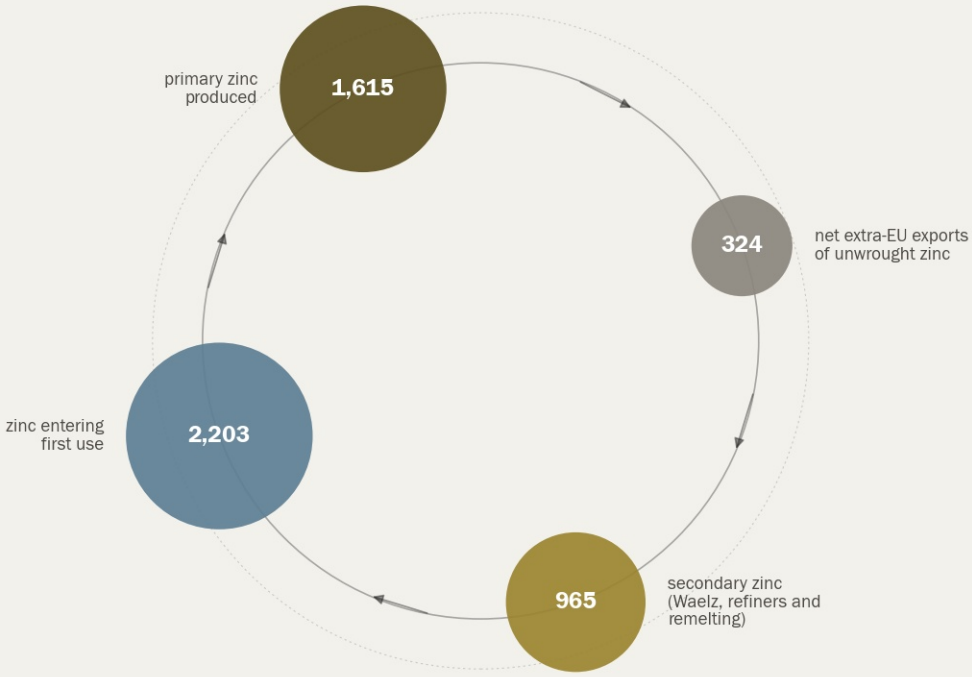
IGMNiR
Economic Chamber of Non-Ferrous Metals and Recycling

Zinc in the EU-27, 2024 (kt of zinc; circle area ∝ tonnes)



IGMNIR REPORT · NOVEMBER 2026

Zinc in the EU-27 economy

Value, circularity and security of supply

An integrated assessment of the zinc industry in the European Union (ZN-EU model)

Base year 2024 · Dynamic stock model 1960–2035 · Transparent, reproducible model

About this report. This report was prepared by the Economic Chamber of Non-Ferrous Metals and Recycling (IGMNiR). It presents ZN-EU, an integrated model that estimates the economic, fiscal, environmental and strategic contribution of the zinc industry to the economy of the European Union. The 27 Member States are treated as one economy: deliveries between Member States are domestic, trade with countries outside the EU is foreign trade. The model distinguishes six segments – zinc mining (Z0), collection and trading of zinc scrap and residues (Z1), secondary zinc from Waelz kilns and secondary refiners (Z2), zinc smelting (Z3), rolled zinc, zinc dust and zinc alloys (Z4) and zinc coating and zinc die-casting (Z5). A dynamic model links the industry to the zinc stock in European buildings, infrastructure, vehicles and equipment. The annexes list all parameters and sources. The report was prepared with the support of artificial-intelligence (AI) tools for data processing, modelling and drafting.

Data cut-off: statistics 31 October 2026; legal and policy status 10 November 2026. **Base year:** 2024 (structural business statistics, PRODCOM, British Geological Survey, company reports); trade data to 2025. **Currency:** EUR, current prices. **Model version:** ZN-EU v1.0 (run ID ZNEU-1.0-fc03a4ecad; random-number seed 20261118, a fixed numeric identifier). **Suggested citation:** IGMNiR (2026), *Zinc in the EU-27 economy: value, circularity and security of supply. An integrated assessment of the zinc industry in the European Union (ZN-EU model)*, Economic Chamber of Non-Ferrous Metals and Recycling, November 2026.

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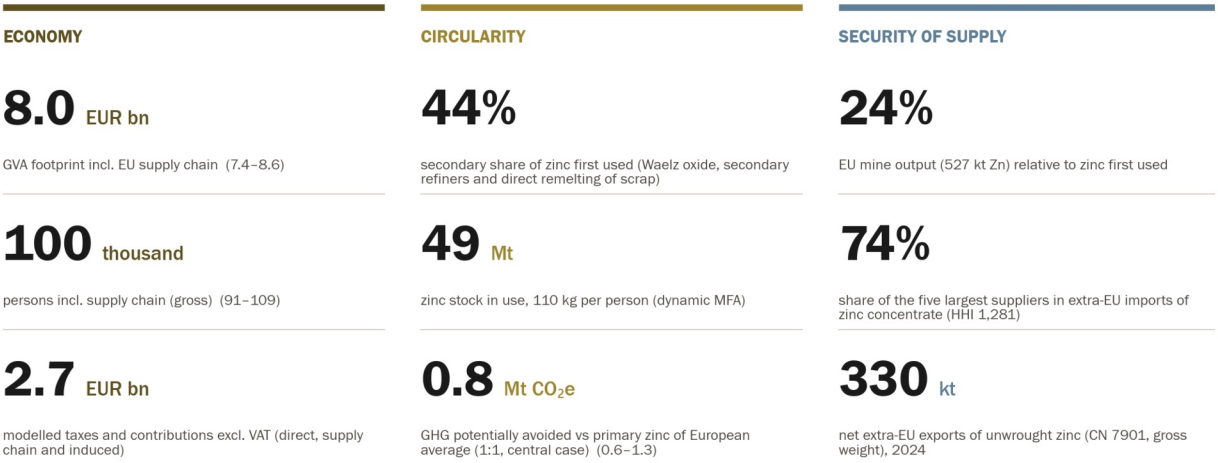
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How to read the numbers. *Observations* (O) are published statistics and company data – Eurostat structural business statistics (SBS), national accounts, input-output tables, PRODCOM and Comext, the EU emissions registry, the British Geological Survey and company reports. *Estimates* (E) combine observations with allocations or calibrated parameters – the zinc shares of ore mining, scrap trading, metal coating and die-casting, the split of the zinc part of NACE 24.43 into secondary producers, smelters and producers of rolled zinc, dust and alloys, and the three routes of secondary zinc. EU aggregates of SBS are partly confidential or rounded by Eurostat; missing 2024 cells are completed from member-state sums or ratios of earlier years and carry status E. *Model results* (M) depend in addition on counterfactual or dynamic assumptions – supply-chain and induced effects, modelled taxes, the zinc stock in use, the emissions and other burdens potentially avoided and the scenarios. Economic results are gross contributions. Value added is at factor cost, which includes operating subsidies; the value added of zinc smelting therefore includes the compensation of indirect emission costs. Tonnages are zinc content unless gross weight is stated; trade statistics are in gross weight. Taxes are model estimates, not a net fiscal balance.

Key findings

The EU-27 smelted about 1,800 kt of refined zinc in 2024 in ten smelters, of which about 185 kt came from Waelz oxide made from steelworks dust; secondary refiners produced about 230 kt of zinc, zinc dust and zinc alloys from residues and scrap, and about 550 kt of zinc in scrap was remelted directly, mainly by brass mills, zinc rollers and alloy producers. EU mines produced 527 kt of zinc in concentrate. Of about 2,200 kt of zinc first used in the EU, secondary zinc supplied 43.8% (90% band 42–48%), against a recycling input rate of 49% for Europe including the United Kingdom, Norway and Switzerland (Rostek and Loibl 2025).

FIGURE 1 The zinc industry in the EU-27 at a glance



Central estimates for 2024; ranges in brackets = P5–P95 of 10,000 Monte Carlo draws within the model structure. Extended value chain: zinc mining, collection and trade of scrap and residues, Waelz kilns and secondary refiners, zinc smelting, rolled zinc, zinc dust and alloys, zinc coating and zinc die-casting. GHG: conditional, substitution-based estimate; for the boundaries adopted the Waelz route has a negative result. Source: IGMNiR ZN-EU v1.0.

SEVEN FINDINGS

- **Value.** The extended zinc value chain generated about EUR 4.5 billion of gross value added in 2024 and employed about 57,000 people. Including the supply chain inside the EU the footprint is EUR 8.0 billion and about 100,000 jobs (90% band EUR 7.4–8.6 billion). These are gross contributions associated with the activity, not the effect of its loss. Zinc coating and die-casting (Z5) account for 52% of direct value added; this share is set by two allocation keys, the zinc shares of metal coating and of non-ferrous casting. Zinc smelting (Z3) accounts for 14%. Z3 value added at factor cost is EUR 610 million (90% band EUR 390–820 million): EUR 380 million from the cost build-up and EUR 230 million of compensation of indirect emission costs. Without compensation the margin of smelters is zero at an electricity price of about EUR 122 per MWh, with compensation at about EUR 154.
- **Recycling.** The recycling chain – collection and trade of zinc scrap and residues (Z1) and secondary zinc from Waelz kilns and secondary refiners (Z2) – generated EUR 620 million of direct value added and about 6,300 jobs; EUR 1,170 million with the supply chain. Zinc remelted directly in brass mills, zinc rolling mills and alloy plants is not a separate segment; its value added is part of the users of the metal.
- **Public finances and energy.** Activity in the extended chain is associated with about EUR 2.7 billion of taxes and

social contributions excluding VAT (90% band EUR 2.5–2.9 billion), most of it on labour. Lead, zinc and tin production (NACE 24.43) is eligible for compensation of indirect emission costs; the amounts recorded for costs of 2024 are EUR 170.2 million for zinc smelters and EUR 30.0 million for NACE 24.43 in Poland (including lead and tin); with amounts not published for the Netherlands, Italy and Bulgaria, ZN-EU includes EUR 230 million in Z3 value added at factor cost. The six electrolytic smelters without lead or Imperial Smelting lines received 300 kt of free allowances in 2024 against verified emissions of 90 kt; the difference is worth about EUR 13.5 million at the 2024 auction price. Electricity dearer by EUR 50 per MWh would raise the costs of smelters by about EUR 370 million a year, 60% of their value added, and those of smelting, secondary production and semis together by EUR 410 million. A treatment charge at the 2025 benchmark would lower Z3 value added by about EUR 210 million (34%) if realised charges moved with the benchmark, and by EUR 250 million at the full change of the benchmark.

- **Zinc in use.** The dynamic model estimates the zinc stock in use in the EU-27 at about 49 Mt in 2024 (110 kg per person). End-of-life products released about 1,780 kt of zinc, of which 267 kt in dissipative uses; about 580 kt was recovered in the EU, 38% of the non-dissipative outflow (90% band 35–42%). Compared with Rostek and Loibl (2025) for the EU-27, the United Kingdom, Norway and Switzerland in 2020 – about 130 kg per person, an end-of-life recycling rate of 53% and an old-scrap ratio of 70% – ZN-EU gives 109 kg, 38% and 50%. The model is not calibrated to that study. The difference reflects mainly the bound on recovery from galvanized steel, whose zinc is recovered in the EU only from the dust of electric-arc furnaces, and a difference of definition: "recovered in the EU" excludes zinc in exported steel scrap, and on a "collected for recycling anywhere" basis the rate would be higher. The secondary share of 43.8% rests on volumes from the literature, the recycling rate on the stock model; the two accounts do not close (residual 212 kt). A new-scrap rate of 18% and a recovery factor of 1.60 on groups other than galvanized steel close them (residual 8 kt) and give an end-of-life recycling rate of about 48%.
- **Environment.** Secondary zinc produced in the EU in 2024 potentially avoided 1.1 Mt CO_2e through remelting and secondary refining (90% band 1.0–1.6 Mt) and added 0.34 Mt through the Waelz route, a net 0.77 Mt, with one-for-one replacement of primary zinc at the European average footprint (2.0 t CO_2e per tonne). Under the boundaries adopted, the Waelz route (3.86 t CO_2e per tonne of zinc) has a higher footprint than European primary zinc; the comparison does not credit the disposal of the dust that the process replaces. The sign of the net result depends on the reference footprint: −0.14 Mt against European zinc from primary feed only (1.06 t; Nyrstar 2023) and 2.2 Mt against the global average (3.5 t); across all counterfactuals the range is from −0.2 Mt (a net increase) to about 2.3 Mt CO_2e.
- **Security of supply.** Relative to zinc first used in the EU (2,200 kt), EU mines correspond to 24%, EU primary smelting to 73% and all zinc produced by EU smelters and secondary refiners to 92%; secondary zinc supplies 44% and zinc from domestic old scrap 21–22%. Zinc is neither a strategic nor a critical raw material under the Critical Raw Materials Act (CRMA); germanium and gallium, recovered from zinc circuits, are. Concentrate imports come mainly from Peru (22%; HHI 1,281), unwrought zinc imports from Norway (45%). The EU was a net exporter of unwrought zinc in 9 of the 11 years 2015–2025 (554 kt exported against 224 kt imported in 2024). It exported 54.3 kt of zinc waste and scrap (CN 7902, gross weight) and imported 14.0 kt; 54% of exports went to India. Concentrate from EU mines and net imports covers 84% of the primary output of smelters; if the 263 kt not covered were secondary feed of smelters, primary smelting would correspond to 61% of first use, secondary zinc to 55.8%, and the net emissions potentially avoided would be 276 kt.
- **Outlook.** In the high-circularity scenario for 2035 secondary zinc rises to 1,168 kt and direct value added to EUR 4.8 billion; the additional secondary feed exceeds the growth of domestic old scrap (dynamic model) and new scrap by about 196 kt of zinc. With first use following the activity of its users and net trade in unwrought zinc as the closing item, net exports of unwrought zinc reach 475 kt in 2035; in the low scenario for 2030 the EU becomes a net importer (32 kt).

TABLE 1 Headline results: central estimate and 90% parameter-uncertainty band

Indicator (2024)	Status	Central	P5	P50	P95	Unit
Direct GVA – recycling chain (Z1+Z2)	E	619	476	640	814	EUR m
Direct GVA – zinc smelting (Z3), incl. compensation	E	610	392	607	823	EUR m
Direct GVA – zinc industry (Z0–Z4)	E	2,152	1,879	2,182	2,495	EUR m
Direct GVA – extended value chain (Z0–Z5)	E	4,467	4,083	4,465	4,840	EUR m

Indicator (2024)	Status	Central	P5	P50	P95	Unit
GVA incl. supply chain (Type I)	M	7,991	7,363	7,986	8,608	EUR m
GVA incl. induced (Type II)	M	10,074	9,288	10,063	10,838	EUR m
Direct employment	E	57,400	52,900	57,100	61,000	persons
Jobs incl. supply chain	M	100,500	91,500	100,000	108,700	persons
Jobs incl. induced	M	127,700	116,100	127,200	138,600	persons
Taxes and contributions (attribution, not net balance)	M	2,694	2,455	2,682	2,920	EUR m
GHG potentially avoided – secondary refining and remelting	M	1,110	998	1,277	1,609	kt CO_2e
GHG potentially avoided – Waelz route	M	−344	−471	−345	−242	kt CO_2e
GHG potentially avoided – net, all secondary zinc produced	M	766	606	924	1,306	kt CO_2e
GHG potentially avoided – domestic old scrap only	M	381	296	456	650	kt CO_2e
GHG potentially avoided – substitution 0.5	M	−199	−384	−142	115	kt CO_2e
Flotation tailings potentially avoided	M	7.7	6.0	8.3	11.0	Mt
Secondary zinc (all routes)	E	965	910	1,004	1,114	kt
Zinc stock in use	M	49	43	50	57	Mt
Old scrap recovered from end-of-life products	M	579	512	591	677	kt
End-of-life recycling rate (non-dissipative outflow)	M	38	35	38	42	%
Balance residual of domestic scrap (residual less bottom-up)	M	212	127	233	345	kt
Secondary share of zinc first used	E	43.8	42.1	45.0	48.0	%
Coverage ratio: domestic scrap supply / scrap used	E	106	104	105	107	%

Source: IGMNiR ZN-EU v1.0; Monte Carlo draws with Gaussian copula; “central” is the deterministic run with modal parameter values. P5–P95 describe parameter uncertainty within the model structure; structural alternatives give a wider range (Chapter 9). With the EU-27 symmetric input-output table of Eurostat (2023) instead of FIGARO 2024, GVA including the supply chain differs by 0.4%. Segments Z0–Z5: see Chapter 4. GVA, jobs and taxes are gross contributions; direct GVA is at factor cost from SBS and includes operating subsidies, among them EUR 230 million of compensation of indirect emission costs in Z3; indirect and induced GVA are at basic prices from FIGARO (valuing direct GVA at basic prices changes GVA including the supply chain by 0.7%). Type II effects assume that household spending responds to income at constant propensities without supply constraints. Taxes exclude VAT. Emissions potentially avoided compare secondary zinc produced in the EU with 1:1 substitution of primary zinc at 2.0 t CO_2e per tonne; the perspectives are alternatives and are not additive. Balance residual: residual estimate of domestic scrap supply less the bottom-up estimate. Coverage ratio on the residual basis: 1 plus net exports of zinc in scrap relative to scrap used.

01 Introduction

Zinc protects steel against corrosion. A zinc coating, applied by hot-dip galvanizing of fabricated steel or on continuous lines for steel strip, sacrifices itself before the steel it covers, which makes zinc a material of buildings, bridges, transmission towers, street furniture, agricultural structures and car bodies. Zinc is also the base of die-casting alloys, the second metal of brass, a roofing and cladding material as rolled zinc and, as zinc oxide and other compounds, an input to tyres, ceramics, chemicals, fertilisers and feed. Worldwide, galvanizing accounts for about 60% of zinc first use, zinc alloys for 15%, compounds for 11%, brass and bronze for 9% and semi-manufactures for 4% (Natural Resources Canada 2026); in Europe galvanizing accounts for 52% and die-casting for 17%, and construction and infrastructure take 66% of zinc by end sector, transport and machinery 28% and consumer goods 5% (European Commission 2020).

The European Union mines, smelts, recycles and uses zinc. In 2024 mines in Sweden, Portugal, Spain, Finland, Greece, Bulgaria and Ireland produced 527 kt of zinc in concentrate, 4.4% of world output, and ten smelters in Spain, Belgium, Finland, the Netherlands, France, Poland, Italy, Bulgaria and Germany produced between about 1,800 kt (implied by data of the International Lead and Zinc Study Group, ILZSG) and 1,989 kt (Idoine et al. 2026) of refined zinc, about 14% of world output (ZN-EU central value 1,800 kt). Waelz kilns recover zinc from the dust of electric-arc steelworks, and brass mills, zinc rolling mills and alloy producers remelt zinc scrap. Zinc is neither a strategic nor a critical raw material under the Critical Raw Materials Act (CRMA); the EU's import reliance for zinc is 56% at the extraction stage and zero at the processing stage (European Commission 2023).

This report treats the EU-27 as one economy. Zinc that moves between Member States – concentrate from Sweden or Ireland smelted in Finland or Belgium, Waelz oxide from Germany or Spain fed to smelters in other Member States, zinc slab rolled or alloyed in another country, scrap collected in one Member State and remelted in another – is a domestic flow; only trade with countries outside the EU is foreign trade. ZN-EU applies to zinc in the Union as a whole the integrated model used by IGMNiR for zinc in Poland and for copper and aluminium in the EU-27 (IGMNiR 2026a; 2026b; 2026c); because segments, data and counterfactuals are metal-specific, its results are not additive with those of the other reports.

1.1 Questions addressed

01 How large is the zinc industry in the EU – in output, value added and jobs – and how is it organised along the value chain?

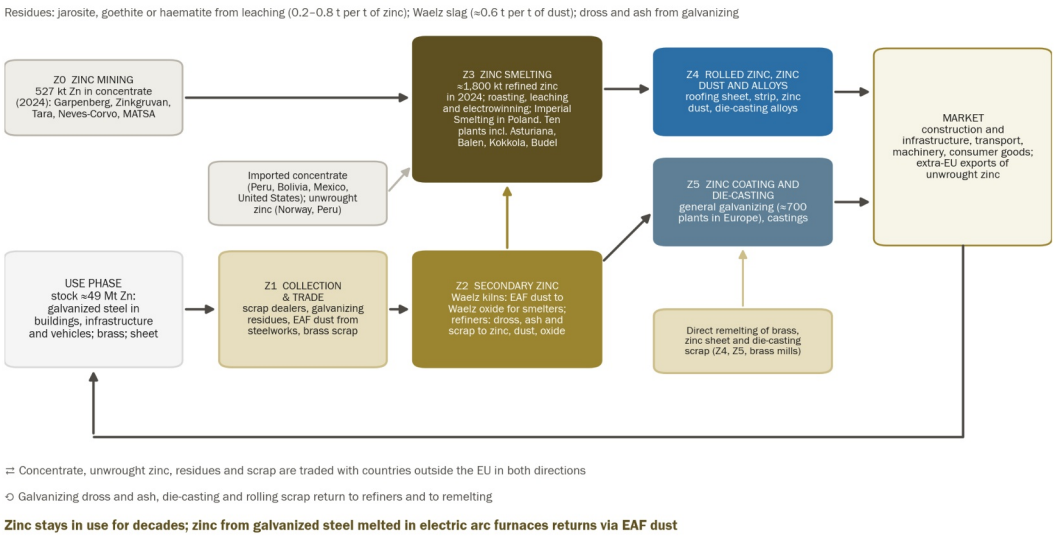
02 How much value added, employment and tax revenue does it support in the EU supply chain and through household spending?

03 How much zinc is in use in the EU, how much of it returns from end-of-life products, and how does this compare with the zinc recycled and traded?

04 Which emissions and other burdens does secondary zinc produced in the EU potentially avoid compared with primary zinc, and on which assumptions does the result depend?

05 How dependent is the EU on imported concentrates and unwrought zinc, how exposed are its smelters to energy prices and treatment charges, and how might this change to 2035?

FIGURE 2 The zinc value chain in the EU-27 and the six segments of the ZN-EU model



Source: IGMNiR; Idoine et al. (2026); company reports; EGGA (2024); Remus et al. (2013); European Commission (2017, BREF Non-Ferrous Metals).

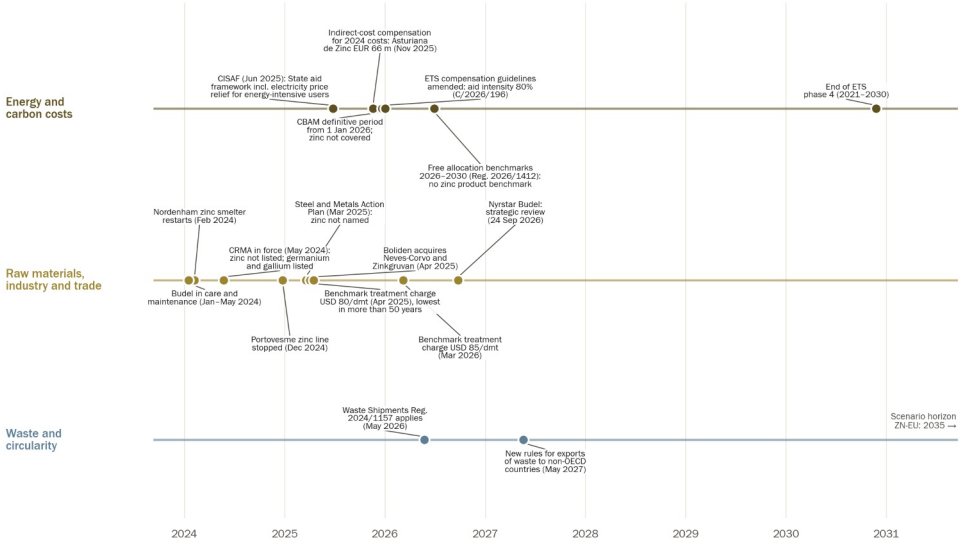
1.2 Structure of the report

Chapter 2 summarises the policy context, Chapter 3 describes the industry and its trade. Chapter 4 presents the model, Chapters 5 to 8 its economic, material-flow, environmental and strategic results, Chapter 9 uncertainty, checks and limitations, and Chapter 10 scenarios to 2035. The final chapter summarises the results. Annexes document data, parameters, installations and terms.

02 Policy and regulatory context

Zinc is affected by EU policy on raw materials, waste and scrap, emissions trading and carbon border adjustment, energy and State aid, and by conditions on the world market for concentrates. The figure lists the main milestones; the sections below summarise their content as of 10 November 2026.

FIGURE 3 Regulatory milestones for the zinc value chain in the EU, 2024–2027



Source: Regulation (EU) 2024/1252; COM(2025) 125; Communication C/2025/3602 (CISAF); Communication C/2026/196; Regulation (EU) 2023/956 (CBAM); Commission Implementing Regulation (EU) 2026/1412; Resolución de 25 de noviembre de 2025 (Spain); Regulation (EU) 2024/1157; Directive 2003/87/EC; Glencore, Nyrstar and Boliden reports and press releases; treatment-charge benchmarks reported by Bloomberg (2025) and SMM (2026). Status 10 November 2026.

