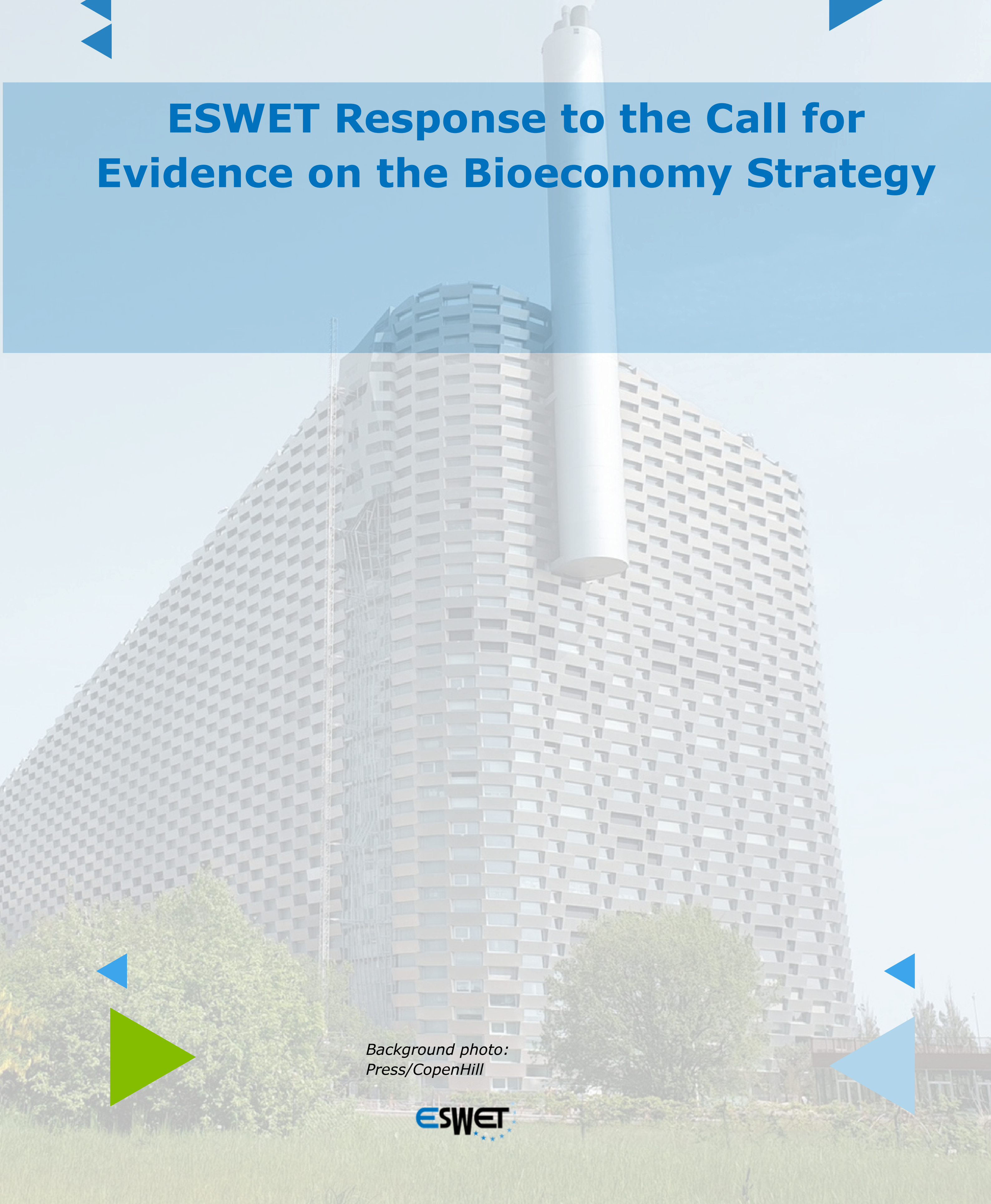

ESWET Response to the Call for Evidence on the Bioeconomy Strategy

Background photo: Press/CopenHill

Brussels, June 2025

ESWET Response to the Call for Evidence on the Bioeconomy Strategy

ESWET – the European Suppliers of Waste-to-Energy Technology represents companies that have built and supplied over 95% of the Waste-to-Energy (WtE) plants in operation in Europe. It seeks to promote the technologies which recover both energy and materials from non-recyclable waste that would otherwise end up in landfills.

