal routes with energy and material recovery (IPCC, 2021; European Parliament, 2008; UNECE, 2022; OECD, 2023). In the coming three decades, the rapid urbanization of the Global South will create a dual urgency: the need to minimize burgeoning waste streams and the demand for stable energy. Integrating WtE into the GMSR 2025 would provide a roadmap for WtE, the only mature, large-scale solution capable of simultaneously addressing both of these challenges simultaneously, whilst preventing the 'locking-in' of methane emissions in the world's fastest-growing cities and whilst generating co-benefits such as material recovery (UNECE, 2022; JRC, 2019).

European countries with high recycling rates also maintain significant WtE capacity, showing complementarity (rather than competition) between recycling and energy recovery aligned with Directive 2008/98/EC (European Parliament, 2008; OECD, 2023). From a regulatory perspective, WtE has limits and best available techniques, reinforcing that eligibility for climate policies associated with safeguards, emissions control, and MRV—criteria not explicitly mentioned in the GMSR 2025 (JRC, 2019). WtE can also evolve towards integration with carbon capture, use, and storage (CCUS), further reducing the net climate (IEAGHG, 2020; CEWEP, 2022).

Although recycling and composting measures are essential, they are not, in isolation, a complete methane mitigation system, as they leave without an explicit solution the inevitable residual fraction, which is not materially recyclable and which continues to be sent to landfills or dumps, perpetuating significant methane emissions for decades: International practice has shown that after all practical efforts for recycling and composting there remains a very large portion, that must be disposed either in landfills or WtE power plants. At the present time, the residual non-recyclable waste of Municipal Solid Waste (MSW) tonnage that goes to WtE plants globally is estimated at about 500 million tons, while over a billion tons go to landfilling. This crucial fact should be highlighted in the 2025 Global Methane report, because of the major contribution to methane emissions by the global landfilling.

Based on this reasoning, we propose enhancing the methodological integrity of the GMSR 2025 in the waste sector: maintaining the legitimate emphasis on upstream measures, but explicitly including WtE as a technological category, define its complementary role, and establishing eligibility criteria aligned with best available techniques, environmental safeguards, and MRV requirements (UNEP, 2025; JRC, 2019; UNECE, 2022). This revision would increase the practical usefulness of the report for governments and financiers, reduce ambiguities, and strengthen the GMSR's ability to guide effective public policies consistent with the climate emergency—especially where the operational reality still includes dumps and suboptimal landfills (World Bank, 2018; UNEP/CCAC, 2021).

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I. INTRODUCTION

This position paper presents a critical analysis, of a technical-scientific nature and oriented towards public policy, on how the Global Methane Status Report 2025 (GMSR 2025) structured its approach to the waste sector and, in particular, on the analytical gap regarding the effective capacity to reduce methane emissions from landfill disposal (UNEP, 2025). Based on literal passages from the report—transcribed with page references—the document demonstrates that GMSR 2025 predominantly emphasizes measures focused on the organic fraction (waste prevention, segregation, composting, anaerobic digestion) and landfill gas capture/use, but does not explicitly recognize waste-to-energy as a structuring mitigation technology for diverting residual non-recyclable waste from landfills, despite its technical relevance in integrated management systems (IPCC, 2021; OECD, 2023).

This omission is not merely semantic: by influencing the language that is often reproduced in NDCs, national strategies, financing instruments, and green taxonomies, the absence of clear reference to this technological pathway can lead to the tacit exclusion of solutions capable of reducing methane more quickly and measurably, especially in contexts where the realistic alternative to definitive waste treatment remains final disposal in poorly managed landfills and dumps (World Bank, 2018; UNECE, 2022).

The relevance of this topic stems from methane's role as a short-lived climate pollutant with a strong impact on global warming over a 20-year horizon, as well as its connection to tropospheric ozone formation and adverse effects on public health (IPCC, 2021; Malley et al., 2017). In addition, recent empirical evidence based on direct measurements, including remote sensing and airborne campaigns, indicates that landfill emissions may be substantially higher than inventory estimates, with "super-emitters" occurring even in facilities equipped with gas capture (Duren et al., 2019; Schuit et al., 2023; Cusworth et al., 2024).

A study based on high-resolution remote sensing shows that the new generation of satellites dedicated to methane detection has substantially changed the ability to independently observe emissions from landfills and dumps. Based on global campaigns conducted between 2021 and 2022, more than 1,400 orbital observations were analyzed at more than 150 final disposal sites spread across six continents, with the ability to detect concentrated plumes above approximately 100 kg of CH₄ per hour. In more than

two-thirds of the observations, emissions were effectively detected, revealing high variability between facilities. The instantaneous rates observed had medians of a few tons of methane per hour, while the relative uncertainty associated with individual estimates remained high, reflecting the intermittent, heterogeneous, and highly dependent nature of landfill operating conditions. (Dogniaux et al., 2025)

A particularly relevant result of these analyses is the finding that top-down estimates derived from satellite observations do not show a significant correlation, at the facility level, with bottom-up estimates reported in official inventories or calculated by conventional methane generation and capture models. The comparisons made indicate very low statistical correlations between observed emissions and data reported by operators or estimated by global inventory systems, suggesting that widely used assumptions—such as average capture efficiency rates or standardized decay curves—do not adequately reflect operational reality. In several cases, emissions detected by direct observation exceed those reported by a factor of several times, reinforcing the evidence of systematic underestimation of actual landfill emissions, even in countries with advanced regulatory frameworks. (Dogniaux et al., 2025)

Another structural finding is the high concentration of emissions in a small number of facilities, resulting in a "heavy tail" distribution, in which a minority of landfills account for most of the methane emitted. Approximately 40% of the units with the highest emissions account for about 80% of the emissions detected, which characterizes the recurring presence of "super-emitters." It was also observed that formally managed landfills tend to have lower emissions per area when compared to dumps, although they remain significant sources of methane, especially at active waste disposal sites. These results reinforce the need for mitigation strategies that are not limited to subsequent gas capture, but that structurally reduce the flow of waste destined for final disposal, preventing the formation of methane at the source and allowing prioritization based on empirical evidence and continuous monitoring. (Dogniaux et al., 2025, NATURE)

In this context, discussing the "effective capacity" for reduction in landfills requires going beyond theoretical modeling and addressing recurring operational limitations — average capture efficiency, persistent fugitive emissions, variability by project/operation, and the multi-decadal duration of methane generation — in order to calibrate mitigation expectations and guide technological choices more consistent with climate urgency (Themelis & Bourtsalas, 2021; UNEP, 2025).

To this end, the document is organized to: (i) highlight, based on specific excerpts from the GMSR 2025, how the report describes mitigation options in the waste sector and where the omission of waste-to-energy materializes; (ii) establish the causal connection between this gap and the structural climate problem of methane emissions from landfills, highlighting why strategies focused solely on capture and "incremental improvements" may be insufficient for rapid and lasting reductions; and (iii) consolidate, in appendices and analytical sections, the technical, regulatory, and socio-environmental foundations that justify the explicit inclusion of waste-to-energy as part of the mitigation portfolio, complementing prevention, recycling, and organic waste treatment (IPCC, 2021; European Parliament, 2008; JRC, 2019; UNECE, 2022).

Ultimately, the aim is to contribute to the methodological integrity of global reports and the quality of recommendations made to governments, ensuring that waste and methane policy design reflects comprehensive systems, with operational closure for unavoidable waste and effective reduction of landfill dependence.

II. OMISSION OF WASTE-TO-ENERGY IN THE GLOBAL METHANE STATUS REPORT 2025

Following the publication of the Global Methane Status Report 2025, CEWEP, WtERT, and ESWET present this joint position paper to highlight an important dimension of methane mitigation in the waste sector that is not explicitly included in the report's assessment, namely the demonstrated contribution of Waste-to-Energy (WtE) technologies, in diverting waste from landfills and preventing the generation of methane emissions.