2.1 Raw materials and industrial policy

Regulation (EU) 2024/1252 (Critical Raw Materials Act, CRMA) does not list zinc as a strategic raw material (Annex I) or as a critical raw material (Annex II). Germanium and gallium, which are recovered from zinc-processing circuits, are listed. The 2023 criticality assessment gives zinc a supply risk of 0.2 and an economic importance of 4.8, an import reliance of 56% at the extraction stage and of zero at the processing stage, and an end-of-life recycling input rate of 34% (European Commission 2023). The European Steel and Metals Action Plan of 19 March 2025 (COM(2025) 125) names aluminium, copper and nickel as the non-ferrous base metals it covers and does not name zinc (European Commission 2025b). A study for Eurometaux expects European zinc demand of 2.8 Mt in 2050, the same as in 2020, with uses linked to the energy transition adding about 11% (Gregoir and Van Acker 2022).

2.2 Scrap, waste and trade policy

Customs surveillance of exports and imports of ferrous, aluminium and copper scrap has applied since 23 July 2025 (European Commission 2025f); zinc waste and scrap (CN 7902) is not among the products named. Under the Waste Shipment Regulation (EU) 2024/1157, exports of non-hazardous waste to countries outside the OECD will from May 2027 be allowed only to countries on a list adopted by the Commission, and shipments of hazardous waste, such as dust from electric-arc steelworks, require prior written notification and consent. Zinc contained in brass scrap is traded as copper scrap (CN 7404 00 91): in 2024 the EU exported 242.3 kt of brass

scrap (gross weight) to countries outside the EU and imported 66.2 kt. No zinc-specific import measure applies; imports of unwrought zinc from Russia were 454 t in 2023 and none in 2024 (Eurostat Comext).

2.3 Emissions trading, carbon border adjustment and compensation

Zinc smelters and stand-alone Waelz plants are covered by the EU Emissions Trading System as installations for the production or processing of non-ferrous metals (Directive 2003/87/EC, Annex I); the Union Registry records most of them under activity 28 (non-ferrous metals), Boliden Kokkola under activity 23 (metal ore roasting or sintering). Some smelters operate Waelz kilns within the smelter installation (ZGH Bolesław). Lead, zinc and tin production (NACE 24.43) is on the EU list of sectors exposed to a risk of carbon leakage for 2021–2030 (Commission Delegated Decision (EU) 2019/708). There is no product benchmark for zinc in the benchmark regulations for 2021–2025 (Regulation (EU) 2021/447) and 2026–2030 (Implementing Regulation (EU) 2026/1412); free allocation to zinc installations follows the fallback approaches for heat, fuel and process emissions. Verified emissions of the ten zinc smelters – including lead production at Portovesme and Plovdiv and the Imperial Smelting furnace at Miasteczko Śląskie, the only one in the EU – were 1,036.8 kt CO_2e in 2024 (970.0 kt in 2023), 0.52 t per tonne of refined zinc; the six electrolytic smelters without lead or Imperial Smelting lines emitted 90.0 kt, 0.05 t per tonne of their output (both intensities on refined output in the national statistics, Idoine et al. 2026; on the model basis – refined output of 1,800 kt and Balen at its capacity of 285 kt, see Section 3.2 – the intensities are 0.58 and 0.06 t). The six electrolytic smelters received 299.2 kt of free allowances in 2024; the difference to their emissions (209.2 kt) is worth about EUR 13.5 million at the average 2024 auction price of EUR 64.74. The seven stand-alone Waelz plants emitted 409.3 kt (407.9 kt in 2023) (European Commission 2026c). The emissions of each installation are listed in Annex C.

Compensation of indirect emission costs is governed by the Guidelines on State aid in the context of the ETS (2020/C 317/04). Lead, zinc and tin production (NACE 24.43) is eligible, and the electricity consumption efficiency benchmark for zinc electrolysis is 3.994 MWh per tonne of zinc (2021/C 528/01). In 2024 fifteen Member States paid about EUR 5.52 billion for costs incurred in 2023 to all eligible sectors (European Commission 2025d). Amounts per company are published only in some Member States. For costs of 2024 they total EUR 170.2 million for zinc smelters, EUR 30.0 million for NACE 24.43 in Poland (including lead and tin), EUR 1.57 million for producers of zinc semis and dust and EUR 1.51 million for one lead smelter (Chapter 5); the Netherlands publishes only sector totals (EUR 68.3 million to 15 companies in the metals sector for costs of 2024; Rijksdienst voor Ondernemend Nederland 2026), and amounts for Italy and Bulgaria were not found. Compensation is an operating subsidy and is part of value added at factor cost in structural business statistics; ZN-EU includes EUR 230 million (range 200–280 million: the smelters, the zinc part of the Polish amount and the amounts not published) in the value added of zinc smelting, which is EUR 610 million at factor cost and EUR 380 million before compensation. The amounts recorded for smelters are 28% of the value added of smelting at factor cost.

Zinc (Chapter 79) is not covered by the Carbon Border Adjustment Mechanism (Regulation (EU) 2023/956, Annex I). Coated flat-rolled steel (CN 7210), including galvanized sheet, falls under the iron and steel goods of Chapter 72 that are covered; the definitive period began on 1 January 2026.

2.4 Energy and State aid

Electrolytic zinc smelting uses about 4.0–4.4 MWh of electricity per tonne: nine EU roast-leach-electrowin plants used between 3,994 and 4,393 kWh per tonne in 2017–2019, 4,167 kWh on average (Kantamaneni et al. 2021), of which electrolysis about 3.45 MWh (Cusano et al. 2017). ZN-EU uses 4.17 MWh per tonne for electrolytic zinc and 1.5 MWh per tonne for the 75 kt of zinc from the Imperial Smelting furnace, about 7.3 TWh for EU smelters in 2024, at an average cost of EUR 70 per MWh before compensation (range 50–95). Non-household electricity in the EU-27 cost on average EUR 0.123 per kWh in 2024 for consumers of 70–150 GWh and EUR 0.113 per kWh for consumers above 150 GWh, excluding VAT and recoverable taxes (Eurostat 2026b).

The Clean Industrial Deal State Aid Framework (CISAF, C/2025/3602) allows Member States to grant temporary electricity price relief to energy-intensive users, capped at half of the wholesale price on half of consumption and not below EUR 50 per MWh; it does not name zinc. Several smelters and mines stopped or curtailed production in 2023–2026.

TABLE 2 **Stoppages, restarts and changes of ownership of EU zinc smelters and mines, 2023–2026**

Plant	Type	Event	Source
Glencore, Nordenham (DE)	Smelter, ≈165 kt	Restarted in February 2024; ramp-up of output from February 2024	Glencore (2025); Reuters (2024)
Boliden, Tara (IE)	Mine	Care and maintenance from July 2023 to August 2024; production restarted in October 2024	Boliden (2025)
Almina, Aljustrel (PT)	Mine	No zinc output in 2024; zinc recovery resumed in the fourth quarter of 2025	International Lead and Zinc Study Group (2026b)
Nyrstar Budel (NL)	Smelter, 315 kt	Care and maintenance from January 2024, restart announced on 30 April 2024; strategic review launched on 24 September 2026, citing energy costs, low treatment charges and network costs	Nyrstar (2024a; 2024b; 2026)
Glencore, Portovesme (IT)	Smelter	Lead line in care and maintenance; zinc line stopped on 23 December 2024 and still shut in January 2026	Glencore (2025); L'Unione Sarda (2024); Il Sole 24 Ore (2026)
Neves-Corvo (PT) and Zinkgruvan (SE)	Mines	Acquired by Boliden from Lundin Mining in April 2025	Boliden (2026)

Source: company and press reports as named; IGMNiR compilation.

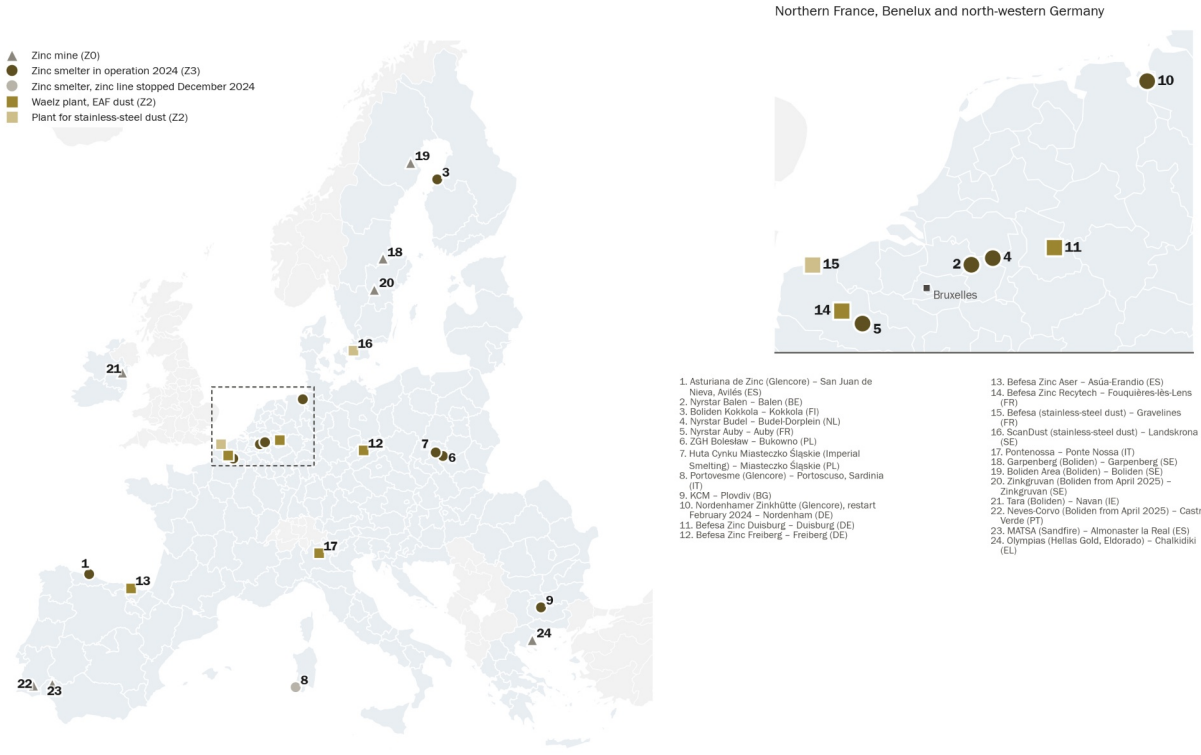
2.5 Treatment charges and the world market

Custom smelters earn mainly the treatment charge paid by miners and the zinc they recover above the payable share of the concentrate (free metal). The annual benchmark treatment charge for zinc concentrate fell from USD 274 per dry tonne in 2023 to USD 165 in 2024 (Fastmarkets 2024) and USD 80 in 2025, the lowest level in more than 50 years according to CRU (Bloomberg 2025), and was set at USD 85 for 2026 (SMM 2026). China imported 2,575 kt of zinc in concentrate in 2025, 29.8% more than in 2024 (International Lead and Zinc Study Group 2026a). Boliden reported that lower treatment charges reduced the result of its smelters (Boliden 2025). The LME zinc price averaged USD 2,776 per tonne in 2024 (World Bank 2025), EUR 2,565 per tonne at the average exchange rate (European Central Bank 2026). In ZN-EU, the gross margin of smelters – treatment charge, free metal and by-products on zinc from concentrate, the margin on zinc from Waelz oxide and the premium – is about EUR 845 per tonne of zinc, against an electricity cost of about EUR 284 per tonne (Chapter 5).

03 The zinc industry in the EU-27

The EU zinc value chain runs from polymetallic mines in Sweden, Portugal, Spain, Finland, Ireland, Greece and Bulgaria, through ten smelters and seven Waelz plants, secondary refiners that turn dross, ash and scrap into zinc, zinc dust and alloys, and producers of rolled zinc and alloys, to general galvanizers, die-casters, brass mills and users in construction, transport and engineering; continuous galvanizing of steel strip takes place in steelworks (NACE 24.10). NACE 24.43 (lead, zinc and tin production) employed 15,136 persons in 2024, NACE 24.54 (casting of other non-ferrous metals) 18,657 and NACE 25.61 (treatment and coating of metals) 290,000 (Eurostat 2026b). The European General Galvanizers Association (EGGA) reports about 700 general galvanizing plants, mostly small and medium-sized enterprises, with about 40,000 employees in Europe (EGGA 2024); Germany accounted for 22% of its members' production in 2024, Italy for 15%, Türkiye for 15%, Poland for 8% and Spain for 7% (Kopf 2025).

FIGURE 4 Zinc mines, smelters and Waelz plants in the EU-27



Source: IGMNiR; Idoine et al. (2026); company reports (Boliden, Glencore, Nyrstar, Befesa, Lundin Mining, Sandfire, Eldorado); EU ETS registry; GISCO boundaries. Locations approximate. Numbers refer to the list on the right.

3.1 Mining

TABLE 3 Zinc mine production in the EU-27 by Member State (kt of zinc in concentrate)

Member State	2023	2024	Mines and notes
Sweden	217.6	239.2	Garpenberg, Boliden Area, Zinkgruvan
Portugal	183.9	109.6	Neves-Corvo, Aljustrel; in 2024 the national total equals the output of Neves-Corvo
Spain	89.2	84.8	MATSA (Sandfire)

Member State	2023	2024	Mines and notes
Finland	58.4	53.8	
Ireland	53.3	6.3	Tara, care and maintenance July 2023 to August 2024
Greece	16.6	14.4	Olympias
Bulgaria	14.2	14.5	
Poland	5.0*	5.5*	
Romania	0.9	4.7	2024 estimate
Slovakia	0.1	0.1	
EU-27	**639.2**	**532.9**	

Source: Idoine et al. (2026), British Geological Survey, World Mineral Production 2020–24; mine names from Boliden (2025), Lundin Mining (2025), Sandfire Resources (2025) and Eldorado Gold (2025). Company figures for 2024: Garpenberg 109 kt, Zinkgruvan 82.1 kt, Neves-Corvo 109.6 kt, MATSA 85.0 kt, Olympias 12.1 kt (payable). * Listed by BGS, not confirmed; not used (Olkusz-Pomorzany closed at the end of 2020). ZN-EU uses 527.4 kt (EU-27 without Poland).

Most EU mines are polymetallic and also produce copper, lead and silver. Mine output fell from 639 kt in 2023 to 533 kt in 2024, mainly because of the stoppage of Tara and the absence of zinc output at Aljustrel; EU mines supplied 4.4% of world output of 12.0 Mt. The EU imported 1,959 kt of zinc ores and concentrates (CN 2608, gross weight) from outside the EU in 2024, mainly from Peru, Bolivia and Mexico (largest partner 22%; HHI 1,281; five largest partners 74%), and exported 270 kt, most of it to the Odda smelter in Norway.

3.2 Smelting

Refined zinc production in the EU-27 is published by the British Geological Survey by country (1,989 kt in 2024; 1,771 kt in 2023). The figure for Belgium rises from 250 kt in 2023 to 480 kt in 2024 and is not reconciled with other sources: European refined output reported by ILZSG (2,117 kt in 2024), less Norway and Russia, implies about 1,800 kt for the EU (International Lead and Zinc Study Group 2026a). PRODCOM records 1,466 kt of unwrought non-alloy zinc and 741 kt of zinc alloys (gross weight). Boliden Kokkola produced 302 kt in 2024 (Boliden 2025). Glencore's European custom zinc operations, which include Asturiana, Nordenham and Portovesme as well as plants outside the EU, produced 874.5 kt in 2024 against 752.6 kt in 2023; the company attributes the increase to the restart of Nordenham (Glencore 2025). The national figure for Germany is 55.2 kt (Idoine et al. 2026); the capacity of Nordenham is about 165 kt of zinc and zinc alloys (Reuters 2024). The capacity of Balen is about 285 kt a year (SMM 2022), and cathodes produced at Balen and Auby are remelted and cast in Pelt (Nyrstar 2020); the Belgian figure may therefore include zinc smelted in France. With Balen at its capacity the national sum would be 1,794 kt. EU smelters produced 2,098 kt of zinc in 12 plants in 2010, and in 2016 EU production comprised 1,699 kt of primary and 296 kt of secondary zinc (Wyns and Khandekar 2019). ZN-EU uses 1,800 kt with a range of 1,720–1,860 kt.

TABLE 4 Refined zinc production in the EU-27 by smelter, 2024 (kt)

Smelter	kt	Grade	Source
Asturiana de Zinc, San Juan de Nieva (ES)	515.0	A	Idoine et al. (2026), Spain
Nyrstar Balen (BE)	480.2	C	Idoine et al. (2026), Belgium; 2023: 250.1
Boliden Kokkola (FI)	302.2	A	Boliden (2025); Idoine et al. (2026), Finland
Nyrstar Budel (NL)	155.2	B	Idoine et al. (2026), Netherlands, estimate
Nyrstar Auby (FR)	149.8	A	Idoine et al. (2026), France
ZGH Bolesław; HC Miasteczko Śląskie (PL)	132.8	A	Idoine et al. (2026), Poland; company reports 153.8
Glencore Portovesme (IT)	127.0	A	Idoine et al. (2026), Italy
KCM Plovdiv (BG)	69.7	A	Idoine et al. (2026), Bulgaria
Glencore Nordenham (DE)	55.2	A	Idoine et al. (2026), Germany; restart February 2024
Romania	2.1	A	Idoine et al. (2026), Romania

Smelter	kt	Grade	Source
Total (British Geological Survey)	**1,989.2**		

Source: Idoine et al. (2026), British Geological Survey, national totals, assigned to the smelters of each Member State; Boliden (2025); IGMNiR compilation. The model uses 1,800 kt (range 1,720–1,860 kt). Grades: A official statistics or company reports, B estimate of the statistical source, C not reconciled with other sources.

Zinc in EU mine output (527 kt) and in net extra-EU imports of concentrate (873 kt at 51.7% zinc) corresponds, at a smelter recovery of 96.5%, to about 1,350 kt of zinc, 84% of the primary output of EU smelters (1,620 kt: refined output less zinc from Waelz oxide). For 2023 the same account – 634.2 kt from mines and 1,300.1 kt of net concentrate imports (gross weight) against refined output of 1,770 kt, with the same zinc from Waelz oxide – gives 79%. A lower zinc content of concentrates would widen the gap, and the gap persists in both years. The published data do not show which of the following explains it: secondary feed of smelters other than Waelz oxide, confidentiality of trade data at the level of CN codes in Comext, or the national production statistics.

TABLE 5 Concentrate account: central case and a variant in which the zinc not covered by concentrate is secondary feed of smelters, 2024

Indicator	Central	Variant
Zinc from Waelz oxide and other secondary feed of smelters, kt	185	448
Primary zinc of smelters, kt	1,615	1,352
Secondary zinc, all routes, kt	965	1,228
Secondary share of zinc first used, %	43.8	55.8
Primary smelting relative to zinc first used, %	73	61
Value added of zinc smelting (Z3), EUR m	610	671
Emissions potentially avoided, net, kt CO_2e	766	276
– of which Waelz route and other secondary feed of smelters	−344	−834
Scrap balance: residual supply less bottom-up supply, kt	212	498

Source: IGMNiR ZN-EU v1.0. In the variant the 263 kt of smelter output not covered by concentrate is treated as secondary feed bought at the price of Waelz oxide and with the footprint of the Waelz route; the published data do not show whether this is the case. The variant closes the concentrate account but widens the residual of the scrap balance from 212 to 498 kt (20% and 38% of the secondary feed), so it is not an upper estimate of recycling. The value added of smelters is higher in the variant only because secondary feed is valued below concentrate at unchanged conversion costs. A lower smelter output would reduce the concentrate gap without adding secondary feed.

3.3 Secondary zinc

Secondary zinc in the EU is produced by three routes, none of which is reported separately by statistics. First, Waelz kilns – in stand-alone plants and within some smelters – recover zinc from the dust of electric-arc steelworks as Waelz oxide, which is leached and electrolysed in zinc smelters. EU electric-arc steelworks produced 57.8 Mt of crude steel in 2024, 44.6% of EU output (EUROFER 2025); at 10–30 kg of dust per tonne of liquid steel (Remus et al. 2013) this corresponds to 580–1,730 kt of dust, which contains 21–43% zinc for carbon and low-alloy steel. Befesa operates Waelz plants in Duisburg and Freiberg (DE), Asúa-Erandio (ES) and Fouquières-lès-Lens (FR) and plants for stainless-steel dust in Gravelines (FR) and Landskrona (SE); the group treated 1,211 kt of dust in 2024, including plants outside the EU, and sold 401 kt of Waelz oxide (Befesa 2025). Pontenossa (IT) also operates a Waelz kiln. Second, secondary refiners distil and remelt galvanizing dross, ash, die-casting scrap and other residues into zinc, zinc alloys, zinc dust and zinc oxide. Third, brass mills, zinc rolling mills and alloy producers remelt scrap directly. The table lists the values used in ZN-EU.

TABLE 6 Secondary zinc produced in the EU-27 by route, 2024 (kt of zinc)

Route	Central	Range	Basis
Zinc from Waelz oxide and other secondary oxides recovered in EU smelters	185	140–240	EAF steel × dust rate × zinc content (EUROFER 2025; Remus et al. 2013)
Zinc, zinc alloys, dust and oxide from secondary refiners	230	150–320	secondary refining in Europe incl. UK, Norway, Switzerland ≈430 kt incl. Waelz oxide (Rostek and Loibl 2025)

Route	Central	Range	Basis
Zinc in scrap remelted directly (brass, rolled zinc, alloys)	550	450–750	≈700 kt recycled without passing through smelters, to be compared with secondary refining and remelting together (European Commission 2020); direct reuse 1.0 Mt in Europe incl. UK, Norway, Switzerland, ≈0.88 Mt scaled to the EU (Rostek and Loibl 2025)
Secondary zinc, total	**965**		44% of zinc first used

Source: IGMNiR ZN-EU v1.0; sources as named. Zinc from Waelz oxide is part of the refined output of smelters (1,800 kt). In the central run the Waelz route treats about 840 kt of dust at 24% zinc and a zinc recovery of 92%.

3.4 Rolled zinc, dust, alloys, coating and castings

TABLE 7 Production of zinc products, galvanizing services and non-ferrous castings in the EU-27 (PRODCOM)

PRODCOM	Product	2023, kt	2024, kt	2024, EUR m
24431230	Unwrought non-alloy zinc	1,589.3	1,466.0	2,531
24431250	Unwrought zinc alloys	828.2	741.0	1,447
24432200	Zinc dust, powders and flakes	244.9	268.4	395
24432300	Zinc bars, rods, profiles, wire, plates, sheets, strip and foil	180.0	180.0	900
20121130	Zinc oxide and peroxide	377.4	398.3	583
24541010	Non-ferrous castings (not light metals) for land vehicles	152.0	150.0	700
24541050	Non-ferrous castings (not light metals) for machinery	128.0	116.3	994
24541090	Non-ferrous castings (not light metals) for other uses	132.1	132.0	1,240
25611130	Hot-dip coating with molten metal (zinc galvanizing or tin dipping)	–	–	3,138
25611170	Electrolytic zinc coating	–	–	1,500

Source: Eurostat PRODCOM (DS-059358), EU27_2020, production quantity (gross weight) and value of sold production. Many EU totals are rounded estimates of Eurostat; galvanizing services are recorded by value only. The unit value of unwrought non-alloy zinc (EUR 1,727 per tonne) is below the LME price (EUR 2,565 per tonne); the published data do not explain the difference. Codes 24541020 and 24541040 (EUR 148 million) are not shown.

Zinc products accounted for EUR 5,270 million, 59%, of the PRODCOM value of all products of NACE 24.43 in 2024 (lead products EUR 3,138 million, tin products EUR 564 million); in ZN-EU the zinc segments Z2–Z4 account for 69% of the value added of the class, and the remainder attributable to lead and tin is about EUR 104 thousand of value added per person employed against the class average of EUR 117 thousand. Hot-dip galvanizing and electrolytic zinc coating together recorded EUR 4,640 million, 11.3% of the output of NACE 25.61. Producers of rolled zinc include titanium-zinc sheet for roofing and cladding; zinc dust is used in anticorrosive paints and in the purification of zinc electrolyte.