ESWET welcomes the European Commission's initiative to update the EU Bioeconomy Strategy. ESWET fully supports the overarching goals of the new strategy to promote circularity, strengthen EU competitiveness, and enhance resource efficiency while addressing the EU's climate and energy goals. In this context, ESWET would like to share its views and recommendations on how WtE technologies and related processes can contribute to a circular and competitive EU bioeconomy.

Waste-to-Energy and Bioeconomy

While the circular economy and bioeconomy rightly prioritise the prevention, reduction, and recycling of waste, it is essential to acknowledge that not all waste - even when of biogenic origin - can be feasibly or safely recycled. Certain waste streams are contaminated, mixed, or degraded to a point where recycling is no longer technically or economically viable. For example, items such as food-soiled paper (e.g., used pizza boxes), heavily contaminated cardboard, biodegradable plastics mixed with conventional plastics, or certain types of composite and multilayer packaging pose significant challenges for recycling technologies.

In these cases, conventional recycling processes are unable to separate or purify the materials to the required standards, resulting in either excessive costs, technical limitations, or compromised material quality. Furthermore, maintaining the safety and integrity of recycled materials - especially for applications such as food contact materials or critical industrial uses - imposes strict quality standards that contaminated streams often fail to meet.

This reality underlines the indispensable role of WtE technologies in the bioeconomy and circular economy frameworks. WtE provides a sustainable and environmentally sound solution for the treatment of non-recyclable waste, allowing for the recovery of both energy and valuable materials while preventing such streams from ending up in landfills. In particular, WtE allows biogenic waste fractions that are unsuitable for material recycling to be recovered in the form of renewable energy, contributing to decarbonisation and energy security. Without WtE, significant portions of the biogenic waste fraction would either accumulate in landfills - with associated methane emissions and land use concerns - or remain underutilised, undermining the EU's goals for climate neutrality, energy transition, and circularity.

Renewable Energy from Biomass

In most European WtE plants, the biogenic fraction - including food waste, paper, cardboard, garden waste, wood residues, and other biodegradable parts - typically constitutes over 50% (even going around 70%) of the total waste input, depending on national consumption and waste sorting patterns. This means that a significant share of the energy produced from WtE is, by definition, renewable[1].

This renewable energy production contributes directly to the EU's Renewable Energy Directive (RED III)[2] targets and supports the energy transition while securing a reliable and continuous source of low-carbon energy, particularly for district heating networks that are essential for decarbonising heating and cooling in Europe. **It is necessary to underline that this renewable energy is recovered from waste streams that would otherwise be landfilled or exported or even illegally treated. Hence, WtE represents an efficient valorisation of unavoidable waste that cannot be prevented, reused, or recycled.**

Importantly, as recycling rates increase and higher-quality recycling streams are prioritised, the remaining residual waste fraction treated in WtE increasingly consists of contaminated or composite materials that are unsuitable for recycling but still contain recoverable biogenic content. This ensures that renewable energy production from WtE does not compete with recycling but rather complements it – as it shown in the figure below, by maximising the energy value of non-recyclable

[1] Frédéric GIOUSE, Elise RAVACHE et Léa MOUTTE. 2020. Détermination des contenus biogène et fossile des ordures ménagères résiduelles et d'un CSR. [ADEME - Cabinet Merlin - ENVEA. Détermination Des Contenus Biogène Et Fossile Des Ordures Ménagères Résiduelles Et D'un Csr, A Partir D'une Analyse 14c Du CO2 Des Gaz De Post-Combustion. Programme UIOM 14C – Campagne de mesures sur UIOM et chaufferie CSR.

