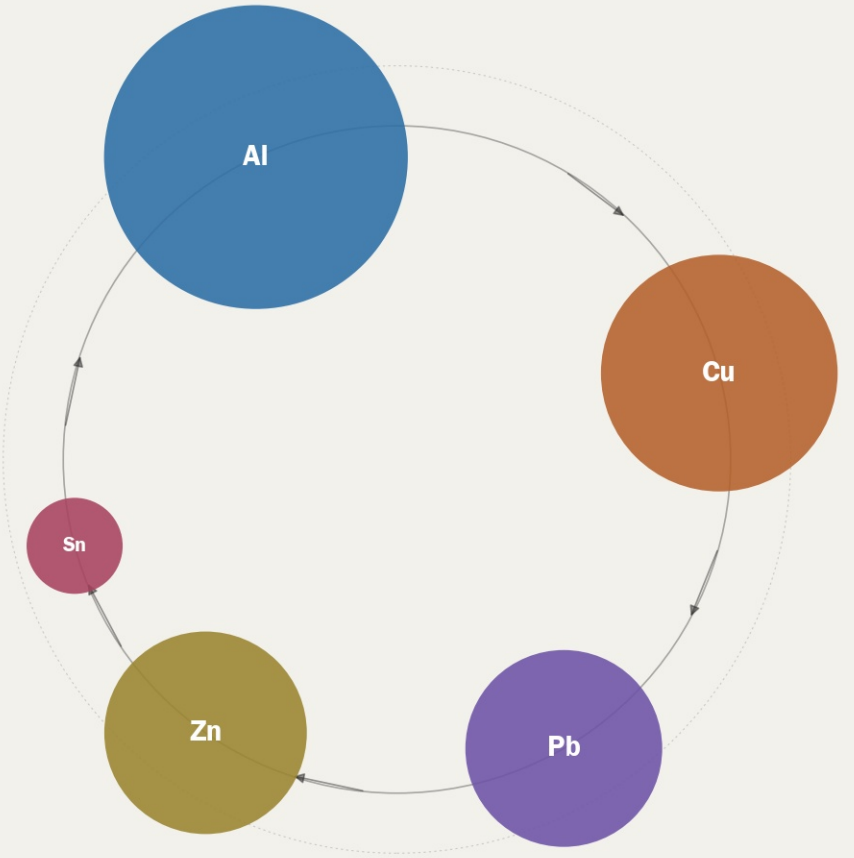
IGMNiR
Economic Chamber of Non-Ferrous Metals and Recycling



Circles: secondary metal produced in Poland, 2024 (area ∝ tonnes)

IGMNIR REPORT · NOVEMBER 2026

The value of non-ferrous scrap recycling to the Polish economy

An integrated model of economic, environmental and strategic benefits (NF-REC-PL v1.3)

Base year 2024 · Scenarios to 2035 · Open, reproducible model

About this report. This report was prepared by the Economic Chamber of Non-Ferrous Metals and Recycling (IGMNiR). It presents NF-REC-PL, an integrated model that estimates the economic, environmental and strategic contribution of non-ferrous scrap recycling enterprises to the Polish economy. The annexes list all parameters and sources; the model code and input data are available from IGMNiR on request. 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 4 November 2026. **Base year:** 2024 (latest year with complete structural business and waste statistics); trade data to 2025. **Currency:** EUR, current prices (2024 average EUR/PLN 4.3058, Eurostat). **Model version:** NF-REC-PL v1.3 (run ID NFRECPL-1.3-153C411685; random seed 20261118); the model package – code, input data, scenario configuration and checks – is archived by IGMNiR. **Suggested citation:** IGMNiR (2026), *The value of non-ferrous scrap recycling to the Polish economy. NF-REC-PL integrated impact model*, Economic Chamber of Non-Ferrous Metals and Recycling, November 2026.

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Key findings

In 2024, companies collecting, trading, preparing and remelting non-ferrous scrap supported about EUR 1.03 billion of gross value added in Poland, including their suppliers, and around 17.0 thousand jobs. In a model comparing recovered metal with primary production, the use of scrap collected in Poland corresponds to a potential avoidance of about 3.26 million tonnes of CO_2e in supply chains, mostly outside Poland, assuming full 1:1 substitution. This is not an additional reduction of national emissions, and the uncertainty includes important definitional and market choices.

FIGURE 1 Contribution of NF scrap recycling in Poland at a glance



Central estimates for 2024; ranges in brackets = P5–P95 of 10 000 Monte Carlo draws. Extended scope: collection, trade, processing and secondary metallurgy. GHG and energy: conditional, substitution-based estimates, mostly outside Poland. Source: IGMNiR NF-REC-PL v1.3.

SEVEN FINDINGS

- **Economic contribution.** Direct gross value added (GVA) of the extended industry is EUR 584 million (90% band 514–677). Including domestic supply chains (Type I) it is EUR 1,026 million and, with household spending (Type II), EUR 1,155 million. Each euro of GVA in the industry supports a further EUR 0.76 in Polish supplier industries.
- **Jobs.** About 8,715 people work directly in NF scrap collection, trade, processing and secondary metallurgy (band 6,508–11,418); 17,033 jobs are supported including suppliers and 19,831 including induced effects. These are gross figures; a part of this labour would find other employment in a tight labour market.
- **Public finances.** Labour taxes and social contributions, corporate income tax and net production taxes linked to the industry and its supply chain amount to about EUR 274 million a year (PLN 1.18 billion).
- **Climate.** Metal recovered from scrap collected in Poland contributes to avoiding about 3.3 Mt CO_2e a year compared with primary metal – a conditional, substitution-based estimate (90% band 2.4–4.5 Mt), mostly at primary smelters abroad; aluminium accounts for 95%. On the alternative remelting-based perspective (not additive), metal remelted in Poland avoids 2.66 Mt, of which 0.61 Mt from scrap collected in Poland. The notional value of the avoided emissions is EUR 211–538 million (EU ETS price to EIB shadow cost).
- **Energy and resources.** Recycling saves about 63 PJ of primary energy a year (the energy equivalent of ≈18 TWh, not electricity) and avoids about 0.62 Mt of bauxite residue, while generating about 0.33 Mt of salt slag and Waelz slag that must be treated.
- **Supply security.** Secondary aluminium output equals 38% of Poland's apparent aluminium consumption in a country without a primary smelter; copper and copper alloys produced from scrap equal 23% of Polish refined copper output. The estimated processing margin of domestic remelting – a hypothetical trade account: the value of the metal minus the market value of the scrap and imported inputs it uses – is about EUR 258 million a year.

- **Growth potential.** Collection growth and the investments already announced – KGHM's scrap programme and upgrades of aluminium remelting plants (Scenario S1, 2030) – would add about EUR 85 million of GVA and 1,067 jobs including supply chains. The main climate lever is collecting and sorting scrap that is currently lost: each additional tonne of aluminium recovered in this way replaces primary metal whose footprint is about 9.2 t CO_2e higher (EU consumption mix; less as primary production decarbonises).

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

Indicator (2024)	Central	P5	P50	P95	Unit
Direct GVA – core scope	374	304	375	447	EUR m
Direct GVA – extended scope	584	514	595	677	EUR m
GVA incl. supply chain (Type I)	1,026	900	1,043	1,187	EUR m
GVA incl. induced (Type II)	1,155	1,010	1,174	1,340	EUR m
Direct employment	8,715	6,508	8,912	11,418	persons
Jobs supported incl. supply chain	17,033	13,835	17,320	21,057	persons
Jobs supported incl. induced	19,831	16,164	20,173	24,453	persons
Fiscal contribution	274	239	279	322	EUR m
Avoided GHG – collection-based	3.26	2.44	3.38	4.52	Mt CO_2e
Avoided GHG – remelting in Poland	2.66	1.99	2.75	3.69	Mt CO_2e
Primary energy saved	63	55	63	71	PJ
Notional carbon value, EU ETS price	211	160	224	302	EUR m
Notional carbon value, EIB shadow cost	538	409	607	884	EUR m
Gross value of secondary metal	2,272	2,099	2,285	2,473	EUR m
Estimated processing margin (FX)	258	189	262	335	EUR m

Source: IGMNiR NF-REC-PL v1.3; Monte Carlo 10 000 draws with Gaussian copula. Extended scope = collection, trade, processing and secondary metallurgy. GVA, jobs and taxes are gross contributions. Avoided GHG and energy are avoided-burden (substitution) estimates: the difference between primary and secondary cradle-to-gate footprints applied to recovered metal, assuming 1:1 substitution; they occur largely outside Poland and do not reduce the national inventory. The two GHG perspectives are alternatives and are not additive.

01 Introduction

Aluminium, copper, lead, zinc and tin can be recycled repeatedly without losing their properties. Recycling them needs a fraction of the energy of primary production and avoids mining, ore processing and – in the case of aluminium – the electrolysis that dominates the sector's carbon footprint. In a country such as Poland, which has no primary aluminium smelter since 2009[1] and imports most of its zinc concentrate, the recycling industry is effectively a domestic "urban mine".

Despite this, the contribution of non-ferrous scrap recyclers to the Polish economy has never been measured. Official statistics hide the industry inside broader categories – waste management, wholesale trade and basic metals. Public debate about scrap exports, energy prices for remelters or the implementation of the Critical Raw Materials Act therefore proceeds without numbers. This report closes that gap.

1.1 Questions addressed

01 How large is the non-ferrous scrap recycling industry in Poland – in enterprises, jobs, turnover and value added – and where is it located?

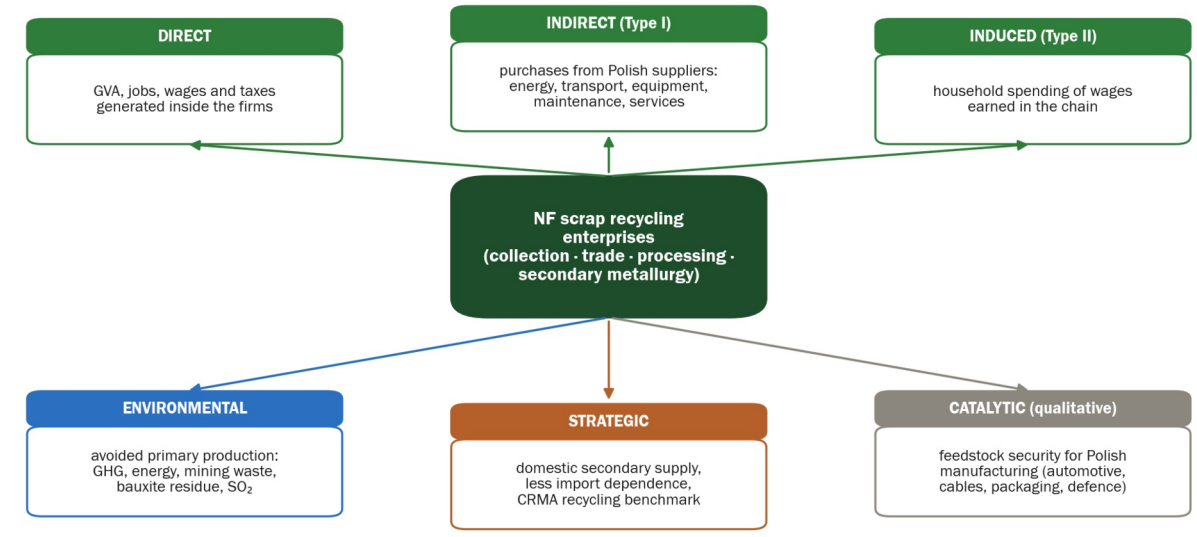
02 What economic activity does it generate in the rest of the economy through its purchases and through the spending of its employees?

03 How much greenhouse-gas emissions and energy does it save compared with primary metal production?

04 What is its strategic value for Poland's supply of aluminium, copper, lead, zinc and tin, and for EU objectives under the Critical Raw Materials Act?

05 How could these benefits change by 2030 and 2035 under different policy and market conditions?

FIGURE 2 Impact channels analysed in this report



Quantified in this report: direct, indirect, induced, environmental, strategic. Catalytic effects are described but not added to totals (avoid double counting).

[1] Polish Geological Institute – National Research Institute (PIG-PIB), portal "Gospodarka surowcami – aluminium"; the electrolysis of Huta Aluminium Konin was closed in 2009.

1.2 Structure of the report

Chapter 2 sets out the policy context. Chapter 3 describes the industry with official statistics, maps and trade flows. Chapter 4 explains the NF-REC-PL model. Chapters 5–7 present economic, environmental and strategic results; Chapter 8 the uncertainty analysis and Chapter 9 the scenarios to 2035. Chapter 10 draws policy conclusions. Annexes document data, parameters, installations, the system boundary and a glossary.