In the specific case of the waste sector, a systematic reading of the report reveals an approach that favors interventions focused on the organic fraction—waste prevention, source separation, composting, anaerobic digestion, and landfill gas capture — while giving minimal attention to the systemic role of waste-to-energy (WtE) as a structuring technology for methane mitigation by diverting waste from landfills.

The pattern of omission is already noticeable in the summary tables of mitigation measures and potentials for the waste sector. When addressing industrial solid waste, the report indicates the following options: "Upgrade to managed landfills with gas recovery & utilization; anaerobic digestion with biogas recovery; composting; energy recovery" (UNEP, 2025, p. 22). The expression "energy recovery" appears in a generic form, without technical definition, without distinction between biological and thermal

routes, and without any explanation of the role of waste-to-energy as infrastructure for the treatment of non-recyclable waste. This ambiguous wording has relevant practical effects, as public policies, NDCs, and financing instruments tend to replicate explicitly named categories, rather than implicit or indeterminate concepts.

This omission becomes even more evident in the chapter specifically dedicated to the waste sector. The report states that “Effective mitigation strategies either prevent its formation by reducing and diverting organic waste from final disposal sites through source segregation, composting, anaerobic digestion, and thermal pre-treatment, or capture and use of landfill gas” (UNEP, 2025, p. 77). Although the term “thermal pre-treatment” is mentioned, the text does not elaborate on it, does not connect it to waste-to-energy as an environmentally controlled pretreatment or final treatment route, nor does it frame it as energy recovery infrastructure with strict standards for emissions control, material recovery, and the possibility of future integration with carbon capture. The isolated mention functions, in practice, as a peripheral reference, insufficient to guide governments on the systemic role of WtE.

This gap is further reinforced when the report presents its key messages for the sector. The text prioritizes “upstream measures, such as mechanisms and incentives to prevent food loss and waste, together with mandatory source separation,” followed by “consistent treatment infrastructure for organic wastes and improved landfill engineering” (UNEP, 2025, p. 77). It then reinforces that “Simple interventions, such as preventing food loss and waste, promoting household- and community-level composting, and enforcing basic operational standards at disposal sites” are sufficient to reduce emissions (UNEP, 2025, p. 77). Although such measures are relevant, they do not constitute, in isolation, a complete methane mitigation system, as they leave without an explicit solution the inevitable residual fraction, which is not materially recyclable and which continues to be sent to landfills or dumps, perpetuating significant methane emissions for decades.

The report itself acknowledges that “methane emissions from waste can persist for decades” and that the efficiency of gas capture in landfills depends on “landfill design, operational practices, and aging infrastructure” (UNEP, 2025, p. 77). Paradoxically, this recognition reinforces the need for structural solutions that prevent methane generation at source, rather than simply attempting to capture it after it has formed. Modern waste-to-energy fulfills precisely this function by diverting waste from landfills, eliminating the

anaerobic environment responsible for methane production, something that the GMSR 2025 fails to explicitly recognize.

When analyzing how countries have been incorporating the waste sector into their Nationally Determined Contributions (NDCs), the report notes that measures generally focus on "reducing food waste, source segregation, separate waste collection, the adoption of composting and waste-valorization technologies such as anaerobic digestion, and the diversion of organic waste from landfills," in addition to "installation of gas-recovery systems for flaring or energy use" (UNEP, 2025, p. 79). The excerpt is revealing: when the report gives examples of "waste-valorization technologies," it cites only anaerobic digestion; when it addresses energy, it limits itself to biogas and landfill gas. Waste-to-energy is not mentioned as a specific technology, despite its widespread use in countries with advanced waste management systems and high recycling rates.

This discursive pattern has practical consequences. By not explicitly naming waste-to-energy, the report contributes to its tacit exclusion from national plans, climate finance strategies, and green taxonomies, especially in middle- and low-income countries, where the realistic alternative to WtE is not comprehensive recycling, but the maintenance of poorly managed landfills and open dumps, with high fugitive methane emissions and severe impacts on public health.

The bias in favor of landfill-centered solutions is also evident when the report addresses economic instruments and cost-effectiveness. It states that "Landfill gas (LFG) capture and use is particularly economic in medium to large landfills" and that early gas recovery can improve results (UNEP, 2025, p. 80). However, the text does not address the structural limitations of this approach, nor does it discuss the actual average efficiency of methane capture in landfills, or the fact that even technically advanced landfills remain significant sources of fugitive emissions over decades. In other words, it does not account for the fact that the solution is not merely to capture methane in landfills, but rather to effectively divert this waste from landfills.

From a technical and scientific perspective, excluding waste-to-energy (WtE) from integrated waste management strategies is inconsistent with the findings of the IPCC Sixth Assessment Report. The IPCC confirms that, even under ambitious scenarios prioritizing waste prevention, reuse, and recycling, a substantial residual fraction of municipal solid waste remains non-recyclable and therefore requires safe and controlled treatment to avoid unmanaged disposal and long-term methane generation in landfills (IPCC, 2022). Within the waste sector, the IPCC identifies thermal treatment with

energy recovery as a complementary mitigation option, alongside recycling, biological treatment, and landfill gas management, particularly for residual waste streams that cannot be materially recovered (IPCC, 2022).

Consistent with this assessment, the Organization for Economic Co-operation and Development characterizes sustainable waste management systems as those that integrate prevention, recycling, and energy recovery, ensuring that residual waste with calorific value is diverted from landfills when recycling is not technically or economically feasible (OECD, 2019). Such balanced systems are considered essential to circular economy strategies, as they reduce landfill dependence, mitigate methane emissions, and improve overall resource efficiency while respecting the waste hierarchy and avoiding lock-in effects associated with uncontrolled disposal (OECD, 2019).

The omission of WtE also affects the internal consistency of the report itself when it acknowledges that methane mitigation in the waste sector generates co-benefits such as renewable energy production, improved air quality, and public health gains. If energy is recognized as a legitimate co-benefit, it would be methodologically necessary to differentiate between energy obtained from capturing methane that has already formed (biogas and landfill gas) and energy obtained from recovering energy from waste that would otherwise produce methane over decades. Both routes are distinct, complementary, and perform different functions within an integrated mitigation system.

The gap becomes even more critical in the context of developing countries. The report mentions the closure of landfills and the need for improvements in waste management, but does not connect these goals to the need for infrastructure capable of absorbing waste in an environmentally safe and financially viable manner. International guidelines for public-private partnerships in waste-to-energy projects exist precisely to fill this void, offering models for governance, risk sharing, and economic viability. By ignoring WtE, the GMSR 2025 misses an opportunity to align the methane mitigation agenda with institutional instruments already available within the United Nations.

Finally, by stating that “few have set quantified waste methane targets” and recommending that NDCs incorporate explicit methane mitigation targets in the waste sector (UNEP, 2025, p. 77), the report commits a methodological inconsistency by failing to present, with equal clarity, the complete set of technologies needed to achieve such targets. A technically robust framework would require, at a minimum, four interconnected pillars: food waste prevention; segregation and treatment of organic waste; closure of dumps and gas capture in existing landfills when unavoidable; and controlled thermal

treatment with energy recovery for non-recyclable waste. The absence of the fourth pillar waste-to-energy leaves the system open and weakens the environmental integrity of the proposed goals.

In summary, by omitting waste-to-energy as an explicitly recognized and analyzed technology, the Global Methane Status Report 2025 presents an incomplete approach to methane mitigation in the waste sector. This omission does not stem from contrary scientific evidence, but from an analytical gap that compromises the report's ability to guide effective, integrated public policies aligned with the operational reality of waste management systems. The explicit inclusion of waste-to-energy, with strict environmental criteria and integration into the waste hierarchy, would not only be consistent with international literature, but essential to achieving rapid, measurable, and lasting reductions in methane on a global scale.