[2] Renewable Energy Directive

waste while recovering metals and minerals from bottom ash. In addition, WtE facilities can serve as stable and dispatchable sources of renewable energy, providing grid stability and resilience to fluctuating renewable energy production from wind and solar energy systems.

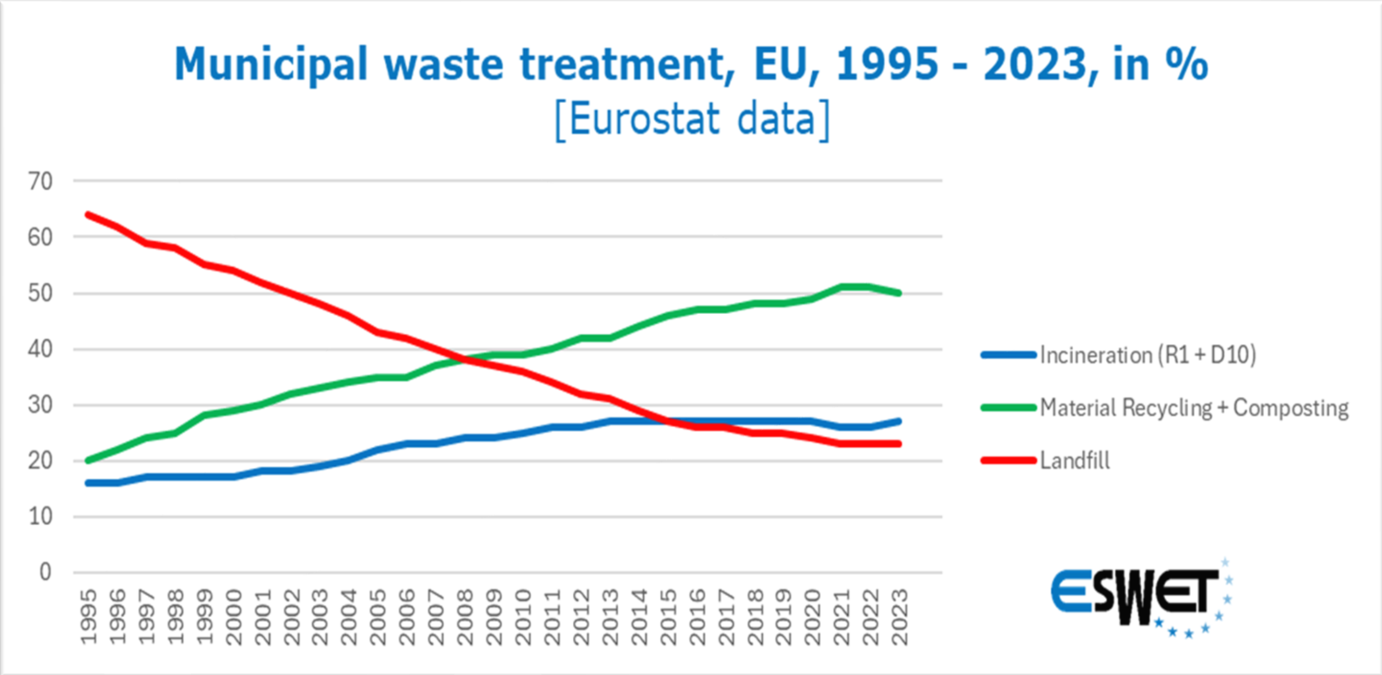

Figure 1: Trends in Municipal Waste Treatment in the EU (1995–2023). Source: ESWET, with data from Eurostat.

Figure 1 above illustrates the long-term shift in municipal waste management across the EU. It shows a clear decline in landfill use, while both material recycling with composting (green line) and Waste-to-Energy (i.e., incineration) (blue line) have increased. The data highlights how recycling and WtE are complementary strategies that work together to reduce landfill dependency, supporting a more sustainable circular economy.