3.5 Official statistics

TABLE 8 Structural business statistics for the activities of the zinc value chain, EU-27, 2024

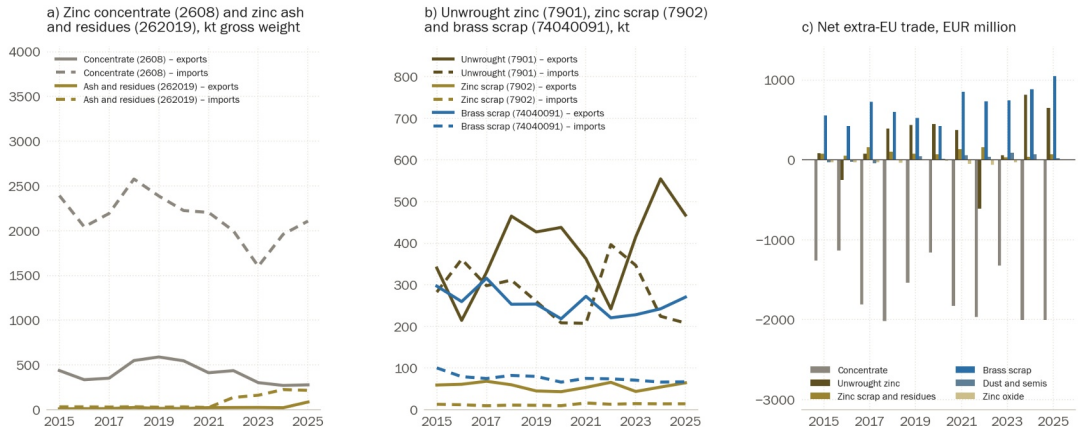
NACE	Activity	Turnover, EUR m	Output, EUR m	Value added, EUR m	Persons employed	Personnel costs, EUR m
B 07.29	Mining of other non-ferrous ores	12,686	11,740	6,586	43,634*	2,123*
G 46.77	Wholesale of waste and scrap	68,196	16,023	7,688	120,000	3,737
E 38.3	Materials recovery	90,000	80,000	18,000	273,002	10,668*
C 24.43	Lead, zinc and tin production	8,836	7,858	1,771	15,136	890
C 24.54	Casting of other non-ferrous metals	4,287	4,151	1,221	18,657	837
C 25.61	Treatment and coating of metals	43,000	41,000	16,700	290,000	11,700

Source: Eurostat SBS (sbs_ovw_act), EU27_2020; Eurostat rounds EU aggregates and suppresses confidential cells. * Estimate by IGMNiR (status E): B0729 EMP_NR: personnel costs / personnel cost per person in mining (NACE B); B0729 EXPN_SAL_BEN_MEUR: value added x personnel-cost share of 2022; E383 EXPN_SAL_BEN_MEUR: sum of reporting member states, scaled by EU employment / employment of the reporting member states.

Several EU aggregates are rounded by Eurostat (for example 25.61 employment 290,000 and output EUR 41,000 million, 46.77 employment 120,000). NACE 24.43 recorded value added of EUR 1,770 million on output of EUR 7,860 million; the class also covers lead and tin.

3.6 Trade with countries outside the EU

FIGURE 5 Extra-EU trade in zinc by stage of processing, 2015–2025



Source: Eurostat Comext DS-045409, EU-27 extra-EU trade (gross weight; brass scrap CN 7404 00 91 contains copper and zinc); IGMNiR ZN-EU. Zinc scrap and residues = CN 7902, 2620 11 and 2620 19; dust and semis = CN 7903–7907.

TABLE 9 Extra-EU trade in zinc by product, 2024

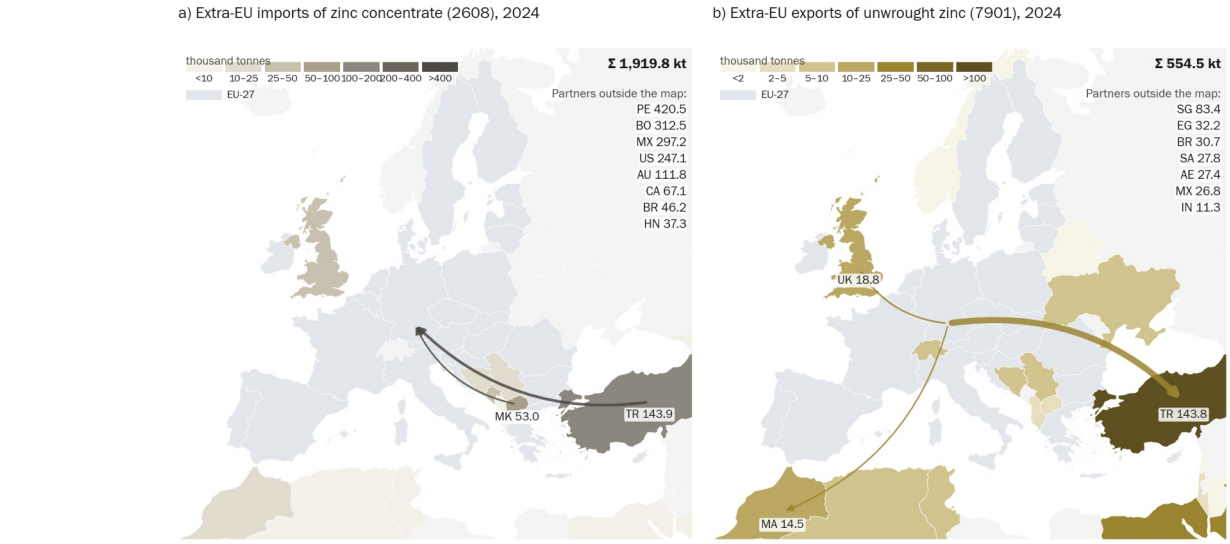
CN	Product	Imports, kt	Exports, kt	Imports, EUR m	Exports, EUR m	Balance, EUR m
2608	Zinc ores and concentrates	1,959.4	270.4	2,215	214	−2,001
262011	Hard zinc spelter	20.9	39.4	40	67	27
262019	Ash and residues containing mainly zinc	224.2	21.4	108	23	−85
2817	Zinc oxide and peroxide	53.1	52.2	116	108	−8
7901	Unwrought zinc	224.4	554.5	617	1,429	812
790111	– of which ≥ 99.99% zinc	104.9	420.3	290	1,070	780
790112	– of which < 99.99% zinc	79.3	44.0	211	116	−95
790120	– of which zinc alloys	40.1	90.2	117	244	127
7902	Zinc waste and scrap	14.0	54.3	25	122	97
7903	Zinc dust, powders and flakes	10.9	66.1	38	132	93
7904	Zinc bars, rods, profiles and wire	2.3	1.3	10	5	−5
7905	Zinc plates, sheets, strip and foil	7.5	9.6	27	50	23
7907	Other articles of zinc	18.6	11.3	200	157	−43
74040091	Brass scrap (copper-zinc alloys)	66.2	242.3	344	1,231	887

Source: Eurostat Comext (DS-045409), reporter EU27_2020, partner extra-EU; gross weight; intra-EU trade is not shown. Unit values: concentrate imports EUR 1,131/t; unwrought zinc imports EUR 2,751/t and exports EUR 2,578/t; zinc scrap imports EUR 1,789/t and exports EUR 2,241/t; ash and residues imports EUR 481/t; LME zinc EUR 2,565/t in 2024 (World Bank 2025; European Central Bank 2026). Brass scrap is classified as copper scrap and is shown for its zinc content.

The EU is a large net importer of zinc concentrate (EUR 2,000 million in 2024) and a net exporter of unwrought zinc (EUR 810 million). It exported more unwrought zinc than it imported in 9 of the 11 years 2015–2025; net imports occurred in 2016 and 2022. In 2024 exports were 554 kt, mainly to Türkiye, Singapore and Egypt (largest partner 26%), and imports 224 kt, mainly from Norway, Peru and Mexico (largest partner 45%; HHI 3,212); Norway belongs to the European Economic Area. Imports of zinc ash and residues (CN 2620 19) rose

from 207.4 kt in 2021 to 224.2 kt in 2024, mainly from Türkiye (44%). The EU exported 54.3 kt of zinc waste and scrap (CN 7902) in 2024 and imported 14.0 kt; 54% of exports went to India. Counting zinc in scrap, hard zinc, ash and brass scrap, net exports of zinc in scrap and residues were about 63 kt. The EU also exported, net, 10.9 Mt of ferrous scrap (CN 7204), part of which carries zinc coatings.

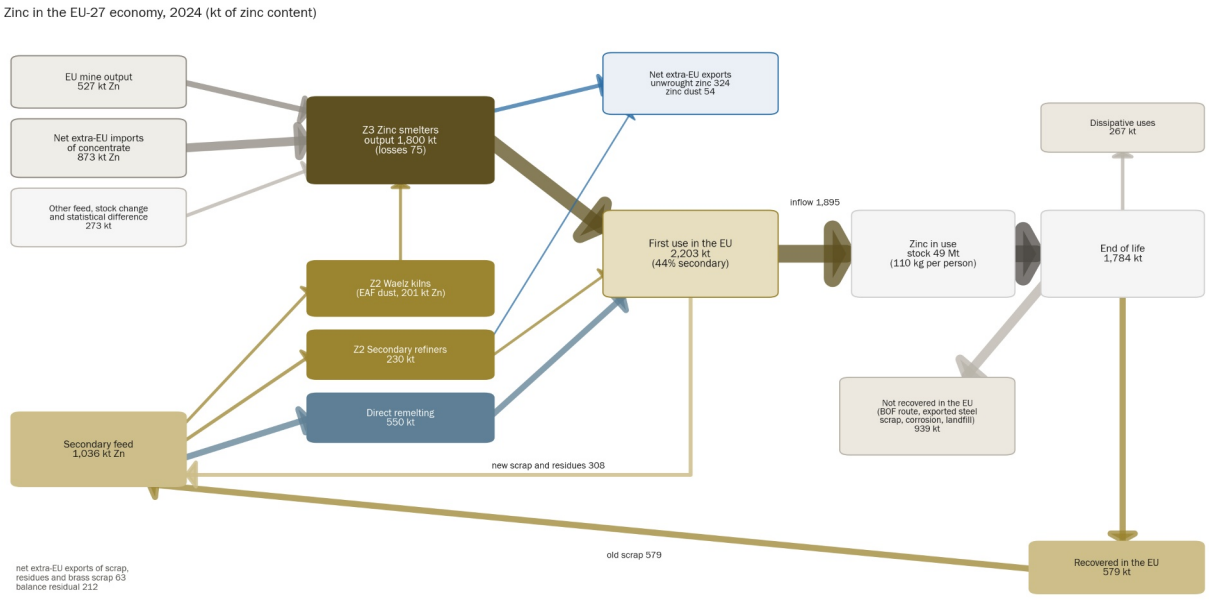
FIGURE 6 **Extra-EU partners in zinc trade, 2024**



Source: Eurostat Comext (DS-045409), CN 2608 and 7901, EU-27 extra-EU trade, gross weight; GISCO boundaries; IGMNiR ZN-EU. EU-27 shown in light grey-blue; partners outside the map are listed at the right.

3.7 Zinc balance

FIGURE 7 **Zinc flows through the EU-27 economy, 2024 (kt of zinc)**



Source: IGMNiR ZN-EU v1.0 (modules M2 and M2b); Idoine et al. (2026); Eurostat Comext and PRODCOM 2024; European Commission (2020); Rostek (2025); Rostek and Loibl (2025). Arrow widths proportional to flows; concentrate zinc content 51.7%, smelter recovery 96.5%. "Other feed, stock change and statistical difference" closes the smelter account and is not interpreted. Model estimates.

TABLE 10 Zinc flows by node, EU-27, 2024 (kt of zinc)

Node and flow	kt	Status
1. Smelting and refining		
Primary zinc produced by smelters	1,615.0	E
Zinc from Waelz oxide	185.0	E
Refined zinc produced by smelters	1,800.0	O/E
Net extra-EU imports of unwrought zinc (CN 7901)	−323.5	O
Apparent use of unwrought zinc	1,476.5	E
Zinc from secondary refiners	230.0	E
less: net extra-EU exports of zinc dust (CN 7903)	−53.6	O
2. First use		
Zinc in scrap remelted directly	550.0	E
Zinc first used	2,202.9	E
3. Scrap and residues		
Zinc in secondary feed (all routes)	1,035.6	E
Net extra-EU imports of zinc in scrap, hard zinc, ash and brass scrap	−63.1	O/E
Domestic supply of scrap and residues, residual	1,098.7	E
Old scrap recovered (dynamic model)	578.7	M
New scrap and residues (14% of zinc first used)	308.4	E
Domestic supply of scrap and residues, bottom-up	887.1	M
Balance residual (residual less bottom-up)	**211.6**	M
4. Zinc in use		
Inflow to use	1,894.5	M
End-of-life outflow	1,783.8	M
– of which dissipative uses	266.6	M
Stock in use, Mt	49.5	M

Source: IGMNiR ZN-EU v1.0, modules M2 and M2b. Status: O observation, E estimate, M model result. Zinc recovery 92% on the Waelz route, 90% in secondary refining and 95% in remelting; zinc content of traded scrap 95%, hard zinc 94%, ash and residues 25%, brass scrap 33%; unwrought zinc 98%.

The residual estimate of the domestic supply of zinc-bearing scrap and residues exceeds the bottom-up estimate by 212 kt, 20% of the secondary feed (90% band 127 to 345 kt). The residual is not allocated. The bottom-up estimate is bounded mainly by galvanized steel: of about 890 kt of zinc in galvanized steel reaching the end of life, about 140 kt is recovered in the EU, because the zinc of galvanized steel is recovered only from the dust of electric-arc furnaces (about 200 kt of zinc in dust processed, including new galvanized scrap); zinc in steel melted in basic oxygen furnaces, in exported ferrous scrap (10.9 Mt net in 2024) and lost by corrosion in use is not recovered. The residual estimate rests on the three routes of secondary zinc, which are themselves estimates. With a rate of new scrap and residues of 18% instead of 14%, new scrap would be about 400 kt instead of 310 kt and the residual 150 kt. The data used do not discriminate between these explanations. The table shows how far the residual moves across the parameter ranges.

TABLE 11 Reconciliation of the scrap balance residual: change by parameter (kt)

Parameter	Range	At low value	At high value
zinc remelted directly	450–750	−65.0	130.0
end-of-life recovery rates	0.85–1.15	65.5	−60.6
the rate of new scrap and residues	0.10–0.18	61.2	−61.2
zinc from secondary refiners	150–320	−56.7	63.8
zinc from Waelz oxide	140–240	−48.9	59.8
net imports of zinc in finished products	−150–150	45.8	−45.8

Parameter	Range	At low value	At high value
zinc recovered from galvanized steel	0.12–0.22	35.6	−53.3
the past per-capita inflow	1.00–1.20	36.1	−36.1

Source: IGMNiR ZN-EU v1.0; one parameter at a time, other parameters central (central residual 211.6 kt). Not covered by parameters: zinc exported in coated ferrous scrap, used vehicles and goods, zinc-bearing dusts traded under codes outside CN 2620 and 7902, and stock changes at traders.

TABLE 12 ZN-EU and published zinc flow studies for Europe

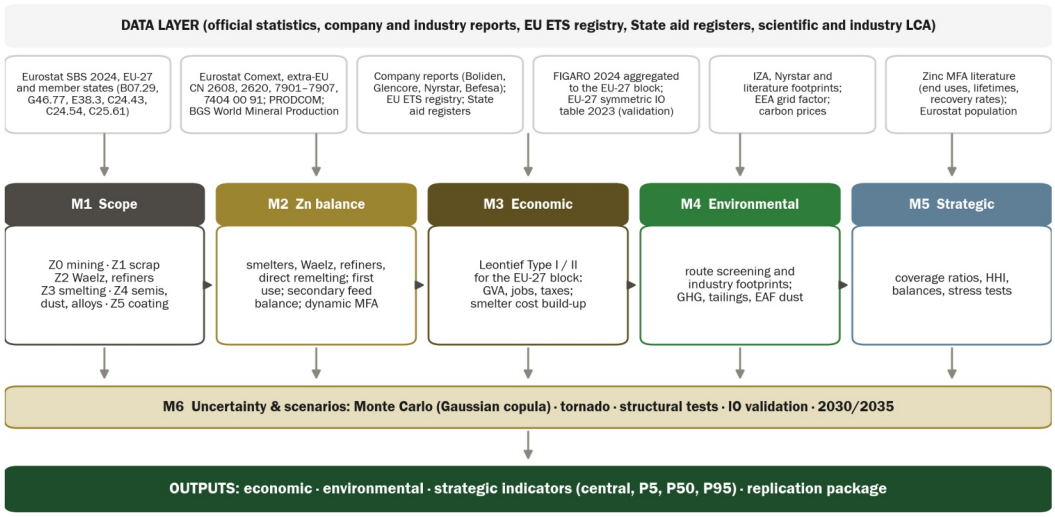
Indicator	ZN-EU	Published value	Source
Stock in use, 2020, kg per person	109 (96–126)	≈130 (69.9 Mt; EU-27, UK, Norway, Switzerland)	Rostek and Loibl (2025)
End-of-life recycling rate, %	38 (35–42)	53 (49–58); Europe 2020	Rostek and Loibl (2025)
Secondary share of zinc first used (recycling input rate), %	43.8	49 (46–51); Europe 2020	Rostek and Loibl (2025)
Old scrap in secondary zinc (old-scrap ratio), %	50	70; Europe 2020	Rostek and Loibl (2025)
Old scrap in zinc first used (EoL-RIR), %	21–22	34 (EU)	European Commission (2023)
Zinc recycled without passing through smelters, kt	780	≈700 (EU); 1,000 direct reuse (Europe incl. UK, Norway, Switzerland), ≈880 scaled to the EU	European Commission (2020); Rostek and Loibl (2025)
Zinc first used, kt	2,200	2,800 (Europe, 2020)	Gregoir and Van Acker (2022)
Net addition to stock, % of inflow to use	6	≈67 (world, c. 1994)	Graedel et al. (2005)
Share of discarded zinc recovered, %	32	41 (world, 1994); ≈40 (world, c. 1994)	Gordon et al. (2004); Graedel et al. (2005)
Use of unwrought zinc, kt	1,480	1,912 (Europe, refined zinc usage, 2024)	International Lead and Zinc Study Group (2026a)

Source: IGMNiR ZN-EU v1.0 (90% band in brackets) and the studies named. The published values refer partly to a wider Europe (with the United Kingdom, Norway and Switzerland, or with Türkiye and other non-EU countries) and to other years; definitions of first use and recycling input differ between studies. ZN-EU is compared with, not calibrated to, Rostek and Loibl (2025). Its dynamic model uses five product groups (galvanized steel, brass and bronze, die-castings, rolled zinc, dissipative uses) with lifetimes based on Rostek (2025, Tables 9 and 14) and bounds the recovery of zinc from galvanized steel by the zinc in dust of electric-arc furnaces processed in the EU; this explains most of the lower end-of-life recycling rate and old-scrap ratio. The volumes of secondary refining and direct remelting draw on the same studies, so agreement there is not independent.

04 The ZN-EU model

ZN-EU combines six modules: allocation of structural business statistics to the zinc value chain (M1), a mass balance of zinc with a scrap balance (M2) and a dynamic model of zinc in use (M2b), an input-output model of the EU-27 economy (M3), screening values of emissions and other burdens (M4), strategic indicators (M5), and Monte Carlo simulation, structural tests and scenarios (M6). The same physical volumes feed the economic, environmental and strategic results. The EU-27 is treated as one economy: deliveries between Member States are domestic, trade with countries outside the EU is foreign trade.

FIGURE 8 Architecture of the ZN-EU model



Source: IGMNiR.

4.1 Scope and segments

All six segments are built from Eurostat structural business statistics (SBS) for the EU-27 in 2024. **Z0** is the zinc share (8.5%) of NACE 07.29 (mining of other non-ferrous metal ores). **Z1** is the zinc share of wholesale of waste and scrap (NACE 46.77; 2.0% of value, 1.5% of employment) and of materials recovery (NACE 38.3; 1.2% and 1.0%). NACE 24.43 (lead, zinc and tin production) contains three zinc segments and a lead and tin remainder. **Z2** (Waelz kilns treating dust from electric arc furnaces, and secondary refiners of dross, ash and scrap) and **Z3** (zinc smelters: electrolytic plants and the Imperial Smelting furnace at Miasteczko Śląskie) take their employment from 24.43 by employment keys (12% and 33%) at the personnel cost per person of 24.43; their output is the gross metal value of their products at the LME price, and their value added follows from a cost structure (Z2) and a cost build-up (Z3). **Z4** (rolled zinc, zinc dust and zinc alloys made outside the smelters; 20% of 24.43 employment) has the PRODCOM value of these products as output and a value-added ratio of 18% (range 13–25%), below the 24.43 average. **Z5** combines the zinc-coating share (11.3%) of NACE 25.61 (treatment and coating of metals) with the zinc share (35%) of NACE 24.54 (casting of other non-ferrous metals). The recycling chain is Z1+Z2, the zinc industry Z0–Z4 and the extended value chain Z0–Z5. Segments are synthetic: they are built from statistics, not from lists of companies.

TABLE 13 Segments of the ZN-EU model, 2024 (central estimate)

Segment	Basis	Output, EUR m	GVA, EUR m	Persons	GVA per person, EUR k
Z0 Zinc mining	SBS 07.29 × zn_mine	998	560	3,710	150.9
Z1 Collection and trade of zinc scrap and residues	SBS 46.77, 38.3 × zinc shares	1,280	370	4,530	81.6
Z2 Secondary zinc (Waelz kilns, secondary refiners)	24.43 × ref_share; gross metal value	924	249	1,820	137.3
Z3 Zinc smelting	24.43 × prim_share; cost build-up	5,072	610	4,990	122.2
Z4 Rolled zinc, zinc dust and alloys	24.43 × semis_share; PRODCOM output × g4	2,018	363	3,030	120.0
Z5 Zinc coating and zinc die-casting	SBS 25.61 × zn_coat + 24.54 × zn_cast	6,086	2,315	39,300	58.9

Source: IGMNiR ZN-EU v1.0; Eurostat SBS (sbs_ovw_act) 2024, EU27_2020. GVA at factor cost. Output of Z2 and Z3 is the gross metal value at the LME price; for Z3, output = value added at factor cost + intermediate consumption − compensation (EUR 230 million). Status E (estimate) for all segments. Figures are rounded; totals may differ from the sum of components.

Eurostat publishes EU-27 aggregates of the SBS rounded and with confidential cells. Cells missing for 2024 are completed from the sum of Member States scaled by EU employment or from ratios of earlier years and carry status E (B0729 EMP_NR, B0729 EXPN_SAL_BEN_MEUR, E383 EXPN_SAL_BEN_MEUR); rounded cells – for example the output and employment of NACE 25.61 – are used as published.

Smelters (Z3). A zinc smelter buys concentrate at the LME price less a treatment charge and keeps the zinc it recovers above the payable share (free metal). For the 1,615 kt of zinc from concentrate its margin is the treatment charge (EUR 250/t of zinc; the 2024 benchmark corresponds to about EUR 305/t of zinc at 51.7% zinc in concentrate), free metal (12% of the 2024 LME price of EUR 2,565/t) and by-products such as sulphuric acid, silver-lead residues, cadmium, germanium and indium (EUR 110/t). Zinc from Waelz oxide (185 kt) is bought at 65% of the LME price, the price received by Z2. All output earns a regional premium for special high grade zinc and alloys (6%). Electricity (4.17 MWh/t for electrolytic zinc – the weighted average of nine EU roast-leach-electrowin plants in 2017–2019 was 4,167 kWh/t (Kantamaneni et al. 2021) – and 1.5 MWh/t for the 75 kt of Imperial Smelting zinc; 7.3 TWh in total at EUR 70/MWh) and other costs (reagents, maintenance, services, transport; EUR 350/t) leave value added of EUR 380 million before compensation. Value added at factor cost in the SBS includes operating subsidies; Z3 therefore includes the compensation of indirect emission costs recognised for 2024 (EUR 230 million; Section 5.1), and its value added at factor cost is EUR 610 million, EUR 339 per tonne (90% band EUR 390–820 million). Electricity enters the first round of the input-output model as a purchase of electricity (CPA D35); concentrates and oxides are chain inputs. Value added falls to zero at an electricity price of about EUR 154/MWh with compensation and EUR 122/MWh without it (Table 14).