02 Policy context

Since 2024 the EU has moved secondary raw materials from waste policy to industrial and security policy. Aluminium and copper are now **strategic raw materials** under the Critical Raw Materials Act (CRMA), which sets a benchmark that EU recycling capacity should cover at least 25% of annual consumption of strategic raw materials by 2030.[2] Zinc, lead and tin are on neither the strategic nor the critical list, but they are essential to batteries, galvanising and electronics.

TABLE 2 EU and Polish policy instruments relevant to NF scrap recycling (status 4 November 2026)

Instrument	Relevance for NF recycling	Status
Critical Raw Materials Act – Reg. (EU) 2024/1252	Al and Cu strategic; 2030 benchmarks: 10% extraction, 40% processing, 25% recycling, max. 65% from one third country	In force since 23.5.2024
CRMA strategic projects (Poland)	Elemental POLVOLT battery recycling (1st list, 25.3.2025); KGHM Integrated Recycling Smelter Legnica (2nd list, Commission decision of 9.10.2026)	Adopted
RESourceEU Action Plan	Secondary raw materials; announced a targeted measure on aluminium scrap	Communication, 3.12.2025
Clean Industrial Deal – COM(2025) 85	24% circular material use by 2030; Circular Economy Act proposal expected Q4 2026 (end-of-waste, WEEE revision)	Communication
European Steel and Metals Action Plan – COM(2025) 125	Consider trade measures to keep scrap available; low-carbon lead markets	Communication
Customs surveillance of metal scrap	Monitoring of imports and exports of ferrous, aluminium and copper scrap	Since 23.7.2025
Aluminium scrap export measure	Duty dropped (Sept 2026); delegated act under the WSR banning waste exports incl. Al scrap to non-OECD countries in preparation	Pending
Waste Shipment Regulation – Reg. (EU) 2024/1157	Non-hazardous waste exports to non-OECD countries only to listed countries (country list pending)	Applies since 21.5.2026; non-OECD rule from 21.5.2027
CBAM – Reg. (EU) 2023/956	Definitive period; Al goods covered, Al scrap (CN 7602) not covered; Dec 2025 proposal: downstream extension from 2028 and pre-consumer scrap treated as a precursor (pending)	Since 1.1.2026
Batteries Regulation – Reg. (EU) 2023/1542	Lead recovery targets (90% by end-2027, 95% by end-2031), recycling-efficiency targets for lead-acid batteries, recycled lead content from 2031	In force; phased obligations
ELV Regulation – Reg. (EU) 2026/1738	Plastics recycled content 15% → 25%; feasibility study for steel and aluminium targets	Adopted 8.7.2026; in force 13.8.2026; applies from 1.9.2028
EU 16th sanctions package against Russia	Ban on imports of Russian primary aluminium after transition quota	Adopted 24.2.2025; full ban since Feb 2026
Polish Raw Materials Policy (PSP 2050)	Council of Ministers Resolution 39/2022 (M.P. 2022 poz. 371); update and CRMA implementing law in preparation	In force / drafts

Sources: EUR-Lex; European Commission (DG GROW, DG TAXUD, DG ENV); Council of the EU; Monitor Polski. The status of the aluminium scrap measure relies on trade press (Fastmarkets, S&P Global).

Three developments make the question of this report urgent. First, the **debate on scrap exports**: the European Commission activated customs surveillance of aluminium and copper scrap in July 2025[3] and has prepared

[2] Regulation (EU) 2024/1252 of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials (Critical Raw Materials Act), OJ L, 3.5.2024, Art. 5(1) and Annexes I–II.

[3] European Commission, DG TAXUD, news item of 23 July 2025 on the surveillance of imports and exports of metal scrap.

measures concerning aluminium scrap exports; in September 2026 it reportedly replaced a planned export duty with a delegated act under the Waste Shipment Regulation targeting exports to non-OECD countries.[4] Second, **sanctions on Russian aluminium**: the 16th sanctions package bans imports of Russian primary aluminium after a transition quota;[5] in 2025 Russia still supplied 11.1% of Poland's imports of unwrought aluminium. Third, **energy and carbon costs**: secondary smelters compete on energy-intensive remelting while CBAM and the ETS change the relative price of primary and recycled metal.

[4] Fastmarkets (7 September 2026) and S&P Global Commodity Insights reports on the Commission's aluminium scrap measure; European Aluminium letter of 7 September 2026. Nothing had been adopted by 4 November 2026.

[5] Council of the EU, 16th package of restrictive measures against Russia, adopted 24 February 2025; European Commission (DG FISMA) news of 24 February 2025.

03 The non-ferrous scrap recycling industry in Poland

3.1 Size of the relevant activities

Three NACE activities contain the industry. Wholesale of waste and scrap (46.77) counted 2,953 enterprises and 17,896 persons employed in 2024; dismantling of wrecks and recovery of sorted materials (38.3) 1,665 enterprises and 11,193 persons; aluminium production (24.42) – which in Poland is entirely secondary or semi-finished – 10,551 persons.[6] These activities also handle ferrous scrap, paper, plastics and other materials, so only part of them belongs to non-ferrous recycling (Chapter 4).

TABLE 3 Activities hosting NF scrap recycling in Poland, 2024 (all materials)

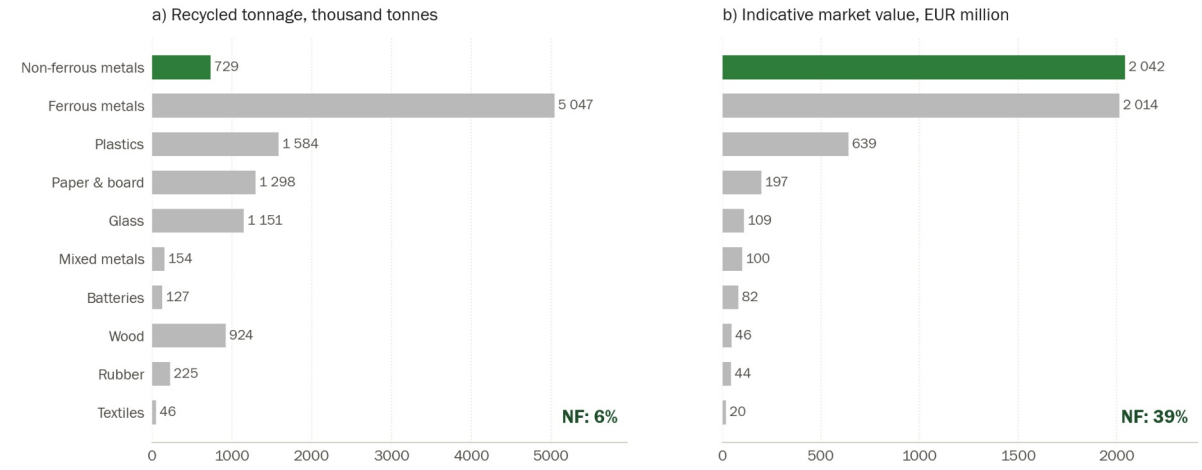
NACE activity	Enterprises	Persons employed	Turnover, EUR m	GVA, EUR m	GVA/person, EUR k
46.77 Wholesale of waste and scrap	2,953	17,896	6,100	636	35.5
38.3 Dismantling of wrecks, materials recovery	1,665	11,193	2,452	498	44.5
24.42 Aluminium production	196	10,551	2,949	509	48.3
24.43 Lead, zinc and tin production	19	2,889	754	220	76.1

Source: Eurostat sbs_ovw_act (2024). Copper production (24.44) is confidential in SBS; KGHM is classified in mining.

3.2 What is recycled: tonnes versus value

In 2024, 729 thousand tonnes of non-ferrous metal waste and 127 thousand tonnes of spent batteries and accumulators were recycled in Poland.[7] Non-ferrous metals are only about 8% of the tonnage of recycled materials but about 40% of their market value – the economic centre of gravity of the recycling sector.

FIGURE 3 Materials recycled in Poland in 2024 by tonnage and value

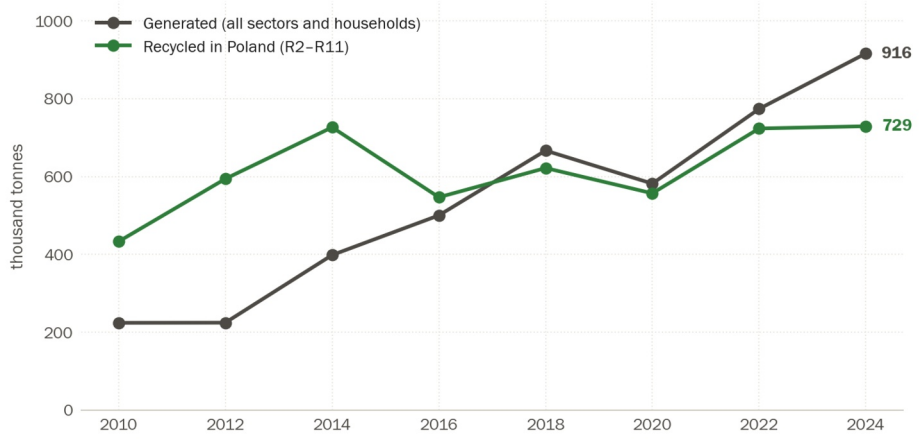


Source: IGMNiR NF-REC-PL; Eurostat env_wastrt (RCV_R, 2024); value = tonnage × 2024 Comext unit value (Annex A).

[6] Eurostat, Structural business statistics, dataset sbs_ovw_act (updated 30 September 2026), Poland, NACE Rev. 2 classes G46.77, E38.3, C24.42, C24.43; 2024.

[7] Eurostat, Treatment of waste by waste category, hazardousness and waste management operations, dataset env_wastrt, Poland 2024, categories W062 and W0841, operation RCV_R.

FIGURE 4 Non-ferrous metal waste generated and recycled in Poland, 2010–2024



Source: Eurostat env_wasgen, env_wastrt (waste category W062, biennial).

Recycling of non-ferrous metal waste in Poland grew by 68% between 2010 and 2024, while generation quadrupled, driven by manufacturing (automotive, packaging, electrical equipment) and by traders who now report sorted scrap as waste generated in their own activity.

3.3 Secondary metal production by metal

TABLE 4 Secondary non-ferrous metal production in Poland, 2024 (model central values)

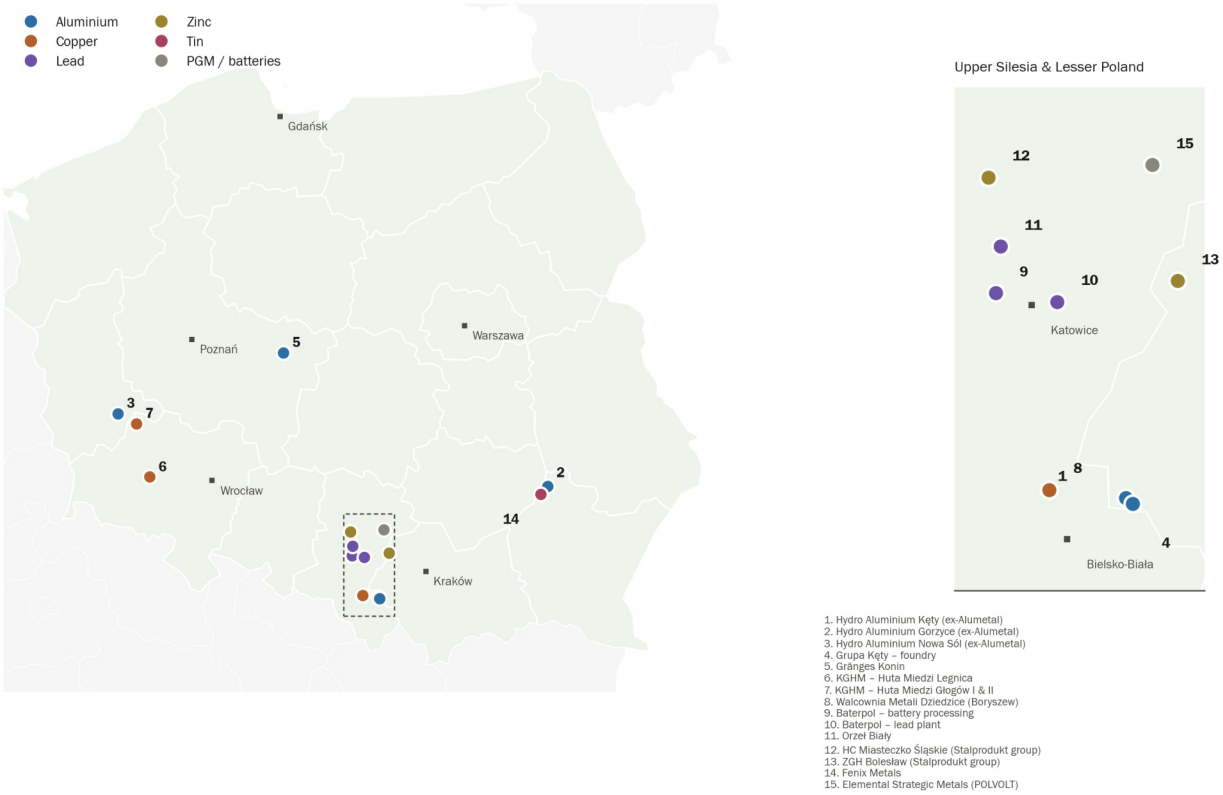
Metal	Secondary output, kt	Range, kt	Scrap consumed, kt	Basis
Aluminium	260.0	210–320	306	PRODCOM 2024: secondary Al alloys 304 kt sold, 486 kt produced; 23.4 kt unalloyed; no primary smelter
Copper	135.0	110–160	173	KGHM processed 159 kt Cu scrap (2024); Cu-alloy remelters
Lead	80.0	65–100	133	Orzeł Biały 64.9 kt + Baterpol 32.8 kt lead and alloys sold (2024); refined Pb total 130.6 kt
Zinc	87.0	75–100	158	Stalprodukt group 2024: 153.8 kt Zn, about 56% of feed from residues (Waelz oxide from steel-plant dust); HC Miasteczko Śląskie 100% secondary oxides
Tin	4.8	4–5	6	100% secondary; 95% exported

Sources: Eurostat PRODCOM (DS-059358, code 24421154); IGSMiE PAN (2025), Gospodarka surowcami mineralnymi w Polsce 2015–2024; Orzeł Biały annual report 2025; Boryszew FY2024 report; Stalprodukt annual reports 2023–2025; KGHM Q4/FY2025 results and Strategy summary 2024; Hydro, ZGH Bolesław. Scrap consumed = output / metallic yield (Annex B).