Bio-fuels, Bio-Hydrogen and Bio-Plastic Production

WtE facilities offer growing technological versatility. In addition to producing heat and electricity, they can also support the generation of renewable and low-carbon hydrogen and fuels through integrated electrolysis systems and advanced conversion technologies. For example, bio-hydrogen can be produced by powering electrolysers from WtE (partly renewable energy coming from the biogenic fraction of the waste) or by gasifying pre-treated biogenic waste. Moreover, biogenic CO_2 captured from WtE plants can be combined with hydrogen - whether generated on-site or sourced externally to produce e-fuels (e.g., synthetic methane or methanol), including Renewable Fuels of Non-Biological Origin (RFNBOs) if coupled with green hydrogen, and low-carbon fuels if coupled with non-renewable hydrogen.

Hydrogen from WtE plants can be used to power fuel cell vehicles, especially in urban environments where WtE facilities are often located close to end users.
By leveraging the plant's ability to sell electricity to the spot market and produce hydrogen when prices are low, the system demonstrates both environmental and economic benefits. This model illustrates how hundreds of existing or refurbished WtE plants across Europe could become decentralised hubs for bio-hydrogen production, contributing to local air quality improvement and emissions reduction.

Beyond transport, hydrogen produced from WtE can support the decarbonisation of industrial sectors such as steel, cement, and chemicals, which require high-temperature processes that cannot be easily electrified. Finally, hydrogen can also be coupled with nitrogen to produce ammonia for agricultural fertilisers, avoiding the use of fossil fuels or natural gas.

Apart from hydrogen, WtE plants can contribute to the production of synthetic fuels such as methane and methanol through processes like methanation. The Waste-to-Methane plant in Switzerland, is a notable example, with an electrolysis capacity of 2.5 MWh producing around 18,000 MWh of synthetic gas per year[3]. This green gas is used for heating, cooking, and fuelling vehicles, enabling CO_2-neutral operations. The facility is estimated to reduce emissions by up to 5,000 tonnes of CO_2 annually - the equivalent of the emissions of approximately 2,000 households. These synthetic fuels provide energy-dense, storable, and renewable alternatives to fossil fuels and can be used in various sectors including transport and heavy industry.

Hydrogen and methane produced through Waste-to-Hyrdogen (WtH) and Waste-to-Fuel (WtF) pathways can also be blended with natural gas, reducing the overall carbon intensity of energy systems. This multifunctional capability highlights WtE's potential as a cornerstone of the EU's integrated decarbonisation, circular economy, and energy resilience strategies.

[3] More information on the article by Swisspower: " Projet phare chez Limeco à Dietikon : Inauguration de la première installation industrielle Power-to-Gas de Suisse".

In parallel, advanced thermal conversion technologies like pyrolysis and gasification further enhance the contribution of biogenic waste to the bioeconomy. These technologies thermochemically convert waste into valuable secondary energy carriers, such as syngas, bio-oil, that can be used for the production of other fuels (e.g. Fischer-Tropsch fuels, methanol). When applied to the organic (biomass) component of municipal solid waste, pyrolysis and gasification can generate biofuels that are renewable, storable, and suitable for use in transport, industry, or combined heat and power generation.

Specifically, gasification operates in oxygen-limited conditions to produce a biogenic synthesis gas (syngas) rich in hydrogen and carbon monoxide, which can be further refined into methanol, ammonia, or synthetic natural gas. Similarly, pyrolysis produces a range of outputs, including biochar and bio-oil. Bio-oil and syngas can be used directly or transformed in other products which can be used as drop-in fuels for existing infrastructure. When scaled and integrated into existing WtE infrastructure, these technologies allow WtE plants to diversify their outputs, creating high-value products from residual waste streams while maximising resource recovery.