In light of this textual evidence that the GMSR 2025 describes mitigation in the waste sector mainly as landfill improvement, gas capture/use, and organic treatment—leaving waste-to-energy outside the explicit framework—it becomes essential to deepen the diagnosis of the "source" of the problem: the physical-chemical and operational dynamics by which landfills (including formally licensed ones) continuously generate methane over long periods, with fugitive emissions sensitive to design, operation, coverage, humidity, and infrastructure aging failures.

This transition is necessary because the critique here is not merely terminological; it depends on demonstrating, based on climatic parameters and empirical evidence, that structural dependence on landfills produces a persistent and often underestimated methane liability, which makes a strategy focused solely on capture and "incremental improvements" insufficient and justifies the explicit incorporation of diversion and definitive treatment solutions for tailings. It is precisely this causal chain—methane as a climate pollutant with high short-term impact, inevitable generation in anaerobic final disposal environments, and practical control limitations—that underpins the next chapter, dedicated to the climate problem of methane emissions from landfills.

III. THE CLIMATE PROBLEM OF METHANE EMISSIONS FROM LANDFILLS

Methane is considered the close second largest contributor to climate change, with a global warming potential more than 80 times greater than that of CO₂ over a 20-year horizon (IPCC, 2022). Studies show that methane emissions in Brazil grew by 52%

between 2005 and 2020 in the waste disposal sector, with landfills being one of the main sources (Reuters, 2024).

In addition, the Global Methane Pledge, signed during COP26, sets an ambitious goal of reducing these emissions globally by 30% by 2030 (UNEP, 2021). In this scenario, WtE plants can play a crucial role, mitigating up to 86 million tons of CO₂ equivalent per year in Brazilian metropolitan areas alone (ABREN, 2020).

According to current greenhouse gas (GHG) inventories, untreated organic waste is the third largest source of anthropogenic methane in the world and in the United States (U.S. EPA, 2021). However, new data suggest that these emissions, and the opportunity to reduce them, are much greater. A series of recent studies, which employ direct measurement of methane plumes from landfills using upwind aircraft, have shown that measured emissions are, on average, more than double the modeled emissions reported in current GHG inventories (Peischl *et al.*, 2013). Based on this growing body of data, methane emissions from landfills are comparable to methane emissions from the entire agricultural sector in the United States (¹). Although the state of California has implemented the most stringent landfill gas control regulations to date, a team of researchers from NASA and several American universities has identified certain California landfills as methane "super-emitters," which are concentrated emissions of methane that form plumes and cause damage to public health (Duren *et al.*, 2019).

According to the United Nations Environment Programme (UNEP), "cutting methane is the strongest lever we have to slow climate change over the next 25 to 30 years" (UNEP, 2021). In the short term, reducing emissions of short-lived climate pollutants such as methane is more effective than reducing CO₂ (*ibid.*). The IPCC's Sixth Assessment Report notes that methane reduction "stands out as an option that combines short- and long-term gains in surface temperature and brings benefits to air quality by reducing global surface ozone levels" (Hu *et al.*, 2013).

In a recent study from September 2023 (Schuit *et al.*, 2023), the super emitters of methane in Brazil are only landfills, as shown in Figure 1 (orange, see Figure 1), including mapping of the oil, gas, and coal sectors at 2,974 points with methane plumes

¹ Total methane emissions from US landfills in 2019, as reported in US EPA (2021), were 4.58 MMT CH₄. On average, landfill emissions measured from recent data referenced here were 2.3 times higher than reported. Adjusting the US inventory by this factor generates total landfill emissions of 10.5 MMT CH₄. Total emissions from the agricultural sector, including enteric fermentation, manure management, rice cultivation, and field burning of agricultural residues were 10.26 MMT CH₄ (Themelis and Bourtsalas, 2021).

in 2021. These super-concentrated methane plumes cause ozone layer destruction and are estimated to be responsible for 1 million deaths per year, according to a study published in *Environmental Health Perspectives* (Malley, 2017). According to UNECE/UN, some countries consider methane a dangerous pollutant from a health and safety perspective (United Nations, 2019). Methane is a powerful greenhouse gas that accelerates global warming and worsens air quality, contributing to the formation of tropospheric ozone, a toxic air pollutant.

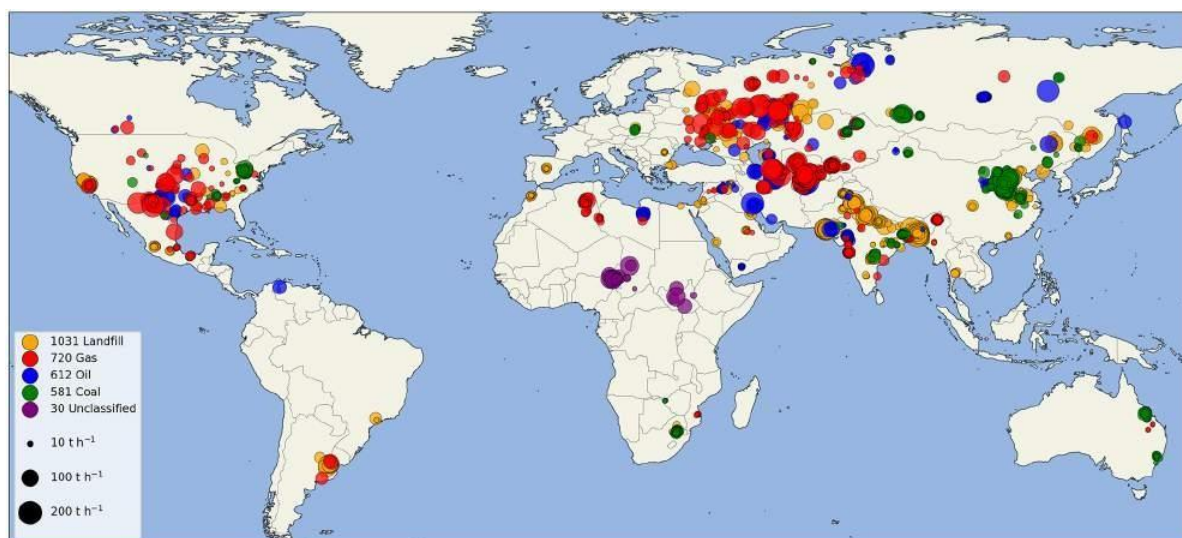


Figure 1 Automated detection and monitoring of methane super-emitters using satellite data, Atmos. Copernicus, 2023

Source: Schuit *et al.*, 2023.

Although methane is a relatively short-lived climate pollutant, as it remains in the atmosphere for a relatively limited period, its atmospheric volumes are continuously replenished. As a result, its high warming potential makes effective methane management an imperative part of climate change mitigation strategies².

The Carbon Mapper program, which includes experts and collaborators from NASA's Jet Propulsion Laboratory and Arizona State University, used an aircraft equipped with satellite instruments to map methane plumes, along with other observation systems and data sets, to assess methane emissions in representative regions and economic sectors around the world.

² Carbon Mapper. Available at: <https://carbonmapper.org/data>.

The largest methane super-emitter in Brazil is the Caieiras landfill (Figure 2), which has an integrated methane capture system for biomethane production, is located in an environmental preservation area, and receives waste from approximately 12 million inhabitants per day. Even with a modern methane capture system (biogas/biomethane) for energy purposes, this landfill has fugitive emissions of 7.7 tons/hour of methane into the atmosphere (2023), which represents 67,400 tons of methane per year. Considering a 20-year scenario (GDP20), this represents 5.8 million tons/year of CO₂ equivalent.