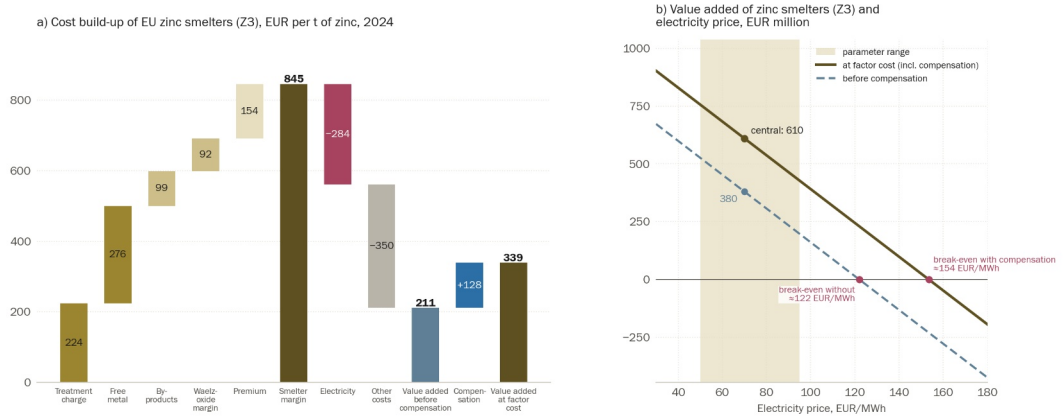
TABLE 14 Cost build-up of EU zinc smelters, 2024 (central estimate)

Item	EUR per t of zinc	EUR m
Margin on zinc from concentrate (1,615 kt): treatment charge, free metal, by-products	599	1,078
Margin on zinc from Waelz oxide (185 kt)	92	166
Premium for special high grade zinc and alloys	154	277
Gross margin of smelting	**845**	**1,522**
Electricity	−284	−511
Other non-chain costs	−350	−630
Value added before compensation	211	380
Compensation of indirect emission costs (operating subsidy)	128	230
Value added at factor cost	**339**	**610**

Item	EUR per t of zinc	EUR m
Break-even electricity price with / without compensation, EUR/MWh	154 / 122	
For reference: gross metal value of output	2,818	5,072

Source: IGMNiR ZN-EU v1.0. Amounts per tonne relate to all 1,800 kt of refined zinc. Annual benchmark treatment charge 2024 USD 165 per dry tonne of concentrate (2023: 274; 2025: 80; Fastmarkets 2024; Bloomberg 2025). Ranges: treatment charge EUR 180–305/t, electricity EUR 50–95/MWh, compensation EUR 195–280 million.

FIGURE 9 **Cost build-up of EU zinc smelters per tonne of zinc and value added against the electricity price, 2024**



Source: IGMNiR ZN-EU v1.0, module M3 (cost build-up); LME 2024 zinc EUR 2,565/t; concentrate zinc (1,615 kt) earns the treatment charge, free metal and by-products; zinc from Waelz oxide (185 kt) is bought at 65% of the LME price; premium on all output; electricity 7.3 TWh (4.06 MWh/t on average; Kantamaneni et al. 2021); other costs and compensation of indirect emission costs recognised for 2024 (EUR 230 m) per Annex B. Value added at factor cost includes operating subsidies (Eurostat SBS). Model estimates for 1,800 kt of smelter output.

As a reference point, a JRC study of production costs found that EU zinc smelters had some of the lowest total average production costs among the countries studied in 2013, with treatment charges of EUR 259–373 per tonne of zinc (Moya and Boulamanti 2016); the related study covers 23 smelters with about 30% of world slab output (Boulamanti and Moya 2016). Both studies predate the rise in energy prices of 2021–2023 and the low treatment charges of 2024–2025.

Secondary zinc (Z2). Waelz kilns recover 185 kt of zinc that enters EU smelters as Waelz oxide, including kilns operated within smelters; secondary refiners produce 230 kt of refined and remelted zinc, zinc alloys, zinc dust and oxide from dross, ash and scrap. Output is a gross metal value (EUR 924 million): Waelz oxide at 65% of the LME price, the refiners' products at the LME price, plus a gate fee of EUR 30 per tonne for the 840 kt of EAF dust implied by the zinc recovered (at 24% zinc in the dust). Zinc-bearing feed (45% of output) and coke, gas, electricity, lime and services (28%) leave value added of 27% of output. **Rolled zinc, dust and alloys (Z4).** Output is the PRODCOM value of zinc plates, sheets, strip and foil (EUR 900 million), zinc dust (EUR 395 million) and 50% of zinc alloys (EUR 1,447 million), EUR 2,018 million in total; value added is 18% of output (EUR 363 million). **Zinc coating and die-casting (Z5).** The zinc-coating share of 25.61 is the PRODCOM value of hot-dip galvanizing (code 25.61.11.30, which includes tin dipping) and electrolytic zinc coating relative to the output of the class; continuous galvanizing of strip in steelworks is classified in NACE 24.10 and is not included.

The two keys of Z5 are transparent but not verified against company data. The zinc-coating key relates the PRODCOM value of hot-dip galvanizing (code 25.61.11.30, which also covers tin dipping) and of electrolytic zinc coating (EUR 1,500 million, a rounded Eurostat estimate) to the output of 25.61 and applies the class ratio of value added to output. The die-casting key (35% of 24.54) is checked against tonnage: the inflow of zinc to die-castings in the dynamic model is about 280 kt, against 440 kt of all non-ferrous castings other than light metals in 24.54 (PRODCOM, mean of 2022–2024, gross weight), or 64% of the tonnage at 35% of the value. This implies lower unit values for zinc castings than for copper-alloy castings, which is an assumption. Z5 accounts for 52% of the direct value added of the extended chain.

TABLE 15 Split of NACE 24.43 (lead, zinc and tin production), EU-27, 2024

Part	GVA, EUR m	Persons	GVA per person, EUR k	Status
NACE 24.43, total (SBS)	1,771	15,140	117	O
Z2 Secondary zinc (Waelz kilns, secondary refiners)	249	1,820	137	E
Z3 Zinc smelting	610	4,990	122	E
Z4 Rolled zinc, zinc dust and alloys	363	3,030	120	E
Implied remainder: lead and tin	549	5,300	104	E

Source: IGMNiR ZN-EU v1.0; Eurostat SBS 2024. The zinc segments Z2–Z4 account for 69% of the value added of the class, against a zinc share of 59% of the PRODCOM value of all 24.43 products (≈62% with unwrought zinc valued at the LME price). The remainder of lead and tin is a check and does not enter the results.

The implied lead and tin remainder has value added of EUR 104 thousand per person, against EUR 117 thousand for the class as a whole. PRODCOM reports 1,466 kt of unwrought non-alloy zinc and 741 kt of zinc alloys (gross weight) for the EU-27 in 2024, with unit values of EUR 1,727/t and EUR 1,952/t, below the LME price of EUR 2,565/t; the output of Z2, Z3 and Z4 together, valued at the LME price, exceeds the SBS output of NACE 24.43 (EUR 7,860 million). The published data do not explain these differences. They do not affect value added, which in Z2 and Z3 follows from margins and costs per tonne and in Z4 from the value-added ratio.

4.2 Zinc mass balance

The physical module works in kilotonnes of zinc content. EU smelters produced 1,800 kt of refined zinc in 2024 (range 1,720–1,860 kt): the sum of the BGS country data is 1,989 kt, with Belgium at 480 kt after 250 kt in 2023, and the European output reported by the International Lead and Zinc Study Group less Norway and Russia implies about 1,800 kt. Of this output, 185 kt is zinc recovered from Waelz oxide, so primary zinc is 1,615 kt. Secondary refiners outside the smelters add 230 kt, and scrap remelted without refining – in brass mills, by producers of rolled zinc and die-casting alloys, and as galvanizing residues – 550 kt (range 450–750 kt). Together these two routes (780 kt) compare with about 700 kt a year recycled in the EU without passing through smelters (European Commission 2020) and with the direct reuse of 1.0 Mt estimated for Europe including the United Kingdom, Norway and Switzerland (Rostek and Loibl 2025), ≈0.88 Mt when scaled to the EU-27. Zinc in galvanized steel and in brass is not recorded by PRODCOM, so no production bridge can be built; the volumes of the three secondary routes are parameters. Zinc first used in the EU is smelter output plus net extra-EU imports of unwrought zinc (CN 7901; −324 kt, i.e. net exports) plus the output of secondary refiners and the zinc remelted directly, less net exports of zinc dust (CN 7903; 54 kt): 2,203 kt. Secondary zinc (965 kt) is 43.8% of first use.

TABLE 16 Physical account of zinc in the EU-27, 2024 (kt Zn)

Item	kt Zn	Status
Refined zinc produced by EU smelters	1,800	E
– of which zinc from Waelz oxide (S_w)	185	E
– of which primary zinc	1,615	E
Net extra-EU imports of unwrought zinc (CN 7901)	−324	O
Secondary refiners: refined and remelted zinc, alloys, dust, oxide (S_r)	230	E
Scrap remelted directly (S_dm)	550	E
Net extra-EU exports of zinc dust (CN 7903)	−54	O
Zinc first used in the EU-27	**2,203**	M
Secondary zinc (S_w + S_r + S_dm)	965	M
Secondary share of first use, %	43.8	M

Source: IGMNiR ZN-EU v1.0; Idoine et al. (2026); Eurostat Comext. Trade in gross weight converted at 98% zinc for CN 7901 and 97% for CN 7903. Status O: official statistics; E: estimate; M: model result.

Scrap feed follows from zinc yields of 92% on the Waelz route (kiln and smelter), 90% in secondary refining and 95% in direct remelting: 1,036 kt of zinc. Extra-EU trade in zinc waste and scrap (CN 7902; 95% zinc), hard zinc (2620 11; 94%), zinc ash and residues (2620 19; 25%) and brass scrap (7404 00 91; 33%) gives net exports of 63 kt of zinc. The trade classification of Waelz oxide and of EAF dust is not specific (Rostek 2025), so these flows are not identified separately. The residual estimate of domestic supply of zinc-bearing scrap and residues is the feed less net imports; the bottom-up estimate is old scrap recovered according to the dynamic model plus new scrap and residues at 14% of first use. Zinc in galvanized steel scrap leaves the EU with ferrous scrap: net extra-EU exports of ferrous scrap (CN 7204) were 10.9 Mt in 2024. The concentrate account – zinc in concentrate available to EU smelters against primary zinc output – is shown in Chapter 3; it covers 84% of primary output in 2024 and does not enter the results.

TABLE 17 **Balance of zinc-bearing scrap and residues, EU-27, 2024 (kt Zn)**

Item	kt Zn
Zinc in scrap feed (C)	1,036
– Waelz route (EAF dust)	201
– secondary refiners	256
– direct remelting	579
Extra-EU imports of zinc in scrap and residues (7902, 2620 11, 2620 19, 7404 00 91)	111
Extra-EU exports of zinc in scrap and residues	174
Domestic supply, residual (A_res = C − net imports)	1,099
Old scrap recovered (dynamic model)	579
New scrap and residues	308
Domestic supply, bottom-up (A_bu)	887
Difference A_res − A_bu (90% band 127 to 345)	212

Source: IGMNiR ZN-EU v1.0; Eurostat Comext, extra-EU trade 2024. The difference (20% of the scrap feed) is not allocated; it measures the joint error of the feed, trade and dynamic-model estimates.

$$fu = P_ref + \text{net imports } 7901 + S_r + S_dm - \text{net exports } 7903 \qquad C = S_w/y_w + S_r/y_r + S_dm/y_dm$$

$$A_res = C - \text{net imports of Zn in scrap} \qquad A_bu = \text{old scrap recovered} + r_new \cdot fu$$

4.3 Dynamic model of zinc in use

The dynamic model follows zinc entering use in the EU-27 from 1960 to 2035 (with a spin-up from 1900) by product group – galvanized steel, brass and bronze, zinc die-castings, rolled zinc and dissipative uses such as chemicals, paints, tyres and fertilisers – and releases it at end of life with normally distributed lifetimes. The shares follow the first uses of zinc (galvanizing 52%, die-casting 17% in Europe; European Commission 2020) and the global split of first uses reported by the ILZSG (Natural Resources Canada 2026); mean lifetimes are weighted from the end-use lifetimes in Rostek (2025, Tables 9 and 14). Recovery of zinc from galvanized steel is bounded by EAF dust: zinc in galvanized steel returns only through steel scrap melted in EU electric arc furnaces and the treatment of their dust (201 kt of zinc in dust processed, including new galvanized scrap), while zinc in steel melted in basic oxygen furnaces, in exported steel scrap and lost by corrosion in use is not recovered in the EU; the model recovers 16% of the zinc in galvanized steel reaching end of life (range 12–22%), 142 kt in 2024. Rolled zinc and brass are recycled at high rates; more than 95% of zinc sheet scrap is recycled (European Commission 2020). The 2024 inflow (1,895 kt) is first use less new scrap (14%) plus net imports of zinc in finished products (0 kt). Per-capita inflow is 0.85 of the 2024 level in 1960 and 1.10 in 2013, linear in between, and declines by 2% a year before 1960. The model gives a stock of 48.9 Mt (109 kg per person) in 2020; it is compared with published estimates in Chapter 6.

TABLE 18 Parameters of the dynamic model of zinc in use: product groups

Product group	Share of inflow, %	Mean life, years	SD, years	Collected, %	Zinc recovered in the EU, %
Galvanized steel	52	35	16	75	16
Brass and bronze	13	25	10	85	80
Zinc die-castings	15	12	5	60	55
Rolled zinc	6	50	23	95	90
Dissipative uses (chemicals, paints, tyres, fertilisers)	14	1	0	0	0

Source: European Commission (2020) and Natural Resources Canada (2026) for first uses; Rostek (2025), Table 7 (separation efficiencies by waste stream), Table 8 (Waelz recovery 95%) and Tables 9 and 14 (lifetimes); IGMNiR ZN-EU v1.0. Recovery from galvanized steel is bounded by zinc in EAF dust processed in the EU; recovery from the other groups is scaled by a common recovery factor.

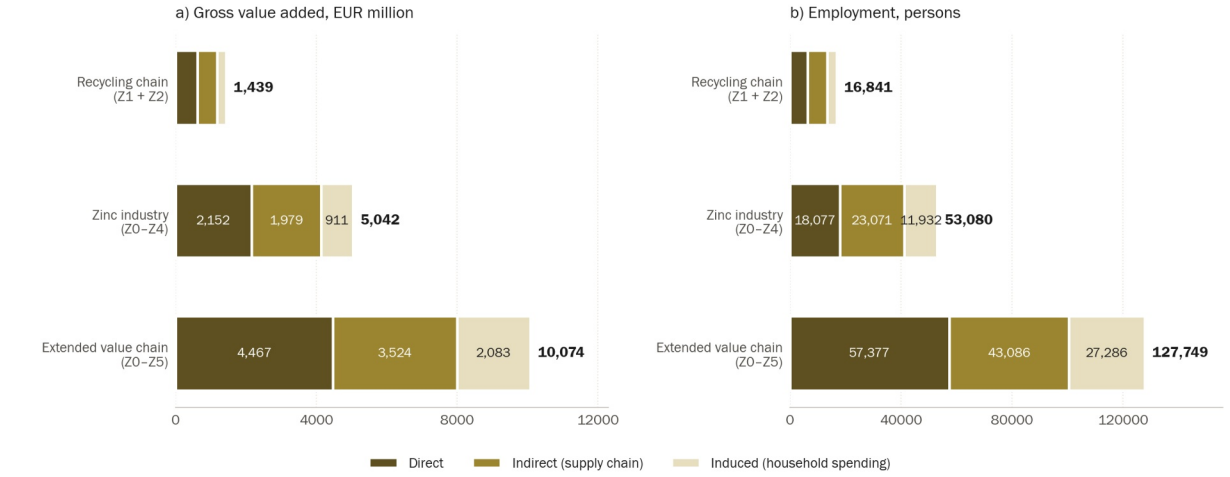
4.4 Economic, fiscal, environmental and strategic modules

Indirect and induced effects are computed with Leontief Type I and Type II multipliers of the EU block of the Eurostat FIGARO inter-country table for 2024 (64 products; Eurostat 2026a), aggregated from the 27 destination countries: deliveries between Member States are domestic and imports from outside the EU are excluded from the multiplier. Only the zinc shares of the chain activities are counted in the segments, so first-round demand excludes purchases of chain products (basic metals, mining products, wholesale and waste services); the FIGARO rows of these products also carry items other than zinc. For Z0 and Z1 the excluded inputs are dropped; for Z2–Z5 the non-chain intermediate consumption of the segment is distributed over the remaining products of the parent column. Smelter electricity enters as CPA D35 at the domestic share of the basic-metals column. Type II effects add household spending out of net labour income (propensity to consume 0.86; tax rate on labour 37.09%). Taxes combine labour taxes (implicit tax rate on labour), corporate income tax (statutory average of 21.8% × taxable share of operating surplus) and net taxes on production and products from FIGARO. The environmental module compares secondary zinc produced in the EU with displaced primary zinc; the strategic module compares EU output with EU use and measures the concentration of extra-EU trade. Monte Carlo draws (58 uncertain parameters, triangular distributions, Gaussian copula for correlated groups) give 90% bands; structural cases test model choices.

05 Economic and fiscal contribution

In 2024 the extended zinc value chain in the EU-27 generated EUR 4,470 million of direct gross value added (90% band 4,080–4,840) and employed about 57,400 persons. Domestic suppliers in the EU added EUR 3,520 million and 43,100 jobs (Type I: EUR 7,990 million, 90% band 7,360–8,610; 100,000 jobs), and household spending a further EUR 2,080 million (Type II: EUR 10,070 million and 128,000 jobs). The zinc industry Z0–Z4 accounts for EUR 2,150 million of direct value added and the recycling chain Z1+Z2 for EUR 620 million.

FIGURE 10 Economic footprint of the zinc value chain in the EU-27, 2024



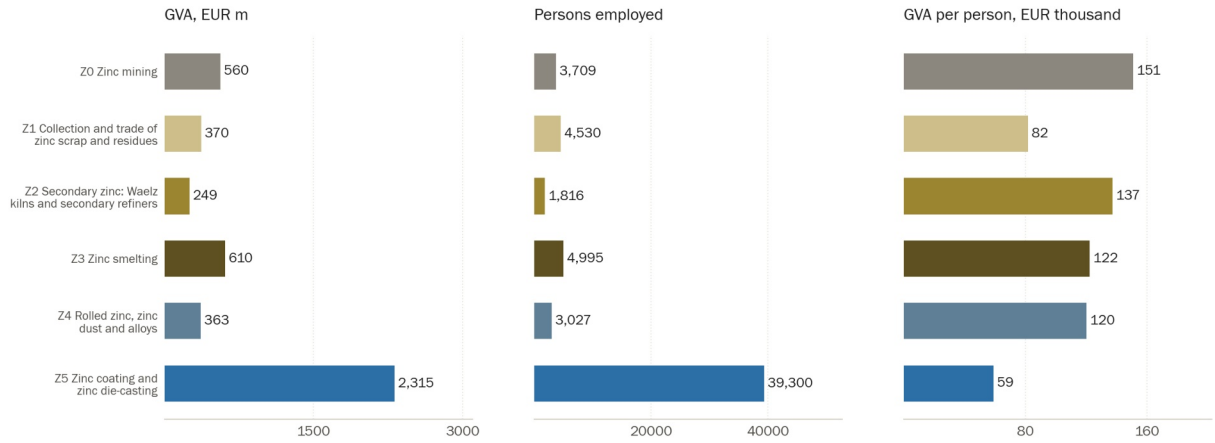
Source: IGMNiR ZN-EU v1.0; Eurostat SBS 2024, PRODCOM 2024, FIGARO 2024 (EU-27 block), Comext; central estimate.

TABLE 19 Economic contribution by segment, 2024 (central estimate)

Segment	GVA direct, EUR m	GVA Type I	GVA Type II	Jobs direct	Jobs Type I	Taxes, EUR m
Z0 Zinc mining	560	847	1,005	3,710	7,300	238
Z1 Collection and trade of zinc scrap and residues	370	741	912	4,530	9,290	246
Z2 Secondary zinc (Waelz kilns, secondary refiners)	249	431	527	1,820	4,050	130
Z3 Zinc smelting	610	1,436	1,759	4,990	13,650	440
Z4 Rolled zinc, zinc dust and alloys	363	676	838	3,030	6,860	219
Z5 Zinc coating and zinc die-casting	2,315	3,860	5,032	39,300	59,310	1,420
Extended value chain Z0–Z5	**4,467**	**7,991**	**10,074**	**57,380**	**100,460**	**2,694**

Source: IGMNiR ZN-EU v1.0. Z3 includes compensation of indirect emission costs of EUR 230 million (value added at factor cost); for Z3, output = value added at factor cost + intermediate consumption − compensation, and the compensation does not enter the first round of supply-chain effects. Z5: zinc coating EUR 1,887 million and 32,800 persons; zinc die-casting EUR 428 million and 6,500 persons. Taxes exclude VAT.

FIGURE 11 Direct GVA, employment and productivity by segment, 2024



Source: IGMNiR ZN-EU v1.0; Eurostat SBS 2024, PRODCOM 2024, FIGARO 2024 (EU-27 block), Comext; central estimate.

Value added per person ranges from EUR 59 thousand to EUR 151 thousand. Zinc coating and die-casting (Z5) account for 52% of direct value added and 68% of employment. Smelting (Z3) accounts for 13.7% of direct value added and 8.7% of employment; 38% of its value added at factor cost is compensation of indirect emission costs. Zinc mining (Z0) has the highest value added per person.

TABLE 20 Reconciliation of employment with official and industry data, 2024

Item	Persons	Status	Source
SBS NACE 24.43, EU-27 (persons employed)	15,136	O	Eurostat SBS
Model: zinc part of 24.43 (Z2 + Z3 + Z4)	9,840	E	ZN-EU
Model: lead and tin remainder of 24.43	5,300	E	ZN-EU
Model: zinc coating (Z5) vs SBS NACE 25.61	32,800 / 290,000	E/O	ZN-EU; Eurostat SBS
General galvanizing in Europe, employees (industry statement)	40,000	O	EGGA (2024)
Model: zinc mining (Z0) vs SBS NACE 07.29	3,710 / 43,600	E	ZN-EU; Eurostat SBS
Model: extended value chain Z0–Z5, direct and Type I	57,000 / 100,000	E/M	ZN-EU

Source: IGMNiR ZN-EU v1.0; Eurostat SBS 2024; EGGA (2024). The EGGA figure covers Europe beyond the EU-27, including Türkiye and the United Kingdom (Section 5.4). Persons employed in NACE 07.29 are estimated from personnel costs (status E).

TABLE 21 Intermediate consumption and first-round demand by segment, 2024 (EUR million)

Segment	Output	GVA	Chain inputs (excluded)	Other inputs	First round in the EU	Indirect GVA
Z0 Zinc mining	998	560	47	391	351	287
Z1 Collection and trade of zinc scrap and residues	1,280	370	437	473	440	371
Z2 Secondary zinc (Waelz kilns, secondary refiners)	924	249	416	259	226	182
Z3 Zinc smelting	5,072	610	3,550	1,141	1,043	826
Z4 Rolled zinc, zinc dust and alloys	2,018	363	1,211	444	388	312
Z5 Zinc coating and zinc die-casting	6,086	2,315	1,660	2,111	1,885	1,546
Total	16,377	4,467	7,321	4,819	4,333	3,524

Source: IGMNiR ZN-EU v1.0. Chain inputs = metal (or feed) share of output (m2, m4, m5c, m5d); for Z3 concentrates and Waelz oxide; for Z0 and Z1 intermediate consumption less non-chain inputs of the parent FIGARO column. Output of Z2 and Z3 is gross metal value. Electricity of smelters is a non-chain input entering the first round as CPA D35. In Z3, value added includes the compensation of indirect emission costs, so output less intermediate consumption exceeds value added before compensation.

TABLE 22 Supply-chain value added by supplying product, extended value chain, 2024

Supplying product (CPA)	GVA, EUR m	Share, %
D35 Electricity, gas, steam and air conditioning	444	12.6
C25 Fabricated metal products	333	9.4
M69_70 Legal, accounting and management consultancy services	229	6.5
H49 Land transport and pipelines	179	5.1
L Real estate services	177	5.0
N80-82 Security, building and office support services	146	4.1
G46 Wholesale trade	129	3.7
H52 Warehousing and transport support	125	3.6
K64 Financial services	117	3.3
N78 Employment services	114	3.2
Other products	1,533	43.5

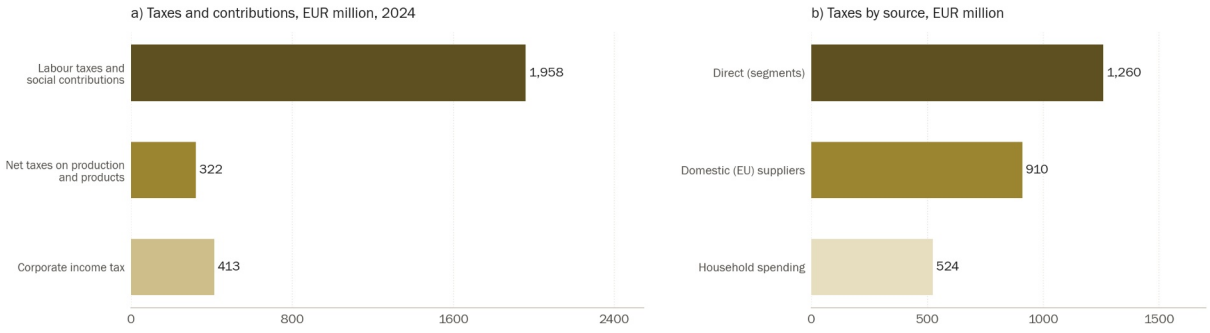
Source: IGMNiR ZN-EU v1.0; FIGARO 2024, EU block.