Moreover, WtE technologies can create synergies with the agricultural and forestry sectors. For instance, biochar produced via pyrolysis can be used as a soil enhancer, while ash residues can be processed to recover critical nutrients such as phosphorus, supporting sustainable agriculture and closing nutrient loops. In the above cases, since the feedstock originates from biogenic sources, including the biogenic fraction of mixed municipal waste, the resulting fuels are classified as advanced biofuels under the RED III[4], contributing to national renewable energy targets and supporting the decarbonisation of hard-to-abate sectors such as industry, maritime, aviation, and heavy-duty transport.

From a systems perspective, biofuel, biohydrogen and low carbon fuels production complements mechanical and biological treatment strategies and contributes to a more flexible and decentralised energy system. Importantly, processing waste fractions that are unsuitable for recycling ensures that no potentially useful carbon is lost to landfill.

Finally, biogenic CO_2 emissions from WtE plants can also be harnessed to produce sustainable materials, as demonstrated by a relevant project in Finland. Through

[4] Advanced biofuels from waste and residues notably (produced from feedstock listed in Part A of Annex IX, in the meaning of Article 2(34) of RED). Directive - 2018/2001 - EN - EUR-Lex

its Carbon2x programme[5], Fortum Recycling successfully used captured CO_2 from waste incineration to produce biodegradable plastic, showcasing a circular use of emissions to replace fossil-based raw materials in sectors like packaging and electronics.

As the EU seeks to strengthen its bioeconomy and secure sustainable sources of strategic fuels and byproducts, supporting the development and deployment of such technologies will be key.

Emissions Mitigation

According to the European Environment Agency's annual GHG inventories[6], fossil CO_2 emissions from WtE plants have consistently accounted for approximately 1% of total greenhouse gas emissions in Europe. Remarkably, this share has remained stable over the past decade, even as the amount of waste processed by WtE facilities has continued to increase in response to growing waste generation and landfill diversion policies. This stability demonstrates the relatively limited and controlled contribution of the WtE sector[7] to overall greenhouse gas emissions in the EU's emissions balance.

It is important to note that a significant proportion of the carbon released during WtE operations originates from the biogenic fraction of the waste stream which is considered zero-rated under climate accounting rules.

When incinerated, this biomass part generates renewable energy in the form of both electricity and heat, displacing fossil fuel consumption and reducing overall greenhouse gas emissions. Unlike fossil carbon, which introduces new carbon into the atmosphere, the combustion of biogenic waste releases carbon that was previously absorbed from the atmosphere during the growth phase of the biomass. Therefore, in accordance with internationally recognised greenhouse gas accounting methodologies - such as the Intergovernmental Panel on Climate Change (IPCC) guidelines[8] - CO_2 emissions from biogenic waste are not counted towards anthropogenic greenhouse gas inventories. Consequently, as is standard

[5] World's first biodegradable plastic produced from CO2 emissions in Finland | Fortum
[6] European Environmental Agency Data viewer on greenhouse gas emissions and removals, sent by countries to UNFCCC and the EU Greenhouse Gas Monitoring Mechanism
[7] CEWEP, Waste-to-Energy Climate Roadmap, CEWEP-WtE-Climate-Roadmap-2022.pdf.pdf
[8] Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories, https://www.ipcc-nggip.iges.or.jp/public/2006gl/

practice in Life Cycle Assessment (LCA) modelling[9], WtE's climate impact is equal to zero, as also recognised by the International Energy Agency (IEA) Greenhouse Gas R&D Programme[10], and as analysed further below.

This distinction is critically important when evaluating the overall climate impact of WtE within the circular economy and the EU's decarbonisation strategy. In fact, the biogenic CO_2 released during WtE can be considered analogous to emissions from sustainably harvested bioenergy sources such as forest residues, agricultural waste, or dedicated energy crops, which are recognised under the Renewable Energy Directive (RED III) as contributing to renewable energy production[11].

