European Suppliers of Waste-to-Energy Technology

ESWET response to the European Commission Consultation on trade measures to ensure sufficient availability of aluminium scrap on the EU market

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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 opportunity to contribute to the European Commission's consultation on possible trade measures to ensure sufficient availability of aluminium scrap on the EU market. Strengthening the EU's circular economy, safeguarding industrial competitiveness and reducing dependency on imported primary raw materials require a reliable and affordable supply of secondary aluminium within Europe.

WtE plays a specific role in the circular economy by managing residual waste that cannot be prevented, reused or recycled. By safely treating these unavoidable fractions, WtE enables the recovery of metals – such as aluminium - that would otherwise be lost, while preventing environmental and health risks associated with landfilling or improper disposal.

Aluminium contained in residual waste cannot be recovered through conventional collection and recycling systems, but can be **efficiently extracted through the treatment of incineration bottom ash (IBA) following WtE processes. In this way, WtE facilities contribute to Europe's aluminium recycling system by retaining valuable materials within the EU.**

Aluminium recovered from WtE residues therefore represents an **already available and fully domestic source of aluminium scrap**, which can be directly reintroduced into industrial value chains, supporting low-carbon aluminium production and reducing reliance on primary aluminium imports.

This contribution sets out ESWET's perspective on the consultation and highlights how aluminium recovery from WtE residues can support the Commission's objectives of strengthening circularity, ensuring scrap availability within the EU, and reinforcing the resilience of European aluminium value chains, in full alignment with the waste hierarchy and broader EU industrial and resource-security policies.

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1. Waste-to-Energy in the circular economy

WtE facilities play a fundamental and irreplaceable role in the EU's waste management system by providing an environmentally sound solution for residual waste that cannot be recycled, such as certain plastics, multi-material packaging, or residual biomass that has no viable recycling pathway.

Beyond their environmental function, WtE plants are also powerful contributors to Europe's energy and resource resilience. The heat generated during treatment can be supplied to district heating and cooling networks, displacing fossil fuels and providing affordable, stable energy for households, hospitals, and industries. The electricity produced supports the European grid, helping to strengthen energy security at a time when diversification of supply is more important than ever.

In 2019, in Europe, WtE generated 43 billion kWh of electricity and 99 billion kWh of heat, which provided 20 million citizens with electricity and 17 million citizens with heat[1]. Since the waste treated in WtE plants is mixed, with a majority of biogenic (biomass) content, over 50% of the energy produced is considered renewable[2]. According to the IPCC guidelines[3], biogenic CO_2 is considered carbon neutral and is therefore excluded from greenhouse gas (GHG) accounting.

In addition to that, WtE facilities also play a crucial role in material recovery. Through advanced treatment processes, valuable secondary raw materials (SRMs),

[1] Confederation of European Waste-to-Energy Plants (CEWEP) (2022). *Waste-to-energy Climate Roadmap: The path to carbon negative.* At: https://www.cewep.eu/wp-content/uploads/2022/06/CEWEP-WtE-Climate-Roadmap-2022.pdf.pdf

[2] Giouse, F., Ravache, E. & Moutte, L. (2020). *Determination of the biogenic and fossil content of residual household waste and of an SRF, based on a ^{14}C analysis of CO_2 from post-combustion gases*. ADEME – Cabinet Merlin – ENVEA. UIOM 14C Program – Measurement campaign on municipal solid waste incineration plants (UIOM) and SRF boiler. [in French]

[3] Intergovernmental Panel on Climate Change (IPCC) (2006). *Guidelines for National Greenhouse Gas Inventories.* Geneva: IPCC. https://www.ipcc-nggip.iges.or.jp/public/2006gl/

metals such as aluminium, copper, zinc, and minerals can be extracted from incineration bottom ash and fly ash. These recovered materials reduce Europe's dependence on imports and support the development of a more resilient industrial base.

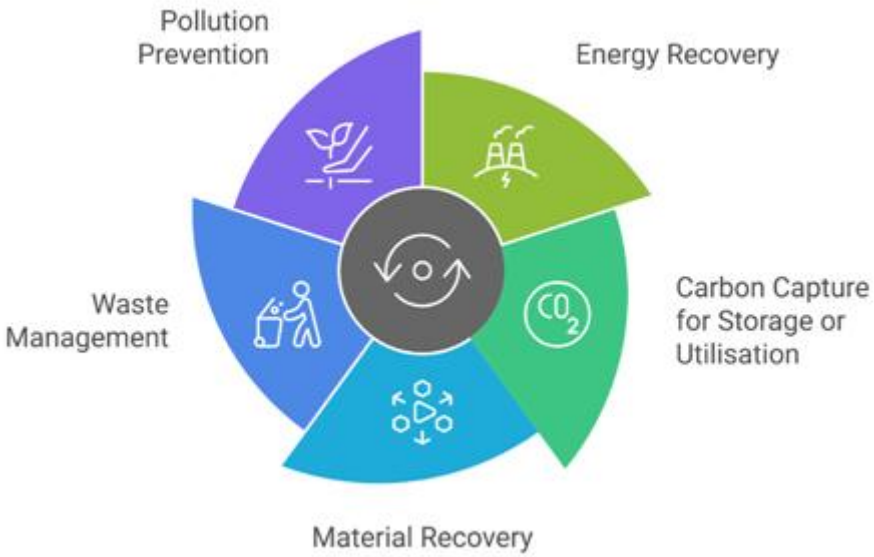

Figure 1. *The role of Waste-to-Energy (WtE) in the circular economy, supporting pollution prevention, waste management, material recovery, and energy recovery to close resource loops. Source: ESWET.*

The climate contribution of WtE extends far beyond energy and material recovery. By diverting residual waste from landfills, WtE prevents the release of methane, a greenhouse gas around 80 times more potent than CO_2 over a 20-year period. Methane leakage from landfills remains one of the most underestimated and persistent sources of emissions in the waste sector. In contrast, WtE ensures that organic waste is safely oxidised and stabilised, avoiding long-term methane generation while recovering usable energy and materials. This landfill diversion effect alone makes WtE one of the most effective near-term mitigation levers in the waste chain.

Furthermore, modern WtE facilities act as advanced pollution prevention systems. Operating under the EU Industrial Emissions Directive (IED) and Best Available Techniques (BAT) standards, they safely destroy pathogens and hazardous organic compounds, including per- and polyfluoroalkyl substances (PFAS) and other persistent pollutants, while controlling acid gases, particulates, and heavy metals through sophisticated flue gas treatment. In doing so, WtE ensures that non-recyclable, contaminated, or sanitary waste streams are managed in a way that protects both the environment and public health.

In addition, integrating carbon capture and storage (CCS) technologies with WtE plants offers a major opportunity to move the sector from carbon neutral to carbon negative, as approximately 60% of WtE emissions are biogenic. When this fraction is captured and permanently stored, WtE provides measurable and durable carbon removals (Bioenergy with CCS, BECCS) that can help the EU achieve its 2040 and 2050 climate targets.