3.4 Where the industry is located

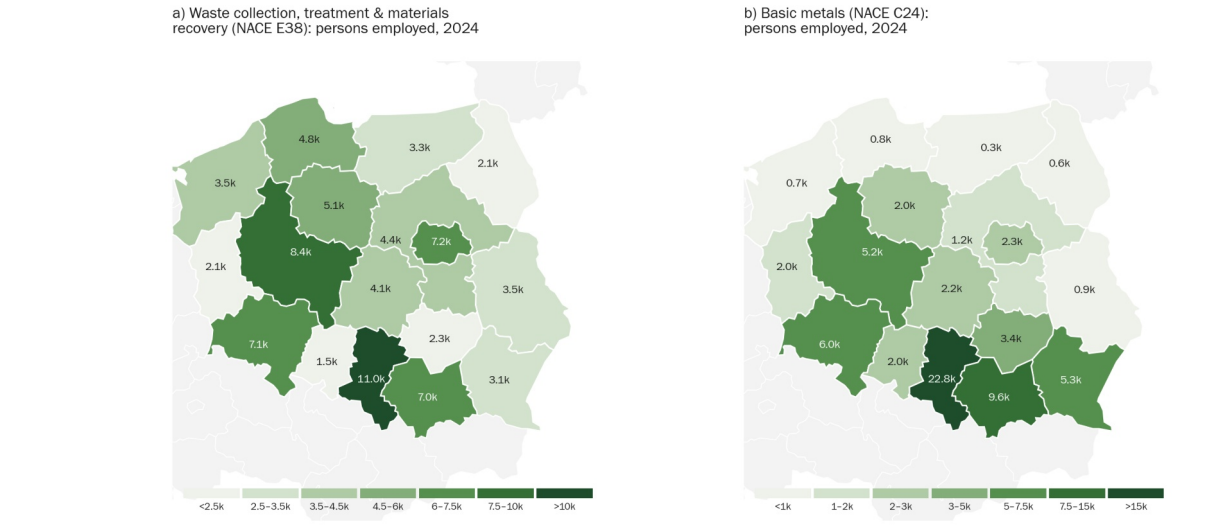
Collection and trade are present across the country, with the largest employment in Silesia, Greater Poland, Lower Silesia, Masovia and Lesser Poland. Secondary metallurgy is concentrated in three clusters: Upper Silesia and western Lesser Poland (lead, zinc, aluminium alloys, copper alloys), the Legnica–Głogów copper basin, and the aluminium plants in Nowa Sól, Konin and Gorzyce.

FIGURE 5 Map of verified NF recycling and secondary-metal installations



Source: IGMNiR; company reports (Hydro, Grupa Kęty, Gränges, KGHM, Boryszew, Orzeł Biały, ZGH Bolesław), IGSMiE PAN (2025), European Commission CRMA strategic projects; GISCO boundaries. Numbers refer to Annex C.

FIGURE 6 Regional employment in waste management and basic metals (NUTS 2), 2024



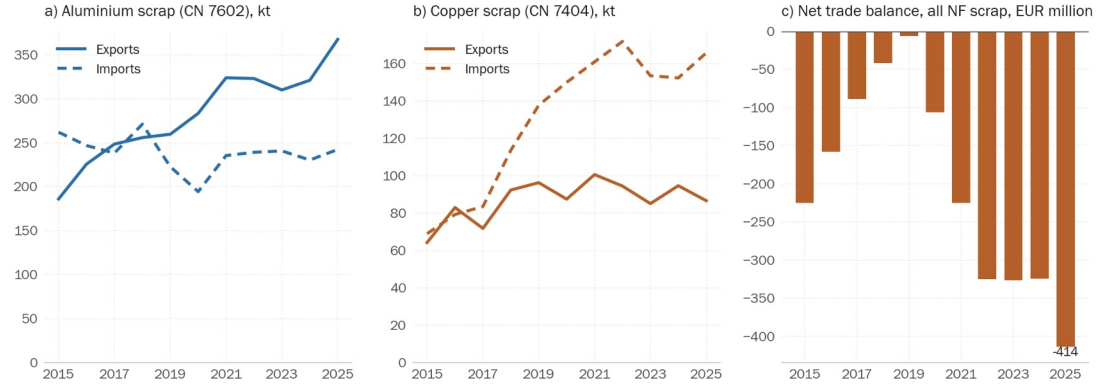
Source: Eurostat sbs_r_nuts2021 (local units, 2024); GISCO NUTS 2021. Points: verified non-ferrous recycling and secondary-metal installations (Annex C).

3.5 Trade in non-ferrous scrap

Poland is a net **exporter of aluminium scrap** (321 kt exported versus 230 kt imported in 2024) and a net **importer of copper scrap** (152 kt versus 95 kt), reflecting KGHM's growing use of purchased scrap. In value

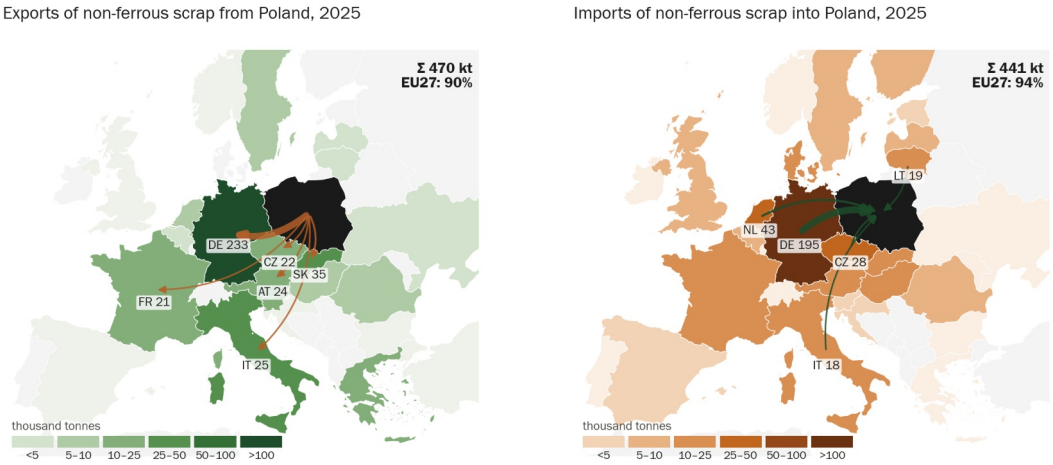
terms the overall balance of non-ferrous scrap trade has been negative since 2015. Around 90% of exports and 94% of imports are traded within the EU, with Germany by far the largest partner.

FIGURE 7 Poland's trade in aluminium and copper scrap and the net balance of NF scrap trade, 2015–2025



Source: Eurostat Comext DS-045409. NF scrap = CN 7404, 7503, 7602, 7802, 7902, 8002, 854810/854911.

FIGURE 8 Destinations and origins of Poland's NF scrap trade in Europe, 2025

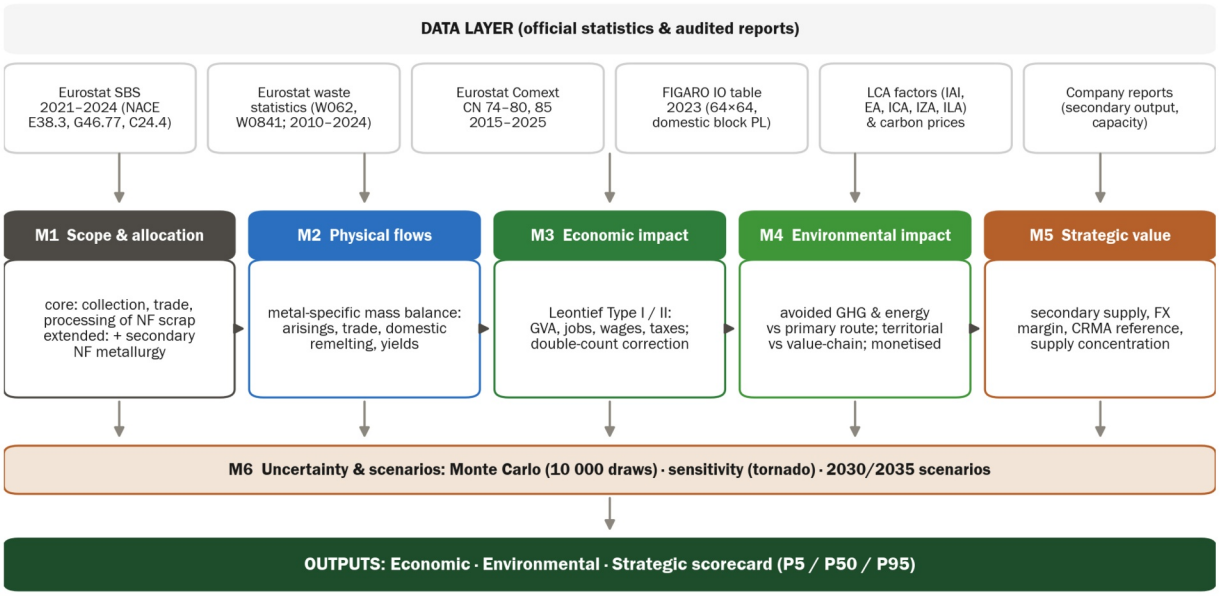


Source: IGMNiR NF-REC-PL model based on Eurostat Comext (DS-045409), CN 7404, 7503, 7602, 7802, 7902, 8002, 854911; GISCO boundaries.

04 Methodology: the NF-REC-PL model

NF-REC-PL is a modular model, documented and reproducible from the archived code, that links official Polish and EU statistics to the physical metallurgy of recycling. It measures the gross economic contribution of the non-ferrous scrap recycling industry and the environmental and strategic value of the metal it returns to use.

FIGURE 9 Architecture of the NF-REC-PL model



Source: IGMNiR. Every module is implemented in Python; all inputs are listed in Annex B with their source and reliability class.

4.1 Design principles

- **Official data first.** Economic magnitudes come from Eurostat Structural Business Statistics (SBS, 2024), Eurostat waste statistics (2024), Eurostat Comext trade data (2015–2025), PRODCOM (2024) and the Eurostat FIGARO input–output table (2023). Company reports are used only where no official statistic exists (secondary metal output, labour intensity, value-added ratios).
- **Physical consistency.** Every economic result is anchored to a metal-specific mass balance: tonnes of scrap collected, traded, remelted and refined. Results that are not physically possible are rejected.
- **Transparency about bias.** Some choices lower the estimate (no catalytic effects; secondary aluminium limited to metal from external scrap; employment coefficients that exclude KGHM smelting jobs); others may raise it (allocation shares not yet validated by a member survey; gross rather than net effects). Both kinds are disclosed and tested.
- **Uncertainty is reported, not hidden.** Allocation shares, output, yields, prices, value-added ratios, labour intensities, emission factors, the propensity to consume, the tax wedge and the scale of employment coefficients are drawn 10 000 times in a Monte Carlo simulation, with correlated groups linked by a Gaussian copula. Results are given as a central estimate with a 90% parameter-uncertainty band (P5–P95).

– **No double counting.** Purchases between segments of the recycling chain are removed explicitly from the supply-chain calculation; turnover and output of segments are not summed.