Overall, WtE delivers the following indirect climate benefits: approximately -360 kg CO_{2eq} per tonne of waste from fossil fuel substitution in energy generation, -600 kg CO_{2eq} per tonne from landfill diversion (methane avoidance), and -60 kg CO_{2eq} per tonne from metal recovery. When these avoided emissions are accounted for, the overall climate balance of WtE is strongly negative, yielding around -620 kg CO_{2eq} per tonne of waste treated. Even when applying a conservative scenario that excludes landfill diversion, WtE maintains a slightly negative or carbon-neutral balance of -20 kg CO_2eq per tonne, demonstrating that it remains at worst climate neutral and at best a contributor to net climate mitigation[12].

Furthermore, the integration of carbon capture, utilisation and storage (CCUS) technologies in WtE facilities offers significant potential for further climate benefits. Capturing both fossil and biogenic CO_2 streams could allow WtE plants not only to achieve carbon neutrality but to generate negative emissions, directly supporting the EU's long-term climate neutrality and carbon removal targets.

Landfill Diversion

As mentioned in the previous section, when evaluating the full climate impact of WtE, it is also necessary to adopt a life-cycle perspective that takes into account not only direct emissions from combustion, but also the multiple indirect climate

[9] Incineration and co-combustion of waste: accounting of greenhouse gases and global warming contributions, Astrup et al., Waste Management & Research, 2009
[10] International Energy Agency Greenhouse Gas R&D Programme (IEAGHG) Annual Review 2020.
[11] According to *Directive (EU) 2023/2413* (Renewable Energy Directive, RED III), Article 2(24) defines "biomass" as *"the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin."*
[12] CEWEP, Waste-to-Energy Climate Roadmap, CEWEP-WtE-Climate-Roadmap-2022.pdf.pdf

benefits generated by WtE operations. Currently, around 100 million tonnes of residual waste are treated annually through WtE in Europe, preventing this waste from being landfilled or exported[13].

According to the IPCC, landfills are a major source of methane emissions, a greenhouse gas 28 times more potent than CO_2 over a 100-year time horizon and 84 times stronger than CO_2 over 20 years[14]. Around 19% of human-caused methane emissions come from waste, mostly due to landfilling[15]. Even when methane capture systems are used, they only capture about half of the emissions, and recent studies show that actual methane leakage is much higher than reported[16].

Environmental risks from landfilling extend beyond emissions. Leachates often contain toxic substances, including PFAS, heavy metals, and persistent organic pollutants, posing serious threats to water, soil, and human health - particularly in developing regions. A UK study recently revealed PFAS levels in landfill leachate 260 times above safe limits[17]. The materials buried are lost forever, undermining the goals of a circular economy. Even closed landfills continue to create problems for decades. The Am Brenten landfill, still causing issues 25 years after closure, is a clear example[18].

[13] CEWEP, Waste-to-Energy Climate Roadmap, CEWEP-WtE-Climate-Roadmap-2022.pdf.pdf
[14] Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories, https://www.ipcc-nggip.iges.or.jp/public/2006gl/
[15] Saunois, M., Martinez, A., Poulter, B., Zhang, Z., Raymond, P., Regnier, P., ... & Zhuang, Q. (2024). Global Methane Budget 2000–2020. Earth System Science Data Discussions, 2024, 1-147.
[16] Balasus, N., Jacob, D. J., Maxemin, G., Jenks, C., Nesser, H., Maasakkers, J. D., Cusworth, D. H., Scarpelli, T. R., Varon, D. J., & Wang, X. (2024). Satellite Monitoring of Annual US Landfill Methane Emissions and Trends. arXiv preprint arXiv:2408.10957v1. Available at: https://arxiv.org/abs/2408.10957v1.
[17] ENDS Report (2024). ENDS Briefing: The PFAS Files. Available at: https://www.endsreport.com/article/1859134/17-landfills-england-producing-toxic-liquid-containing forever-chemicals-they
[18] WtERT article: "Costs of the "Am Brenten" household waste landfill 25 years after the end of operations." Available at: https://www.wtert.net/bestpractice/3140/Costs-of-the-Am-Brenten household-waste-landfill-25-years-after-the-end-of-operations.html