Lastly, integrating carbon capture and utilisation (CCU) in WtE plants enables the sector to reach a new level of resource recovery through carbon circularity, by supplying captured CO_2 for reuse in industrial applications.

This role in the circular economy was already acknowledged by the European Commission in 2017 in a Communication[4] and by the European Economic and Social Committee (EESC) in its Opinion[5] in 2024. In the latter, the EESC recognises the untapped potential of WtE in advancing a more resource-efficient economy. It specifically notes that "both incinerator bottom ash and fly ash - residues from incineration - hold potential as sources of SRMs. It is essential to incentivise the recovery of metals, minerals, aggregates, potassium, sodium and calcium in salt form at EU level via appropriate legislation and by removing regulatory barriers [...]". The EESC also recommends including WtE in the EU Taxonomy Delegated Acts, a proposal ESWET strongly supports, as it would provide long-overdue recognition of the sector's environmental and economic value.

It is also worth noting that in July 2025, in the draft Implementing Regulation[6] under Article 26 of the Critical Raw Materials Act (CRMA), **the European Commission explicitly recognised IBA from waste incineration as a waste stream with a high Critical Raw Material (CRM) recovery potential.**

The United Nations Economic Commission for Europe (UNECE) recognised WtE's contributions in a 2022 report, describing WtE as "the most sustainable solution for non-recyclable waste as it recovers energy and materials while providing an alternative to highly polluting landfills and waste exports"[7]. Therefore, WtE is regarded as a vital link in a comprehensive, circular, and climate-aligned waste management chain.

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[4] European Commission. (2017). *The role of waste-to-energy in the circular economy*. COM(2017) 34 final. At: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0034&from=en

[5] European Economic and Social Committee (EESC). (2024). *From waste plants to resource plants*. Opinion CCMI/228-EESC-2024. At: https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/waste-plants-resource-plants

[6] European Commission. (2025). *Commission Implementing Regulation (EU) …/... listing the products, components and waste streams considered as having a relevant critical raw materials recovery potential under Regulation (EU) 2024/1252 (INTCOM Ares(2025)5155732). EUR-Lex.* At: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=intcom:Ares(2025)5155732

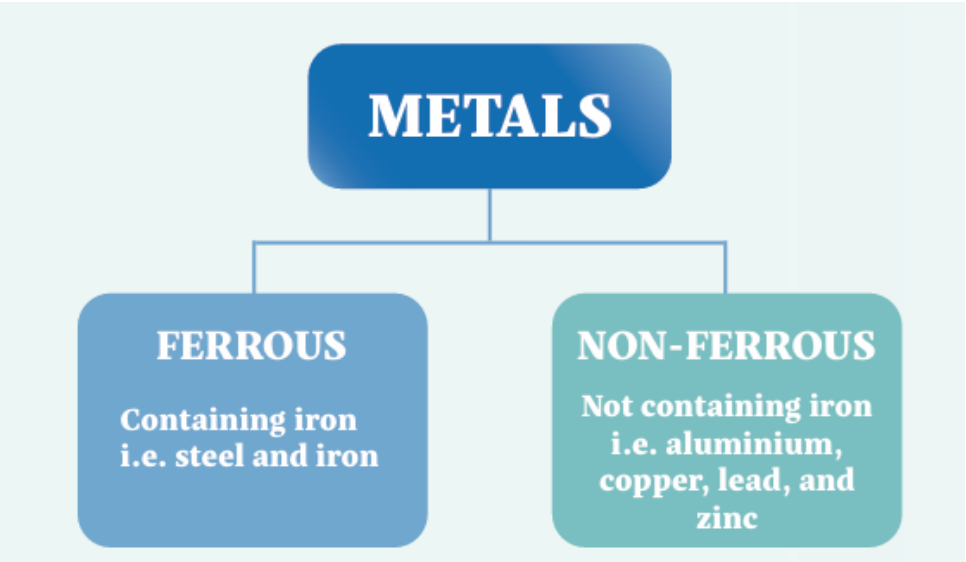
[7] United Nations Economic Commission for Europe (UNECE) (2022). *Guidelines on Public-Private Partnerships for the Sustainable Development Goals in Waste-to-Energy Projects for Non-Recyclable Waste: Pathways towards a Circular Economy.* At: https://unece.org/sites/default/files/2022 10/ECE_CECI_WP_PPP_2022_03-en.pdf

Despite this strong performance, the full contribution of WtE remains often overlooked in EU climate policy - even though its role spans landfill diversion, pollution prevention, renewable and local energy generation, material recovery, and an increasing potential for carbon capture. Taken together, these pillars make WtE one of Europe's most comprehensive tools for achieving both circularity and climate neutrality.

2. Contribution to the supply of critical and non-critical raw materials

2.1. IBA as a source of materials

IBA is composed of 80 to 85% of minerals, 10 to 12% of ferrous metals (iron, steel), and 2 to 5% of non-ferrous metals (such as aluminium, copper, zinc, lead, silver, gold, and others) (Figures 2 and 3). Aluminium, in particular, constitutes up to 2.2% of the overall mass of IBA[8]. Under the current practices applied, along with copper it exhibits the highest market value among the materials recovered by the IBA[9]. In addition, Table 1 below exhibits the distribution of various elements in IBA from various incinerators for municipal solid waste (MSW) compared to the concentrations found in the lithosphere. As indicated, many of the minor and trace elements are significantly enriched in the IBA compared to the average composition of the lithosphere. Moreover, it is evident that the concentration of aluminium in IBA is at the same order as its concentration in the lithosphere and can be close enough (up to around 90%).



[8] Šyc, M., Krausová, A., Kameníková, P., Šomplák, R., Pavlas, M., Zach, B., Pohořel ý, M., Svoboda, K. & Punčochář, M. (2018). Material analysis of Bottom ash from waste-to-energy plants. *Waste Management, 73*, 360-366.
[9] Neuwahl, F., Cusano, G., Benavides, J. G., Holbrook, S. & Roudier, S. (2019). *Best Available Techniques (BAT) Reference Document for Waste Incineration.* Seville: Joint Research Center.

Figure 2. *Classification of metals into ferrous and non-ferrous. Source: ESWET*[10].