4.2 Scope and allocation (module M1)

National accounts do not contain a sector called "non-ferrous scrap recycling". The industry is spread over three NACE activities: wholesale of waste and scrap (46.77), dismantling of wrecks and recovery of sorted materials (38.3) and the secondary part of non-ferrous metal production (24.42–24.45). Following the approach used by the Fraser of Allander Institute for the UK aluminium industry,[8] the model extracts the non-ferrous share of each activity and treats the result as a composite (synthetic) sector.

– **Core scope (R1 + R2):** collection, trading, sorting and processing of NF scrap. Separate shares are used for value items (output, GVA, operating surplus) and for employment and labour cost, because non-ferrous metals account for about 40% of the value but only 8% of the tonnage of materials recycled in Poland. Central values: NACE 46.77 – value 40%, employment 24%; NACE 38.3 – value 24%, employment 15%.
– **Extended scope (+ R3):** secondary non-ferrous metallurgy – remelting, refining and alloying of scrap and zinc-bearing residues into secondary aluminium alloys, copper, lead, zinc and tin. Because SBS cannot separate primary from secondary production, R3 is modelled bottom-up: secondary output (t) × metal price × value-added ratio, with labour intensity, labour cost and value-added ratios calibrated on annual reports of Polish producers (Alumetal 2022, Orzeł Biały 2024).

4.3 Physical flows (module M2)

For each metal m the model closes a mass balance of scrap in Poland (gross tonnes; trade converted with the metal content of each CN code):

$$A_m = C_m + X_m - M_m , \quad C_m = S_m / y_m$$

where S is secondary metal produced in Poland from external (non-runaround) scrap, y the metallic yield, C the scrap consumed by Polish plants, X and M scrap exports and imports (Comext), and A the domestic scrap arisings collected. For zinc the secondary route is recycling of zinc-bearing electric-arc-furnace dust via Waelz oxide, which is a residue rather than scrap; zinc therefore has no scrap trade balance. In the scenarios A is set exogenously and imports close the balance.

4.4 Economic contribution (module M3)

The economic module is a Leontief demand-driven input–output model built from the domestic block of the Eurostat FIGARO inter-country table for Poland, 2023 (64 products). With A the matrix of domestic technical coefficients and $L = (I - A)^{-1}$, the supply-chain output required by a vector of first-round domestic purchases f is L·f. GVA, employment, compensation and production-tax coefficients (v, e, w, t) convert output into effects:

$$\text{Direct} = \text{SBS / bottom-up} \qquad \text{Indirect (Type I)} = v \cdot L \cdot f \qquad \text{Induced (Type II)} = v \cdot (L - L) \cdot f + v \cdot L \cdot c \cdot W(1 - \tau)$$

f is the segment's intermediate consumption (from SBS or company cost structures) distributed with the input structure of its parent product, restricted to domestic supply and with purchases from the other chain segments removed. L* is the Leontief inverse closed for households: net labour income $W(1 - \tau)$, with tax wedge τ = 34.7%[9], is spent with an average propensity to consume of 0.88 following the domestic share c of household consumption at purchasers' prices. Employment coefficients are 2024 persons employed per euro of 2024 output.

[8] Fraser of Allander Institute (2024), The Aluminium Industry in the UK, report for the Aluminium Federation (ALFED), University of Strathclyde, pp. 19–24.
[9] OECD (2025), Taxing Wages 2025: tax wedge for a single worker at the average wage in Poland, 2024.

Fiscal contributions are estimated as (i) labour taxes and social contributions = tax wedge × total compensation (direct + indirect + induced), (ii) corporate income tax = 19% × gross operating surplus of the direct activity × taxable share, and (iii) net taxes on products and production from FIGARO coefficients applied to direct, indirect and induced output. VAT on final consumption of the industry's products is not included.

GROSS CONTRIBUTION, NOT NET BENEFIT

The GVA, jobs and taxes reported in Chapter 5 are a gross footprint: the activity associated with the industry and its supply chain. They are not the net change that would follow if the industry disappeared – in a tight labour market part of the labour and capital would find other uses. As an indication, a 50% displacement rate, common in additionality assessments, would halve the net employment effect. The environmental and FX indicators, by contrast, are explicitly counterfactual.

4.5 Environmental impact (module M4)

Each tonne of secondary metal is assumed to replace a tonne of primary metal (an upper bound for aluminium, where secondary foundry alloys replace primary metal mainly in castings). The avoided burden is the difference between the cradle-to-gate footprint of the primary route and that of the secondary route. This is an avoided-burden (substitution) estimate. Two allocation perspectives of the same avoided burden are reported; they are never added:

$$\Delta GHG_{collection} = \Sigma_m A_m \cdot y_m \cdot (EF_m^{prim} - EF_m^{sec}) \qquad \Delta GHG_{remelting} = \Sigma_m S_m \cdot (EF_m^{prim} - EF_m^{sec})$$

The **collection-based** indicator (headline) credits the Polish recycling chain with all metal recovered from scrap collected in Poland, wherever it is remelted. The **remelting-based** indicator credits metal remelted in Poland and is split into domestic and imported scrap; the imported part is attributable to foreign collectors. Shifting remelting between countries relocates emissions savings rather than creating new ones, so a change in the location of remelting is not counted as additional climate benefit. Avoided emissions occur mainly at primary smelters abroad, may also be claimed by other actors in the value chain, and do not reduce Poland's national inventory; the secondary route itself emits CO_2 in Poland and generates residues (salt slag, Waelz slag), which are reported. Monetisation at the EU ETS price and at the European Investment Bank shadow cost of carbon is a notional valuation, not a cash flow to Poland.

4.6 Strategic value (module M5)

- **Gross value of secondary metal** – secondary output × price; a measure of domestic supply, not a foreign-exchange gain.
- **FX margin** – the counterfactual-consistent foreign-exchange effect: without domestic remelting the scrap would be exported, so the gain is the value of metal minus the market value of the scrap consumed (domestic feed at export prices, imported feed at import prices) and the imported inputs.
- **Secondary output-to-consumption ratio** – secondary output relative to apparent consumption (for aluminium: secondary output plus net imports of unwrought aluminium); not a recycling input rate in the UNEP IRP/JRC sense.
- **Supply concentration** – Herfindahl–Hirschman index (HHI) of Poland's import sources for unwrought metals.
- **Policy benchmarks** – reference to the Critical Raw Materials Act benchmark that EU recycling capacity should cover at least 25% of annual EU consumption of strategic raw materials; the benchmark applies to the EU as a whole.

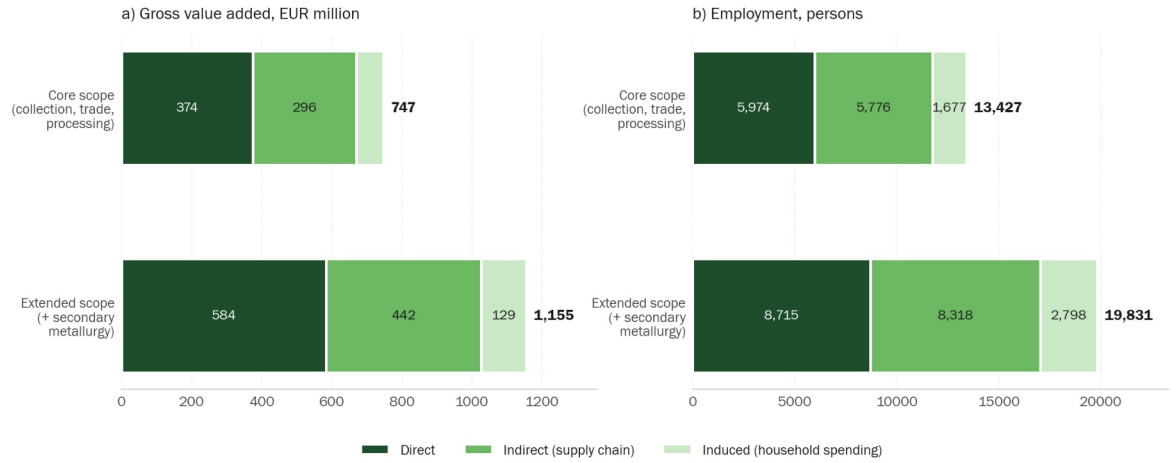
4.7 Uncertainty, sensitivity and scenarios (module M6)

All uncertain parameters receive triangular distributions (low, central, high) documented in Annex B. Correlated groups – the four allocation shares, metal prices, value-added ratios and paired emission/energy factors – are linked by a Gaussian copula. The Monte Carlo simulation uses 10 000 draws and a fixed seed; the P5–P95 band expresses parameter uncertainty under subjective ranges, not a statistical confidence interval. Structural choices – substitution rate, treatment of new scrap, displaced primary route – are tested separately (section 6.3). One-at-a-time sensitivity ranks parameters for GVA, jobs, taxes and avoided emissions (tornado charts). Scenarios for 2030 and 2035 set domestic scrap arisings, secondary output, feed yields and the footprints of both routes exogenously and re-run the whole model.

05 Economic contribution

In 2024 the extended NF scrap recycling industry generated EUR 584 million of direct gross value added and employed 8,715 people. Through its Polish supply chains it supported a total of EUR 1,026 million of GVA and 17,033 jobs (Type I), and EUR 1,155 million and 19,831 jobs including household spending (Type II).

FIGURE 10 Direct, indirect and induced GVA and employment



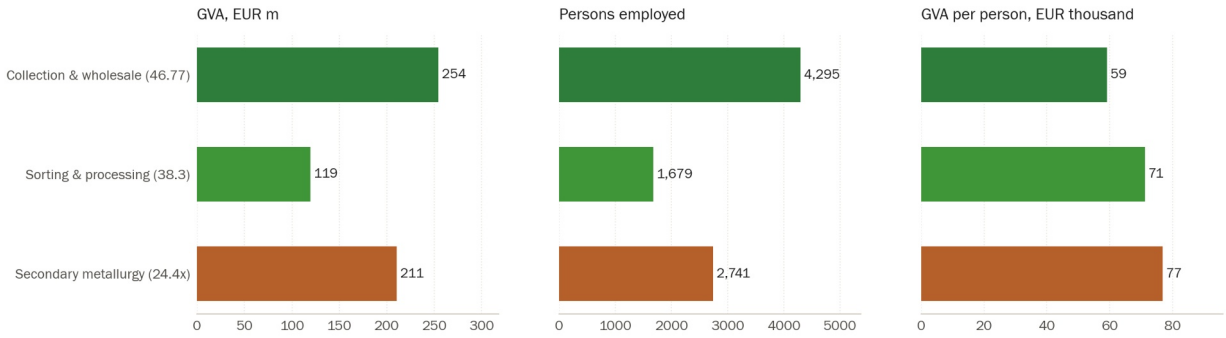
Source: IGMNiR NF-REC-PL; Eurostat SBS 2024, FIGARO 2023; central estimate.

TABLE 5 Economic contribution by segment, 2024 (EUR million; persons)

Segment	Turnover	Output	Direct GVA	GVA Type I	GVA Type II	Direct jobs	Jobs Type I	Jobs Type II
R1 Collection & wholesale	2,440	564	254	422	470	4,295	7,633	8,676
R2 Sorting & processing	588	469	119	248	277	1,679	4,116	4,750
R3 Secondary metallurgy	2,272	2,272	211	356	408	2,741	5,284	6,404
Core scope (R1+R2)	–	–	**374**	**670**	**747**	**5,974**	**11,750**	**13,427**
Extended scope (R1+R2+R3)	–	–	**584**	**1,026**	**1,155**	**8,715**	**17,033**	**19,831**

Source: IGMNiR NF-REC-PL v1.3, central values. R1 and R2: NF shares of SBS 2024 – value items 46.77 × 40% and 38.3 × 24%; employment 46.77 × 24% and 38.3 × 15%. R3: bottom-up from secondary output (Table 3). Turnover of R1 includes the value of traded goods and output of wholesale is the trade margin; turnover and output are not summed across segments because R3 buys scrap from R1/R2.

FIGURE 11 Direct GVA, employment and labour productivity by segment



Source: IGMNiR NF-REC-PL; Eurostat SBS 2024, FIGARO 2023; central estimate.

TABLE 6 Bridge between the three segments, 2024 (EUR million)

Segment	Output	Intermediate consumption	GVA	Labour cost	Gross operating surplus
R1 Collection & wholesale	564	309	254	71	183
R2 Sorting & processing	469	350	119	35	85
R3 Secondary metallurgy	2,272	2,062	211	95	116
Chain total (GVA only is additive)	**–**	**–**	**584**	**201**	**384**

Source: IGMNiR NF-REC-PL v1.3. GVA = labour cost + gross operating surplus in each segment. The output of R1 is the trade margin (not turnover); R3 buys scrap from R1/R2 and abroad, so output and intermediate consumption are not summed across segments – only GVA is. Purchases between segments are removed from the supply-chain calculation.