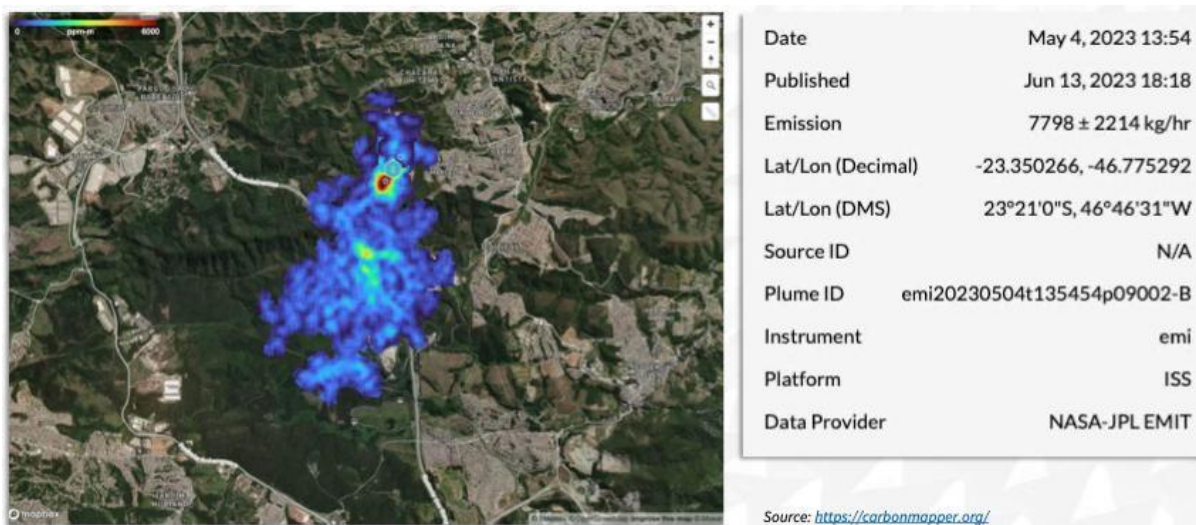


Figure 2 Carbon Mapper data. Caieiras Landfill, Brazil, 2023.

Currently, 19% of anthropogenic methane emissions come from the waste sector, with most of them coming from landfills (Saunois *et al.*, 2024). Although some engineered landfills take measures to capture methane, on average, capture efficiency is 48% (Themelis and Bourtsalas, 2021), meaning that large amounts escape into the atmosphere. In addition, recent studies have shown that landfill emissions reports significantly underestimate the actual amount of methane emitted into the atmosphere (Balasus *et al.*, 2024). Landfills contribute more GHG emissions than WtE, especially also when adopting a Life Cycle perspective and considering WtE plants avoided emissions such as fossil fuels substitution for energy production and metal recycling from incineration bottom ash. (CEWEP Climate Roadmap, 2022)

The study *Quantifying Methane Emissions from United States Landfills* analyzed methane emissions from 250 landfills in 18 US states using airborne imaging spectrometers, including NASA's AVIRIS-NG and the Global Airborne Observatory (GAO) from Arizona State University. The research found that methane emissions from

these landfills were, on average, 2.7 times higher than those reported by the EPA's Greenhouse Gas Reporting Program (GHGRP). It was also documented that some landfills emitted up to 6 tons of methane per hour. In addition, the study revealed that persistent point sources, detected in 52% of landfills, contributed disproportionately to overall emissions, often resulting in long-term high-emission events (Cusworth *et al.*, 2024 and [ESA - Satellites detect large methane emissions from Madrid landfills](#)).

Methane itself is not directly harmful at low concentrations, but it contributes to the formation of ground-level ozone, a powerful respiratory irritant.

Waste-to-Energy has established itself in recent decades as one of the most effective technologies for mitigating greenhouse gas emissions and for ecological transition. According to the *World Bank* (2018, p. 112), the world generated 2.01 billion tons of municipal solid waste in 2016, and this volume is expected to reach 3.4 billion tons by 2050 if there are no structural changes in public policies. The same projection indicates that waste production will grow three times faster in low-income countries than in developed nations, reflecting population growth, rapid urbanization, and emerging consumption patterns.

The *Intergovernmental Panel on Climate Change* (IPCC, 2021, p. 49) points out that the waste sector is responsible for about 3% to 5% of global greenhouse gas (GHG) emissions, mainly due to the release of methane (CH₄) during the anaerobic decomposition of organic waste in landfills and dumps. According to the *European Environment Agency* (EEA, 2023, p. 76), about 20% of global anthropogenic methane emissions come from the disposal of municipal and industrial solid waste.

The *Atlas Waste Management and Climate Change Mitigation 2025*, published by the *International Solid Waste Association* with the support of the French Development Agency, compiles data from more than 100 countries and identifies that the waste sector represents a key point of global mitigation, with the potential for indirect emissions reductions of up to 20% when considering emissions avoided through recycling, composting, biogas, and energy recovery (World Bank, 2022, p. 139; IPCC, 2021, p. 58). This potential, however, remains underutilized, as most countries still rely on landfills and dumps—accounting for more than 90% of sector emissions in developing countries.

According to the *United Nations Environment Programme* (UNEP, 2022, p. 65), methane is responsible for approximately 30% of current global warming, and its immediate reduction is considered one of the most cost-effective measures to limit the

increase in global average temperature to 1.5°C. The UNEP report highlights that actions in the waste sector can reduce global methane emissions by up to 15% by 2030, mainly through the elimination of landfills and the implementation of WtE and anaerobic digestion technologies.

The *OECD Environmental Outlook* (2023, p. 91) reinforces that the growth in waste generation is strongly associated with the increase in Gross Domestic Product (GDP) per capita, and that upper-middle-income countries have the highest per capita disposal rates, between 400 and 800 kg per inhabitant per year. This trend, according to the *European Environment Agency* (2023, p. 98), creates a double pressure on the climate: on the one hand, increased methane emissions from landfills; on the other, the growing need for stable energy to sustain urbanized and digitized economies.

Analyses by *the World Bank* (2020, p. 167) show that East Asia and the Pacific account for 23% of global waste, while Latin America and the Caribbean contribute 12%. The Middle East and North Africa together account for 6%. Europe and North America, although they have lower total volumes, have the highest per capita rates, reflecting high consumption and consolidated urbanization. Sub-Saharan Africa is the region with the highest projected growth, with the potential to quadruple its waste generation by 2050.

The *Global Methane Assessment* (UNEP/CCAC, 2021, p. 34) estimates that about 20% of global methane emissions derive directly from inadequate solid waste management and that mitigation measures in the sector can be implemented at reduced marginal costs compared to other emitting sectors..

These data support the thesis that integration between waste and energy policies is crucial for decarbonization. Energy recovery converts non-recyclable waste into electricity and heat, replacing fossil fuels and eliminating the need for large-scale landfills. Studies by *the European Commission Joint Research Centre* (JRC, 2019, p. 117) show that modern WtE plants in the European Union operate with energy recovery efficiencies of up to 85% in cogeneration systems, and their air pollutant emissions remain below detection limits for dioxins, mercury, and fine particles.

Waste-to-Energy can also reliably deal with PFAS (UBA/ RWTH study 01/26).

Based on this evidence, it can be seen that WtE is not only a waste treatment solution, but also an essential infrastructure for the energy transition. The *European Green Deal* (European Commission, 2020, p. 203) explicitly recognizes the importance of the sector in achieving climate neutrality by 2050, integrating it into the circular

economy and European industrial policy. The same reasoning is defended by *the United Nations Economic Commission for Europe* (UNECE, 2022, p. 49), which classifies WtE as the “most sustainable solution for non-recyclable waste,” highlighting its contribution to the Sustainable Development Goals (SDGs 7, 11, 12, and 13).