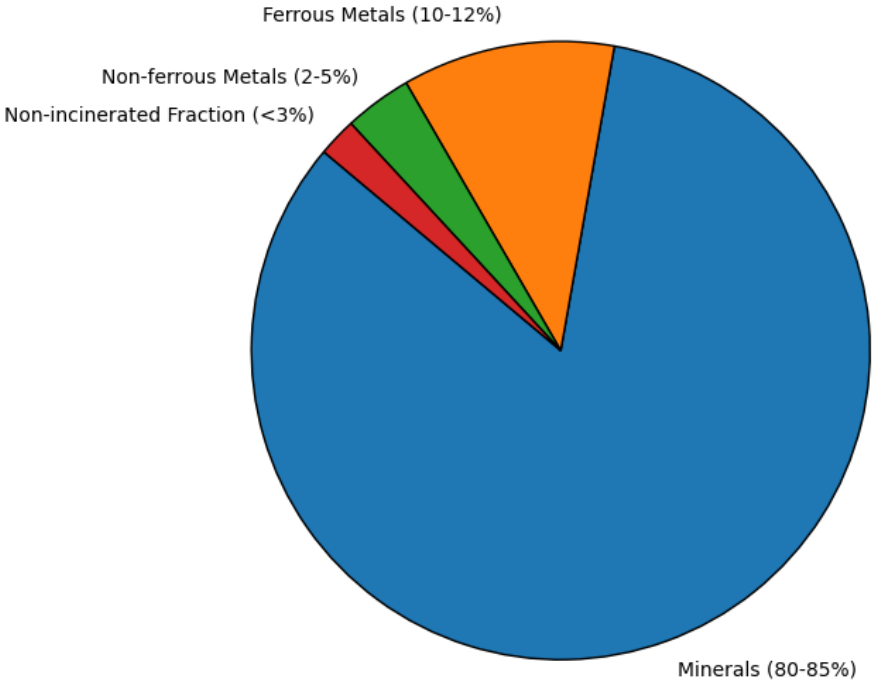


Figure 3. *Composition of raw IBA. Source: ESWET based on data from Neuwahl et al. (2019)*[11].

Table 1. *Composition of MSW IBA (in mg/kg) and the lithosphere based on total analysis. Source: Hjelmar et al. (2011)*[12].

Element	MSW IBA		Lithosphere
	Min	Max	
Si	91,000	310,000	276,000
Ca	60,000	120,000	36,000
Fe	4,100	150,000	51,000
Al	***22,000***	***73,000***	***81,000***
Na	2,900	42,000	28,000
K	800	16,000	26,000
C	10,000	60,000	950
Mg	400	26,000	21,000
S	1,000	5,000	600
Ti	2,600	9,500	6,000

[10] ESWET (2023). *Integrated Resources Recovery Facility.* At: https://eswet.eu/documents/recovering-the-non-recyclable-the-integrated-resource-recovery-facility/.
[11] ESWET (2023), same source as above; Neuwahl et al. (2019), same source as above.
[12] Hjelmar, O., Johnson, A. & Comans, R. (2011). Incineration : Solid Residues. In Th. H. Christensen (ed.), Solid Waste Technology & Management (pp. 430-462). Hoboken, NJ : John Wiley & Sons.

Cu	190	8,200	70
Zn	610	7,800	80
Cl	800	4,200	500
Pb	98	14,000	16
Ba	400	3,000	430
Mn	83	2,400	900
Ag	0.3	37	0.007
As	0.12	190	5
B	38	510	10
Br	1.4	150	2.5
Cd	0.3	71	0.2
Co	6	350	40
Cr	23	3,200	200
Cs	1	2	3.2
Fe	200	1,100	625
Hg	0.02	7.8	0.1
I	2	10	0.3
Mo	2.5	280	2.3
Ni	7	4,300	100
Sb	10	430	-
Se	0.05	10	0.09
Sn	2	380	40
Sr	85	1,000	150
V	20	120	150

2.2. Metals

Currently, IBA is increasingly viewed as a significant source of metals, as it **contains significant quantities of both CRM (e.g., aluminum and copper) and non-CRM yet strategic metals, which can be recovered through advanced treatment processes.** CRMs are essential for Europe's green and digital transition, powering technologies including electric vehicles, batteries, renewable energy systems, high-voltage cables, semiconductors, and data infrastructure. As several CRMs are imported from geopolitically unstable regions, strengthening domestic sources has become a strategic priority under the EU CRMA. WtE contributes directly to this objective: this makes IBA one of Europe's most accessible and underexploited secondary CRM sources. In recognition of this opportunity, as previously written, in July 2025, the Commission explicitly recognised IBA from waste incineration as a waste stream with a **high CRM recovery potential** in its draft Implementing Regulation under Article 26 of the CRMA.

Among the non-ferrous metals recovered from treated IBA, aluminium is the primary focus of this consultation. As better explained in the next subchapter, aluminium recovered from bottom ash can be reintroduced into European recycling and manufacturing value chains, contributing to the availability of secondary aluminium within the EU while delivering substantial energy and greenhouse-gas savings compared to primary production.

Copper is also recovered from treated IBA and plays a key role in the EU's industrial and energy transitions, notably for electrification, renewable energy systems and grid infrastructure. In line with the approach envisaged for aluminium scrap, the RESourceEU Action Plan[13] indicates that the Commission may assess the need for similar measures for copper scrap, subject to market monitoring and supply conditions. In this light, copper recovered from IBA should be regarded as part of the EU's broader effort to strengthen domestic scrap supply and reduce exposure to external supply risks.

These examples illustrate how non-ferrous metals contained in incineration residues can support the EU's objectives on circularity and raw-material security when effectively recovered.

With approximately 500 WtE facilities operating in Europe, producing more than **20 million tonnes of IBA annually[14]**, the metal recovery potential is significant, but only **one-third of the non-ferrous metals it contains are currently recycled**[15].

In 2021, the market potential of fully recovered metals from IBA was estimated at €2 billion[16], while reducing the extraction of virgin materials and avoiding up to 14.5 million tonnes of CO_2 emissions[17].

Redirecting just 300,000 tonnes of aluminium, copper, zinc, and lead currently lost to landfilling or downcycling[18] into true recycling could significantly improve the EU's raw material resilience and contribute to circular economy goals.

In addition to its role in supporting aluminium and copper scrap availability, IBA can contain **rare earth elements**, which, due to their distinctive optical and magnetic characteristics, are essential for a variety of advanced technologies, such as electronics, hybrid and electric vehicles, wind turbines, photovoltaics, as well as

[13] RESourceEU Action Plan (2025). Available at: 01c448d6-dc93-40d7-9afe-4c2af448d00c_en.

[14] TU Delft. (n.d.). *Incinerator bottom ash recycling* [Research & Innovation, Recycling Technologies]. At: https://www.tudelft.nl/en/ceg/about-faculty/departments/engineering-structures/sections-labs/resources-recycling/research-innovation/recycling-technologies/incinerator-bottom-ash-recycling/

[15] ESWET. (2023). *Integrated Resources Recovery Facility.* At: https://eswet.eu/documents/recovering-the-non-recyclable-the-integrated-resource-recovery-facility/.

[16] Blasenbauer, D., Huber, F., Lederer, J., et al. (2020). Legal situation and current practices of waste incineration bottom ash utilisation in Europe. *Waste Management, 102*, 868-883. At: https://hal.science/hal-02472497.

[17] From internal calculations based on figures from Geschäftsbericht der ZAV Recycling AG (2020).