5.1 Multipliers and comparison

The implied GVA multiplier of the extended industry is 1.76 (Type I) and 1.98 (Type II); the employment multiplier is 1.95 and 2.28. For secondary metallurgy alone (R3) the employment multiplier is higher (1.93 / 2.34) because its direct labour intensity is low. The only recent European input–output study of scrap recycling – RWI's analysis of the German and EU steel-scrap industry, commissioned by the German scrap association BDSV – reports GVA multipliers of 2.1 (Germany) and 2.0 (EU-27) and employment multipliers of 2.5 and 2.4 (full-time equivalents).[10] The comparison places the Polish estimates in a plausible range; it is not a validation, because the material, the country and the employment concept differ.

TABLE 7 Input–output multipliers for Poland (FIGARO 2023) and comparison

Product / study	Output I	GVA I	GVA II	Jobs I	Jobs II
Wholesale services (parent of R1)	1.68	1.64	1.87	1.89	2.24
Waste management & recovery (parent of R2)	1.60	1.60	1.85	1.65	1.95
Basic metals (reference for R3)	1.72	2.02	2.36	2.32	2.83
NF recycling – core scope (this study)	–	1.79	2.00	1.97	2.25
NF recycling – secondary metallurgy R3 (this study)	–	1.69	1.94	1.93	2.34
NF recycling – extended scope (this study)	**–**	**1.76**	**1.98**	**1.95**	**2.28**
Steel-scrap recycling, EU-27 (RWI 2025, FTE)	–	–	2.0	–	2.4

Source: IGMNiR calculation on Eurostat FIGARO inter-country IO table 2023 (naio_10_fcp_ip4), domestic block of Poland; employment nama_10_a64_e 2024. Type II closes the model for households (tax wedge 34.7%, APC 0.88, domestic share of consumption at purchasers' prices).

Type II adds two distinct household-spending flows: the net wages paid directly by the industry (computed from SBS labour costs) and the net wages paid along the supply chain (from the Leontief inverse closed for

[10] RWI – Leibniz-Institut für Wirtschaftsforschung (Rothgang M., Dehio J., Janßen-Timmen R.), Economic Significance of the Steel Scrap Recycling Industry, study for BDSV, December 2025, pp. 14–17. RWI multipliers include induced effects and should be compared with Type II.

households). The two flows do not overlap, because the supply-chain impulse excludes the industry's own wages; each euro of labour income is therefore spent once in the model.

5.2 Contribution to public finances

TABLE 8 Fiscal contribution including supply chain and induced effects, 2024 (EUR million)

Scope	Labour taxes & SSC	CIT	Net taxes on products & production	Total EUR m	Total PLN m
Core scope	85	23	46	154	665
Extended scope	**142**	**33**	**99**	**274**	**1,180**

Source: IGMNiR NF-REC-PL v1.3. Labour taxes = tax wedge 34.7% (OECD Taxing Wages 2025; includes employee and employer social contributions) × compensation; CIT = 19% × gross operating surplus of the direct activity × taxable share 45% (assumption, range 30–60%); net taxes on products and production from FIGARO coefficients. VAT on final consumption of the industry's products is excluded. These are modelled estimates, not observed tax receipts.

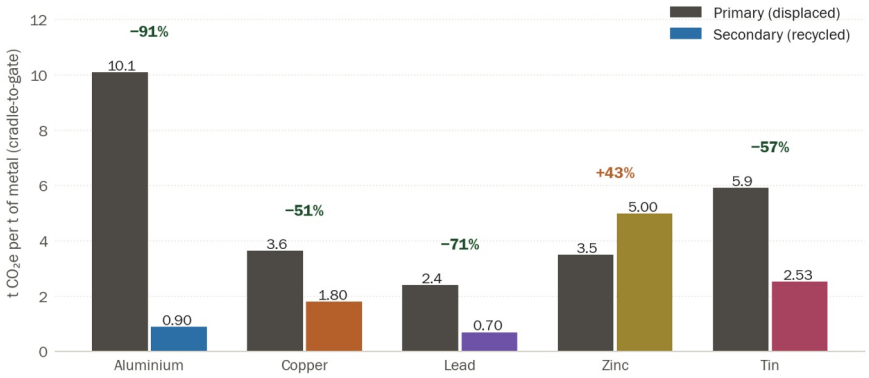
HOW TO READ THESE NUMBERS

- **Gross, not net.** The figures measure the economic activity associated with the industry (a "footprint"), not the net loss that would follow if it disappeared. With a 50% displacement rate the net employment effect would be about half of the gross figure.
- **Type I is the headline.** Type II effects depend on assumptions about household behaviour and are shown for completeness.
- **Headcount, not FTE.** Employment is persons employed (SBS, national accounts).
- **Catalytic effects are excluded.** Polish foundries, extruders, cable makers and battery producers rely on secondary metal; that activity is not counted here.

06 Environmental impact

Metal recovered from non-ferrous scrap collected in Poland in 2024 contributed to avoiding about 3.26 Mt CO_2e compared with the primary route – mostly at primary smelters outside Poland – and about 63 PJ of primary energy.

FIGURE 12 Carbon footprint of primary and secondary routes by metal



Source: European Aluminium EPR 2024 (Al primary, EU consumption mix 2023); IAI (Al secondary); ICA (Cu primary); IZA (Zn); Nuss & Eckelman 2014 (Cu, Pb secondary/primary); ITA, Aurubis (Sn). Zn secondary: IGMNiR assumption for Waelz route. Ranges: Annex B.

The comparison uses cradle-to-gate footprints. For aluminium the displaced primary metal is the EU consumption mix of 2023 (10.1 t CO_2e/t), which includes imports from carbon-intensive smelters; the secondary route is refining of mostly post-consumer scrap (0.9 t CO_2e/t, range 0.42–1.4).[11] For copper the global average cathode (3.64 t) is compared with secondary copper (1.8 t); the factors come from different methods and years, which is reflected in a wide range down to the footprint of KGHM cathode (1.69 t), at which the copper benefit would vanish.[12] Zinc is different: the secondary route in Poland – Waelz treatment of steel-plant dust followed by electrolysis or the ISP furnace – emits about 5 t CO_2e per tonne of zinc (Scope 1 and 2 of the Stalprodukt zinc companies, 2024), more than the global average for primary zinc (3.5 t), so the zinc result is negative.[13] Its value lies elsewhere: zinc is recovered from hazardous electric-arc-furnace dust that would otherwise have to be landfilled, and mining is avoided. The zinc result is conditional: the primary factor is a cradle-to-gate LCA value, the secondary factor is derived from corporate Scope 1 and 2 emissions of plants that also co-produce lead, and the allocation between zinc and lead has not been modelled. The 87 kt of secondary zinc is approximated from the share of residues in the feed and should be confirmed with an element balance.

Three qualifications apply. First, domestic arisings include new (pre-consumer) scrap from Polish manufacturers, which public statistics do not separate from old (post-consumer) scrap; end-of-life indicators used by UNEP IRP and the JRC count only old scrap. If 40% of aluminium and copper arisings were new scrap and only old scrap were credited, the collection-based indicator would be about 2.0 Mt CO_2e instead of 3.3 Mt. Second, secondary aluminium foundry alloys replace primary metal mainly in cast applications, so 1:1 substitution is an upper bound. Third, the same avoided emissions may also be claimed by foreign remelters of Polish scrap or by

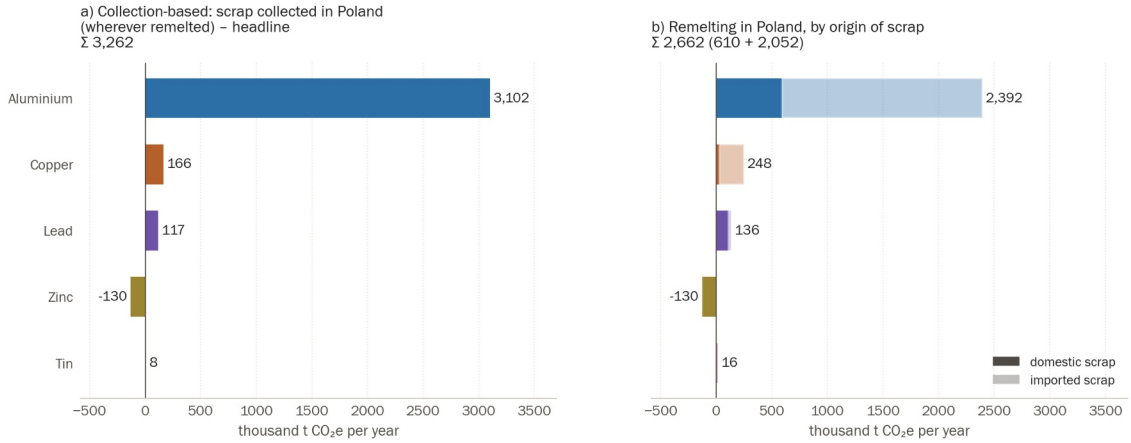
[11] European Aluminium (2024), Environmental Profile Report 2024, v2.0, p. 5; International Aluminium Institute, Aluminium recycling factsheet (2022 data); Nuss P., Eckelman M.J. (2014), Life Cycle Assessment of Metals: A Scientific Synthesis, PLoS ONE 9(7): e101298.

[12] International Copper Association, Copper cathode environmental profile (2023 data), as cited in Aurubis environmental product declaration (2026); Nuss & Eckelman (2014), Supporting information Table S38; IGSMiE PAN LCA of KGHM products (2024 data).

[13] Stalprodukt S.A., Management report of the Stalprodukt Group for 2024, sustainability statement (ESRS E1); annual report 2023 (structure of zinc feed). Per-tonne factor calculated by IGMNiR.

manufacturers reporting recycled content. The indicator therefore expresses a contribution, not an exclusive claim, and must not be added to other countries' or companies' figures.

FIGURE 13 Avoided GHG emissions by metal – collection-based and remelting-based perspectives



Source: IGMNiR NF-REC-PL v1.3; LCA factors: European Aluminium EPR 2024, IAI, ICA, IZA, Nuss & Eckelman (2014), ITA. Central estimate. The two panels are alternative attributions and must not be added.

TABLE 9 Environmental indicators by metal, 2024

Metal	Secondary output, kt	Avoided t CO_2e/t	Avoided GHG – collection, kt	Avoided GHG – remelting in PL, kt	of which domestic scrap, kt	Energy saved, PJ	Indicative footprint of secondary route, kt (mixed scope)
Aluminium	260.0	9.20	3,102	2,392	590	58.7	234
Copper	135.0	1.84	166	248	30	2.8	243
Lead	80.0	1.70	117	136	112	1.1	56
Zinc	87.0	-1.50	-130	-130	-130	0.1	435
Tin	4.8	3.39	8	16	8	0.6	12
Total	**566.8**	**–**	**3,262**	**2,662**	**610**	**63.2**	**980**

Source: IGMNiR NF-REC-PL v1.3. Collection-based = metal from scrap collected in Poland wherever remelted (headline). Remelting-based = metal remelted in Poland, incl. imported scrap attributable to foreign collectors. Energy: collection basis.

6.1 Notional monetary value

Valued at the 2024 average EU ETS allowance price of EUR 64.8/t[14] the avoided emissions are worth EUR 211 million a year; at the EIB shadow cost of carbon for 2025 (EUR 165/t, 2016 prices)[15] EUR 538 million. These are notional values: most avoided emissions would have occurred at smelters outside the EU ETS, and no payment flows to Poland. The two valuations use different price bases (EU ETS 2024, nominal; EIB, 2016 prices) and must not be added to GVA or tax figures.

6.2 Other avoided and generated burdens

- **Bauxite residue (red mud) avoided (remelting basis):** about 0.62 Mt per year (2.4 t per t of primary aluminium).
- **Copper mining waste avoided (remelting basis):** displacing 135 kt of primary cathode avoids about 12.6 Mt of tailings, 7.7 million m^3 of blue water and 4.2 kt of SO_2 (ICA global averages) – indicative, because the avoided mines are outside Poland.

[14] European Environment Agency (2025), EU Emissions Trading System data – average EUA price 2024.

[15] European Commission (2021), Technical guidance on the climate proofing of infrastructure in the period 2021–2027, OJ C 373, 16.9.2021, Tables 5–6.

- **Residues generated:** about 65 kt of salt slag from aluminium remelting and 261 kt of Waelz slag from zinc-dust recycling, which require recovery or safe disposal.
- **Indicative footprint of secondary production in Poland:** about 980 kt CO_2e a year, combining factors of mixed scope (cradle-to-gate LCA and, for zinc, corporate Scope 1 and 2); this is not a territorial emissions inventory. For aluminium, copper, lead and tin the secondary footprint is lower than that of the primary route; for zinc it is higher in this accounting.

6.3 Sensitivity to counterfactual choices

The Monte Carlo band covers parameter values, not the structure of the comparison. The table below changes three structural choices – the rate at which secondary metal displaces primary metal, whether new (pre-consumer) scrap is credited, and the footprint of the displaced primary aluminium. The collection-based result is most sensitive to these choices; under a combination of a 70% substitution rate and crediting only 60% of aluminium and copper scrap it falls by more than half.