IV. THE SOCIO-ENVIRONMENTAL BENEFITS OF WASTE-TO-ENERGY COMPARED TO LANDFILLS

WtE facilities are far from representing a linear use of resources; instead, they enhance the concept of “closing the loop,” achieving not only material recovery but also energy recovery. Modern WtE plants incorporate advanced material recovery processes that enable the extraction of valuable materials, such as metals and minerals, from incineration ash. This recovery offers an opportunity to reduce the energy-intensive extraction of virgin materials, which provides an additional benefit in indirect emissions reductions (ESWET, 2023). Danish WtE plants, for example, first recover recyclable metals from the ash and then reuse 99% of the remainder for construction purposes (ESWET, 2021).

This process not only reduces waste volume, but also recycles materials back into the economy, promoting a circular economy. In fact, the United Nations Economic and Social Council has found that WtE is currently the most sustainable solution for non-recyclable waste, as it recovers energy and materials while offering an alternative to landfills and waste exports (United Nations Economic and Social Council, 2022).

WtE facilities increase recycling rates (IEA Bioenergy, 2022) and complement, rather than compete with, recycling and waste reduction efforts. Waste that cannot be recycled or reused is treated in solid waste recovery plants, ensuring that the energy contained in this waste is recovered rather than deposited in landfills. These plants ensure that non-recyclable waste does not contribute to environmental risks and is instead used for energy recovery, significantly reducing greenhouse gas (GHG) emissions compared to landfills.³

Therefore, the claim that energy recovery from solid waste competes with (informal) recycling sectors is based on a misunderstanding of the waste management

³NB: Landfill standards differ significantly around the world. In Europe, the future BREF Landfill will introduce some minimum requirements, likely going beyond the technical requirements set out in the 1999 EU Landfill Directive.

hierarchy. WtE mainly deals with non-recyclable materials, which have already passed through sorting and recycling systems. Informal recyclers focus on collecting materials with economic value, while WtE processes the residual waste stream. In addition, modern WtE plants include strict environmental controls and bottom ash and fly ash recovery systems, which optimize recycling rates.

Figure 3 illustrates the long-term shift in municipal waste management across the EU-27 and the relationship between recycling and energy recovery from solid waste. Over the 28-year period (1995–2023), both pathways have developed in parallel, reducing reliance on landfilling and increasing the diversion of non-recyclable (but recoverable) waste. The figure highlights how recycling and Waste-to-Energy are complementary strategies that jointly reduce landfill dependency and support a more sustainable circular economy.

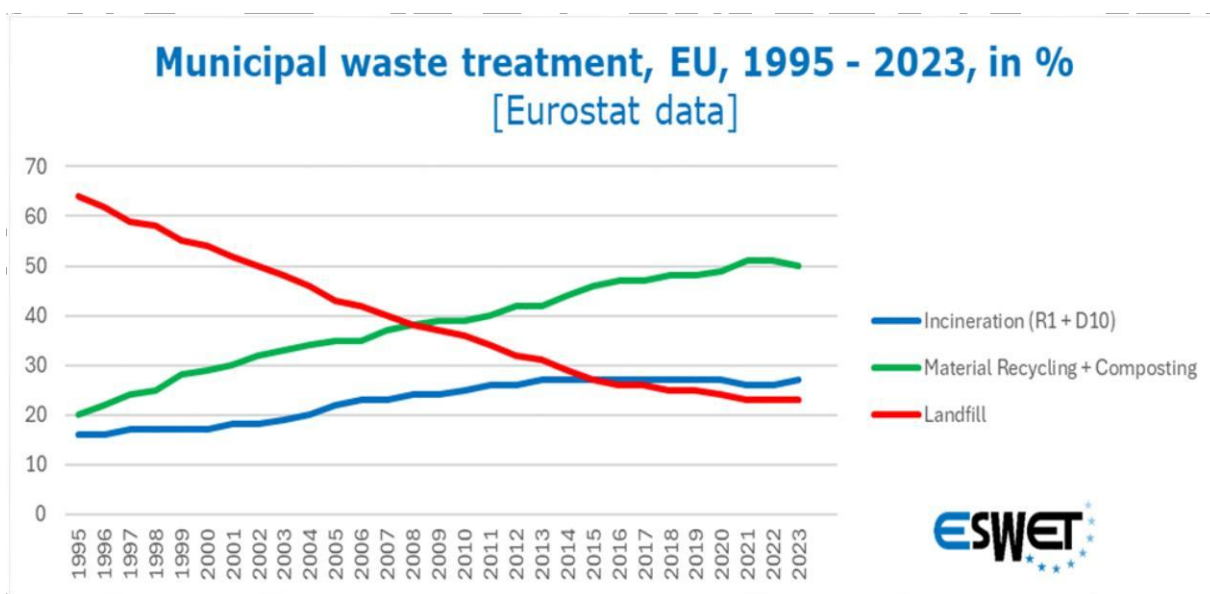


Figure 3 Trends in Municipal Waste Treatment in the EU (1995–2023). Data source: Eurostat (2025)⁴. Graphic source: ESWET.

Therefore, the real dichotomy is not between recycling and Waste-to-Energy, but between the latter and landfilling; hence, to support landfill diversion (and thus, greatly reducing the waste management sector emissions) it is essential to support other modes

⁴ Eurostat (2025). Available at: https://ec.europa.eu/eurostat/databrowser/view/env_wasmun/default/table?lang=en

of treatment, including Waste-to-Energy, and introduce restrictions to landfills that should accept only ultimate waste. Evidence shows that countries that implemented robust landfill taxes and restrictions, alongside increased WtE and MBT capacity, achieved dramatic reductions in landfill-related greenhouse gas emissions over the past decades. For example, The Netherlands and Germany, both of which introduced strict landfill bans and high landfill taxes, have reduced their landfill methane emissions by more than 80% since the 1990s. In contrast, countries with less stringent landfill policies continue to report much higher emissions from landfilling.

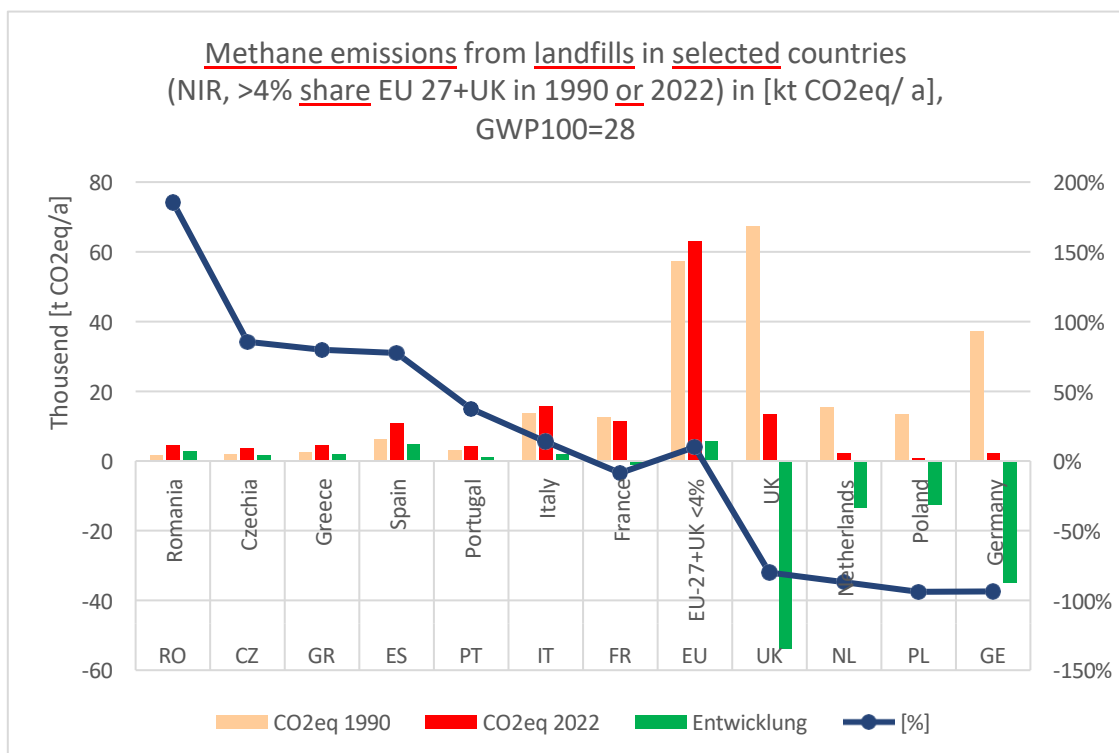


Figure 4 CH₄ emissions from landfills in selected EU countries and UK, 1990 vs 2022, with policy impact shown. Data source: National Inventory Reports (NIR) with >4% share of EU27+UK total⁵. Graphic source: ESWET.