[18] TU Delft. (n.d.). *Incinerator bottom ash recycling* [Research & Innovation, Recycling Technologies]. At: https://www.tudelft.nl/en/ceg/about-faculty/departments/engineering-structures/sections-labs/resources-recycling/research-innovation/recycling-technologies/incinerator-bottom-ash-recycling/

defense applications like missile guidance systems and satellites. As mining activities are almost inevitably associated with serious environmental pollution and corresponding human health risks and social resistance, recovering rare earths from alternative sources, such as IBA, has attracted the interest of the scientific literature[19].

IBA represents a consistent and highly enriched secondary source of precious metals, with concentrations several orders of magnitude higher than natural ores. In addition, their recovery requires far less energy and environmental impact compared with conventional mining and refining.

The study by Chuchro et al. (2025)[20] found average contents of 6,973 ppb silver, 314 ppb gold, 41 ppb palladium, and 14 ppb platinum, corresponding to 930, 7,800, 27, and 275 times their average levels in the Earth's crust. Notably, silver concentrations exceed those reported in the benchmark Swiss Hinwil plant (5,300 ppb) and are comparable to high-performing Italian facilities, confirming Europe-wide recoverability potential. The results demonstrate that these metals occur without seasonal or trend variability, ensuring **stable recovery yields throughout the year**, while 14–20% of samples showed outlier concentrations, pointing to particularly rich fractions that could significantly increase profitability when targeted with advanced separation methods. Figure 4 highlights this steady occurrence and the presence of numerous high-value outliers, demonstrating the consistency and profitability potential of IBA-based recovery.

[19] Wen, Y., Hu, L., Boxleiter, A., et al. (2023). Rare Earth Elements Recovery and Waste Management of Municipal Solid Waste Incineration Ash. *ACS Sustainable Resource Management, 1*(1), 17-27.
[20] Chuchro, M., Jędrusiak, R., & Bielowicz, B. (2025). Statistical analyses of precious metal contents in waste incineration bottom ashes. *Scientific Reports, 15*, 8149. At: https://doi.org/10.1038/s41598-025-91855-7

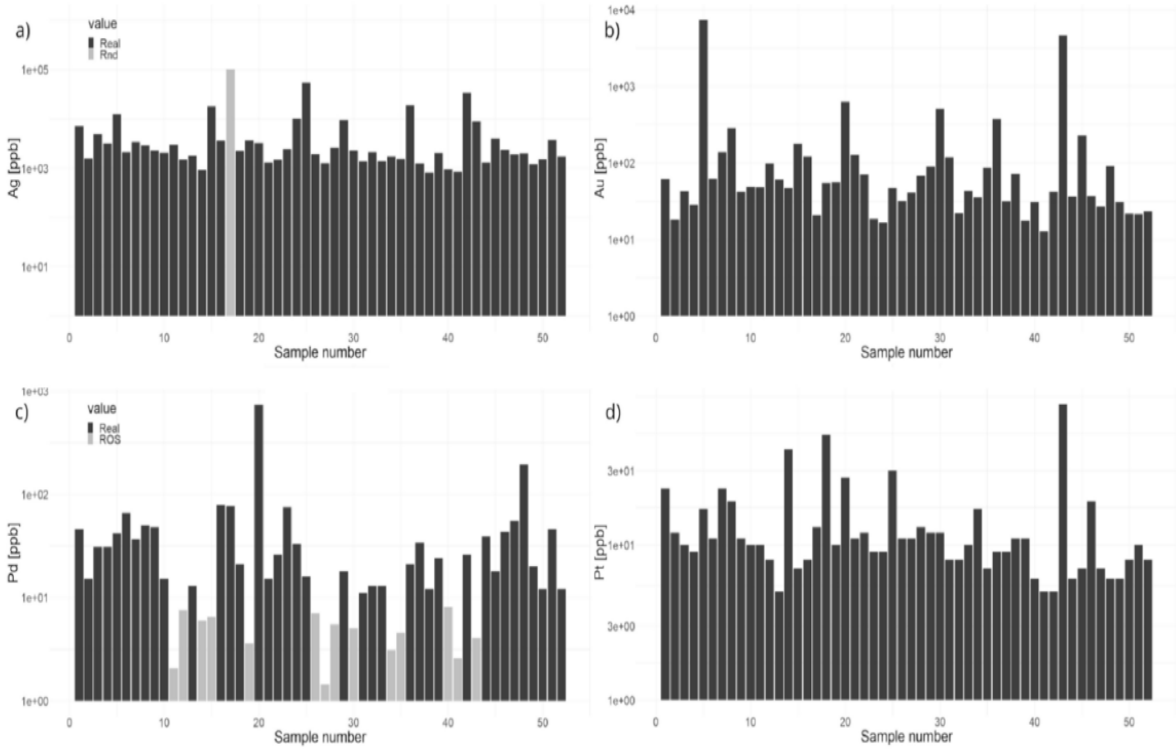


Figure 4. *Concentrations of precious metals (Ag, Au, Pd, Pt) in weekly IBA samples from the Krakow Thermal Waste Treatment Plant, showing stable recoverability and numerous high-value outliers. Source: Chuchro et al., 2025.*

Although the standalone Internal Rate of Return (IRR) for precious metals recovery was calculated at 4.4 %, comprehensive recovery of both precious and non-ferrous metals - as already implemented in several European facilities - **can raise returns well above 20%, underlining IBA's strategic importance in securing Europe's access to critical and high-value raw materials**, as illustrated in Figure 5.

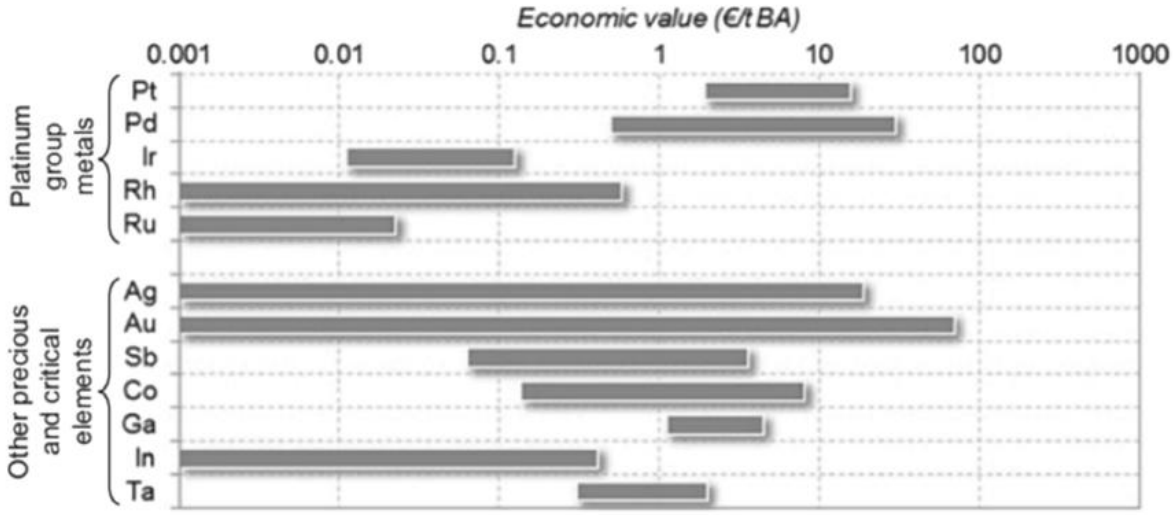


Figure 5. *Estimated total economic value of precious metals (Ag, Au, Pd, Pt) contained in IBA, illustrating the financial and material potential of Waste-to-Energy residues as a secondary raw materials source. Source: Adapted from Chuchro et al. (2025), based on Astrup et al. (2016)*[21].