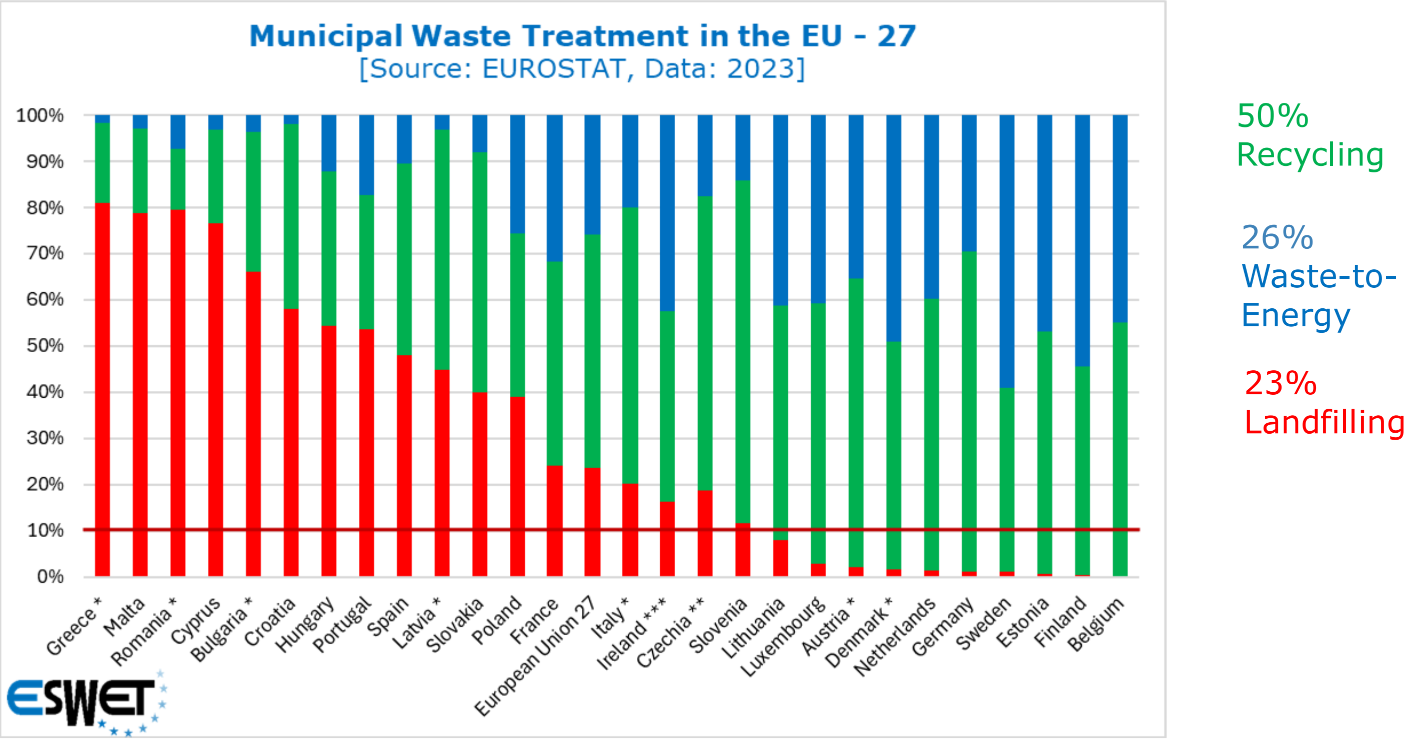

Figure 2: Municipal waste treatment in the EU-27. Source: ESWET, with data from Eurostat.