The figure above shows the development of methane emissions from landfills (1990–2022) in selected EU countries and the UK. The chart illustrates how countries

⁵ Source: EEA 12/2024, Annual European Union greenhouse gas inventory 1990 2022 and inventory document 2024, EU NID 2024_F.pdf, based on UNFCCC 2024, Common Reporting Format (CRF) 2024, Table 5A1.
https://www.eea.europa.eu/en/analysis/publications/annual-european-union-greenhouse-gas-inventory/eu-nid-2024_f

with higher shares of WtE and supportive measures, such as landfill taxes, restrictions, or alternative treatments (e.g., MBT together with WtE), have achieved greater reductions in landfill methane emissions, while those relying more on landfilling continue to emit at higher levels. Also, despite gas capture systems, emissions from landfills persist due to leakage. Air pollution resulting from the combustion process carried out at these facilities is significantly mitigated thanks to the solid technical basis provided by the BREF document (European Commission, Joint Research Center, 2019), the available technologies, and state-of-the-art flue gas cleaning systems. Several studies have assessed the environmental and health impacts of WtE emissions and found marginal or insignificant effects, demonstrating that their efficient operation ensures compliance with strict emissions regulations (ISWA, 2023).

Modern WtE facilities are equipped with state-of-the-art filtration and pollution control technologies that significantly reduce harmful emissions, including dioxins, furans, and particulate matter (CEWEP, 2022). State-of-the-art WtE facilities have been shown to have a "very low impact on local air quality" (Lonati, Cambiaghi, and Cernuschi, 2019), with pollutant levels well below emission limits (Chen *et al.*, 2022), with air quality tests in France "generally confirming the waste hierarchy (recycling > thermal treatment > landfill) for the waste materials investigated (Beylot *et al.*, 2018).

Although WtE processes emit CO₂, they also help mitigate GHG emissions by diverting waste from methane-producing landfills, which are much more harmful to the climate. Diverting waste from landfills to WtE results in a net reduction of approximately 600 kg of CO₂ eq per ton of waste treated over a 100-year period (CEWEP, 2022). However, as mentioned, methane emitted from landfills is more than 80times more potent than CO₂ over a 20-year period (GWP20) (IPCC, 2014); therefore, reducing methane emissions is the fastest way to achieve climate benefits. Methane is considered one of the main contributors to global warming (IEA, 2022), and the United Nations Environment Programme (UNEP) has stated that "reducing methane emissions represents the most effective strategy for mitigating climate change over the next 25 years."

Additional carbon offsets can be accounted for WtE; in terms of materials, the treatment of incineration ash recovers minerals, ferrous and non-ferrous metals, which can be reintroduced into the production chain; in terms of energy, it represents a carbon-neutral energy source capable of replacing fossil fuel energy. Furthermore, energy

export can be maximized if heat production is included and supplies district heating networks in large cities, such as in Malmö, Brescia, or Barcelona (ISWA, 2023), or industries, such as the paper mill in the case of the Renergia plant in Lucerne (Hitachi Zosen Inova, 2018).

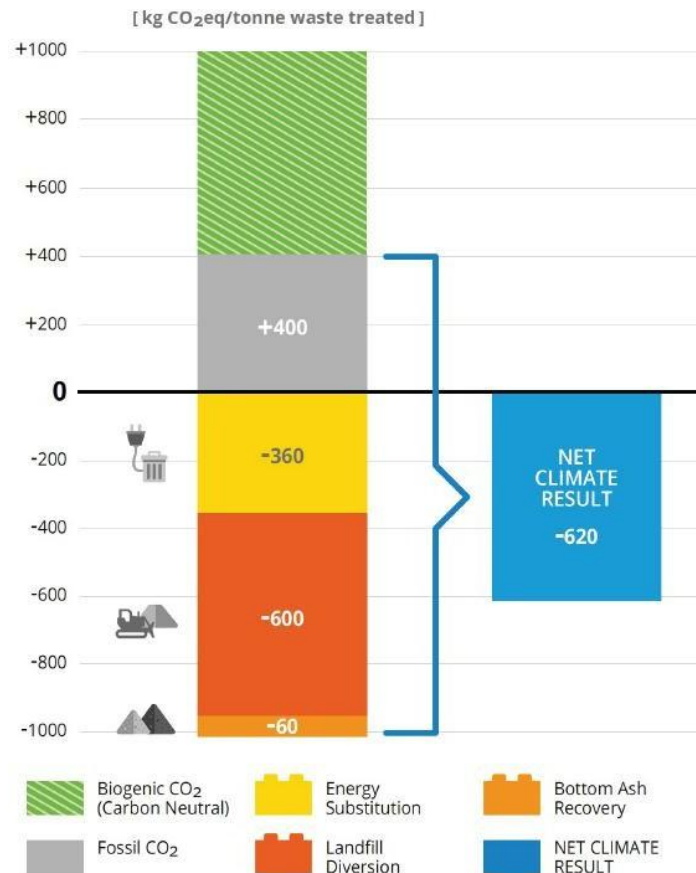


Figure 5 Current net carbon balance of the European WtE sector, considering landfill diversion, Source: CEWEP Climate Roadmap 2022.

In addition, many WtE plants in Europe are in the process of integrating Carbon Capture, Utilization, and Storage (CCUS) technologies, which can transform these plants into carbon-negative facilities, capturing not only fossil carbon emissions but also biogenic emissions (IEAGHG, 2020)

The development of CCUS technology represents an opportunity for policymakers to strengthen the involvement of the WtE sector in achieving climate and emissions targets (ISWA, 2024), CEWEP [2024].

Many industrialized countries rely on energy recovery from solid waste to manage non-recyclable waste. Currently, there are more than 2,700 WtE lines in operation worldwide; this number is expected to increase to more than 3,000 plants by 2032 (Ecoprog, 2024). For example, countries such as Germany, Sweden, and Denmark have integrated solid waste-to-energy into their national waste management strategies, where this technology plays a key role in complementing high recycling rates and reducing dependence on landfills. These countries have proven that energy recovery from solid waste can coexist with ambitious waste reduction, reuse, and recycling policies.

More than that, over the past two decades, global WtE application has grown to more than 300 million tons of collected municipal waste. On a *per capita* basis, due to the various benefits of WtE over landfills, China for instance has invested approximately \$70 billion in new WtE plants and included WtE in its five-year plan for transitioning to renewable energy. This is one of the large-scale examples of how integrated waste management systems can overcome urban waste crises while reducing dependence on landfills. Other developing nations are also investing in WtE; for example, Indonesia (Ecadin, 2026)⁶ which has recently equally adopted strategic waste management policies incorporating WtE, or Turkey, with its one million ton WtE plant, which serves the city of Istanbul, with approximately 16 million inhabitants.

A Key driver of these large scale developments is the reality of rapid urbanization which causes many cities to face what has widely been described as “cities besieged by waste,” as landfill capacity struggled to keep pace with rising municipal waste generation. Waste sorting and recycling are integral parts of such transformations, but are only helping to partly solve the problem.