All economic results are gross contributions: they describe the value added and employment linked to the activity in 2024, not what would be lost if the activity stopped, since part of the labour, capital and demand would move to other uses and part of the supply would be replaced by imports. The model does not quantify such a counterfactual; the only reduction it quantifies is the stress scenario S3 (Chapter 10).

5.1 Taxes, public revenue and public support

Activity in the extended chain is associated with about EUR 2,690 million of taxes and social contributions excluding VAT (90% band 2,460–2,920): EUR 1,260 million in the segments, EUR 910 million at domestic suppliers and EUR 520 million from household spending (Table 23). Labour taxes and contributions account for EUR 1,960 million. Lead, zinc and tin production (NACE 24.43) is on the list of sectors deemed exposed to a genuine risk of carbon leakage due to indirect emission costs, and zinc electrolysis has an electricity consumption efficiency benchmark of 3.994 MWh per tonne of zinc under the ETS State aid Guidelines. Compensation recorded in public sources for 2024 costs (Table 24) amounts to EUR 170.2 million for five zinc smelters, EUR 30.0 million for NACE 24.43 in Poland (including lead and tin), EUR 1.57 million for producers of zinc semis and powder and EUR 1.51 million for a lead smelter. The model recognises EUR 230 million in Z3 (range 195–280): the smelters, the zinc part of the Polish amount and the amounts not published for the Netherlands, Italy and Bulgaria. Compensation is an operating subsidy and part of value added at factor cost of Z3; the amount recorded for smelters equals 28% and the recognised amount 38% of that value added. The free allocation of allowances is shown separately.

FIGURE 12 Taxes and contributions linked to the zinc value chain, 2024



Source: IGMNiR ZN-EU v1.0; implicit tax rate on labour, EU-27 2024 (DG TAXUD); FIGARO 2024 (EU-27 block). Model estimates attributing public revenue to the activity; VAT excluded; not a net fiscal balance. Compensation of indirect emission costs is not shown.

TABLE 23 Taxes, contributions and public support by category, 2024 (EUR million)

Category	EUR m	Status	Basis
(i) Labour taxes and social contributions	1,958	M	37.09% × labour cost (SBS, FIGARO)
(ii) Corporate income tax	413	M	statutory average 21.8% × taxable share of operating surplus
(iii) Net taxes on production and on products used, net of other subsidies	322	M	FIGARO coefficients
Total (excl. VAT)	2,694	M	
Free allocation of allowances 2024, ten zinc smelters and seven stand-alone Waelz plants, at EUR 64.74	106	E	European Commission (2026c); not deducted
Compensation of indirect emission costs recognised in Z3 value added, 2024 costs	230	E	recorded for smelters EUR 170.2 m (Table 24)

Source: IGMNiR ZN-EU v1.0; European Commission, DG TAXUD (2026); European Commission (2026c). Row (iii) uses FIGARO coefficients of taxes less subsidies on production and products; for basic metals these coefficients already contain other subsidies on production, so the row is partly net of public support. Compensation is part of the operating surplus of Z3 and therefore of the base of corporate income tax.

TABLE 24 Compensation of indirect emission costs recorded for zinc producers, 2024 costs (EUR million)

Recipient	EUR m	Source
Asturiana de Zinc (ES)	66.30	Resolución de 25 de noviembre de 2025 (2024 costs)
Nyrstar Belgium (BE)	33.19	State aid transparency register, SA.103704, granted 17 Nov 2025; cost year 2024 (inferred)
Nordenhamer Zinkhütte (DE)	31.96	DEHSt beneficiary list 2024
Nyrstar France (FR)	26.07	State aid transparency register, SA.63404, granted 12 Jun 2025; cost year 2024 (inferred)
Boliden Kokkola (FI)	12.72	Energiavirasto, aid paid 2025 (2024 costs)
Subtotal: zinc smelters	**170.24**	
NACE 24.43 in Poland, incl. lead and tin	29.99	URE Information 64/2025: PLN 129.1 m at 4.3058
ZH Zink Halbzeug; Grillo Zinc Metals; Grillo Zinc Powder (DE)	1.57	DEHSt beneficiary list 2024
Nyrstar Stolberg (DE), lead smelter	1.51	DEHSt beneficiary list 2024
Total recorded	**203.31**	
Recognised in Z3 value added (smelters, zinc part of Poland, the Netherlands, Italy, Bulgaria)	230.0	ZN-EU
For comparison: value added of zinc smelters (Z3) at factor cost	610.2	ZN-EU

Source: Ministerio de Industria y Turismo (2025); DEHSt (2026); Urząd Regulacji Energetyki (2025); Energiavirasto (2025); European Commission (2026d). Amounts by company are not published for the Netherlands, Italy and Bulgaria.

5.2 Split keys and boundaries with other IGMNiR reports

Employment keys split NACE 24.43 between secondary zinc (12%), smelters (33%), rolled zinc, dust and alloys (20%) and the lead and tin remainder. Value added of Z2 and Z3 follows from physical volumes, prices, margins and costs, and that of Z4 from its value-added ratio; the employment keys therefore move jobs, not value added. The table shows the effect of alternative keys and of the main parameters of Z3 and Z4.

TABLE 25 Alternative split keys and parameters of Z3 and Z4, 2024

Case	GVA Z3	GVA Z4	GVA Z0–Z5	Jobs Z2	Jobs Z3
Central case	610	363	4,467	1,820	4,990
Smelters 27% of jobs	610	363	4,467	1,820	4,090
Smelters 40% of jobs	610	363	4,467	1,820	6,050
Z2 8% of jobs	610	363	4,467	1,210	4,990
Z2 16% of jobs	610	363	4,467	2,420	4,990

Case	GVA Z3	GVA Z4	GVA Z0–Z5	Jobs Z2	Jobs Z3
Z4 ratio 13%	610	262	4,366	1,820	4,990
Z4 ratio 25%	610	505	4,608	1,820	4,990
Compensation EUR 195 m	575	363	4,432	1,820	4,990
Compensation EUR 280 m	660	363	4,517	1,820	4,990
Z3 without compensation	380	363	4,237	1,820	4,990
Electricity EUR 50/MWh	756	363	4,613	1,820	4,990
Electricity EUR 95/MWh	428	363	4,284	1,820	4,990
TC EUR 180/t	497	363	4,354	1,820	4,990
TC EUR 305/t	699	363	4,556	1,820	4,990
Z1 by employment key	610	363	4,393	1,820	4,990

Source: IGMNiR ZN-EU v1.0. GVA in EUR million, jobs in persons.

ZN-EU covers the whole EU-27 and therefore contains the activities analysed in the IGMNiR report on zinc in Poland (IGMNiR 2026a). Within ZN-EU each activity is counted once. Three boundaries matter when ZN-EU is combined with other IGMNiR reports. First, brass mills belong to copper production (NACE 24.44): the zinc they remelt with brass scrap is counted in the physical balance of ZN-EU as direct remelting, but their value added and jobs are not in any ZN-EU segment. Second, lead production at Portovesme and Plovdiv and the lead output of the Imperial Smelting furnace at Miasteczko Śląskie (the only one in the EU) are outside Z3, which counts only zinc. Third, continuous galvanizing lines of steelworks (NACE 24.10) are outside Z5. National reports and ZN-EU are alternative perspectives and are not added up.

5.3 Comparison with other studies of zinc flows in Europe

Several public studies describe zinc flows, stocks and recycling; they differ in geography (EU-27, Europe including the United Kingdom, Norway and Switzerland, or the world), year, unit and method. The matrix summarises scope, method, key results and data access, without ranking them. No public study combining an economic input-output model, a mass balance, a dynamic stock model, screening emission values and a Monte Carlo analysis for zinc in the EU-27 was identified in the search for this report.

TABLE 26 Studies of zinc flows: scope, methods, results and data access

Study	Scope	Method	Key results	Data access
Gordon et al. (2004)	World, 1994	Static MFA (Stocks and Flows Project)	Recycling captured 41% of the discard flow	Journal article
Graedel et al. (2005)	World and regions, c. 1994	Multilevel static MFA	About 2/3 of zinc entering use added to stock; about 40% of discarded zinc recovered; prompt-scrap ratio 0.070	Journal article
Graedel et al. (2011), UNEP IRP	World	Literature synthesis	End-of-life recycling rate >50%; recycled content >10 –25%	Public report
Meylan and Reck (2017)	World, 2010	Static MFA	End-of-life recycling rate 33%; 27% of fabricated zinc from secondary sources	Journal article
Rostek et al. (2022)	World, 1900 –2019	Dynamic MFA	About 250 Mt in use (2019); end-of-life recycling rate 27%, recycling input rate 29% (2010–2019)	Journal article
Rostek and Loibl (2025)	EU-27, UK, NO, CH, 2020	Linked regional dynamic MFA	Stock 69.9 Mt (≈130 kg/person); end-of-life recycling rate 53%; recycling input rate 49%; old-scrap ratio 70%	Open-access article

Study	Scope	Method	Key results	Data access
European Commission (2023), CRM study	EU	Criticality assessment	Not critical; import reliance 56% (extraction), 0% (processing); EoL-RIR 34%	Public report
Wyns and Khandekar (2019), IES-VUB	EU, 2010–2016	Industry analysis	Primary zinc 1,699 kt and secondary 296 kt (2016); production 2,098 kt in 12 plants (2010)	Public report
Gregoir and Van Acker (2022), KU Leuven	Europe, 2020–2050	Scenario study	Demand 2.8 Mt in 2020 and 2050; energy transition +11%	Public summary
ZN-EU (this report)	EU-27, 2024	IO, mass balance, dMFA, screening LCA, Monte Carlo	See Chapters 5–8	Model package on request

Source: as stated. EoL-RIR: end-of-life recycling input rate (definitions differ between studies).

For zinc entering use in the EU-27 in 2024, the dynamic model adds 6% to the stock ((inflow − outflow) / inflow), against about two thirds worldwide around 1994 (Graedel et al. 2005), when stocks were still growing quickly.

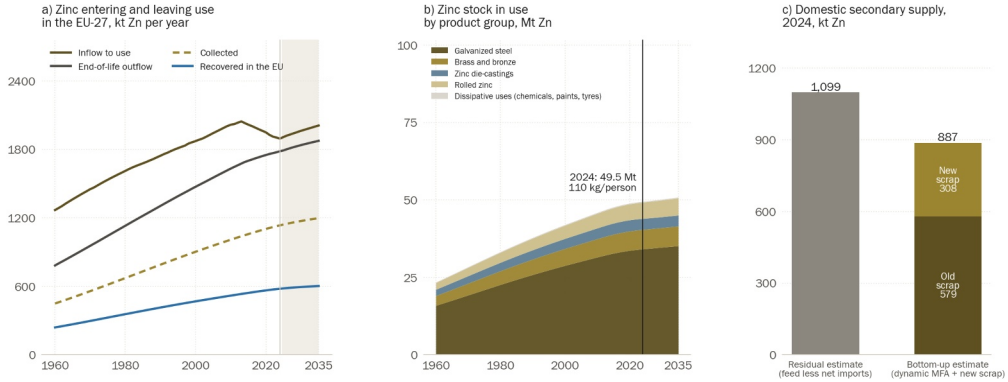
5.4 Comparison with economic contribution studies

No published study of the economic contribution of the zinc industry in the EU as a whole was identified. Company and sector studies provide checks of order of magnitude. A study for Nyrstar puts its contribution to the Belgian economy at nearly half a billion euros a year (EUR 471 million) and 1,750 direct and indirect jobs (Nyrstar 2024c); the definition is spending in the economy rather than value added. EGGA reports about 700 general galvanizing plants, mostly small and medium-sized enterprises, with about 40,000 employees in Europe (EGGA 2024; Kopf 2025); ZN-EU attributes 32,800 persons to zinc coating in the EU-27, which also includes electrolytic zinc coating. The ratio of Type I to direct jobs in ZN-EU (1.75) uses only domestic EU suppliers and a narrow first round, so it is lower than ratios of studies that include induced effects or the whole of Europe.

06 Zinc in use and scrap supply

The dynamic model estimates that about 49.5 Mt of zinc was in use in the EU-27 in 2024, or 110 kg per person (90% band 96–127). Galvanized steel holds 69% of the stock and rolled zinc 11%. In 2024 about 1,890 kt of zinc entered use and 1,780 kt left it, of which 270 kt in dissipative uses from which zinc is not recovered. Of the 1,520 kt reaching end of life in recoverable products, 580 kt (38%) was recovered in the EU; galvanized steel contributed 142 kt of this. Recovery rises to 600 kt in 2035.

FIGURE 13 Zinc in use in the EU-27, 1960–2035, and domestic scrap supply in 2024



Source: IGMNiR ZN-EU v1.0, module M2b; inflow-driven stock model 1960–2035 by product group (galvanized steel, brass and bronze, die-castings, rolled zinc, dissipative uses); lifetimes normal (mean and SD by group) after Rostek (2025); zinc recovered in the EU from galvanized steel 16% of zinc reaching end of life (via EAF dust only); per-capita path anchored on the ZN-EU balance for 2024; stock compared with ≈130 kg per person for EU-27, UK, Norway and Switzerland in 2020 (Rostek and Loibl 2025); population Eurostat (demo_gind, EUROPOP2023). Model estimates; 2025–2035 under the central inflow growth of 0.5% a year.

TABLE 27 Zinc stock in use and end-of-life flows by product group, 2024 and 2035

Product group	Stock 2024, Mt	End of life 2024, kt	Stock 2035, Mt	End of life 2035, kt
Galvanized steel	34.1	889	35.1	954
Brass and bronze	6.3	241	6.4	253
Zinc die-castings	3.5	299	3.5	291
Rolled zinc	5.3	88	5.5	97
Dissipative uses (chemicals, paints, tyres, fertilisers)	0.3	267	0.3	280
Total	49.5	1,784	50.9	1,876

Source: IGMNiR ZN-EU v1.0, module M2b. Model results (status M). Dissipative uses leave the stock within the year.

TABLE 28 Sensitivity of the dynamic model

Case	Stock 2020, kg/person	End of life 2024, kt	Recovered 2024, kt	EoL-RR 2024, %	Recovered 2035, kt
Central	109	1,784	579	38	603
Lifetimes −20%	90	1,854	603	38	619
Lifetimes +20%	127	1,705	552	38	583
Per-capita inflow 2013 at 1.00 of 2024	102	1,692	543	38	573
Per-capita inflow 2013 at 1.20 of 2024	117	1,876	615	38	632
Per-capita inflow 1960 at 0.70 of 2024	106	1,704	553	38	587
Per-capita inflow 1960 at 1.00 of 2024	113	1,863	605	38	618
Recovery factor (other than galvanized steel) 0.85	109	1,784	513	34	535
Recovery factor (other than galvanized steel) 1.15	109	1,784	639	42	665

Case	Stock 2020, kg/person	End of life 2024, kt	Recovered 2024, kt	EoL-RR 2024, %	Recovered 2035, kt
Recovery from galvanized steel 12%	109	1,784	543	36	565
Recovery from galvanized steel 22%	109	1,784	632	42	660
No inflow growth after 2024	109	1,784	579	38	601
Inflow growth 2% a year	109	1,784	579	38	609
Inflow 1998–2008 +25%	117	1,874	617	38	634
Flat per-capita inflow from 1990	105	1,737	558	38	583
Log-normal lifetimes	109	1,791	581	38	605
Recovery from die-castings halved	109	1,784	496	33	523
Higher galvanized-steel share	116	1,772	536	34	559
Higher dissipative share	103	1,792	534	37	556
New-scrap rate 18%, balance closed by recovery (factor 1.60)	105	1,701	694	48	717

Source: IGMNiR ZN-EU v1.0, module M2b. EoL-RR: zinc recovered in the EU relative to zinc reaching end of life in recoverable products (dissipative uses excluded). In the last row the stock is that of 2024.

Recycling indicators differ in definition and region. In ZN-EU 38% of zinc in recoverable end-of-life products is recovered in the EU (90% band 35–42%), the stock is 109 kg per person in 2020 (96–126) and old scrap is 50% of secondary zinc. Compared with Rostek and Loibl (2025) for the EU-27, the United Kingdom, Norway and Switzerland in 2020 – an end-of-life recycling rate of 53%, about 130 kg per person and an old-scrap ratio of 70% – all three values are lower. The difference reflects the bound on recovery from galvanized steel through EAF dust processed in the EU, the wider region and differences in definitions, among them whether zinc in exported scrap counts as recovered. Global averages of the end-of-life recycling rate are 27–33% (Rostek et al. 2022; Meylan and Reck 2017). Secondary zinc is 44% of first use, against a recycling input rate of 49% for the wider European region; zinc from domestic old scrap is 21–22% of first use, against an end-of-life recycling input rate of 34% in the EU criticality assessment (European Commission 2023).

The old-scrap share of secondary zinc is (old scrap recovered − net exports of zinc in scrap) × (secondary output / secondary feed) / secondary output = (579 − 63) × (965 / 1,036) / 965 ≈ 50%. The formula assumes that all net exports of zinc in scrap and residues are old scrap; exports also include hard zinc, galvanizing ash and brass scrap of mixed origin, and with net exports split in proportion to domestic supply of old and new scrap the share would be 52%. The zinc in the feed of direct remelting (579 kt) and the old scrap recovered (579 kt) are about equal by coincidence.

The secondary share of first use (43.8%) rests on volumes of the secondary routes taken from the literature, and the end-of-life recycling rate (38%) comes from the stock model. The two accounts do not close: the scrap balance leaves a residual of 212 kt. With a new-scrap rate of 18% and a recovery factor of 1.60 on the product groups other than galvanized steel, the balance closes (residual 8 kt); the end-of-life recycling rate is then 48% and the old-scrap ratio 61%. The difference from the 53% of Rostek and Loibl (2025) is also one of definition: ZN-EU counts zinc recovered in the EU and excludes zinc in exported steel scrap; on a basis of zinc collected for recycling anywhere the rate would be higher.

The residual estimate of domestic supply of zinc-bearing scrap and residues (1,099 kt) exceeds the bottom-up estimate (887 kt: 579 kt of old scrap recovered and 308 kt of new scrap and residues) by 212 kt, or 20% of the scrap feed (90% band 127 to 345 kt). The difference is not allocated to a specific flow.

The dynamic model has five limitations. Its product groups combine European first uses with lifetimes weighted from a model for the wider European region; the path of inflow before 2024 is an assumption rather than a time series of consumption; recovery from galvanized steel is bounded through EAF dust and does not represent the routes of steel scrap explicitly; exports of used vehicles are not represented; and corrosion losses of coatings in use are not modelled separately.

TABLE 29 Zinc recycling indicators: ZN-EU compared with published values

Indicator and definition	ZN-EU 2024	Published	Source
End-of-life recycling rate (recovered / end of life, recoverable products)	38%	53% (49–58%), Europe 2020; >50%	Rostek and Loibl (2025); Graedel et al. (2011)
Recycling input rate (secondary / first use)	44%	49% (46–51%), Europe 2020	Rostek and Loibl (2025)
End-of-life recycling input rate (old scrap in input)	21–22%	34%	European Commission (2023)
Old-scrap ratio (old scrap / secondary zinc)	50%	70%, Europe 2020	Rostek and Loibl (2025)
Stock in use 2020, kg per person	109	≈130 (69.9 Mt), Europe 2020	Rostek and Loibl (2025)
Global end-of-life recycling rate	–	27% (2010–2019); 33% (2010)	Rostek et al. (2022); Meylan and Reck (2017)

Source: IGMNiR ZN-EU v1.0 and as stated. The EoL-RIR range corresponds to new-scrap rates of 18% and 14%. Rostek and Loibl (2025) cover the EU-27, the United Kingdom, Norway and Switzerland.

07 Environmental contribution

Primary zinc produced in Europe has a lower carbon footprint than the global average: according to the International Zinc Association, special high grade zinc carried a cradle-to-gate footprint of 2.0 t CO_2e per tonne in Europe (including Norway) and 3.5 t worldwide for primary production in 2021 (International Zinc Association 2023). The EU-27 is a net exporter of unwrought zinc, so the zinc used in the EU is mainly zinc produced in Europe; the central case therefore uses the European average as the footprint of displaced primary zinc. Secondary zinc is produced by three routes with different footprints. Remelting of zinc and brass scrap needs little energy. Secondary refining of dross, ash and scrap by distillation and remelting uses more. The Waelz route – treatment of EAF dust in rotary kilns with coke, followed by leaching and electrolysis of the Waelz oxide in a smelter – has a footprint above that of European primary zinc.

TABLE 30 Screening and published footprints for zinc routes, t CO_2e per t of zinc (cradle to gate)

Route	t CO_2e/t	Range	Basis
Direct remelting of zinc and brass scrap, incl. scrap preparation	0.40	0.10–0.60	remelting 0.08 (Grund and van Genderen 2024); remelted zinc ≈0.6 (Grund 2026)
Secondary refining of dross, ash and scrap	1.00	0.60–1.60	IGMNiR screening value
Waelz route: Waelz oxide, leaching and electrolysis	3.86	3.40–4.71	Nyrstar (2023); low from verified emissions of EU Waelz plants plus smelting; high Rinne et al. (2022)
Secondary zinc, weighted by output	1.21		weights: remelting 550, refining 230, Waelz 185 kt
Primary zinc, European average (central)	2.00	1.86–2.55	International Zinc Association (2023)
Nyrstar European zinc: average; primary feed only; Waelz-oxide feed only	1.86; 1.06; 3.86		Nyrstar (2023)
Primary zinc, global average (2021 data; 2018 data)	3.50; 3.64		International Zinc Association (2023; 2022)

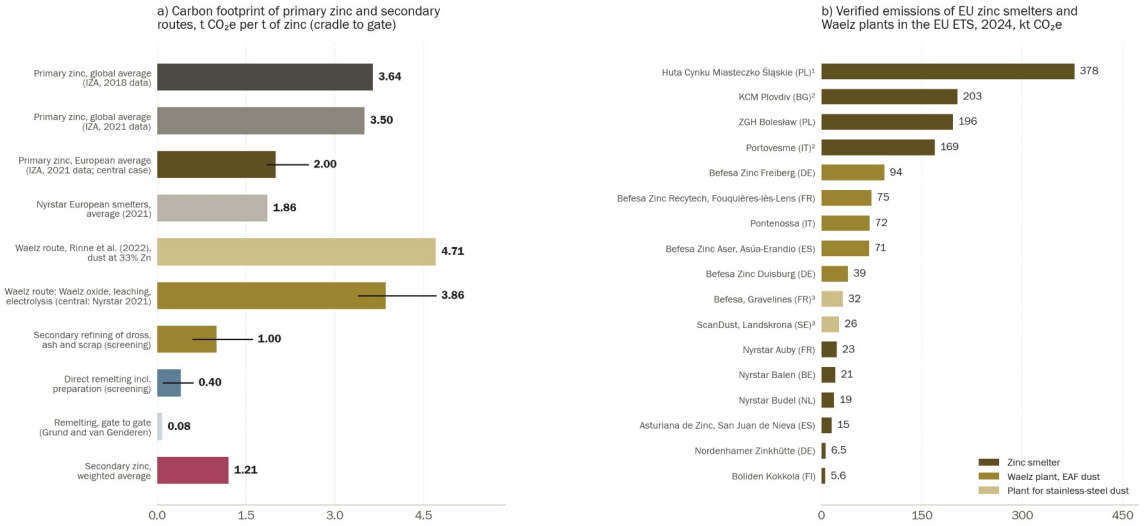
Source: IGMNiR ZN-EU v1.0 and as stated. International Zinc Association values use mass allocation with system expansion for sulphuric acid. Waelz-route values depend on the zinc content of the dust and rise steeply at low zinc contents (Rinne et al. 2022).

Under these values, remelting and secondary refining in the EU-27 in 2024 potentially avoided 1,110 kt CO_2e (90% band 1,000–1,610 kt; 880 kt from direct remelting and 230 kt from secondary refining), while the result of the Waelz route was −340 kt (90% band −470 to −240 kt); the net result is 770 kt (610–1,310 kt). On the Waelz route zinc carries a higher footprint than the European primary zinc it may displace. For the boundaries adopted, the result of the Waelz route is negative in every structural case of Section 7.1, including the global primary average. The comparison credits zinc only. EAF dust is a hazardous waste (code 10 02 07* of the List of Waste, Commission Decision 2000/532/EC); the Waelz process recovers its zinc and returns an iron-bearing slag, and all EAF dust produced in Europe is recycled (European Commission 2020). The screening comparison does not credit the disposal of the dust that the process replaces, or the recovered iron.