TABLE 10 Avoided GHG and energy under alternative counterfactual choices, 2024

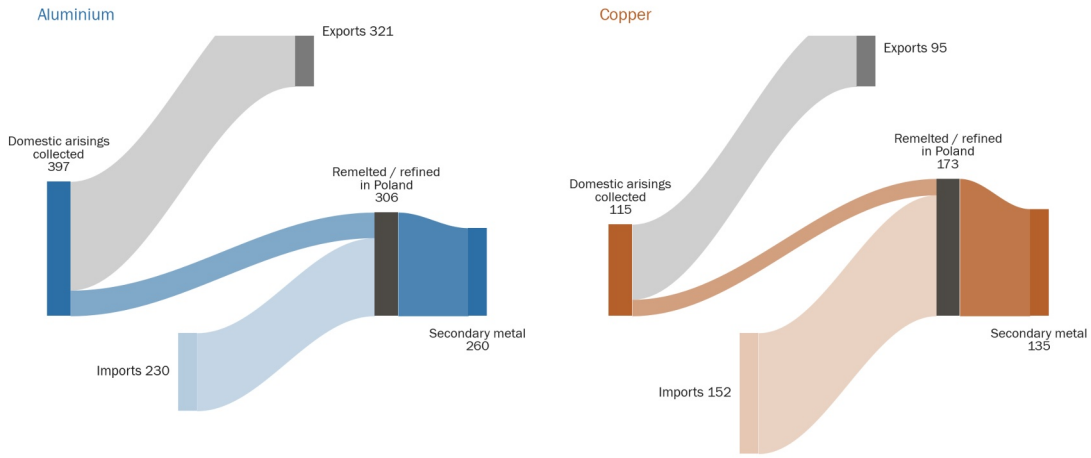
Variant	GHG – collection, Mt CO_2e	GHG – remelting, Mt CO_2e	Energy – collection, PJ
Model base: 1:1 substitution, all scrap credited	**3.26**	**2.66**	**63**
Aluminium substitution 90%	2.92	2.40	57
Aluminium substitution 70%	2.24	1.87	44
Aluminium substitution 50%	1.56	1.35	31
Only 60% of Al and Cu scrap credited (old scrap)	1.96	2.66	39
60% of Al/Cu scrap credited and 70% substitution	1.28	1.73	26
Displaced primary Al at 6.6 t CO_2e/t (EU-produced)	2.08	1.75	63

Source: IGMNiR NF-REC-PL v1.3, central parameter values. The 60% old-scrap share is an illustrative assumption: public statistics do not separate new from old scrap. Substitution variants apply to the displaced primary footprint and energy.

07 Strategic value

Secondary smelters in Poland turn domestic and imported scrap into metal worth EUR 2.27 billion a year, equivalent to 38% of apparent aluminium consumption and 60% of lead; secondary zinc output exceeds domestic zinc consumption, as about two thirds of Polish zinc is exported. Because scrap has a market value – it can be sold abroad and is also bought abroad – the estimated processing margin – a hypothetical trade account – is about EUR 258 million a year. It is an accounting measure of value added in Poland, not an argument for or against scrap exports.

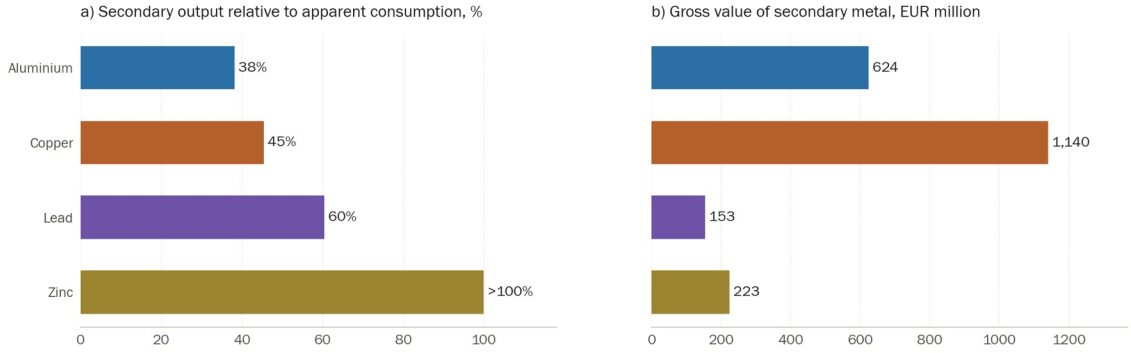
FIGURE 14 Mass balance of aluminium and copper scrap in Poland, 2024



Source: IGMNiR NF-REC-PL mass balance (M2); Eurostat Comext 2024; IGSMiE PAN (2025); KGHM (2025). Arisings derived as A = C + X − M.

The balance shows strong two-way trade within an integrated European scrap market. Poland exported 321 kt and imported 230 kt of aluminium scrap in 2024, as different grades move to the plants best equipped to process them. For copper, KGHM's growing scrap intake relies partly on imports (152 kt), while 95 kt of copper scrap was exported.

FIGURE 15 Secondary supply share and value of secondary metal by metal



Source: IGMNiR NF-REC-PL; IGSMiE PAN (2025) apparent consumption; Eurostat Comext; World Bank prices 2024. Zinc and tin: output exceeds domestic consumption (mostly exported).

TABLE 11 Strategic indicators by metal, 2024

Metal	Apparent consumption, kt	Secondary share	Gross value of secondary metal, EUR m	Processing margin (FX), EUR m	CRMA status
Aluminium	680.7	38%	624	120	strategic & critical
Copper	297.0	45%	1,140	15	strategic & critical
Lead	132.4	60%	153	64	–
Zinc	85.7	>100% (net exporter)	223	40	–
Tin	1.1	>100% (net exporter)	132	20	–

Sources: IGMNiR NF-REC-PL v1.3; apparent consumption: Al = secondary output + net imports of unwrought Al (Comext 2024); Cu, Pb, Zn, Sn IGSMiE PAN (2025). Processing margin = value of secondary metal − market value of the scrap consumed (domestic feed at export unit values, imported feed at import unit values; battery scrap at the CN 854911 unit value) − imported inputs. Zinc: residue-based route (Waelz oxide); zinc and tin output exceed domestic consumption because most is exported. CRMA Annexes I–II.

7.1 Concentration of primary metal supply

TABLE 12 Poland's imports of primary metals by partner, 2025

Product (CN)	Imports, kt	HHI	Top-3 partners	Russia
Unwrought aluminium (7601)	694.6	1,714	NL 35%, RU 11%, SE 10%	11.1%
Refined copper (7403)	12.7	4,273	DE 63%, FR 13%, BE 9%	0.0%
Unwrought zinc (7901)	53.5	2,308	FI 28%, DE 27%, BE 26%	0.0%
Unwrought lead (7801)	69.2	1,580	SE 27%, DE 25%, EE 8%	0.0%
Unwrought tin (8001)	2.1	2,566	AE 41%, CN 21%, BE 20%	0.0%
Unwrought nickel (7502)	2.2	4,706	NL 66%, US 13%, FR 10%	0.0%

Source: IGMNiR calculation on Eurostat Comext DS-045409. HHI = Herfindahl–Hirschman index of partner shares (0–10 000; >2 500 = highly concentrated). For intra-EU arrivals the partner is the country of consignment (e.g. Dutch hubs), not of origin.

Secondary aluminium produced in Poland is one of several sources of supply on a market where imports of Russian primary aluminium have been banned since February 2026 and where the EU relies on imports for most of its primary metal. Poland imported 695 kt of unwrought aluminium in 2025, of which 11.1% came from Russia; this source ended when the transition quota of the 16th sanctions package expired. Secondary foundry alloys replace primary metal mainly in casting applications.

7.2 Relation to the CRMA recycling benchmark

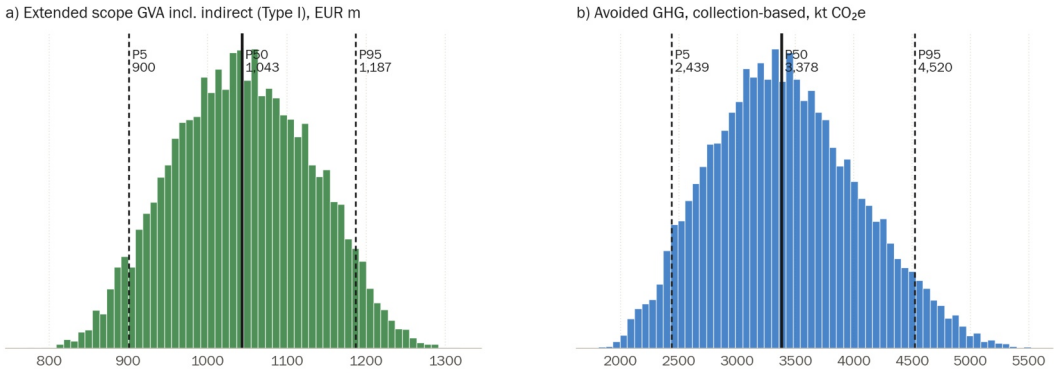
The CRMA benchmark applies to the EU as a whole, but national capacity contributes to it. Polish secondary aluminium output (260 kt) equals 38% of national aluminium consumption and secondary copper (135 kt) 45% of national copper consumption. Growth of secondary production depends on capacity, energy costs and the availability of suitable scrap grades; copper smelting already relies partly on imported scrap. KGHM targets about 350 kt of scrap processing by 2030, more than double the 2024 level,[16] and its Legnica recycling smelter was selected as a CRMA strategic project in October 2026.

[16] KGHM Polska Miedź S.A., Strategy summary for 2024 (KPI table, p. 5) and Q4/FY2025 results presentation (March 2026), slides 7, 10 and 13.

08 Uncertainty and sensitivity

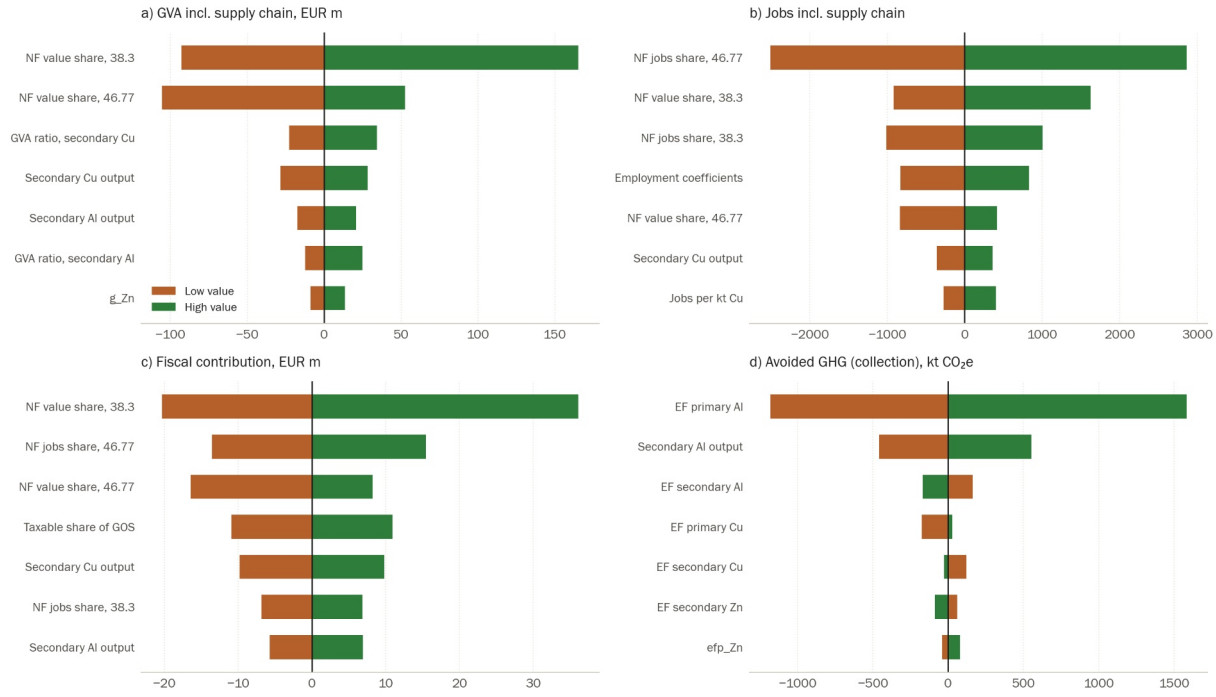
The Monte Carlo simulation propagates the ranges of all 56 uncertain parameters jointly, with correlated groups linked by a Gaussian copula. The 90% band of extended-scope GVA including supply chains is EUR 900–1,187 million (±14%). Employment is more uncertain (±21%) because the share of NF scrap in the workforce of mixed-material recyclers is not observed. Avoided emissions vary by ±32% because the footprint of displaced primary aluminium differs widely between smelters.