As a result, waste treatment patterns change dramatically: the share of municipal waste disposed in landfills declined – in the case of China - from about 85% in 2005 to roughly 15% in 2024, while thermal treatment through WtE increased to about 85% of urban waste treatment capacity, while drastically reducing landfill use, conserving land resources, and preventing methane formation associated with anaerobic waste decomposition.

Large-scale and sustained investment has driven significant reductions in both capital (CAPEX) and operational (OPEX) costs, making WtE technologies increasingly competitive and accessible for developing countries. Affordable solutions are available for a variety of waste streams, including such with high moisture content and low calorific

⁶ Ecadin publication: “Indonesia to Begin 34 Waste-to-Energy (WtE) Projects in 2026, link: <https://ecadin.org/indonesia-to-begin-34-waste-to-energy-wte-projects-in-2026/>

value, characteristics common in many developing nations, thereby offering a practical and scalable solution.

To make these changes happen a coordinated policy, infrastructure investment, and technological deployment is required to transform waste management from a landfill-dependent system into a circular urban infrastructure that simultaneously addresses waste, land use, and methane mitigation challenges.

Another positive feature of WtE is that it can be integrated into existing infrastructure, supporting a cleaner and more sustainable energy transition. For example, the ZMS Schwandorf plant in Germany is an excellent example of adapting solid waste to energy recovery, where a former lignite-fired power plant site has been successfully converted into a modern waste-to-energy facility.⁷

The key to understanding the role of WtE is to recognize that this technology is not intended to be a stand-alone solution capable of replacing waste reduction, reuse, or recycling. Instead, waste-to-energy is designed to manage residual waste that remains after all other options have been exhausted. In regions with high recycling rates, there will always be some level of non-recyclable waste, and WtE ensures that this waste is converted into energy rather than being sent to landfills. It is a complementary technology that supports the transition to circular economy goals.

Plastics are an example that illustrates the significant amount of non-recyclable waste to be treated. From a global perspective, in 2019, the recycling rate, considering all types of plastic, was only 6.5% (Schade *et al.*, 2024). Furthermore, plastic recycling still has to deal with many disadvantages, such as , the consolidation of a market for recycled materials, and some technological limitations; therefore, WtE remains a key solution for further recovering the energy embodied in plastics. In particular, in 2023, in Italy, 66% of collected plastic waste was successfully sorted and recycled into new products, and the remaining fraction (Plasmix) is considered ideal for thermal energy recovery due to its adequate LHV.

⁷ Waste Culture article: "Conversion of a lignite-fired power plant into a waste-to-energy plant using the example of the ZMS Schwandorf, Germany." Available at: <https://wasteculture.com/bestpractice/289/Conversion-of-a-lignite-fired-power-plant-into-a-waste-to-energy-plant-using-the-example-of-the-ZMS-Schwandorf-Germany.html>



Figure 6 Differences between mixed and separately collected plastic waste in Europe.
 Source: Plastics Europe, 2022.

WtE provides a reliable source of local base load energy, reducing dependence on fossil fuels and increasing energy security. This is particularly important in regions where alternative energy sources may be intermittent or unavailable. In Europe, for example, WtE plants produce enough electricity to power 20 million people per year, and provide heat to 17 million people annually. (CEWEP, 2022) By generating energy from non-recyclable waste, WtE can also reduce the use of primary energy sources, such as coal or natural gas, which are associated with higher GHG emissions.

While many governments are prioritizing waste reduction and recycling, WtE remains a necessary part of the safe treatment of remaining waste. It forms an important part of a sustainable waste management hierarchy in regions that need energy recovery solutions for waste. The argument that energy recovery from solid waste is not "environmentally sound" ignores advances in technologies, which now incorporate strict emissions controls and material recovery systems. WtE plants around the world have strict regulations to minimize environmental impacts and ensure emissions remain within safe limits (IEA Bioenergy, 2022).

For developing countries, WtE represents a way to address several concerns. For example, the technology addresses land demand by reducing waste volume; reduces GHG emissions not only through material and energy recovery, but also by

diverting waste from landfills; reduces methane and leachate emissions from landfills; and represents a more hygienic way to treat waste (ISWA, 2023).

It is worth noting that the argument that energy recovery from solid waste is less "economical" compared to other waste treatment methods does not consider the long-term financial and environmental costs of landfilling, such as methane emissions, land use, and the need for post-closure care. The fact that thousands of plants are operating profitably around the world is proof of the economic viability of WtE. This is true even for developing nations; a technical-economic assessment of Cameroon's WtE potential found that electricity generated by WtE would make it economically viable in all regions of Cameroon (Longfor *et al.*, 2023).

According to the IPCC, "the environmental and economic benefits make its high financial costs justifiable." WtE plants reduce dependence on landfills, recover valuable materials from ash, and provide energy, thus offering a holistic economic and environmental solution for the management of non-recyclable waste. In recognition of the many environmental and economic benefits of solid waste-to-energy recovery

Landfill leachate contains harmful chemicals such as heavy metals, persistent organic pollutants, and other toxic substances. This requires careful treatment, as landfill standards vary greatly around the world. Landfill leachate causes serious environmental problems, especially in developing countries, polluting groundwater, soil, and air, with "adverse effects on human health and [...] impeding health and economic development" (Salam and Nilza Mattu, 2021). According to Loy *et al.* (2023), "it remains an inadequate approach to waste management due to the leaching of toxic substances into soil and waterways." Recent research on landfills in the United Kingdom found PFAS at levels 260 times higher than the level considered safe for human consumption.⁸

Landfills require large areas of land, which are permanently lost for other uses. This is particularly problematic in urban areas, where space is scarce. One study estimates that a WtE plant in Malta, treating 32,500 kg/h of waste, would result in land use savings of 13,500 to 17,000 m² per year (Pirota, Ferreira, and Bernardo, 2013). In addition, materials buried in landfills represent a loss of resources. In contrast, WtE plants reduce waste volume by 90% (Alao, Popoola, and Ayodele, 2022), recover

⁸ ENDS Briefing: The PFAS Files. Available at: <https://www.endsreport.com/article/1859134/17-landfills-england-producing-toxic-liquid-containing-forever-chemicals-they>

valuable materials and energy, and ensure that waste is used as a resource rather than being wasted.

Unlike WtE, landfills offer little opportunities for energy recovery.

Landfills discard valuable materials that could otherwise be recovered and reintroduced into the economy. Materials that are buried in landfills are lost forever, contributing to resource scarcity and hindering circular economy efforts. In contrast, WtE plants help as well recover materials from ash and prevent resource loss. The EU Circular Economy Action Plan (2015) states that converting waste into energy is preferable to disposing of MSW in landfills.

In many countries, landfill access fees are very low, making them economically attractive and discouraging alternative management solutions such as recycling and material and energy recovery. Instead, landfill volumes should ultimately be used for specific waste streams that cannot be recovered in terms of material and energy (e.g., some construction and demolition waste streams, asbestos, specific hazardous waste streams, remaining fraction from Incineration Bottom Ash and fly ash, etc.).

It is important to note that in countries where WtE development has increased, landfill taxes are well established or landfilling is banned, and the use of alternative waste management is highly supported (i.e., WtE). An example of this is the United Kingdom, which introduced landfill taxation in 1996 and, from 2025, no biodegradable waste may be deposited in landfills (CEWEP, 2021). In addition, the tax is expected to reach up to EUR 126.15 per ton of waste from 2025, making the disposal of MSW in landfills excessively costly (Letsrecycle.com, 2024).

Even after a landfill site is closed, it continues to present environmental and financial liabilities. The case of the Am Brenten domestic waste landfill, 25 years after the end of operations, is a prime example. Landfill sites require long-term monitoring and management to prevent leaks, gas emissions, and environmental degradation. This generates significant long-term costs. One study estimates that 80% of the UK population lives within 2 km of an active or closed landfill, and found excessive risks of birth defects and low birth weight near landfills (Elliott *et al.*, 2001).