Direct emissions of the installations are reported in the EU Emissions Trading System; the full list of installations is in Annex C. In 2024 ten zinc smelters verified 1,040 kt CO_2e (2023: 970 kt), or 0.52 t per tonne of refined zinc reported in national statistics (1,989 kt; Idoine et al. 2026). Four installations – those with lead production at Portovesme and Plovdiv, the Imperial Smelting furnace at Miasteczko Śląskie (the only one in the EU) and ZGH Bolesław, which operates Waelz kilns within the smelter installation – account for 91% of this. The six electrolytic smelters without lead or Imperial Smelting lines verified 90.0 kt, or 0.05 t CO_2 per tonne of their 1,658 kt of output on the same basis (0.58 and 0.06 t on the model basis, with refined output of 1,800 kt and Balen at its capacity of 285 kt; see Section 3.2), because their main energy input is electricity; they received 299.2 kt of free allowances, 209.2 kt more than their verified emissions, worth EUR 13.5 million at the 2024 average auction price. Seven stand-alone Waelz plants, two of which treat stainless-steel dust, verified 410 kt

CO_2e (2023: 410 kt). Free allocation in 2024 was 1,220 kt for the smelters and 410 kt for the stand-alone Waelz plants; there is no product benchmark for zinc, so allocation is based on fall-back benchmarks for heat, fuel and process emissions.

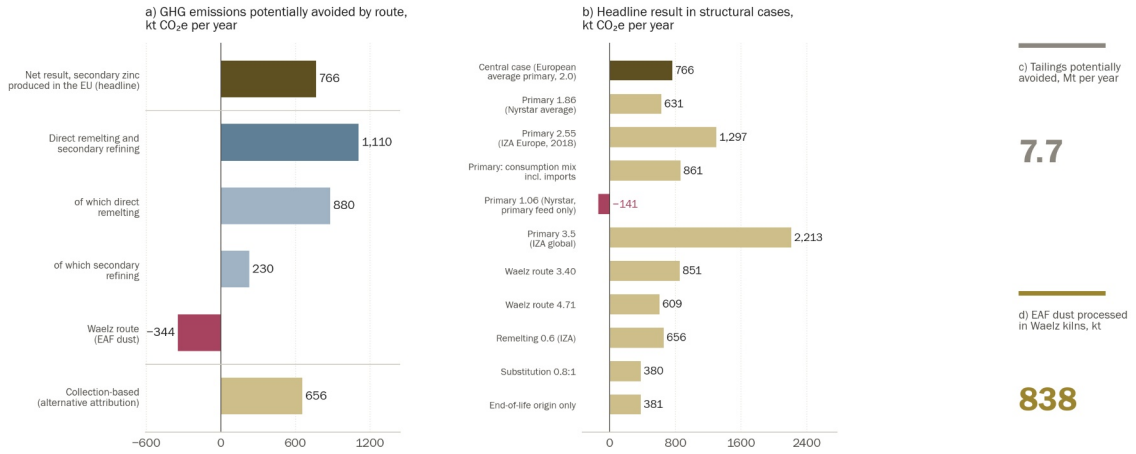
FIGURE 14 **Carbon footprints of zinc routes and verified emissions of EU installations**



Source: IZA (2022, 2023); Nyrstar (2023); Rinne et al. (2022); Grund and van Genderen (2024); IGMNiR screening values for secondary refining and direct remelting (Chapter 7); EU ETS verified emissions (Union Registry, extraction 1 April 2026). Not ISO 14044 comparative LCAs; lines show ranges in Annex B. [1] Imperial Smelting process. [2] Zinc and lead. [3] Stainless-steel dust. Totals 2024: ten smelters 1,037 kt, seven Waelz plants 409 kt; emissions of electricity used are not included.

Counting only zinc from domestic old scrap, the emissions potentially avoided are 380 kt CO_2e; based on the zinc collected from EU arisings rather than on the zinc produced, the result is 660 kt. Other burdens potentially avoided include about 7.7 Mt of flotation tailings (at 8 t per tonne of primary zinc, with allocation to lead, silver and copper) and 16.9 kt SO_2-equivalent of acidification (Van Genderen et al. 2016). The zinc recovered on the Waelz route implies about 840 kt of EAF dust treated in the EU at 24% zinc; EU electric arc furnaces produced 57.8 Mt of steel in 2024 (EUROFER 2025), which at 10–30 kg of dust per tonne (Remus et al. 2013) gives 580–1,730 kt of dust.

FIGURE 15 **Emissions and other burdens potentially avoided by secondary zinc produced in the EU-27, 2024**



Source: IGMNiR ZN-EU v1.0, module M4; 1:1 substitution of primary zinc (central case: European average 2.0 t CO_2e/t, Annex B) by secondary zinc produced in the EU; for the boundaries adopted, the Waelz route has a higher footprint than primary zinc of European average and the result for this route is negative. The net result in a) is the sum of direct remelting and secondary refining and of the Waelz route; the collection-based bar is an alternative attribution. Avoided burdens arise partly outside the EU.

7.1 Structural sensitivity

The headline result depends on the counterfactual. The table shows alternative choices of the displaced primary zinc, of substitution, of the secondary footprints and of the volumes of the secondary routes; each case changes one choice.

TABLE 31 Structural sensitivity of the emissions potentially avoided, 2024 (kt CO_2e)

Case	Remelting and refining	Waelz route	Net	Collection-based	Secondary footprint, t/t
Central case: European primary average (2.0 t)	1,110	−344	766	656	1.21
Substitution 0.8	798	−418	380	325	1.21
Substitution 0.5	330	−529	−199	−171	1.21
Zinc from domestic old scrap only	553	−171	381	656	1.21
Displaced: EU primary and imports of 7901, weighted (2.10 t)	1,187	−326	861	738	1.21
Displaced: Nyrstar European average (1.86 t)	1,001	−370	631	540	1.21
Displaced: Nyrstar, primary feed only (1.06 t)	377	−518	−141	−121	1.21
Displaced: European average, 2018 data (2.55 t)	1,539	−242	1,297	1,111	1.21
Displaced: global average, 2021 data (3.5 t)	2,280	−67	2,213	1,896	1.21
Displaced: global average, 2018 data (3.64 t)	2,389	−41	2,349	2,012	1.21
Waelz route 3.40 t	1,110	−259	851	729	1.12
Waelz route 4.71 t	1,110	−501	609	521	1.37
Secondary refining 0.60 t	1,202	−344	858	735	1.11
Secondary refining 1.60 t	972	−344	628	538	1.35
Remelting 0.10 t	1,275	−344	931	797	1.04
Remelting 0.60 t	1,000	−344	656	562	1.32
Direct remelting 450 kt	950	−344	606	552	1.30
Direct remelting 750 kt	1,430	−344	1,086	843	1.07
Waelz route 140 kt	1,110	−260	850	764	1.08
Waelz route 240 kt	1,110	−446	664	537	1.35

Source: IGMNiR ZN-EU v1.0. In the weighted case extra-EU imports of unwrought zinc have a weight of 12% and EU primary production of 88%; imports from Norway carry the European average and other imports the global average.

7.2 Boundaries and comparability

The screening values are not comparative life-cycle assessments under ISO 14044. They answer a narrow question: by how much does a tonne of zinc from secondary materials add to the emissions of the EU zinc industry, compared with the primary tonne it may displace? The values per route come from different studies with different allocation rules; the Waelz-route value depends strongly on the zinc content of the dust, and the treatment of coke, iron-bearing slag and lead in Waelz oxide differs between studies. The results by route are therefore shown with their ranges and with the structural cases.

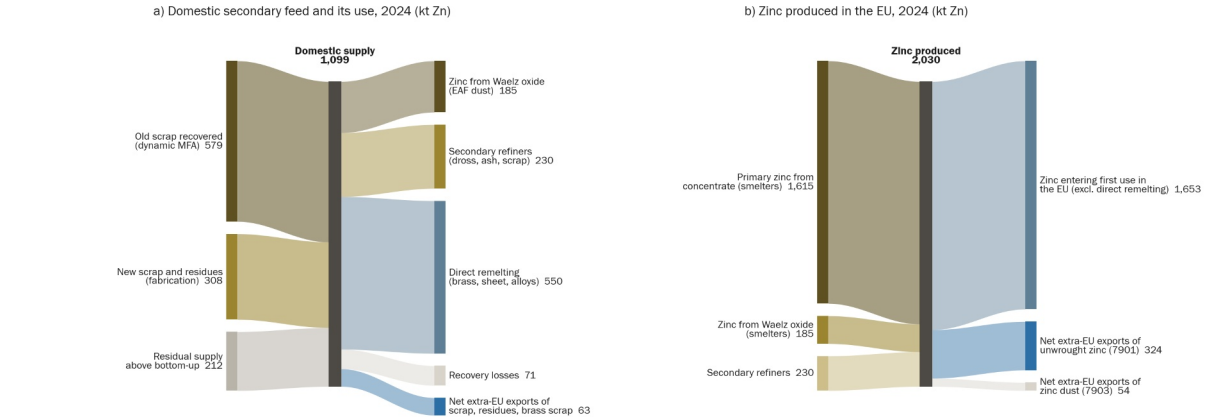
7.3 Uncertainty from the counterfactual

The emissions potentially avoided depend more on the counterfactual than on the screening values. Across the cases in Section 7.1 the headline result ranges from −200 to 2,350 kt CO_2e; the Monte Carlo band (610–1,310 kt) is narrower. With the global average as the displaced primary zinc the net result is 2,210 kt; with Nyrstar's European zinc from primary feed only it is −140 kt; with a substitution of 0.5 it is −200 kt. The sign of the net result therefore depends on the reference footprint of primary zinc.

08 Strategic contribution

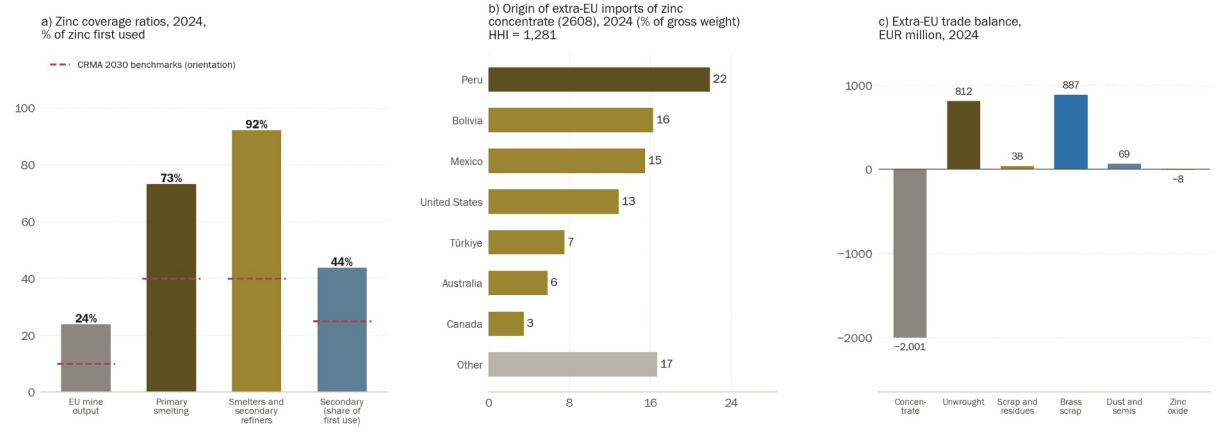
EU mines produced 527 kt of zinc in concentrate in 2024 and EU smelters 1,800 kt of refined zinc, of which 1,615 kt primary. Extra-EU imports of zinc ores and concentrates were 1,960 kt (gross weight) and exports 270 kt. The EU-27 is a net exporter of unwrought zinc: extra-EU exports of 554 kt exceeded imports of 224 kt in 2024. Zinc first used in the EU was 2,203 kt, of which 44% secondary.

FIGURE 16 Zinc flows in the EU-27, 2024



Source: IGMNiR ZN-EU v1.0 mass balance (M2) and dynamic MFA (M2b); Idoine et al. (2026); European Commission (2020); Rostek and Loibl (2025); Eurostat Comext 2024 (zinc content: CN 7902 95%, 2620 11 94%, 2620 19 25%, brass scrap 33%; CN 7901 98%). The difference between the residual and the bottom-up estimate of domestic supply is a balance residual.

FIGURE 17 Supply security indicators for zinc, 2024



Source: IGMNiR ZN-EU v1.0; Eurostat Comext (DS-045409; extra-EU trade, imports by country of origin); Idoine et al. (2026); Regulation (EU) 2024/1252, Art. 5(1). Zinc is not listed in Annex I or II of Regulation (EU) 2024/1252; the benchmarks for strategic raw materials are shown for orientation only. The secondary share relates secondary zinc to zinc first used. Smelter output includes zinc from Waelz oxide, which also counts in the secondary share. HHI: Herfindahl–Hirschman index of partner countries (0–10,000).

Zinc is neither a strategic nor a critical raw material under the Critical Raw Materials Act (CRMA); germanium and gallium, which are recovered in zinc circuits, are. The EU criticality assessment gives zinc a supply risk of 0.2 and an import reliance of 56% at extraction and 0% at processing (European Commission 2023). The table shows coverage ratios of EU output relative to EU first use; the CRMA benchmarks for strategic raw materials do not apply to zinc and are listed for reference only.

TABLE 32 Zinc coverage ratios and concentration, 2024, with the CRMA benchmarks for reference

Indicator	Zinc 2024	CRMA benchmark (not applicable)
Extraction: EU mine output / zinc first used	24%	10%
Processing: primary zinc / zinc first used	73%	40%
Processing: smelter and secondary refiners output / zinc first used	92%	40%
Recycling: secondary zinc / zinc first used	44%	25%
Largest supplier of concentrate (Peru), share of extra-EU imports	22%	65%
Largest supplier of unwrought zinc (Norway), share of extra-EU imports; share of EU first use	45%; 4.5%	65%

Source: IGMNiR ZN-EU v1.0; Regulation (EU) 2024/1252, Art. 5; Comext. Coverage ratios use output in 2024; the CRMA benchmarks refer to capacity in 2030 relative to annual EU consumption of strategic raw materials. Shares of extra-EU imports are upper values of exposure.

TABLE 33 Concentration of extra-EU zinc trade by partner country, 2024

Flow	kt, gross weight	HHI	Largest partner	Top 1, %	Top 5, %
Zinc ores and concentrates (2608), imports	1,919.8	1,281	Peru	22	74
Unwrought zinc (7901), imports	224.4	3,212	Norway	45	96
– of which ≥99.99% zinc (7901 11), imports	105.0	2,590	Norway	40	94
Unwrought zinc (7901), exports	554.5	1,090	Türkiye	26	57
Zinc ash and residues (2620 19), imports	224.2	2,372	Türkiye	44	79
Zinc waste and scrap (7902), exports	54.3	3,891	India	54	95
Zinc plates, sheets, strip and foil (7905), exports	9.6	1,395	the United Kingdom	30	69

Source: Eurostat Comext (DS-045409), reporter EU27_2020, extra-EU partners; IGMNiR ZN-EU v1.0. Totals are sums over identified partners and may differ slightly from Comext totals. HHI: Herfindahl–Hirschman index (0–10,000).

Concentrate imports are spread over several countries in the Americas and elsewhere (HHI 1,281); imports of unwrought zinc, which are small relative to EU use, come mainly from Norway. The treatment charge, the main revenue of smelters buying concentrate, fell from a benchmark of USD 274 per dry tonne of concentrate in 2023 to USD 165 in 2024 and USD 80 in 2025, the lowest level in more than five decades, before USD 85 in 2026 (Fastmarkets 2024; Bloomberg 2025; SMM 2026); China's imports of zinc in concentrate rose by 29.8% in 2025 to 2,575 kt (International Lead and Zinc Study Group 2026a).

TABLE 34 Stress indicators for the EU zinc value chain, 2024 basis

Test	Size	Relative to
Electricity +EUR 50/MWh for smelting, Waelz and refining, and semis	EUR 410 m a year	34% of GVA of Z2–Z4; smelting alone 60% of smelter GVA
Treatment charge at the 2025 benchmark	EUR 208–254 m a year	34% of smelter GVA (realised charge moved with the benchmark); upper value: benchmark to benchmark
Loss of the largest concentrate supplier (Peru)	220 kt Zn	13% of EU primary zinc output
One-month outage of the largest smelter (Asturiana de Zinc, 515 kt a year)	42.9 kt	2.4% of EU refined output
Closure of a smelter with 315 kt of capacity (Nyrstar Budel; 2024 national figure 155 kt)	315 kt	18% of EU refined output; EUR 107 m of smelter GVA at the average per tonne
Halving of zinc recovered on the Waelz route	92 kt Zn	4.2% of zinc first used; 5.1% of smelter feed
Change in net exports of zinc in scrap and residues by ±63 kt Zn	±63 kt Zn	±6.1% of zinc in the scrap feed
Zinc price +30% against the 2024 average (EUR 2,565/t), margins unchanged	EUR 2,050 m of metal and feed value bought by Z2–Z5	14.5% of output of Z2–Z5; one month of additional purchases, EUR 171 m, as a one-off need for working capital

Source: IGMNiR ZN-EU v1.0; Comext; Idoine et al. (2026). Electricity use of smelting 7,300 GWh (4.06 MWh per tonne on average). Smelter GVA at factor cost, including compensation. The tests are static and first-order: no price, margin or capacity response. The closure test uses the capacity of Nyrstar Budel (315 kt), for which a strategic review was announced in September 2026 (Nyrstar 2026).

An increase of EUR 50/MWh in the electricity price would absorb 60% of the value added of smelters at factor cost: smelters use about 7.3 TWh a year, and their value added falls to zero at an electricity price of about EUR 154/MWh with compensation and EUR 122/MWh without it. A treatment charge at the 2025 benchmark would reduce smelter value added by 34%.

TABLE 35 Strategic indicators for the EU zinc value chain, 2024

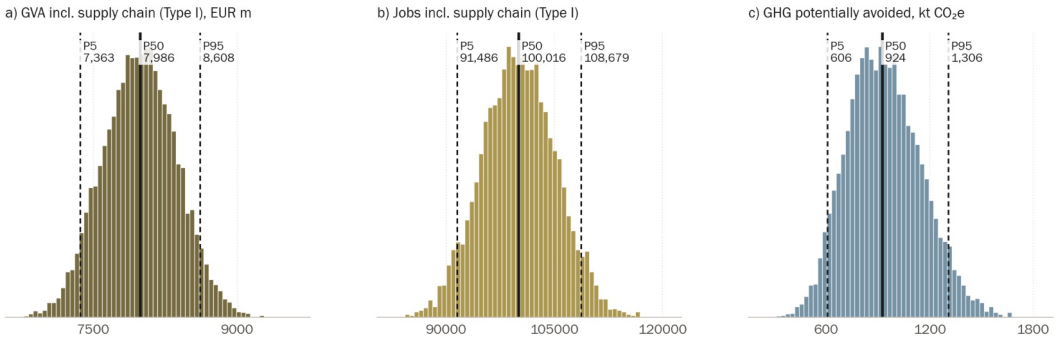
Indicator	Value	Source
Zinc in concentrate mined, kt	527	Idoine et al. (2026)
Refined zinc produced (incl. Waelz oxide), kt	1,800	compiled (Chapter 3)
Unwrought zinc used (apparent), kt	1,476	ZN-EU
Secondary zinc (all routes), kt	965	ZN-EU
Coverage ratio: domestic scrap supply / scrap used (residual; bottom-up)	106%; 86%	ZN-EU
Trade balance, zinc ores and concentrates (2608), EUR m	−2,001	Comext
Trade balance, unwrought zinc (7901), EUR m	812	Comext
Trade balance, zinc scrap, hard zinc, ash and residues (7902, 2620 11, 2620 19), EUR m	38	Comext
Trade balance, brass scrap (7404 00 91), EUR m	887	Comext
Trade balance, zinc dust, bars, sheet and other articles (7903–7907), EUR m	69	Comext
Trade balance, zinc oxide (2817), EUR m	−8	Comext

Source: IGMNiR ZN-EU v1.0; Eurostat Comext (extra-EU trade); Idoine et al. (2026). Positive balances are net exports.

09 Uncertainty, checks and limitations

The 90% band of GVA including the supply chain is EUR 7,360–8,610 million, of jobs including the supply chain 91,000–109,000 and of the emissions potentially avoided 610–1,310 kt CO_2e. The economic results depend most on the zinc-coating share of NACE 25.61, the zinc share of NACE 24.54 and the zinc value share of materials recovery; the emissions potentially avoided on the footprint of primary zinc displaced, the zinc remelted directly and the footprint of remelting. Smelter value added has the widest relative band (EUR 390–820 million) and depends most on the electricity price of smelters, the premium on smelter output and the other costs of smelters.

FIGURE 18 Monte Carlo distribution of key results



Source: IGMNiR ZN-EU v1.0, module M6; 10,000 draws, triangular distributions with Gaussian copula (Annex B), seed 20261118. Parameter-uncertainty band within the model structure, not a statistical confidence interval.

FIGURE 19 Sensitivity of results to individual parameters



Source: IGMNiR ZN-EU v1.0, module M6; one-at-a-time sensitivity on Annex B ranges; extended value chain.

TABLE 36 Robustness of the uncertainty band to the statistical design

Design	GVA Type I, EUR m (P5–P95)	Jobs Type I (P5–P95)	GHG potentially avoided, kt (P5–P95)
Reference (4,000 draws, seed 7)	7,370–8,620	92,000–109,000	610–1,300
No correlation	7,450–8,520	93,000–107,000	610–1,300
Correlation 0.95 in all groups	7,350–8,650	92,000–109,000	610–1,300
PERT distributions	7,420–8,570	93,000–108,000	580–1,160

Source: IGMNiR ZN-EU v1.0, module M6. Separate test design (4,000 draws, seed 7) compared with the headline run (10,000 draws, seed 20261118). Convergence: with other seeds and 20,000 draws the percentiles of the key results change by at most 1.4%.

TABLE 37 Structural tests of the economic results

Case	GVA Z0–Z5, EUR m	GVA Type I, EUR m	Jobs Type I	GVA Z3, EUR m	Taxes, EUR m
Central case	4,470	7,990	100,000	610	2,690
Supply-chain effects −20%	4,470	7,290	92,000	610	2,470
Supply-chain effects +20%	4,470	8,700	109,000	610	2,920
EU-27 SIOT 2023	4,470	8,020	100,000	610	2,640
Narrow first round	4,470	7,360	92,000	610	2,470
Z4 ratio, low	4,370	7,960	101,000	610	2,710
Z4 ratio, high	4,610	8,030	99,000	610	2,670
Compensation, low	4,430	7,960	100,000	580	2,690
Compensation, high	4,520	8,040	100,000	660	2,700
No compensation	4,240	7,760	100,000	380	2,670
Coating share, low	4,170	7,520	93,000	610	2,520
Coating share, high	4,670	8,310	105,000	610	2,810
Casting share, low	4,280	7,610	95,000	610	2,560
Casting share, high	4,650	8,370	106,000	610	2,830
Z1 by employment key	4,390	7,850	100,000	610	2,660
Basic prices	4,530	8,050	100,000	620	2,690
All keys low, chain −20%	3,410	5,490	71,000	610	1,910
All keys high, chain +20%	5,520	10,950	135,000	610	3,610

Source: IGMNiR ZN-EU v1.0. The metal-purchase variant, which double-counts metal bought within the chain, is not shown. Without compensation, value added falls by the amount of compensation, supply-chain jobs are unchanged and taxes fall with the lower operating surplus.

TABLE 38 Parameter-uncertainty band and range of structural cases

Result	P5	P95	Structural minimum	Structural maximum
GVA Type I, EUR m	7,360	8,610	5,490	10,950
Jobs Type I	91,000	109,000	71,000	135,000
GHG potentially avoided, kt CO_2e	610	1,310	−200	2,350

Source: IGMNiR ZN-EU v1.0. The Monte Carlo band is conditional on the model structure: it does not cover errors of data classification or choices of system boundary, which the structural cases illustrate. The two ranges are not combined into one probability interval; the double-counting variant is excluded.