From an operational perspective, IBA treatment has historically been organised through centralised facilities in order to secure sufficient volumes and achieve economic viability. Recent technological developments have broadened the range of possible treatment configurations. Depending on local conditions, these may include centralised, regional, or plant-adjacent solutions, where such options are justified from a case-by-case techno-economic perspective. This flexibility can, in certain contexts, simplify the integration of material recovery into existing WtE infrastructure, without implying a one-size-fits-all approach.

Moreover, based on internal industry analysis, the addition of IBA treatment capacity, where deemed appropriate, is estimated to represent less than approximately 5% of the total investment cost of a WtE plant, making it a relatively limited incremental cost. However, the actual environmental and economic benefits depend strongly on the chosen processing concept, local market conditions, logistics, and regulatory frameworks.

As decarbonisation pressures intensify, Europe cannot afford to overlook domestic sources of secondary raw materials that can strengthen the circular economy, particularly where these materials - such as aluminium recovered from WtE residues - can contribute to the production of advanced and strategic applications.

[21] Astrup, T., Rosenblad, C., & Sloot, H. A. van der. (2016). Treatment and reuse of incineration bottom ash. In R. D. Billings & E. E. Park (Eds.), Environmental materials and waste: Resource recovery and pollution prevention (pp. 607–645). Elsevier. At: https://doi.org/10.1016/B978-0-12-803837-6.00024-X

2.3. Aluminium

Aluminium production has expanded significantly in recent decades, driven by the growth of the consumer base and the emergence of new uses for this highly adaptable metal. In 2019, worldwide aluminium consumption reached 89.9 million metric tonnes. Of this total, 26% was allocated to transportation, 24% to the construction sector, 11% to electrical products and machinery respectively, 8% to packaging and foil stock applications respectively, and 6% to consumer durable goods[22].

The availability of aluminium scrap within the EU has become an increasingly strategic issue, as highlighted by the Commission in both this Call for Evidence on trade measures for aluminium scrap and the RESourceEU Action Plan[23].

As demand continues to grow, the Commission recognises that the aluminium market is highly dynamic, characterised by strong international competition for scrap, price volatility and increasing export pressure. These dynamics risk diverting valuable secondary raw materials away from the EU, undermining circular-economy objectives and weakening the EU's domestic recycling base.

In this context, WtE contributes to the availability of aluminium scrap by recovering aluminium from residual waste streams. Aluminium recovered from IBA represents a stable and under-utilised domestic source of aluminium scrap: advanced technologies, such as dry extraction systems, could enable the recovery of up to **0.7 million tonnes of aluminium** - **equivalent to 11% of EU imports[24]**.

From just one tonne of municipal waste, 180–250 kg of bottom ash can be recovered - across Europe, this translates into 1.2 million tonnes of iron and 250,000 tonnes of aluminium annually, equivalent to the metal content of roughly 8 billion smartphones. [25]

According to the European Environmental Agency, 52 Mt of municipal waste were landfilled in the EU in 2022[26]. If this waste were instead treated in WtE plants, it would generate around 10-13 Mt of IBA (20-25% of input[27]), from which approximately 350,000 - 455, 000 t of aluminium. With European aluminium

[22] Gökelma, M., Vallejo-Olivares, A. & Tranell, G. (2021). Characteristic properties and recyclability of the aluminium fraction of MSWI bottom ash. *Waste Management, 130*, 65-73.
[23] RESourceEU Action Plan (2025). Available at: 01c448d6-dc93-40d7-9afe-4c2af448d00c_en.
[24] ESWET. (2023). *Integrated Resources Recovery Facility.* At: https://eswet.eu/documents/recovering-the-non-recyclable-the-integrated-resource-recovery-facility/. For reference, a tonne of aluminium is worth about 2,209 € (February 2023).
[25] ESWET (2022) The Beauty in the Beast Campaign. Available at: Turning trash into gold - The Beauty in The Beast Campaign!
[26] European Environment Agency (EEA), (2025) *Diversion of waste from landfill in Europe - Indicator*, available at:https://www.eea.europa.eu/en/european-zero-pollution-dashboards/indicators/diversion-of-waste-from-landfill-in-europe-indicator
[27] Blasenbauer, D., Huber, F., Lederer, J., et al. (2020). Legal situation and current practices of waste incineration bottom ash utilisation in Europe. *Waste Management, 102*, 868-883. At: https://hal.science/hal-02472497.

demand projected at around 18 million tonnes by 2050[28], aluminium recovered from WtE residues could cover roughly 6.4% of total EU demand.

Extracting aluminium from IBA is both financially and environmentally justified, as the energy required and the associated GHG emissions for aluminium recycling through re-melting are substantially lower than those involved in the production of primary aluminium[29].

Recovering all available aluminium from WtE facilities could make a meaningful contribution to increasing the supply of secondary aluminium within the EU, helping to close the gap between demand and domestic availability. This is particularly relevant in light of the pressure currently faced by EU recyclers and downstream industries, which depend on reliable access to scrap to maintain production, invest in decarbonisation and remain competitive.

In addition to conventional recovery routes, some advanced waste-treatment configurations demonstrate that aluminium contained in complex waste streams, particularly in composite materials, can be effectively recovered. This is especially relevant for aluminium embedded in products that have traditionally been considered difficult or uneconomic to treat through standard collection and recycling systems.

Under certain treatment configurations, including gasification-based systems applied to specific waste streams, aluminium can be recovered in metallic form, avoiding the energy-intensive reduction of aluminium oxides. This pathway can offer efficiency advantages, but remains underutilised due to high capital requirements and limited market visibility.

According to this study[30], gasification treatment of non-recycled plastic packaging material containing aluminum was able to recover from 79% to 105% of aluminium, with a purity level of 73.1 wt% - 100 wt%. This can reduce the need for energy-intensive downstream processing steps and facilitate its reintegration into existing aluminium recycling and remelting routes.

A concrete example is provided by integrated treatment plants[31], which treat composite packaging waste and enable aluminium to be recovered, melted and cast into blocks for reuse in aluminium foil production. This demonstrates that even very thin aluminium layers used in packaging, previously regarded as non-

[28] European Aluminum. Data available at: https://european-aluminium.eu/about-aluminium/aluminium-industry/?.