In contrast, WtE offers a cleaner and more sustainable solution for managing non-recyclable waste, providing energy and recovering materials that would otherwise be lost. Similarly, as concluded by ISWA, "*Energy from waste (EfW) (considered as a*

resource recovery treatment) is the preferred option for dealing with all remaining municipal solid waste that cannot be reused, recycled, or composted, especially in large cities where land availability, health, environmental impacts, and climate change are major concerns, and large quantities need to be treated." (ISWA, 2023)

Also, the Global Methane Status Report 2025 offers itself the proof of the obvious by stating on page 112, as part of the section “Existing investment in methane mitigation” “The waste sector received the second largest volume with US\$4.1 billion per year in investment in 2021 and 2022. Most investment in the waste sector, 94 per cent, however, supported projects involving waste incineration, with three-quarters of that investment coming from the private sector.

Indeed, as stated throughout this report, methane avoidance through landfill diversion is one of the most effective mitigation strategies available today. It underscores that WtE is not competing with methane mitigation goals; it is one of the main instruments enabling them. The European Union has consolidated *Waste-to-Energy* as a central element of its environmental and energy policy. Directive 2008/98/EC established the waste management hierarchy—prevention, reuse, recycling, and finally energy recovery—recognizing that some waste will remain non-recyclable and require controlled disposal (*European Parliament, 2008*).

Recent epidemiological studies refute historical concerns about health impacts. The *UK Health Security Agency* reviewed 12 studies conducted after Directive 2000/76/EC and concluded that there is no correlation between proximity to modern plants and increased mortality, cancer, or gestational abnormalities (UKHSA, 2025). Independent reviews by Traven (2023) confirm that emissions from modern incinerators are small compared to those from urban combustion sources such as transportation and domestic heating. This evidence has led European governments to promote full transparency: in Denmark, Sweden and other countries, emission data is disclosed to citizens in real time (EEA, 2023, p. 95).

The *Confederation of European Waste-to-Energy Plants* report shows that dioxin emissions from WtE plants account for less than 0.2% of total industrial emissions on the continent (CEWEP, 2022). Studies conducted in Italy, the Czech Republic (<https://eswet.eu/wp-content/uploads/2026/01/Suzova-J.-Vesely-P.-2024.-Research-on-contamination-of-eggshells-With-AI-summary-translation.pdf>), and the United

Kingdom have proven, through chemical digital fingerprinting analyses, that the dioxin profile in soil and eggs near plants differs from that emitted by chimneys, ruling out mistaken attributions of causality).

The *European Green Deal* explicitly positions WtE as an integral part of the circular economy and urban energy security. The plan recognizes that the transition to clean energy requires firm and predictable sources to complement the variability of renewables, a function that WtE fulfills by generating continuous energy from residual waste (European Commission, 2020).

The potential for climate mitigation is significant. The *Global Methane Assessment* calculated that closing landfills and replacing them with WtE plants could avoid up to 70 Mt of CO₂ equivalent per year by 2030 (UNEP/CCAC, 2021). In emerging countries, where landfill disposal still predominates, the climate gain would be up to three times higher.

These results reinforce that WtE should be understood as essential infrastructure for balancing sanitation and energy policies. The *World Bank* (2020, p. 172) points out that incorporating WtE into national urban waste programs can create significant economic synergies: local job creation, energy security, and attraction of private investment. According to the *International Energy Agency* (IEA, 2023, p. 128), the average cost of electricity generation from WtE is already competitive with natural gas-fired thermal power plants in densely populated regions.

The *IPCC* (2021, p. 83) acknowledges that even in high recycling scenarios, around 30% of waste will remain non-recyclable and will require controlled thermal treatment. The *OECD* (2023, p. 97) adds that the ideal balance combines prevention, recycling, and energy recovery, ensuring that no material with energy value is wasted.

In summary, scientific, regulatory, and economic evidence shows that *Waste-to-Energy* is a mature, safe, and indispensable technology for ecological transition. Modern plants operate under strict environmental standards and play a decisive role in methane reduction, energy security, and resource recovery. Ignoring this evidence in favor of ideological views would be an environmental and climate setback.

The rational integration of prevention, recycling, and energy recovery is therefore the most solid technical and scientific path to a circular and decarbonized economy.

For all the reasons mentioned, policies should focus on minimizing the use of landfills to waste that cannot be used for energy and material recovery. WtE is a

fundamental component of integrated waste management strategies, in accordance with the waste management hierarchy.

V. CONCLUSIONS

The analysis developed throughout this document shows that the Global Methane Status Report 2025 makes a significant contribution by consolidating diagnoses and recommendations for methane mitigation, especially by emphasizing prevention measures, segregation at source, treatment of organic waste, and improvements in the management of final disposal sites (UNEP, 2025).

However, a systematic reading of the chapter on waste and its summary tables indicates that the approach adopted does not provide a sufficiently comprehensive framework to guide, with technical rigor and systemic coherence, the effective reduction of methane emissions associated with landfill disposal.

In particular, by not explicitly stating the role of waste-to-energy as a treatment technology for non-recyclable waste—and, therefore, as an instrument for the structural diversion of waste from landfills — the report may induce restrictive interpretations in national policies, NDCs, climate finance instruments, and green taxonomies, especially in countries where the factual alternative to treatment infrastructure remains the continuation of final disposal under suboptimal conditions (IPCC, 2021; World Bank, 2018; UNECE, 2022).

This point is even more sensitive because the report itself acknowledges that methane emissions from the sector can persist for decades and that capture performance in landfills depends on factors such as design, operation, and infrastructure aging (UNEP, 2025). In light of the international literature, this finding reinforces the need to explicitly incorporate solutions that prevent methane formation by reducing the flow of waste destined for final disposal, complementing the treatment of organics with safe and controlled routes for the unavoidable residual fraction, as recognized in IPCC assessments and international circular economy guidelines (IPCC, 2021; European Parliament, 2008).

The absence of such a framework compromises the methodological integrity of the proposed portfolio, as it leaves the destination of non-recyclable waste "open" and, as a result, maintains structural pressure on landfills and dumps — precisely the mechanism that generates the problem it seeks to mitigate.

In view of this, it is recommended, in a constructive spirit and in line with the common goal of accelerating rapid and measurable reductions in methane, that UNEP consider conducting a technical review of the sectoral waste content of the GMSR 2025, with a view to improving the clarity and completeness of the set of mitigation options presented.

Such a review could, in a balanced manner and consistent with the waste hierarchy, (i) explicitly identify waste-to-energy as a technological category applicable to the treatment of non-recyclable waste; (ii) delimit its complementary role to prevention, recycling, and treatment of organic waste; and (iii) establish eligibility criteria based on best available techniques, environmental safeguards, and monitoring, reporting, and verification requirements, in order to strengthen public confidence and regulatory predictability (JRC, 2019; UNECE, 2022).

Such an adjustment would not alter the report's legitimate emphasis on upstream measures; on the contrary, it would increase its practical usefulness for governments and financiers by offering a more comprehensive system design to reduce dependence on landfills and, consequently, mitigate methane more effectively and consistently (OECD, 2023; IPCC, 2021).

The cities and countries that have opted for WtE processing rather than landfilling their residual non-recyclable waste MSW, have done so at major capital investments, in order to avoid landfill methane emissions and use of land over the years. The 2025 Global Methane Report should recognize and encourage this major effort to mitigate climate change.

In summary, the report remains valuable as an agenda-setting and mobilization tool, but would benefit from technical refinement in the waste sector to more fully reflect the operational reality of waste streams and the solutions available for closing the system. A review conducted by UNEP, with open dialogue and pluralistic participation by experts, would contribute to increasing the methodological robustness of the document, reducing interpretive ambiguities, and strengthening its capacity to guide effective public policies aligned with the climate emergency and sustainable development goals.

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