9.1 Consistency checks

TABLE 39 Consistency checks of the ZN-EU model

Check	ZN-EU value	Reference	Reference source	Independent of model parameters
Refined zinc: model central value vs sum of country data (BGS), kt	1,800	1,989	Idoine et al. (2026)	no
Secondary share of first use vs recycling input rate (Europe incl. UK, NO, CH)	44%	49% (46–51%)	Rostek and Loibl (2025)	no
Old-scrap ratio vs published value	50%	70%	Rostek and Loibl (2025)	partly
Stock in use 2020, kg per person	109	≈130	Rostek and Loibl (2025)	partly
End-of-life recycling rate	38%	53% (49–58%)	Rostek and Loibl (2025)	partly
Zinc first used (model) vs European demand 2020 (wider Europe), kt	2,203	2,800	Gregoir and Van Acker (2022)	yes
Concentrate account: zinc in concentrate available / primary zinc output (Chapter 3)	84%	100%	Comext; BGS	yes

Check	ZN-EU value	Reference	Reference source	Independent of model parameters
EAF dust implied by the Waelz route vs EAF steel × 10–30 kg/t, kt	840	580–1,730	EUROFER (2025); Remus et al. (2013)	no
Zinc segments Z2–Z4, share of 24.43 value added, vs share of zinc in PRODCOM value	69%	59%	Eurostat SBS; PRODCOM	yes
Lead and tin remainder of 24.43: GVA per person vs class average, EUR k	104	117	Eurostat SBS	by construction
Zinc coating (Z5) persons vs general galvanizing employees in Europe	32,800	40,000	EGGA (2024)	no
Employment of the total EU-27 economy reproduced by FIGARO coefficients, million (construction check)	219	219	nama_10_a64_e	by construction
GVA Type I with the EU-27 SIOT vs FIGARO, %	0.4	0	naio_10_cp1700	yes
Monte Carlo convergence, max. change of percentiles, %	1.4	–	seeds 1, 2, 3; 20,000 draws	–
Replication from package files, max. absolute difference	0.001	0	replication script	–

Source: IGMNiR ZN-EU v1.0. “No” marks comparisons with data used to set the model parameters: refined output is set between the estimate based on ILZSG data and the sum of BGS country data; the volumes of the secondary routes are set with published recycling indicators in view; the Waelz route is derived from EAF steel and dust data; the zinc-coating share uses the EGGA employment figure. “Partly” marks dynamic-model results that use lifetimes and recovery rates from the same source. The employment check is in millions. European demand refers to a wider region than the EU-27.

9.2 Limitations

- **SBS gap filling.** EU-27 aggregates of the SBS are rounded and partly confidential; missing cells were completed from Member State sums or earlier ratios (status E).
- **Allocation keys.** The zinc shares of NACE 07.29, 46.77, 38.3, 25.61 and 24.54 and the employment keys within 24.43 are assumptions (class C) not checked against company accounts; the keys assume equal personnel cost per person within 24.43.
- **Possible double counting.** Waelz plants may be registered in NACE 38.3 and thus partly also in Z1; zinc dust and secondary alloys may appear both in the output of secondary refiners (Z2) and in the PRODCOM output of Z4.
- **Physical valuation.** Z2 and Z3 output is gross metal value at 2024 prices; PRODCOM unit values of unwrought zinc are below the LME price and the output of Z2–Z4 exceeds the SBS output of 24.43; the published data do not explain these differences.
- **Compensation.** Z3 value added at factor cost includes EUR 230 million of compensation of indirect emission costs, of which amounts for the Netherlands, Italy and Bulgaria are estimated.
- **Refined and secondary output.** Refined output differs between the BGS and an estimate based on ILZSG data; the volumes of the three secondary routes are not published and are estimates.
- **Scrap balance.** The residual and bottom-up estimates of domestic scrap supply differ by 212 kt (90% band 127 to 345 kt); EAF dust and Waelz oxide have no specific trade codes.
- **Dynamic model.** Product groups combine European first uses with lifetimes from a model for the wider European region; the inflow path before 2024 is assumed; recovery from galvanized steel is bounded through EAF dust; exports of used vehicles and corrosion losses of coatings are not represented.
- **Prices and margins.** Value added reflects zinc prices, treatment charges, energy prices and margins of 2024; the model has no price or margin response.
- **Fiscal and environmental modules.** Labour taxes use the EU-27 implicit tax rate on labour and corporate tax a statutory average; footprints are screening values from different studies, and the result depends on the displaced primary zinc and on the footprint of the Waelz route.

10 Scenarios to 2035

The scenarios are illustrative combinations of assumptions, not forecasts. They keep 2024 prices and input-output coefficients and change volumes, footprints and labour productivity (+1.0% a year, applied to all jobs). Old scrap recovered follows the dynamic model, independently of the activity assumed. S1 (2030) and S2 (2035) assume more secondary zinc and stable or rising smelter activity; S3 (2030) is a stress scenario with a quarter less smelter activity, lower mining and less secondary zinc. Primary smelter output follows the smelter index and zinc from Waelz oxide follows the secondary routes. First use follows the activity of the users of zinc (65% coating and die-casting, 35% rolled zinc, dust and alloys), and net trade in unwrought zinc (CN 7901) closes the balance. The weights are an IGMNiR assumption based on the first uses in the dynamic model: galvanizing and die-casting take 67% of the inflow; brass and zinc compounds (27%) have no segment of their own and are assigned to the index of rolled zinc, dust and alloys.

TABLE 40 Scenario assumptions (change versus 2024)

Driver	S1 2030	S2 2035	S3 2030
Waelz route and secondary refiners (Z2)	+10%	+25%	−10%
Direct remelting of scrap	+8%	+18%	−8%
Scrap collection and trade (Z1)	+6%	+15%	−8%
Zinc mining (Z0)	0%	0%	−20%
Primary zinc smelting (Z3)	0%	+5%	−25%
Rolled zinc, dust and alloys (Z4)	+3%	+6%	−8%
Zinc coating and die-casting (Z5)	+3%	+6%	−5%
Footprint of primary zinc	−5%	−15%	−5%
Footprint of secondary zinc	−15%	−30%	−5%
Resulting change in refined zinc output (primary and Waelz zinc)	+1%	+7%	−23%

Source: IGMNiR ZN-EU v1.0. The Waelz route and secondary refiners are limited to 520 kt and direct remelting to 850 kt of zinc. Additional scrap feed has a lower yield and a higher footprint.

TABLE 41 Zinc balance in the scenarios (kt Zn)

Item	2024	S1 2030	S2 2035	S3 2030
Primary zinc produced by smelters	1,615	1,615	1,696	1,211
Zinc from Waelz oxide	185	204	231	166
Refined zinc produced by smelters	1,800	1,818	1,927	1,378
Secondary refiners	230	253	288	207
Direct remelting	550	594	649	506
Zinc first used (follows the users)	2,203	2,269	2,335	2,070
Net imports of unwrought zinc, CN 7901 (closing item; negative = net exports)	−324	−343	−475	32
Old scrap recovered (dynamic model)	579	594	603	594
Additional zinc in scrap feed vs 2024	0	101	239	−92
Additional domestic scrap vs 2024	0	24	43	−4
Additional feed not covered by additional domestic scrap	0	76	196	−88

Source: IGMNiR ZN-EU v1.0. Negative values of the uncovered feed mean that additional domestic scrap exceeds the additional feed. In 2024 net extra-EU exports of zinc in scrap and residues were 63 kt and gross exports 174 kt.

In S1 direct value added rises to EUR 4,600 million and in S2 to EUR 4,800 million; in S3 it falls to EUR 4,020 million. Refined zinc output changes by +1% in S1, +7% in S2 and −23% in S3. Employment including the supply

chain, adjusted for productivity, is about 98,000 in S1, 96,000 in S2 and 87,000 in S3, against 100,000 in 2024. The emissions potentially avoided are 880 kt CO_2e in S1, 860 kt in S2 and 670 kt in S3. In S2 the additional scrap feed is larger than the growth of domestic old and new scrap by about 196 kt of zinc. Net imports of unwrought zinc (negative values are net exports) move from −324 kt in 2024 to −343 kt in S1, −475 kt in S2 and 32 kt in S3, where the EU becomes a net importer of unwrought zinc.

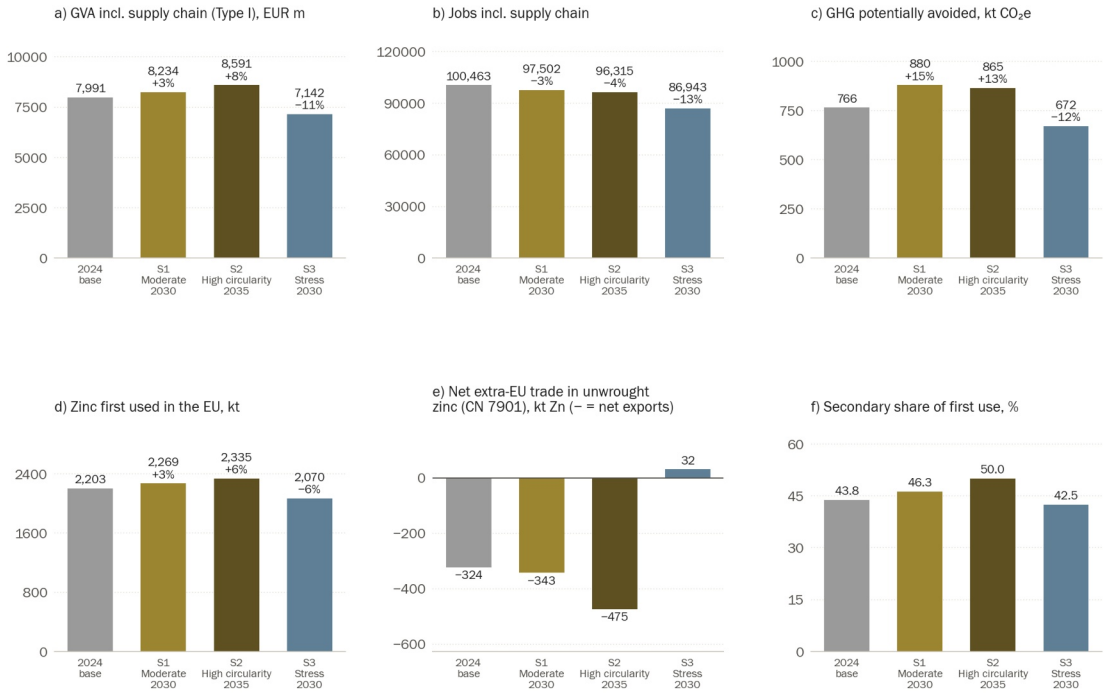
Published outlooks place these assumptions in context. A study for Eurometaux expects European zinc demand of 2.8 Mt in both 2020 and 2050, with the energy transition adding 11%, mainly in electric vehicles and solar power (Gregoir and Van Acker 2022). Recycling already supplies 40–55% of Europe's aluminium, copper and zinc according to the same study.

TABLE 42 **Decomposition of the change in emissions potentially avoided from 2024 to scenario S2, kt CO_2e**

Step	Result	Change
2024 base	766	
More secondary zinc (volume)	896	130
Lower-grade marginal feed	858	−37
Cleaner secondary routes	1,215	357
Cleaner displaced primary zinc	865	−350

Source: IGMNiR ZN-EU v1.0; sequential decomposition, order as listed. A cleaner displaced primary zinc lowers the emissions potentially avoided; cleaner secondary routes raise them, mainly through the Waelz route.

FIGURE 20 **Scenario results: change versus 2024**



Source: IGMNiR ZN-EU v1.0; 2024 prices; assumptions in the scenario table; labour productivity +1% a year; footprints of all routes decline over time. Net trade in e) closes the balance of unwrought zinc in each scenario.

The scenarios have no feedback between scrap prices, treatment charges, energy prices and capacity use, and they do not show that the volumes are economically feasible. Not modelled are: the supply of EAF dust, which depends on the route of EU steelmaking; the zinc content of the dust; the availability of electricity for smelters at competitive prices; and trade policy.

11 Summary

In 2024 the EU-27 mined 527 kt of zinc in concentrate, smelted about 1,800 kt of refined zinc and produced about 965 kt of secondary zinc, and it exported, net, 324 kt of unwrought zinc to countries outside the EU. The extended zinc value chain – from mining through scrap trading, Waelz kilns and secondary refining, smelting, rolled zinc, dust and alloys to galvanizing and die-casting – generated about EUR 4.5 billion of direct value added and employed about 57,000 people; with its EU supply chain it supported EUR 8.0 billion of value added and about 100,000 jobs, and about EUR 2.7 billion of taxes and contributions excluding VAT. Zinc coating and die-casting account for 52% of the direct value added.

Secondary zinc – about 185 kt from Waelz oxide, 230 kt from secondary refiners and 550 kt remelted directly – supplied 43.8% of zinc first used in the EU. Value added of zinc smelting at factor cost is EUR 610 million (90% band EUR 390–820 million), of which EUR 230 million is compensation of indirect emission costs; the amounts recorded for zinc producers, about EUR 200 million, are 33% of it. Electricity dearer by EUR 50 per MWh would raise the costs of smelters by about EUR 370 million a year. The zinc stock in use is compared with, not calibrated to, published estimates; recovery from galvanized steel is bounded by the zinc in dust of electric-arc furnaces processed in the EU. The zinc stock in use is about 49 Mt (110 kg per person); end-of-life products released about 1,780 kt of zinc in 2024, of which about 580 kt was recovered in the EU. Net exports of zinc in scrap and residues were about 63 kt.

Replacing primary zinc one-for-one at the European average footprint, secondary zinc produced in the EU in 2024 potentially avoided 1.1 Mt CO_2e through remelting and secondary refining and added 0.34 Mt through the Waelz route, whose footprint under the adopted boundaries exceeds that of European primary zinc; the net result is 0.77 Mt, and across the counterfactuals it ranges from −0.2 Mt (a net increase) to about 2.3 Mt CO_2e. EU mines correspond to 24%, EU primary smelting to 73% and all zinc produced by EU smelters and secondary refiners to 92% of zinc first used in the EU; in scenario S2 (2035) secondary zinc reaches 1,170 kt.

Three features of the results follow from the data available. More than half of direct value added (52%) comes from galvanizing and die-casting, whose zinc shares are set by allocation keys. The secondary share of 43.8% rests on volumes from the literature and does not close with the stock model (residual 212 kt). The sign of the emissions potentially avoided depends on the reference footprint of primary zinc: from −0.14 Mt against European zinc from primary feed only to 2.2 Mt against the global average.

A Data sources

TABLE 43 Main data sources of the ZN-EU model

Domain	Source	Use in ZN-EU
Structural business statistics	Eurostat (2026b): sbs_ovw_act, EU-27 and member states, 2021–2024	Output, value added, employment, labour costs, turnover (07.29, 24.43, 24.54, 25.61, 46.77, 38.3); missing EU cells completed from member-state sums and earlier ratios
Production and trade	Eurostat (2026b): PRODCOM (DS-059358), 2019–2024; Comext DS-045409, reporter EU27_2020, 2015–2025	Unwrought zinc and alloys, zinc dust, rolled zinc, lead and tin products of 24.43, non-ferrous castings, zinc coating services, zinc oxide; extra-EU trade in CN 2608, 2620 11, 2620 19, 2817, 7901–7907, 7404 00 91 and 7204, partners, unit values
Input-output and national accounts	Eurostat (2026a): FIGARO naio_10_fcp_ip4, 2024, aggregated to the EU-27 block; EU-27 symmetric table of Eurostat (naio_10_cp1700, 2023) as validation; nama_10_a64(_e)	Intra-EU coefficients, value added, household demand; employment
Mines and smelters	Idoine et al. (2026), World Mineral Production 2020–24; International Lead and Zinc Study Group (2026a, 2026b); U.S. Geological Survey (2026); company reports: Boliden (2025, 2026), Lundin Mining (2024, 2025), Sandfire Resources (2024, 2025), Eldorado Gold (2025), Glencore (2025), Nyrstar (2024a, 2024b, 2026)	Zinc in concentrate and refined zinc by member state and plant; closures, restarts and reviews of smelters
Secondary zinc and steel dust	Befesa (2024, 2025); EUROFER (2025); Remus et al. (2013); Cusano et al. (2017); European Commission (2020)	Waelz capacity and throughput; EAF steel; dust generation and zinc content; residues
Stocks, flows and recycling	Rostek and Loibl (2025); Rostek (2025); Rostek et al. (2022); Meylan and Reck (2017); Graedel et al. (2011); European Commission (2020, 2023); International Zinc Association (2026); Gregoir and Van Acker (2022); Eurostat demo_gind and proj_23np	End-use shares, lifetimes, recovery rates, recycling indicators, demand outlook, stock for calibration; population
Policy, taxes and public support	EUR-Lex: Directive 2003/87/EC, Delegated Decision (EU) 2019/708, Delegated Regulation (EU) 2019/331, Implementing Regulations (EU) 2021/447 and 2026/1412, Regulations (EU) 2023/956 and 2024/1252; European Commission (2025b, 2025d, 2026d); compensation of indirect emission costs: DEHSt (2025, 2026), Ministerio de Industria y Turismo (2025), Energiavirasto (2025), Urząd Regulacji Energetyki (2025), Rijksdienst voor Ondernemend Nederland (2026); European Commission, DG TAXUD (2026)	Legal framework; free allocation; compensation of indirect emission costs; tax rate on labour
Prices and exchange rates	World Bank (2025), Pink Sheet; European Central Bank (2026)	LME zinc price 2024 in USD; EUR/USD annual average
Energy and emissions	European Environment Agency (2026); Union Registry verified emissions (European Commission 2026c); International Zinc Association (2023; 2022); Nyrstar (2023); Grund and van Genderen (2024); Rinne et al. (2022); Van Genderen et al. (2016); Kantamaneni et al. (2021)	Grid factor; footprints of primary zinc, the Waelz route and remelting; electricity of electrolysis; verified emissions of installations

Data as available on 31 October 2026; company reports and registers as available on 10 November 2026.

TABLE 44 Structural business statistics of the industries used, EU-27, 2024

NACE Rev. 2	Segment	Output, EUR m	Value added, EUR m	Persons employed, thousand	Personnel costs, EUR m	Turnover, EUR m
07.29 Mining of other non-ferrous metal ores	Z0	11,740 (0)	6,586 (0)	43.6 (E)	2,123 (E)	12,686 (0)
46.77 Wholesale of waste and scrap	Z1	16,023 (0)	7,688 (0)	120.0 (0)	3,737 (0)	68,196 (0)
38.3 Materials recovery	Z1	80,000 (0)	18,000 (0)	273.0 (0)	10,668 (E)	90,000 (0)
24.43 Lead, zinc and tin production	Z2–Z4	7,858 (0)	1,771 (0)	15.1 (0)	890 (0)	8,836 (0)
24.54 Casting of other non-ferrous metals	Z5	4,151 (0)	1,221 (0)	18.7 (0)	837 (0)	4,287 (0)
25.61 Treatment and coating of metals	Z5	41,000 (0)	16,700 (0)	290.0 (0)	11,700 (0)	43,000 (0)

Source: Eurostat sbs_ovw_act (EU27_2020 and member states), as available on 31 October 2026. 0 – published EU value; E – estimate: missing EU cell completed from the sum of reporting member states scaled by employment, from the output/turnover ratio or from the personnel-cost share of an earlier year (mining: persons employed from personnel costs per person in NACE B). Segments use the zinc shares of these industries (Annex B).

TABLE 45 First-round demand within the EU by segment and product group, 2024 (EUR m)

Product group (CPA)	Z0	Z1	Z2	Z3	Z4	Z5
Electricity, gas, steam	40	24	41	506	70	164
Coke and refined petroleum	16	10	9	25	15	31
Chemicals	12	9	10	30	17	65
Rubber and plastics	3	6	4	12	7	53
Other non-metallic minerals	10	4	6	16	9	34
Transport and storage	51	57	31	90	53	159
Repair and installation	26	10	13	37	22	68
Fabricated metal, machinery	15	19	30	88	52	606
Professional and support services	80	134	32	91	54	270
Motor-vehicle trade and retail trade	18	20	10	30	18	76
Other products	79	148	41	118	70	359
Total first-round demand within the EU	351	440	226	1,043	388	1,885
Non-chain intermediate consumption, all origins	391	473	259	1,141	444	2,111
First round within the EU relative to the row above	90%	93%	87%	91%	87%	89%

Source: IGMNiR ZN-EU v1.0; FIGARO 2024 aggregated to the EU-27 block (intra-EU and all-origin coefficients). For Z0 and Z1 the first round equals the intra-EU input coefficients of the parent products (CPA_B, CPA_G46, CPA_E37-39), with purchases within the chain removed, times output; for Z2, Z4 and Z5 purchases of metals, ores, oxides, residues and scrap (the zinc share of output) are removed and the remaining intermediate consumption is spread with the all-origin structure of CPA_C24 (zinc coating: CPA_C25). For Z3 concentrates and Waelz oxide are excluded and electricity enters the first round as a non-chain input.

TABLE 46 Specification of the input-output module

Element	Specification
Table	Eurostat FIGARO, product-by-product, 2024 (naio_10_fcp_ip4, edition of July 2026), downloaded for each of the 27 member states as destination and aggregated: deliveries from any member state count as domestic (origin EU), deliveries from outside the EU as imports; 64 CPA products. Validation with the EU-27 symmetric table of Eurostat (naio_10_cp1700, 2023).
Multipliers	Type I: $L = (I - A_{EU})^{-1}$; Type II: households endogenised – labour income × (1 – tax rate on labour) × propensity to consume, spent with the household consumption structure of products made in the EU
Employment	Persons employed 2024 (nama_10_a64_e, EU27_2020) per unit of output of the table, by CPA product; where 2024 is published only for the NACE section, the 2023 detail is scaled by the 2023–2024 change of its section. Applied to the FIGARO output the coefficients give 219 thousand persons against 219 thousand in national accounts.
Z0 and Z1 first round	Intra-EU input coefficients of CPA_B (07.29), CPA_G46 (46.77) and CPA_E37-39 (38.3) excluding chain products, times the output of the zinc share; structural test: all SBS intermediate consumption spread over the parent column

Element	Specification
Z2, Z4, Z5 first round	Non-metal intermediate inputs = output − GVA − zinc share × output; spread with the all-origin structure of CPA_C24 (zinc coating: CPA_C25) excluding metals, ores, oxides, residues and scrap; the part produced in the EU enters the Leontief model
Z3 first round	Zinc concentrates and Waelz oxide (chain inputs) excluded; electricity costed explicitly (MWh per t of zinc × price) and entered as CPA_D35 at the EU-origin share of the CPA_C24 column; other inputs = output − GVA − zinc-bearing feed − electricity, spread with the CPA_C24 structure without D35
Value added	Z0, Z1 and Z5 from structural business statistics (value added at factor cost) and zinc shares; Z2 from its cost structure, with output valued physically (zinc in Waelz oxide at a share of the LME price, secondary zinc at the LME price, gate fees for dust); Z3 from a cost build-up of smelters (treatment charge, free metal, premium and by-products less electricity and other non-chain costs, plus compensation of indirect emission costs as an operating subsidy); Z4 as a value-added ratio times output from PRODCOM; indirect and induced value added at basic prices (FIGARO); conversion of direct value added to basic prices with FIGARO net other taxes on production as a structural test
Taxes	Implicit tax rate on labour of the EU-27 × labour cost; corporate income tax at the EU-27 average statutory rate (21.8%, IGMNiR estimate, class C) × taxable share of operating surplus; net taxes on production and on products used from FIGARO coefficients, net of other subsidies; VAT excluded

Model package. The ZN-EU package archived by IGMNiR contains the model modules M1–M6 and M2b (Python), all input data with extraction dates and dataset codes, the parameter file with sources and ranges (Annex B), scenario definitions, automated consistency checks and the run log. Machine-readable files accompany each run: results by segment, first-round demand vectors, the zinc balance, the smelter cost build-up, compensation of indirect emission costs and verified emissions, Monte Carlo draws and percentiles, structural cases, scenario results and the stock model series. The run identifier (ZNEU-1.0-fc03a4ecad) is a hash of the parameters, code and input data; the random-number seed is fixed.

TABLE 47 Input data files of the model package

File	Content	Size, KB	SHA-256 (first 16 characters)
comext_eu_extra.csv	Comext, extra-EU trade in zinc ores, residues, oxide, unwrought zinc, scrap and products	43	15d39e9127dc9189
comext_eu_extra_aux.csv	Comext, extra-EU trade in brass scrap (CN 7404 00 91) and ferrous scrap (CN 7204)	15	40c8deed03ce91e0
comext_eu_intra.csv	Comext, intra-EU trade in zinc ores, residues, unwrought zinc and products	16	1b7de9929f499c53
comext_eu_partners.csv	Comext, trade by partner country	411	b496624a41c34167
figaro_eu_2024.csv	FIGARO 2024 (naio_10_fcp_ip4) aggregated to the EU-27 block	453	1592e127348e2772
nama_emp.csv	Employment by industry, EU-27 (nama_10_a64_e)	14	9de1201f70535eca
nama_gva.csv	Output and value added by industry, EU-27 (nama_10_a64)	32	87635fdbae4cec3e
pop_eu.csv	Population on 1 January (demo_pjan)	2	b1c030433a387315
pop_eu_gind.csv	Population on 1 January, 1960–2026 (demo_gind)	1	d482e1492f5f2cdf
popproj_eu.csv	Population projections EUROPOP2023 (proj_23np)	0	cae7ca1b1e6f1238
prodcom_eu.csv	PRODCOM, zinc products, non-ferrous castings, zinc coating and zinc oxide, EU-27 (DS-059358)	8	436c9240d8bb0b20
prodcom_eu_2443.csv	PRODCOM, all products of NACE 24.43 (lead, zinc, tin) and zinc oxide, 2022–2024	3	6c9e767e5bd86ca8
sbs_eu.csv	Structural business statistics, EU-27 and member states (sbs_ovw_act)	467	39ecc65a45082fc9
siot_eu.csv	Symmetric input-output table of the EU-27, Eurostat (naio_10_cp1700), 2021–2023	2,566	784ea53d739d887b
siot_eu_2023.csv	Same table, 2023, converted to the FIGARO layout (validation)	385	adb811bad14e15c6

Source: IGMNiR ZN-EU v1.0, package file 09 (full hashes of code, data and results). Eurostat data as available on 31 October 2026.