FIGURE 16 Monte Carlo distributions of GVA and avoided emissions



Source: IGMNiR NF-REC-PL v1.3, module M6; triangular distributions with Gaussian copula for correlated groups (Annex B), seed 20261118. Parameter-uncertainty band, not a statistical confidence interval.

FIGURE 17 Tornado charts: most influential parameters



Source: IGMNiR NF-REC-PL v1.3, module M6; one-at-a-time sensitivity on Annex B ranges; extended scope.

Economic results are most sensitive to the allocation shares (NF value share, 38.3; NF value share, 46.77) – a direct consequence of the absence of official statistics on non-ferrous recycling. Better data on turnover,

employment and tonnage by material would narrow the band more than any other improvement. Environmental results depend above all on the EF primary Al and on secondary aluminium output.

8.1 Plausibility checks and data gaps

- **Scrap consumption vs waste statistics.** Modelled scrap consumption for aluminium, copper and tin (485 kt) equals 67% of non-ferrous metal waste recycled in Poland according to Eurostat (729 kt, W062). The gap is consistent with categories not modelled (precious metals, nickel, drosses, magnesium) and with double reporting of traded scrap; the test is a plausibility check, not proof.
- **Lead.** The model implies 133 kt of battery-equivalent feed, against 89 kt of hazardous battery waste recycled according to Eurostat (W0841) and about 98 kt of lead and alloys sold by the two battery recyclers. The discrepancy cannot be resolved with public data and is reflected in the 65–100 kt range for secondary lead.
- **Productivity.** Direct GVA per person employed is EUR 59k in collection and trade, EUR 71k in processing and EUR 77k in secondary metallurgy, against EUR 48k for NACE 24.42 and EUR 76k for 24.43 (SBS 2024). The higher R3 value reflects capital-intensive smelting; Orzeł Biały's 2024 annual report implies EUR 177k per employee. Productivity in R1/R2 follows from the ratio of value and employment shares and is therefore not an independent check.
- **Open issues.** (i) Data on turnover, employment and tonnage by material for mixed-material recyclers; (ii) plant-level 2024 tonnages for secondary aluminium and lead; (iii) KGHM's metallurgical employment and the scrap share of its smelters; (iv) the footprint of the Waelz route in Poland.

8.2 Limitations

- **Input–output assumptions.** Fixed technical coefficients, no capacity or price constraints; the FIGARO 2023 product-by-product table is applied to 2024 activity.
- **Mixed valuation.** Direct GVA comes from SBS (factor cost); indirect and induced effects are at basic prices – a difference of about 2–3%.
- **Structural choices.** The P5–P95 bands cover parameters only; the substitution rate, the treatment of new scrap and the displaced primary route are tested separately (section 6.3).
- **Gross, static estimates.** No displacement, price or rebound effects (additional secondary supply may lower prices and raise consumption); a single base year.
- **Allocation shares are not observed.** The non-ferrous share of mixed-material collectors and processors is estimated from value and tonnage shares.
- **New and old scrap.** Public statistics do not separate pre-consumer from post-consumer scrap; avoided emissions credit both (Chapter 6).
- **Trade balance.** Arisings A = C + X − M assume that imported scrap is consumed in Poland; re-exports net out.
- **Data vintages.** Emission factors (2021–2025) and energy factors (ecoinvent-based, 2014) come from different years and methods.
- **Secondary output.** Plant-level tonnages for 2024 are not published for all producers; secondary aluminium and lead are estimated within ranges.

09 Scenarios to 2030 and 2035

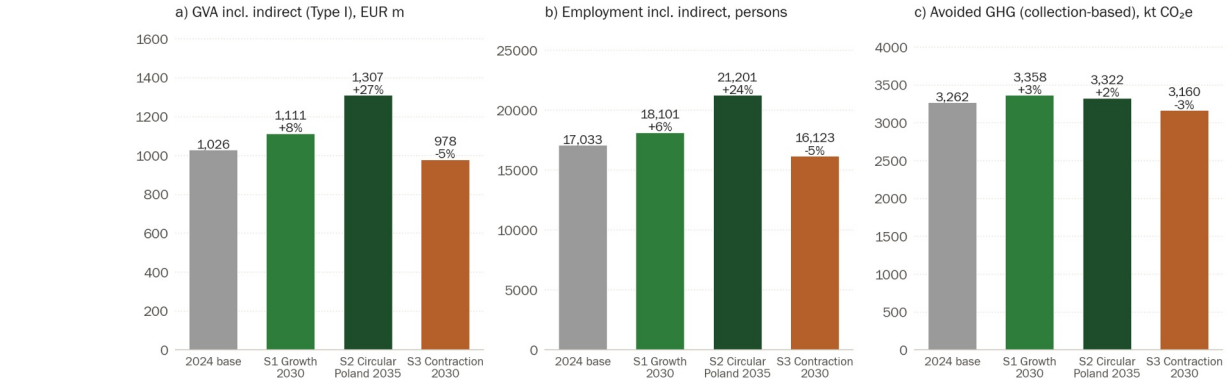
Four scenarios test how the contribution responds to policy and market conditions. All are expressed in constant 2024 prices and use the same model. Domestic scrap arisings are set exogenously, the structure of trade is kept as in 2024 and imports close the balance; the footprints of both primary and secondary routes decline over time. The scenarios are conditional projections, not forecasts: they assume that the required investments, permits and scrap supply materialise.

TABLE 13 Scenario assumptions and physical flows (kt)

Scenario	Narrative	Secondary Al / Cu	Arisings Al / Cu	Al scrap imports / Cu scrap imports
Base 2024	Observed 2024	260 / 135	397 / 115	230 / 152
S1 Growth 2030	Arisings +10%; Hydro/Grupa Kęty upgrades; KGHM scrap programme; trade shares as in 2024; primary footprint −8%, secondary −10%	300 / 170	436 / 127	270 / 220
S2 Circular Poland 2035	Arisings +25–30% (ELV/WEEE sorting); new Al capacity; KGHM Legnica recycling smelter (low-grade feed, yield 0.6); trade shares as in 2024; footprints −20% / −25%	380 / 220	496 / 150	353 / 340
S3 Contraction 2030	Arisings +5%; energy-cost squeeze and capacity closures; trade shares as in 2024; primary footprint −8%	210 / 120	416 / 121	168 / 132

Source: IGMNiR NF-REC-PL v1.3. Core (collection/trade/processing) activity scales with the market value of scrap collected in Poland. S1 and S2 require higher scrap purchases (domestic and imported) and, in S2, new aluminium remelting capacity beyond the 205 kt confirmed at Hydro plants – these are preconditions, not outcomes.

FIGURE 18 Scenario results



Source: IGMNiR NF-REC-PL; constant 2024 prices; assumptions in the scenario table; primary and secondary footprints decline over time.

Economically, the spread between the growth and the contraction path is large: by 2035 Scenario S2 adds EUR 281 million of GVA including supply chains and 4,168 jobs, while S3 reduces GVA by EUR 49 million. The climate picture is different. Collection-based avoided emissions change little (3.26 → 3.32 Mt), because growing collection is offset by the decarbonisation of primary metal; where scrap is remelted does not change the climate benefit. Remelting in Poland rises with new capacity, from 2.66 to 3.24 Mt of avoided emissions. Economic results are driven by capacity and investment; climate results by collection and sorting.

10 Conclusions and recommendations

The results describe an industry whose activity depends on access to scrap of suitable quality, competitive energy and timely permits, within an integrated European scrap market. The recommendations aim at more collection, better sorting and a level playing field for processing capacity. IGMNiR proposes seven actions.

01 **Recognise NF recycling in the national implementation of the CRMA** – include secondary aluminium and copper capacity explicitly in the update of the Polish Raw Materials Policy and in the CRMA implementing act.

02 **Energy costs** – ensure that secondary smelters classified in NACE 24.42–24.44 can effectively use the existing indirect-cost compensation scheme and long-term renewable power contracts; energy is a smaller cost item than scrap, but decisive for margins in low-price years (in 2024 the zinc producers of the Stalprodukt group received about PLN 122 million of energy-cost compensation).

03 **Faster permits for recycling capacity** – apply for CRMA strategic-project status where eligible, and introduce national deadlines and a single point of contact for other remelting, refining and sorting plants, with clear fire-safety and financial-guarantee requirements for scrap yards.

04 **Sorting technology and scrap quality** – co-finance sensor-based sorting (LIBS, XRF, X-ray transmission) for end-of-life vehicles, WEEE and packaging from EU funds, and support alloy-specific quality standards and EU end-of-waste criteria, so that Polish scrap can be upgraded to wrought-alloy quality.

05 **Make recycled content count** – use green public procurement and the forthcoming ELV and construction-products criteria to reward low-carbon and recycled metal, including clear rules for how recycled (scrap-based) content is counted in CBAM embedded-emission calculations.

06 **Collection of metal-bearing waste** – improve collection and pre-treatment of WEEE, end-of-life vehicles, cables and spent batteries, including readiness for the lead-recovery and recycled-content requirements of the Batteries Regulation (EU) 2023/1542.

07 **Skills** – vocational programmes for metallurgy, sorting and quality control in the Silesian, Lower Silesian and Lubusz clusters.

A Data sources and reliability

TABLE 14 Data sources and reliability classes

Source	Content	Period	Class
Eurostat SBS (sbs_ovw_act, sbs_r_nuts2021)	Enterprises, employment, turnover, GVA by NACE class and region	2021–2024	A
Eurostat waste statistics (env_wasgen, env_wastrt)	NF metal waste generated and recycled; recovered materials	2010–2024	A
Eurostat Comext (DS-045409)	Trade in scrap and metals by CN code and partner	2015–2025	A
Eurostat FIGARO (naio_10_fcp_ip4)	Inter-country input–output table, domestic block PL	2023	A
Eurostat national accounts (nama_10_a64, _e)	Output and employment by A64 industry	2022–2024	A
IGSMiE PAN (2025) / PIG-PIB	Production, trade and consumption of metals in Poland	2015–2024	A
World Bank Pink Sheet; Eurostat ert_bil_eur_a	Metal prices; exchange rates	2023–2026	A
OECD Taxing Wages 2025	Tax wedge	2024	A
EEA; EC climate-proofing guidance (EIB)	Carbon prices	2024–2025	A
Nuss & Eckelman (2014), PLoS ONE	LCA of metals (peer-reviewed)	2014	A
European Aluminium EPR 2024; IAI; ICA; IZA; ILA; ITA	Emission factors primary/secondary	2021–2025	B
KGHM, Hydro, Grupa Kęty, Gränges, Boryszew, Orzeł Biały, Stalprodukt (incl. ESG/ESRS statements)	Secondary output, capacity, employment, emissions	2022–2026	B
RWI (2025) for BDSV; EuRIC; KU Leuven for Eurometaux (2022)	Benchmarks	2020–2025	B
Trade press (Fastmarkets, S&P Global, Mining Weekly)	Status of pending EU measures	2025–2026	C

Class A: official statistics, EU law, peer-reviewed publications, statutory financial statements; B: industry association or company publication; C: media, used only for the status of pending measures.