[29] Rüttinger, L., Treimer, R., Tiess, G. & Griestop, L. (2016). *Environmental and social impacts of bauxite mining and aluminium production in Pará, Brazil* [in German]. Berlin: adelphi.

[30] Cheng H., Kung Y. C. (2017), Gasification of non-recycled plastic packaging material containing aluminum: Hydrogen energy production and aluminum recovery. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0360319917336698.

[31] See for instance, the Corenso Varkaus gasifier for recycling aluminium from juice packaging board waste in Finland.

recoverable, can be effectively returned to the aluminium industry, while other material fractions are simultaneously valorised.

However, the utilisation of materials recovered from WtE processes still varies widely across Member States reflecting differences in regulatory requirements, availability of primary raw materials, and public acceptance. The recovery of aluminium from WtE residues represents not only an economic opportunity but also a climate and resource-efficiency imperative. **It should therefore be recognised as a relevant component of the EU's strategy to safeguard domestic aluminium scrap availability.**

Another important point about the need to strengthen domestic sources of aluminium scrap is the context of broader market situations, which currently undermine the economic viability of aluminium recycling. As the Commission acknowledges in this Call for Evidence, the current market structure reveals a structural paradox: the price of aluminium scrap is close to that of primary aluminium. This gap risks discouraging recycling investments, despite the clear environmental advantages of secondary aluminium in terms of energy savings and greenhouse-gas reductions. For this reason, **ensuring a level playing field between virgin and secondary raw materials remains one of the key steps to achieve the circular transition.** This includes incentives for manufacturers to replace primary materials with recycled inputs, for example through recycled-content requirements in key sectors. In parallel, dedicated financial support is needed to help scale up recycling and material-recovery technologies and to support investments that reduce dependence on primary raw materials. In this respect, **ensuring the eligibility of material-recovery technologies from WtE facilities under EU funding programmes such as the Innovation Fund, InvestEU and EIB instruments is essential to support scale-up and deployment.** Equally important is **the recognition of IBA treatment and, more broadly, WtE material-recovery activities under the EU Taxonomy**, which would provide regulatory certainty and facilitate access to sustainable finance. Together, these measures would help align market conditions with environmental objectives and strengthen the EU's recycling base. Without targeted policy measures, this situation could lead to a decline in EU recycling capacity, even as demand for low-carbon aluminium continues to rise.

Aluminium recovery from IBA offers a concrete, immediately available pathway to strengthen the EU's secondary aluminium supply while delivering clear climate and resource-efficiency benefits. Unlocking this potential requires a supportive policy and investment framework that recognises the role of WtE in recovering aluminium from residual waste streams and addresses existing market distortions between primary and secondary materials. By doing so, the EU can safeguard recycling capacity, support downstream industries, and advance its circular-economy and

decarbonisation objectives in a context of growing demand for low-carbon aluminium.

3. Technical and economic considerations

Over the past few decades, only a limited number of recycling technologies in WtE facilities have been developed and adopted at large scale, primarily due to their high capital and/or energy costs and relatively unattractive economic returns. However, the Critical Raw Materials Act (CRMA), officially published in May 2024, has highlighted the strategic importance of strategic materials (e.g. aluminium, copper) that can be recovered from WtE units. This recognition of this potential for the recovery of metals from WtE facilities can significantly enhance the economic feasibility of advanced recycling technologies, especially in view of growing demand for strategic and critical raw materials.

In this context, it is essential that EU competition rules support - not hinder - the deployment of the most efficient recycling solutions. Policy frameworks should go beyond enabling only the most established or visible technologies and actively create space for innovative, high-efficiency methods that may involve greater upfront investments. As the economic and strategic value of such solutions increases, EU guidance must ensure that collaborative innovation in this space can move forward without being constrained by outdated interpretations of competition law.

Moreover, the ongoing green transition and its emphasis on renewable energy (RE) production create opportunities for synergies between the RE and WtE sectors, as energy-intensive recovery processes in WtE facilities can utilise surplus renewable electricity, helping to stabilise grid loads and smooth the intermittency of RE generation. These interactions not only improve the overall efficiency of the energy system but also support the EU's broader goals for clean energy, circularity, and sustainability.

Ultimately, a target of the WtE facilities must be the maximum efficiency of recovery, ensuring that both economic value and critical resource potential are fully utilised.

4. Calculating the environmental, climate, and strategic benefits of material recovery from Waste-to-Energy

Across the EU, moving residual waste up the hierarchy from landfilling to recycling and WtE has already driven more than a 40% cut in waste-sector emissions since 1990. The climate value of WtE comes from three integrated effects: landfill diversion that avoids methane emissions, fossil energy substitution via reliable baseload electricity and heat, and material recovery from IBA.

According to CEWEP[32], the diversion of non-recyclable waste from landfills to WtE results in **avoiding the emission of more than 600 kg of CO_2 per tonne of waste treated** in a 100-year time perspective. In other words, WtE plants prevent the formation of landfill gas by treating the organic methane-producing compounds in MSW, therefore decreasing their net emissions. Additionally, the energy recovered by WtE plants can displace energy from fossil fuel sources, **helping abate GHG emissions, at an estimated 360 kg of CO_{2eq} per tonne of waste treated**, while for **material recovery, the abated emissions are 60 kg CO_2 equivalent** per tonne of waste treated. Overall, WtE plants generate emissions of about 400-450 kg of fossil CO_2 per tonne processed by delivering a public service of general interest and providing a treatment option for residual waste, but above all, **WtE plants help prevent CO_2 emissions with avoided emissions amounting to more than 1000 kg CO_2 per tonne of waste treated.**

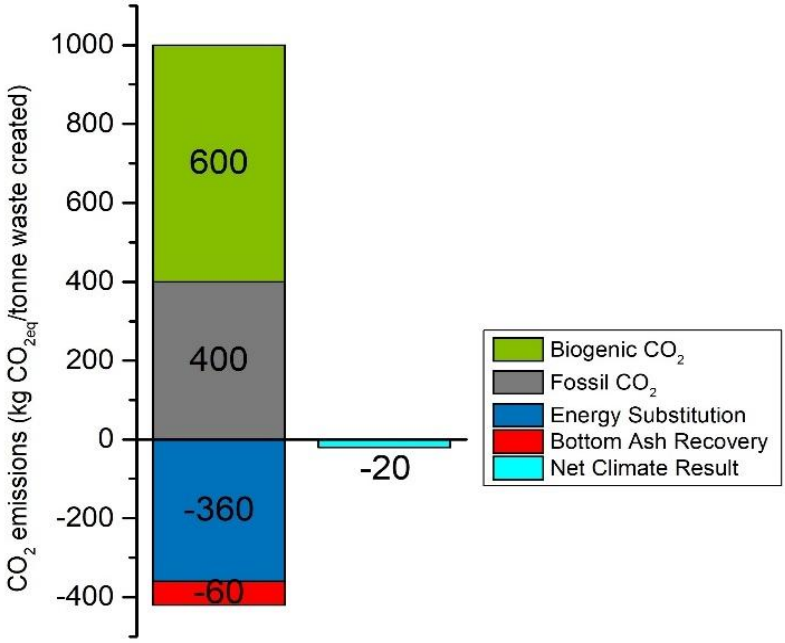


Figure 7. *Net climate effect of treating one tonne of residual waste via Waste-to-Energy (WtE). Data source: CEWEP Climate Roadmap, 2022. Graphic source: ESWET.*

[32] Confederation of European Waste-to-Energy Plants (CEWEP) (2022). *Waste-to-Energy Climate Roadmap Technical Annex (TA) main assumptions & methodology.,* Düsseldorf: CEWEP.