Reference run. All results in this report correspond to run ZNEU-1.0-fc03a4ecad. **Replication.** The package runs with Python 3 (numpy, pandas, scipy, matplotlib, pypdf), Node.js with the docx library and LibreOffice. The command bash build_all.sh recomputes the model, the Monte Carlo runs, the figures and the EN and PL reports; bash build_all.sh --no-mc reuses the stored Monte Carlo results. The download script eu_download.py retrieves the Eurostat inputs (the FIGARO extraction is downloaded country by country and aggregated). The replication script reproduces the central results from the package files and reports the largest absolute difference.

B Parameters and uncertainty ranges

Each uncertain parameter is described by a triangular distribution (low, central, high) within one dataset family; alternative datasets, boundaries, split keys and footprints are treated as structural cases (Chapters 5, 7 and 9). Reliability classes: A – official statistics, scientific literature or company financial statements; B – industry or company data; C – IGMNiR assumption or derived value. Quantities are in kt of zinc content unless stated otherwise.

TABLE 48 ZN-EU parameters

Parameter	Central	Low	High	Class	Basis and source
Zinc share of 07.29	0.085	0.060	0.110	A/C	zinc share of NACE 07.29 (mining of other non-ferrous metal ores) in the EU-27: 527 kt Zn in concentrate in 2024 (Idoine et al. 2026, without Poland) × net value to the mine of ≈EUR 1,900/t Zn (payable 85% of LME less treatment charge) against 07.29 output of EUR 11.7 bn; most mines are polymetallic
Zinc value share, 46.77	0.020	0.012	0.030	C	zinc share of the value of NACE 46.77 (wholesale of waste and scrap) in the EU-27: non-ferrous share ≈0.40 × zinc share of non-ferrous scrap and residue value ≈0.05; zinc in brass scrap is traded as copper scrap
Zinc employment share, 46.77	0.015	0.008	0.025	C	zinc share of employment in NACE 46.77
Zinc value share, 38.3	0.012	0.006	0.020	C	zinc share of the value of NACE 38.3 (materials recovery): galvanizing residues, zinc-bearing dusts and sludges, shredder fractions
Zinc employment share, 38.3	0.010	0.005	0.016	C	zinc share of 38.3 employment
Zinc share of 24.43 value added (check only)	0.620	0.550	0.700	A/C	zinc share of the value added of NACE 24.43 (lead, zinc and tin production), used only to check the lead and tin remainder: PRODCOM 2024 zinc products EUR 5,273 m of EUR 8,975 m for all 24.43 products (0.59); ≈0.64 with unwrought zinc valued at the LME price
Waelz kilns and secondary refiners, share of 24.43 employment	0.120	0.080	0.160	C	Waelz kilns and secondary zinc refiners (distillation, remelting of dross and ash, zinc dust and oxide from residues), share of persons employed in NACE 24.43 (15,136): ≈1,200–2,400 persons; some plants may be registered in NACE 38.3 or 20.12

Parameter	Central	Low	High	Class	Basis and source
Zinc smelters without lead lines, share of 24.43 employment	0.330	0.270	0.400	C	zinc smelters (electrolytic plants and the Imperial Smelting furnace at Miasteczko Śląskie), share of persons employed in NACE 24.43, without lead lines of integrated plants: ten plants, ≈4,000–6,000 persons
Rolled zinc, dust and alloys, share of 24.43 employment	0.200	0.150	0.250	C	producers of rolled zinc, zinc dust and zinc alloys outside the smelters, share of persons employed in NACE 24.43
Zinc-bearing inputs, share of Z2 output	0.450	0.300	0.600	C	zinc-bearing scrap, residues and oxides as share of the output value of Waelz kilns and secondary refiners; EAF dust is taken in against a gate fee
Other inputs, share of Z2 output	0.280	0.200	0.360	C	non-chain inputs of Waelz kilns and secondary refiners (coke, natural gas, electricity, lime, services) as share of output value
Value of zinc in Waelz oxide relative to LME	0.650	0.550	0.750	C	value of zinc in Waelz oxide and other secondary oxides sold to smelters relative to the LME price
Gate fee for EAF dust, EUR/t of dust	30.0	0.0	60.0	C	gate fee received for EAF dust, EUR per t of dust (not published)
Treatment charge, EUR/t of zinc	250	180	305	B/C	realised treatment charge of EU smelters 2024, EUR per t of zinc: annual benchmark USD 165/dmt (2023: 274; 2025: 80) ≈EUR 305 per t of zinc at 51.7% Zn and 96.5% recovery; part of the feed is bought on lower spot terms (Fastmarkets 2024; Bloomberg 2025)
Free metal relative to LME	0.120	0.100	0.130	C	free metal: zinc recovered above the payable share of concentrate zinc (payable 85% or zinc content less 8 points; recovery ≈96–97%), relative to the LME price
Premium and alloy value relative to LME	0.060	0.030	0.100	C	regional premium for special high grade zinc and value of alloys relative to the LME value of smelter output
By-products, EUR/t of zinc	110	60	180	C	by-products per t of zinc from concentrate: sulphuric acid ≈1.8 t per t of zinc, silver-lead residues, cadmium, copper cement, germanium and indium, EUR
Electricity of electrolytic smelting, MWh/t	4.17	3.99	4.39	A	electricity of electrolytic zinc smelting, MWh per t of zinc: nine EU roast-leach-electrowin plants 2017–2019, weighted average 4,167 kWh/t, range 3,994–4,393 (Kantamaneni et al. 2021); electricity consumption efficiency benchmark 3.994 MWh/t (ETS State aid Guidelines, Annex II)

Parameter	Central	Low	High	Class	Basis and source
Electricity cost of smelters, EUR/MWh	70.0	50.0	95.0	C	average electricity cost of EU zinc smelters 2024, EUR/MWh, before compensation of indirect emission costs
Other non-chain costs of smelters, EUR/t	350	270	430	C	other non-chain costs of smelters per t of zinc: reagents, oxygen, maintenance, services, transport, insurance, EUR; with electricity and personnel costs, conversion costs of ≈EUR 800 per t of zinc
Share of zinc alloys made outside smelters	0.500	0.300	0.700	C	share of the PRODCOM value of zinc alloys produced outside the smelters (alloyers and remelters)
Zinc share, rolled zinc, dust and alloys	0.600	0.500	0.700	A/C	zinc share of the output value of rolled zinc, zinc dust and zinc alloys
Value added / output, rolled zinc, dust and alloys	0.180	0.130	0.250	C	value added / output of rolled zinc, zinc dust and zinc alloys made outside the smelters, below the 24.43 average of 0.23
Compensation of indirect emission costs, smelters, EUR m	230	195	280	A/C	compensation of indirect emission costs recognised by EU zinc smelters for 2024, EUR m (operating subsidy, part of value added at factor cost): recorded for smelters EUR 170 m (Spain, Belgium, Germany, France, Finland) plus NACE 24.43 in Poland (EUR 30 m, incl. lead and tin) and the Netherlands, Italy and Bulgaria, not published
Zinc-coating share of 25.61	0.113	0.095	0.125	A/B	zinc-coating share of NACE 25.61 (treatment and coating of metals): PRODCOM 2024 hot-dip galvanizing (incl. tin dipping) EUR 3,138 m and electrolytic zinc coating EUR 1,500 m of 25.61 output EUR 41.0 bn (0.113); European General Galvanizers Association (EGGA): ≈40,000 employees in Europe incl. Türkiye and the UK; continuous strip galvanizing in steelworks (NACE 24.10) not included
Zinc share, zinc coating	0.280	0.220	0.340	A/C	zinc share of the output value of zinc coating: ≈470 kt of zinc in general galvanizing (≈6.7 Mt of steel at ≈70 kg Zn per t, Galvanizers Association 2025; Kopf 2025) and ≈30 kt in electrogalvanizing × EUR 2,600/t against EUR 4.6 bn
Zinc-alloy share of 24.54	0.350	0.200	0.500	C	zinc-alloy share of NACE 24.54 casting of other non-ferrous metals (rest mainly copper alloys)
Zinc share, zinc die-castings	0.250	0.180	0.330	C	zinc-alloy share of the output value of zinc die-castings

Parameter	Central	Low	High	Class	Basis and source
Refined zinc produced by EU smelters, kt	1,800	1,720	1,860	A/C	refined zinc produced by EU smelters in 2024, incl. zinc from Waelz oxide: Idoine et al. (2026) member-state sum 1,989 kt with Belgium 480 kt (2023: 250 kt; with 250 kt the sum is 1,759 kt); European output of the International Lead and Zinc Study Group (2026a) less Norway and Russia ≈1,800 kt; PRODCOM unwrought non-alloy zinc 1,466 kt plus alloys 741 kt (gross)
Zinc from Waelz oxide recovered in smelters, kt	185	140	240	A/C	zinc recovered in EU smelters from Waelz oxide and other secondary oxides, kt, incl. kilns operated within smelters: EU EAF steel 57.8 Mt (EUROFER 2025) × 10–30 kg dust per t of liquid steel × 21–43% Zn for carbon-steel dust, 18–35% in dust treated (Remus et al. 2013); all EAF dust produced in Europe is recycled (European Commission 2020); dust treated by Befesa group 1,211 kt in 2024, incl. plants outside the EU (Befesa 2025)
Secondary zinc from refiners outside smelters, kt	230	150	320	A/C	secondary zinc from refiners outside the smelters (refined and remelted zinc and alloys from dross, ash and scrap, zinc dust and oxide from residues), kt; secondary refining in Europe incl. UK, Norway and Switzerland ≈430 kt incl. Waelz oxide (Rostek and Loibl 2025)
Zinc in scrap remelted directly, kt	550	450	750	A/C	zinc in scrap remelted directly without refining (brass mills, rolled zinc, die-casting alloys, galvanizing residues used in alloys), kt: ≈700 kt a year recycled in the EU without passing through smelters, incl. secondary refiners (European Commission 2020), i.e. ≈470 kt net of S_r; direct reuse in Europe incl. UK, Norway and Switzerland 1.0 Mt, ≈0.88 Mt scaled to the EU-27 (Rostek and Loibl 2025)
Zinc recovery, EAF dust to refined zinc	0.920	0.880	0.950	A/C	zinc recovered per t of zinc in EAF dust: Waelz kiln 0.93–0.95 (Rostek 2025, Table 8) × smelter recovery ≈0.97
Zinc recovery, secondary refining	0.900	0.850	0.950	C	zinc recovered per t of zinc in dross, ash and scrap processed by secondary refiners
Zinc recovery, direct remelting	0.950	0.920	0.980	C	zinc recovered per t of zinc in scrap remelted directly
Zinc content of CN 2620 19	0.250	0.170	0.400	C	zinc content of extra-EU trade in CN 2620 19 (slag, ash and residues containing mainly zinc): 0.17 (Rostek 2025, Table 15); unit value 2024 EUR 482/t

Parameter	Central	Low	High	Class	Basis and source
Zinc content of brass scrap (CN 7404 00 91)	0.330	0.280	0.380	C	zinc content of brass scrap CN 7404 00 91
New scrap and residues per t of zinc first used	0.140	0.100	0.180	C	new (fabrication) scrap and residues per t of zinc in first use: brass turnings and mill scrap, galvanizing dross and ash (20–30% of zinc used in general galvanizing), continuous-line dross, rolling and casting scrap returned outside the plant
Per-capita inflow 2013 relative to 2024	1.10	1.00	1.20	C	per-capita inflow in 2013 relative to 2024 (path piecewise linear through 1960, 2013 and 2024)
Net imports of zinc in finished products, kt	0.000	−150.000	150.000	C	net imports of zinc contained in finished products and coated steel into the EU-27, kt
Per-capita inflow 1960 relative to 2024	0.850	0.700	1.000	C	per-capita inflow in 1960 relative to 2024; stock in use for EU-27, UK, Norway and Switzerland 69.9 Mt in 2020, ≈130 kg per person (Rostek and Loibl 2025)
Inflow growth 2025–2035, per year	0.005	0.000	0.015	A/C	annual growth of per-capita inflow 2025–2035; European demand 2.8 Mt in 2020 and 2050 (Gregoir and Van Acker 2022)
Zinc recovered in the EU per t in end-of-life galvanized steel	0.160	0.120	0.220	C	zinc recovered in the EU per t of zinc in galvanized steel at end of life: zinc in EAF dust processed (≈200 kt) less zinc from new galvanized scrap (≈35 kt), against ≈1,000 kt of zinc in galvanized steel reaching end of life; zinc in steel scrap melted in basic oxygen furnaces, in exported steel scrap (net 10.9 Mt in 2024) and lost by corrosion in use is not recovered
Scaling of product lifetimes	1.00	0.80	1.20	A/C	scaling of mean product lifetimes (Rostek 2025, Tables 9 and 14)
Scaling of end-of-life recovery rates	1.00	0.85	1.15	C	scaling of end-of-life recovery rates by product group
Propensity to consume	0.860	0.820	0.900	A/C	average propensity to consume out of net labour income; gross household saving rate EU-27 2024 14.67% (Eurostat tec00131)
Tax rate on labour	0.371	0.355	0.385	A	implicit tax rate on labour, EU-27 2024 (European Commission, DG TAXUD 2026)
Scaling of employment coefficients	1.00	0.90	1.10	C	uncertainty of FIGARO employment coefficients
Taxable share of operating surplus	0.400	0.250	0.550	C	operating surplus net of production taxes, depreciation, interest and losses

Parameter	Central	Low	High	Class	Basis and source
Footprint of displaced primary zinc, t CO_2e/t	2.00	1.86	2.55	B	primary special high grade zinc displaced, cradle to gate: European average incl. Norway, primary only, 2.0 t CO_2e/t (International Zinc Association 2023, 2021 data, 94% of European production); low Nyrstar European average 1.86 (Nyrstar 2023); high IZA European average for 2018 data 2.55 (International Zinc Association 2022); the EU-27 is a net exporter of unwrought zinc, so the European average is close to the consumption mix; global average 3.5 as structural case
Waelz route, t CO_2e/t of zinc	3.86	3.40	4.71	A/B/C	Waelz route (Waelz oxide, leaching, electrolysis), t CO_2e per t of zinc: Nyrstar European zinc from Waelz-oxide feed only 3.86 (Nyrstar 2023); low ≈3.4 from verified emissions of EU Waelz plants (≈2.4 t per t of zinc in Waelz oxide) plus smelting and upstream fuels; high Rinne et al. (2022) 4.71
Secondary refining, t CO_2e/t of zinc	1.00	0.60	1.60	C	secondary refining of dross, ash and scrap (distillation, remelting, oxide and dust production)
Direct remelting incl. scrap preparation, t CO_2e/t	0.400	0.100	0.600	A/B/C	direct remelting of zinc and brass scrap incl. scrap preparation: remelting 0.08 t CO_2e per t of zinc (Grund and van Genderen 2024); remelted zinc ≈0.6 t CO_2e/t (Grund 2026)
EU grid factor, t CO_2e/MWh	0.183	0.165	0.206	A	EU-27 electricity, t CO_2e per MWh: early estimate 2024 of the European Environment Agency (2026): 183.4 g/kWh (2023: 205.7)
Flotation tailings per t of primary zinc, t	8.00	5.00	12.00	A/C	t of flotation tailings per t of primary zinc, with allocation to lead, silver and copper in polymetallic ores; ≈12 t without allocation (Van Genderen et al. 2016)
Acidification of primary zinc, kg SO_2-eq/t	17.5	10.0	30.0	A	acidification of primary zinc, kg SO_2-eq per t (Van Genderen et al. 2016)
EU ETS price, EUR/t	64.7	60.0	74.0	A	EU ETS average auction price 2024, EUR 64.74/t (European Commission 2025d)

Correlated groups (Gaussian copula parameter): zinc shares of scrap trade and recovery (ρ = 0.8); zinc from Waelz oxide and zinc recovered from end-of-life galvanized steel (0.7); footprints of secondary refining and remelting (0.6); zinc shares of output of secondary refining, rolled zinc and alloys, zinc coating and die-casting (0.5); lifetimes and per-capita inflow (−0.3); secondary refining and direct remelting (−0.4); zinc share of zinc-coating output and zinc-coating share of 25.61 (−0.5). Zinc first used and the 2024 inflow to use are recomputed in each draw from the balance.

TABLE 49 Product groups of the dynamic model of zinc in use

Product group	Share of inflow	Mean lifetime, years	Standard deviation, years	Collected at end of life	Recovered in the EU
Galvanized steel	52%	35	16	75%	16%
Brass and bronze	13%	25	10	85%	80%
Zinc die-castings	15%	12	5	60%	55%

Product group	Share of inflow	Mean lifetime, years	Standard deviation, years	Collected at end of life	Recovered in the EU
Rolled zinc	6%	50	23	95%	90%
Dissipative uses (chemicals, paints, tyres, fertilisers, feed)	14%	1	0	0%	0%

Source: IGMNiR ZN-EU v1.0. Lifetimes are normally distributed (Rostek 2025, Tables 9 and 14); separation efficiencies by waste stream from Rostek (2025, Table 7) and Waelz recovery from Rostek (2025, Table 8). Recovery from galvanized steel is the parameter of Annex B; recovery rates of all groups are scaled together in the uncertainty analysis. Zinc in dissipative uses is not recovered.

C Zinc installations in the EU emissions trading system

Refined zinc by smelter in 2024 is listed in the smelter table of Chapter 3; the table below lists the zinc smelters and the stand-alone Waelz plants with their verified emissions and free allocation in 2024. Some smelters operate Waelz kilns within the smelter installation (ZGH Bolesław); their emissions are included in the smelter figure.

TABLE 50 Verified emissions and free allocation of zinc installations, 2024 (kt CO_2e)

Installation	Member State	Activity	Verified emissions	Free allocation	Segment
Nyrstar Balen	BE	28	21.1	58.3	Z3
Nyrstar Budel	NL	28	18.5	75.0	Z3
Nyrstar France, Auby	FR	20	23.2	37.2	Z3
Boliden Kokkola, zinc plant	FI	23	5.6	48.5	Z3
Asturiana de Zinc, San Juan de Nieva	ES	28	15.0	70.1	Z3
Nordenhamer Zinkhütte	DE	28	6.5	10.1	Z3
Portovesme (zinc and lead)	IT	28	169.1	264.2	Z3
KCM Plovdiv (zinc and lead)	BG	28	203.3	173.1	Z3
ZGH Bolesław	PL	28	196.3	170.3	Z3
Huta Cynku Miasteczko Śląskie (Imperial Smelting, zinc and lead)	PL	28	378.1	316.4	Z3
Befesa Zinc Duisburg	DE	28	39.3	39.6	Z2
Befesa Zinc Freiberg	DE	28	94.3	96.8	Z2
Befesa Zinc Aser, Asúa-Erandio	ES	28	70.9	72.6	Z2
Befesa Zinc Recytech, Fouquières-lès-Lens	FR	28	74.6	61.9	Z2
Befesa Circular Alloys France, Gravelines (stainless-steel dust)	FR	28	31.8	33.7	Z2
ScanDust, Landskrona (stainless-steel dust)	SE	24	26.2	34.1	Z2
Pontenossa (Waelz)	IT	28	72.1	73.1	Z2
Zinc smelters (10 installations)			1,036.8	1,223.2	Z3
of which electrolytic smelters without lead lines (6 installations)			90.0	299.2	Z3
Stand-alone Waelz plants (7 installations)			409.3	411.7	Z2

Source: European Commission (2026c), Union Registry, file verified_emissions_2025_en.xlsx (extraction of 1 April 2026). Activity codes as recorded in the Registry: 20 combustion of fuels; 23 metal ore roasting or sintering; 24 production of pig iron or steel; 28 production or processing of non-ferrous metals. Lead production at Portovesme and Plovdiv; the Imperial Smelting furnace at Miasteczko Śląskie (the only one in the EU) produces zinc and lead. Scope 1 emissions only; electricity is not included. Lead smelters, recyclers of other metals and galvanizing lines are not listed.

D Glossary

- **CBAM** – carbon border adjustment mechanism, Regulation (EU) 2023/956; zinc (CN chapter 79) is not among the goods listed in Annex I.
- **Compensation of indirect emission costs** – state aid for emission costs passed through in electricity prices (Directive 2003/87/EC, Art. 10a(6)); NACE 24.43 is eligible, with an electricity consumption efficiency benchmark of 3.994 MWh per t of zinc for electrolysis. In structural business statistics it is an operating subsidy and part of value added at factor cost.
- **Coverage ratio** – EU supply or output relative to EU use; not a measure of self-sufficiency.
- **CRMA** – Critical Raw Materials Act, Regulation (EU) 2024/1252; zinc is listed neither as a strategic nor as a critical raw material; germanium and gallium, recovered in part from zinc circuits, are listed.
- **Dross and ash** – zinc-iron alloy settling in galvanizing baths (bottom dross, hard zinc) and oxidised zinc skimmed from the bath surface (ash); both are recycled.
- **EAF dust** – dust from the electric arc furnace route of steelmaking; it contains the zinc of galvanized steel scrap and is a hazardous waste.
- **EoL-RR / EoL-RIR** – share of zinc in end-of-life products that is recovered / share of end-of-life scrap in metal input.
- **Extra-EU / intra-EU trade** – trade of member states with countries outside the EU / with other member states; ZN-EU treats intra-EU deliveries as domestic.
- **FIGARO / SIOT** – EU inter-country input-output tables of Eurostat, aggregated in ZN-EU to one EU-27 block / symmetric input-output table of the EU-27 (naio_10_cp1700), used for validation.
- **Free metal** – zinc recovered by a smelter above the payable share of the zinc in concentrate.
- **General and continuous galvanizing** – hot-dip coating of fabricated steel articles in batch plants / coating of steel strip on continuous lines, mostly in steelworks (NACE 24.10, outside Z5).
- **Gross contribution / net effect** – activity associated with the chain at fixed coefficients / change after a policy or shock and reallocation of resources; the report shows gross contributions only.
- **GVA** – gross value added: output minus intermediate consumption; from structural business statistics at factor cost.
- **HHI** – Herfindahl–Hirschman index of concentration (0–10,000).
- **Jarosite, goethite, haematite** – iron-bearing residues of the leaching step of electrolytic zinc production.
- **New and old scrap** – scrap and residues from fabrication and galvanizing / scrap from products at the end of their life. The new-scrap rate is new scrap and residues per tonne of zinc first used.
- **Observation / estimate / model result (O/E/M)** – status of a figure: published data / data combined with allocations or calibrated parameters / result depending on counterfactual or dynamic assumptions.
- **Potentially avoided burden** – environmental credit for displacing primary production with secondary material, conditional on the substitution assumed.
- **Primary / secondary zinc** – zinc produced from ores and concentrates / zinc produced from scrap, residues and dusts. Secondary zinc in ZN-EU follows three routes: Waelz oxide treated in smelters, secondary refining outside smelters and direct remelting.
- **Roast-leach-electrowin / Imperial Smelting** – electrolytic route of zinc production (roasting, leaching, purification, electrolysis) / pyrometallurgical route producing zinc and lead in a shaft furnace; in the EU only at Miasteczko Śląskie.

- **Special high grade (SHG) zinc** – zinc of at least 99.995% purity, the grade delivered against the LME contract.
- **Treatment charge (TC)** – fee deducted by the smelter from the value of payable zinc in concentrate; the annual benchmark is set between a major miner and a major smelter.
- **Type I / Type II effects** – direct plus supply-chain effects / plus effects induced by household spending.
- **Value added at factor cost** – value added in structural business statistics: output less intermediate consumption, less other taxes on production, plus other subsidies on production (operating subsidies such as the compensation of indirect emission costs).
- **Waelz process / Waelz oxide** – treatment of EAF dust in a rotary kiln with coke, producing a crude zinc oxide that is fed to zinc smelters.
- **Zinc first used** – unwrought zinc used in the EU (smelter output plus net imports), secondary zinc from refiners and zinc remelted directly, less net exports of zinc dust (2,203 kt in 2024); the denominator of the secondary share.

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Izba Gospodarcza Metali Nieżelaznych i Recyklingu

ZN-EU is a transparent, reproducible model linking official EU statistics, company and industry reports, the EU emissions registry, published product footprints, a dynamic model of zinc in use and the process metallurgy of zinc. It estimates the gross economic and fiscal contribution of the zinc industry in the European Union – zinc mining, collection and trade of scrap and residues, Waelz kilns and secondary refiners, zinc smelting, rolled zinc, zinc dust and alloys, zinc coating and die-casting – the emissions and other burdens potentially avoided by secondary zinc, and the industry's importance for the security of supply.

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