Figure 2 above illustrates the varying performance of EU-27 Member States in managing municipal waste. While some countries like Sweden, the Netherlands, and Denmark have nearly phased out landfill through high rates of recycling and WtE, others such as Greece, Romania, and Bulgaria continue to rely heavily on landfilling. These differences reflect disparities in waste management infrastructure and policy implementation. ESWET advocates for an integrated approach — anchored in the EU waste hierarchy — that combines waste prevention, reuse, and recycling, with the treatment of non-recyclable waste in advanced WtE facilities. As EU Member States strive toward the 2035 target of landfilling less than 10% of municipal waste, this data underscores the need for EU-level support and recognition of WtE as an essential and complementary technology to recycling.

To confirm this, the United Nations Economic Commission for Europe (UNECE) has identified WtE as the most sustainable option for managing non-recyclable waste,

as it enables both energy and material recovery while offering a cleaner alternative to landfill disposal and waste exports.[19]
Moreover, WtE facilities contribute to local job creation and support high-skilled employment across engineering, operations, and research sectors. By fostering innovation in thermal conversion and materials recovery, the WtE industry strengthens Europe's industrial base and supports regional development, particularly in less-developed areas where landfill alternatives are limited.

Conclusions

The updated EU Bioeconomy Strategy should explicitly acknowledge the role of non-recyclable, biomass-derived waste as a sustainable and largely untapped resource for renewable energy production. This biogenic fraction constitutes a renewable source of energy that complements intermittent renewables such as solar and wind, and should therefore be better reflected in bioeconomy policies.

ESWET emphasises the importance of advancing WtE technologies which are increasingly employed to transform biomass and biogenic waste into biofuels, biohydrogen, low-carbon fuels, synthetic gas, carbon-rich residues like biochar, and bio-plastics These innovative processes support energy security and decarbonisation goals while offering additional carbon sequestration potential.

Avoiding landfilling must remain a priority, as it represents the least favourable option in the waste hierarchy and a major source of methane emissions. The revised Strategy should set clear objectives to phase out the landfilling of biogenic and organic waste, redirecting such materials towards recovery pathways that maximise both material and energy value.

It is crucial that WtE continues to be recognised as a complementary solution within EU climate and bioeconomy frameworks. WtE plays a dual role in safely managing non-recyclable waste and producing renewable energy, while also enabling resource recovery and contributing to indirect emissions reductions.

In this context, ESWET calls for the following **policy recommendations** to ensure the WtE sector is effectively integrated into the update of the EU Bioeconomy Strategy:

[19] UNECE (2022). Guidelines on Public-Private Partnerships for the Sustainable Development Goals in Waste-to-Energy Projects for Non-Recyclable Waste: Pathways towards a Circular Economy. Available at: https://unece.org/sites/default/files/2022 10/ECE_CECI_WP_PPP_2022_03-en.pdf

1. **Support the deployment and scale-up of advanced WtE technologies**. These technologies provide carbon-neutral fuels while contributing to energy security, innovation, and decarbonisation. Dedicated funding should be made available through EU instruments such as Horizon Europe and the Innovation Fund.

2. **Landfilling of biogenic and organic waste should be progressively phased out**. Landfills are a major source of methane emissions and represent the lowest step of the waste hierarchy. ESWET calls for stronger policy signals at EU level, accompanied by regulatory coherence with other key legislative files such as the Waste Framework Directive, the upcoming Circular Economy Act and the Renewable Energy Directive.

3. **Adopt a technology-neutral, outcome-oriented approach** that integrates all sustainable solutions for biogenic waste management. WtE should be recognised as a complementary option alongside prevention, reuse, and recycling to help achieve EU circular economy, climate neutrality, and energy security goals.

4. **Recognise across EU legislation the contribution of WtE processes in the production of bio-hydrogen, bio-fuels, and renewable and low-carbon fuels**, and enable public support accordingly.

Recognising the full potential of biogenic waste streams - and the essential role of Waste-to-Energy in managing them – will be crucial for shaping a resilient, circular, and climate-neutral European economy within the updated Bioeconomy Strategy.

ESWET – European Suppliers of Waste-to-Energy Technology
Transparency Register #56047551356-84
Avenue Adolphe Lacomblé 59, B-1030 Brussels
www.eswet.eu