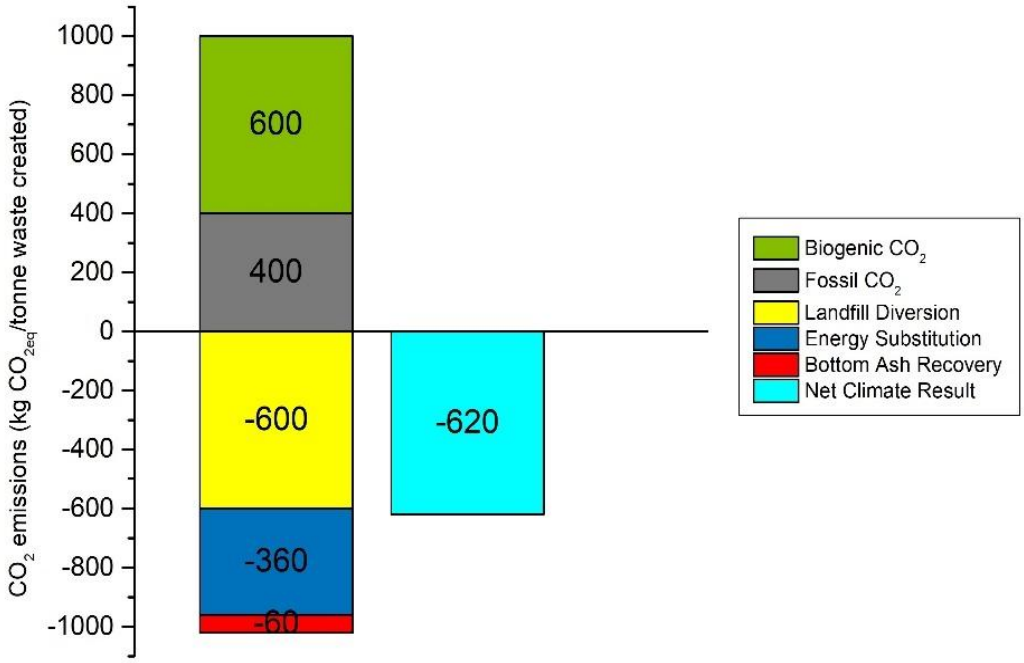


Figure 8. *Net climate effect of treating one tonne of residual waste via WtE, taking into consideration also landfill diversion. Data source: CEWEP Climate Roadmap, 2022. Graphic source: ESWET.*

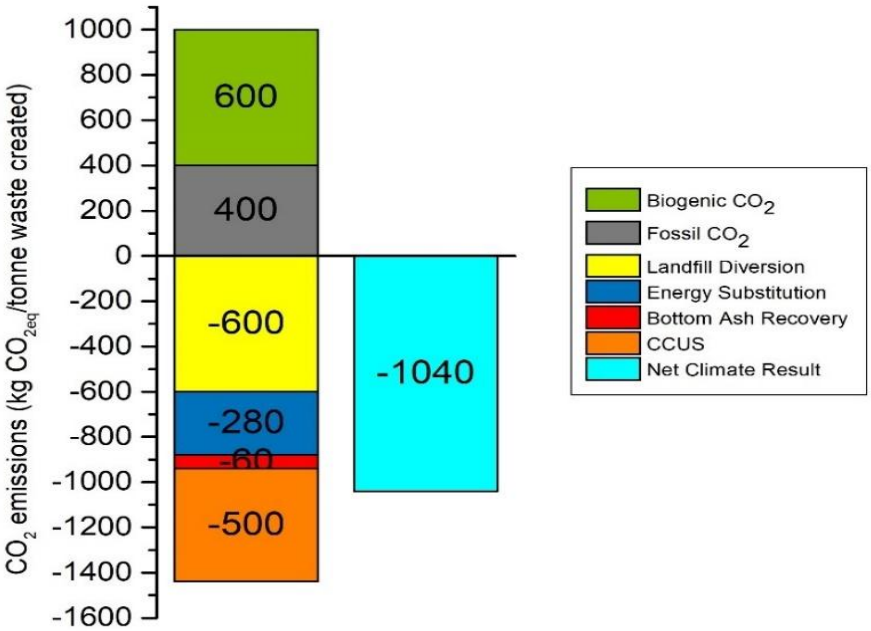


Figure 9. *Net climate effect of treating one tonne of residual waste via WtE, taking into consideration also landfill diversion and CCUS. Data source: CEWEP Climate Roadmap, 2022. Graphic source: ESWET.*

The three graphs above show the net climate effect of treating one tonne of residual waste via WtE, highlighting the contributions from emissions and avoided impacts:

1. **Graph 1 (Figure 7) (Baseline – electricity-only WtE):** When only electricity is recovered, WtE delivers a marginal **climate benefit** of **20 kg CO_{2eq}/tonne**, as fossil CO_2 emissions are only partially offset by energy substitution and bottom ash recovery.
2. **Graph 2 (Figure 8) (WtE with landfill diversion):** Diverting waste from landfills to WtE adds a **substantial climate benefit** due to avoided methane emissions, leading to a net result of **620 kg CO_{2eq}/tonne**.
3. **Graph 3 (Figure 9) (WtE with CCUS):** Combining landfill diversion with Carbon Capture, Utilisation and Storage (CCUS) **further enhances the climate performance**, achieving a total **benefit** of **1040 kg CO_{2eq}/tonne**.

[Data and analysis from CEWEP Climate Roadmap, 2022].

These figures highlight the significant climate mitigation potential of WtE, which is highly relevant in the context of climate targets and broader decarbonisation efforts. The primary mission of the WtE sector is to safely treat society's residual, non-recyclable waste; unlike other industrial sectors, WtE cannot "switch fuels" (it should be noted that waste in general, and residual, non-recyclable waste more specifically, is not a fuel) or control the composition of its input, as it is determined by upstream consumption and product design. Despite this, WtE delivers substantial greenhouse gas reductions by diverting waste from landfills, preventing methane emissions, recovering energy that substitutes fossil fuels, and enabling material recovery from incineration bottom and fly ashes. This means that, when considering the full system benefits, the sector is already close to climate neutrality or even net negative in terms of emissions. However, these societal and environmental benefits are often **not fully captured** in standard assessments or in the design of carbon pricing mechanisms like the ETS. As a result, the unique role of WtE in supporting both climate and circular economy objectives risks being **overlooked**, potentially leading to policies that do not reflect the sector's true contribution to decarbonisation and resource efficiency.

The Intergovernmental Panel on Climate Change (IPCC) explicitly acknowledges WtE's climate mitigation role, stating that **"When WtE technologies are equipped with proper air pollution reduction facilities, they can contribute to clean electricity production and reduction of GHG emissions"**.[33] Furthermore, The United Nations Economic Commission for Europe has defined WtE as **"the most sustainable solution for non-recyclable waste as it**

[33] Intergovernmental Panel on Climate Change (IPCC) (2022). *Climate Change 2022 Mitigation of Climate Change. Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change 2022.* At: https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf

recovers energy and materials while providing an alternative to highly polluting landfills".[34]

When evaluating the climate impact of WtE, it is important to consider the broader context: approximately 100 million tonnes of residual waste are treated annually through WtE in Europe - waste that might otherwise end up in landfills or be exported outside the EU.

With emissions savings of up to 2,000 kg CO_{2eq} per tonne of recycled metal, the recovery of metals from WtE alone could save up to 3.8 million tonnes of CO_{2eq} each year, highlighting the sector's key role in reducing emissions and bolstering Europe's material security in a time of growing geopolitical uncertainty.

Additionally, as briefly mentioned in the previous chapters, bottom ash and fly ash offers promising potential for CO_2 sequestration through natural carbonation. As the mineral fraction of the ash matures through exposure to air and rain, the lime it contains reacts with atmospheric CO_2 - permanently capturing it - to form stable calcium carbonate ($CaCO_3$). This process can capture around 30 to 65 kg of CO_2 per tonne of ash, contributing further to the sector's carbon mitigation potential.[35]

The carbon sequestration potential of IBA was also recognised by the European Commission in the proposed Act[36] on permanent CCU, which aimed to define the conditions under which greenhouse gas emissions can be considered permanently embedded in a product.

In the UK, an "end-of-waste" status was granted for the carbon negative aggregate - made of fly ash and captured CO_2 - by the Environment Agency in 2011[37], meaning that it can be considered as a product at the legislative and commercial level.

Moreover, on the environmental benefits of material recovery, fly ash can also be used as an adsorbent in flue gas and wastewater treatment, either within the facility itself or externally, further enhancing the sector's circular economy profile. Fly ash also contains recoverable heavy metals such as zinc, which can substitute virgin materials in industrial processes. One promising example is a pilot-scale zinc recovery process applied to acid-

[34] United National Economic Commission for Europe (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. At: https://unece.org/sites/default/files/2022-10/ECE_CECI_WP_PPP_2022_03-en.pdf

[35] Costa, G., Baciocchi, R., Polettini, A., et al. (2007). Current status and perspectives of accelerated carbonation processes on municipal waste combustion residues. *Environmental Monitoring and Assessment, 135*, 55-75. At: https://link.springer.com/article/10.1007/s10661-007-9704-4.

[36] European Commission. (2023). *Emissions trading system (ETS) - permanent emissions storage through carbon capture and utilisation*. At: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14135-Emissions-trading-system-ETS-permanent-emissions-storage-through-carbon-capture-and-utilisation_en

[37] Gunning P., Hills C.D. and Carey P.J. (2013), Commercial application of accelerated carbonation: Looking back at the first year, ACEME.

washed fly ash[38]. While various treatment methods for fly ash already exist and can be further deployed, targeted funding and policy support are essential to scale up these technologies and unlock their full potential.

Supporting the recovery of valuable materials from (treated) IBA and fly ash offers wide-ranging environmental and strategic advantages. In addition, it directly contributes to the objectives of the Landfill Directive by reducing the volume of residual waste sent to landfill and at the same time reduces reliance on primary resource extraction, thus lowering environmental degradation and aligning with EU sustainability goals.

5. Policy recommendations

Ensuring sufficient availability of aluminium scrap within the EU is essential to support the decarbonisation of the aluminium value chain, strengthen industrial competitiveness, and reduce dependence on primary aluminium and external suppliers. Aluminium plays a strategic role in clean technologies, construction, transport and energy systems, and its circular use is a key enabler of the EU's climate and industrial objectives.

In this context, WtE contributes to the secure supply of secondary aluminium by recovering aluminium from incineration residues, in particular from bottom ash. Aluminium recovered from WtE residues constitutes a stable, domestically sourced stream of secondary raw material that is already collected, treated and processed within the EU waste-management system. This recovered aluminium can be reintroduced into recycling and manufacturing chains, complementing other scrap streams and supporting the EU's objective of retaining valuable materials within the internal market.

To fully harness this contribution and strengthen the availability of aluminium scrap in Europe, a coherent and enabling policy framework is required. In this context, ESWET calls for the following:

Policy recommendations

1. **Ensure that trade and market measures aimed at retaining aluminium scrap within the EU take into account all relevant secondary sources**, including aluminium recovered from all WtE technologies, including incineration and gasification.
2. **Recognise WtE material-recovery activities, including IBA treatment technologies, under the EU Taxonomy**, in order to provide regulatory clarity, improve access to sustainable finance, and support circular investments.

[38] Karlfeldt Fedge, K. & Andersson, S. (2020). Zinc recovery from Waste-to-Energy fly ash – A pilot test study. *Waste Management, 118*, 90-98.

3. Support investment, innovation and scale-up of aluminium recovery technologies from WtE residues, **ensuring their eligibility under EU funding and financing instruments such as InvestEU, the Innovation Fund, the EIB** and other relevant programmes, in order to maximise recovery rates, material quality and environmental performance.
4. **Ensure a level playing field between virgin and secondary raw materials.**
5. Consider extending similar, proportionate trade measures to other strategic non-ferrous metal scrap streams, such **as copper**, where market monitoring and supply conditions demonstrate risks to EU availability, in line with the approach outlined in the RESourceEU Action Plan.
6. **Guarantee coherence across EU policy frameworks**, including the Circular Economy Act, the Critical Raw Materials Act, the Advanced Materials agenda the Clean Industrial Deal and sustainable finance tools, to ensure that recovery pathways for **aluminium, as well as other key secondary materials, from WtE residues** are consistently reflected and supported.

Strengthening the recovery and retention of aluminium scrap within the EU, including aluminium recovered from WtE residues, would enhance resource efficiency, reduce reliance on primary and imported materials, and contribute to a more resilient and circular aluminium value chain. Aligning trade, waste and industrial policies around this objective is key to ensuring long-term availability of aluminium scrap for Europe's strategic industries.

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