B Model parameters

TABLE 15 Uncertain parameters: central value and triangular range

Parameter	Central	Low	High	Source / basis
s_trade_val	0.400	0.300	0.450	NF share of market value of materials recycled in PL 2024: Eurostat env_wastrt x Comext unit values (A, IGMNiR calc.)
s_trade_emp	0.240	0.100	0.400	Blend of value (0.40) and tonnage (0.08) shares (C)
s_proc_val	0.240	0.150	0.400	Blend of value and tonnage shares for NACE 38.3 (C)
s_proc_emp	0.150	0.060	0.240	38.3 incl. labour-intensive municipal sorting with negligible NF content (C)
S_Al	260.0	210.0	320.0	Capacity balance: Hydro 205 kt cap. x 0.8-0.9 less primary/Si correction; Grupa Kety; Granges; 23.4 kt unalloyed; upper bound PRODCOM 24421154 304 kt sold (A/B)
S_Cu	135.0	110.0	160.0	KGHM 159 kt Cu scrap processed 2024 (dry) x Cu content; Cu-alloy remelters e.g. WM Dziedzice brass 20 kt (B)
S_Pb	80.0	65.0	100.0	Battery recyclers (W0841 HAZ 88.6 kt x 0.6 = 53 kt + Pb scrap 7802; Orzel Bialy 64.9 + Baterpol 32.8 kt sold) + HC Miasteczko Slaskie 14.8 kt refined lead from secondary oxides 2024 (Stalprodukt Q4-2024 report) (A/B)
S_Zn	87.0	75.0	100.0	Stalprodukt group 2024: Zn 153.8 kt x 56.4% feed from residues (Waelz oxide from EAF dust, imported oxides, zinc-bearing dusts); HCM 100% secondary oxides (Stalprodukt annual reports 2023-2024) (A/B)
S_Sn	4.76	4.50	5.00	IGSMiE PAN 2025 p.65-66: 4,757 t, 100% secondary (A)
y_Al	0.850	0.800	0.920	Boin & Bertram (2005) JOM 57(8); post-consumer 0.80-0.88, process scrap 0.95 (A/B)
y_Cu	0.780	0.650	0.880	KGHM scrap mix; ICSG (B)
y_Pb	0.600	0.550	0.650	ILA: Pb content of spent lead-acid batteries 60-65% (B)
y_Zn	0.550	0.500	0.600	Zn content of Waelz oxide (B)
y_Sn	0.750	0.600	0.900	IGMNiR assumption, solder/tin scrap (C)
p_Al	2,400.0	2,235.0	2,600.0	World Bank 2024: 2,419 USD/t + foundry-alloy premium (A)
p_Cu	8,446.0	8,000.0	8,800.0	World Bank 2024: 9,142 USD/t (A)
p_Pb	1,911.0	1,800.0	2,050.0	World Bank 2024: 2,069 USD/t (A)
p_Zn	2,565.0	2,400.0	2,700.0	World Bank 2024: 2,776 USD/t (A)
p_Sn	27,777.0	26,000.0	29,500.0	World Bank 2024: 30,066 USD/t (A)
g_Al	0.080	0.060	0.120	Alumetal FY2022 annual report: (EBITDA+personnel)/revenue 11.7% (record year) (A)
g_Cu	0.070	0.050	0.100	refining margin of scrap-based cathode (C)
g_Pb	0.200	0.140	0.220	Orzel Bialy 2024: 21%; 2025: 22% (A)
g_Zn	0.190	0.150	0.250	Stalprodukt zinc segment 2024: (segment result + depreciation + est. personnel costs)/revenue, excl. energy-cost compensation 19%, incl. 25% (A/C)
g_Sn	0.060	0.040	0.100	IGMNiR assumption (C)
j_Al	2.40	1.80	3.20	Alumetal FY2022: 628 staff / 247.8 kt; Hydro plants 2025-26 (A/B)
j_Cu	5.00	3.00	8.00	scrap share of Legnica/Glogow staffing (C)
j_Pb	3.00	2.50	4.50	Orzel Bialy 2024: 191 staff / 64.9 kt (A)
j_Zn	13.0	10.0	15.0	ZGH group headcount 2,425 (end-2023) / $_{\text{150 kt Zn; core smelting}}$ 13 jobs/kt (Stalprodukt AR 2023) (A/C)
j_Sn	15.0	10.0	20.0	IGMNiR estimate, small refiners (C)
apc	0.880	0.800	0.950	average propensity to consume out of net labour income (C)
tau	0.347	0.335	0.360	OECD Taxing Wages 2025, Overview Table 1.2: single worker without children at average wage, Poland 2024 (A)

Parameter	Central	Low	High	Source / basis
ec_scale	1.00	0.900	1.10	uncertainty of employment coefficients (product/industry mismatch) (C)
taxable_share_gos	0.450	0.300	0.600	GOS net of depreciation, interest and losses; IGMNiR assumption (C)
efp_Al	10.1	6.60	14.8	European Aluminium EPR 2024 v2.0 p.5 (EU consumption mix 2023); low EU-produced; high IAI 2023 global (B)
efs_Al	0.900	0.420	1.40	refining of post-consumer scrap: EA EPR 2024 0.415 + preparation; Nuss & Eckelman 2014 1.4 (A/B)
efp_Cu	3.64	1.69	3.96	ICA global cathode 2023 data (via Aurubis EFD 2026); low = KGHM cathode 2024 (counterfactual domestic) (B)
efs_Cu	1.80	0.440	2.10	Nuss & Eckelman 2014 SI Tab.S38 (A)
efp_Pb	2.40	1.63	2.80	Nuss & Eckelman 2014 (A)
efs_Pb	0.700	0.400	0.800	Nuss & Eckelman 2014; ILA (A/B)
efp_Zn	3.50	3.03	4.40	IZA LCA 2023 (B)
efs_Zn	5.00	4.30	6.00	Stalprodukt ESRS 2024: Scope 1+2 (location-based) of ZGH and HCM 5.1 t CO2e/t Zn; ISP/Waelz route 5-6, electrolysis ~4.3 (A/B, derived)
efp_Sn	5.92	5.92	6.63	ITA 2024 via Aurubis EFD (B)
efs_Sn	2.53	1.00	2.79	Aurubis Beerse 2025 (B)
enp_Al	194.0	170.0	210.0	Nuss & Eckelman 2014 (A)
ens_Al	20.0	10.0	24.0	Nuss & Eckelman 2014, post-consumer scrap 23.8 (A)
enp_Cu	59.3	45.0	65.0	Nuss & Eckelman 2014 (A)
ens_Cu	28.1	22.0	32.0	Nuss & Eckelman 2014 (A)
enp_Pb	28.0	24.0	32.0	Nuss & Eckelman 2014 (A)
ens_Pb	12.0	6.00	14.0	Nuss & Eckelman 2014; BIR 2008 (A/B)
enp_Zn	54.4	45.0	60.0	Nuss & Eckelman 2014 (A)
ens_Zn	53.8	45.0	80.0	Stalprodukt 2023: ZGH group ~53.8 GJ/t Zn (A/B, derived)
enp_Sn	321.0	280.0	340.0	Nuss & Eckelman 2014 (A)
ens_Sn	58.0	30.0	70.0	Aurubis Beerse 2025 (B)
salt_slag	0.250	0.150	0.500	t salt slag per t secondary Al (rotary-furnace share) (C)
eua	64.8	60.0	74.0	EEA: EU ETS average 2024; high ESMA 2025 average (A)
scc	165.0	130.0	250.0	EIB shadow cost of carbon 2025 (2016 prices), OJ C 373/2021 Tab.5-6 (A)

Units: s_, g_, apc, tau, taxable_share_gos shares; ec_scale index; S_ kt metal; y_ t metal/t scrap; p_ EUR/t; j_ jobs per kt; efp_/efs_ t CO_2e/t; enp_/ens_ GJ/t; salt_slag t/t; eua, scc EUR/t CO_2e. Correlated groups (Gaussian copula): allocation shares ρ=0.8; prices ρ=0.6; GVA ratios ρ=0.5; Al and Zn secondary EF/energy ρ=0.8. Fixed: CIT 19%; labour cost per job Al 30, Cu 48, Pb 45, Zn 29, Sn 27 EUR k.

C Verified installations

TABLE 16 NF recycling and secondary-metal installations shown on the map

#	Installation	Location	Metal	Activity	Capacity / output
1	Hydro Aluminium Kęty (ex-Alumetal)	Kęty (małopolskie)	Al	Scrap remelting to secondary foundry alloys	87.5 kt/yr
2	Hydro Aluminium Gorzyce (ex-Alumetal)	Gorzyce (podkarpackie)	Al	Scrap remelting to foundry and master alloys	57.5 kt/yr
3	Hydro Aluminium Nowa Sól (ex-Alumetal)	Nowa Sól (lubuskie)	Al	Scrap sorting (LIBS) and remelting	60 kt/yr alloys; 120 kt/yr sorting
4	Grupa Kęty – foundry	Kęty (małopolskie)	Al	Remelting scrap into extrusion billets	>30 kt scrap/yr
5	Gränges Konin	Konin (wielkopolskie)	Al	Recycling & casting centre and rolling mill	100-140 kt/yr rolled
6	KGHM – Huta Miedzi Legnica	Legnica (dolnośląskie)	Cu	Copper smelting & refining with scrap; CRMA strategic recycling-smelter project	135 kt Cu/yr target (2030)
7	KGHM – Huta Miedzi Głogów I & II	Żukowice (dolnośląskie)	Cu	Smelting & electrorefining (primary + purchased materials)	~470 kt/yr cathode
8	Walcownia Metali Dziedzice (Boryszew)	Czechowice-Dziedzice (śląskie)	Cu	Melting incl. scrap to copper and brass semis	n/a
9	Baterpol – battery processing	Świętochłowice (śląskie)	Pb	Breaking and processing of lead-acid batteries	70 kt/yr battery scrap
10	Baterpol – lead plant	Katowice-Szopienice (śląskie)	Pb	Lead smelting and refining	incl. above
11	Orzeł Biały	Piekary Śląskie (śląskie)	Pb	Battery-scrap recycling to refined lead and alloys	~100 kt/yr battery scrap
12	HC Miasteczko Śląskie (Stalprodukt group)	Miasteczko Śląskie (śląskie)	Zn	ISP zinc-lead smelter running on 100% secondary oxides (2024)	14.8 kt refined Pb (2024)
13	ZGH Bolesław (Stalprodukt group)	Bukowno (małopolskie)	Zn	Electrolytic zinc (~40% secondary feed in 2024) and Waelz kilns processing steel-plant dust	130 kt/yr Zn & alloys; group Zn 153.8 kt (2024)
14	Fenix Metals	Chmielów (podkarpackie)	Sn	Secondary tin refining	share of 4.76 kt (PL 2024)
15	Elemental Strategic Metals (POLVOLT)	Zawiercie (śląskie)	PGM/ Ni/Co	PGM refining; battery recycling (CRMA strategic project)	1 050 t PGM-bearing material (2025)

Sources as listed in data/facilities.csv (company websites and reports, IGSMiE PAN 2025, European Commission). The list is not exhaustive: hundreds of collection and sorting yards are not shown.

D Scope diagram and glossary

FIGURE 19 System boundary of the model

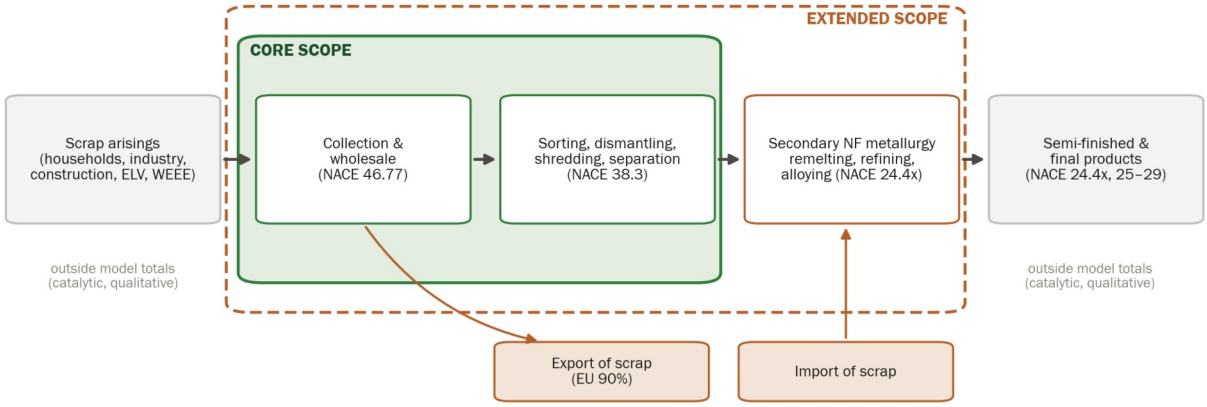


TABLE 17 Glossary

Term	Meaning
GVA	Gross value added at basic prices = output − intermediate consumption
Type I / Type II	Multipliers including supply-chain (I) and additionally household-spending (II) effects
FIGARO	Full International and Global Accounts for Research in input-Output analysis (Eurostat/JRC)
HHI	Herfindahl–Hirschman index of market concentration
CRMA	Critical Raw Materials Act, Regulation (EU) 2024/1252
WSR	Waste Shipment Regulation (EU) 2024/1157
CBAM	Carbon Border Adjustment Mechanism
ELV / ELVR	End-of-life vehicles / ELV Regulation (EU) 2026/1738
WEEE	Waste electrical and electronic equipment
EF	Emission factor, t CO_2e per t of metal
Waelz	Rotary-kiln process recovering zinc oxide from electric-arc-furnace dust
P5 / P50 / P95	Percentiles of the Monte Carlo distribution

References

Aurubis AG (2026), Environmental product declaration – copper cathode and tin (citing ICA 2023 and ITA 2024 data).

Council of the European Union (2025), 16th package of restrictive measures against Russia, 24 February 2025.

European Aluminium (2020), Circular Aluminium Action Plan. Brussels.

European Aluminium (2024), Environmental Profile Report 2024, version 2.0. Brussels.

European Commission (2021), Technical guidance on the climate proofing of infrastructure in the period 2021–2027, OJ C 373, 16.9.2021.

European Commission (2025), The Clean Industrial Deal, COM(2025) 85; European Steel and Metals Action Plan, COM(2025) 125.

European Commission, DG TAXUD (2025), Surveillance of imports and exports of metal scrap, 23 July 2025.

European Environment Agency (2025), EU Emissions Trading System data and average allowance prices.

EuRIC (2020), Metal Recycling Factsheet. Brussels.

Eurostat (2026), Structural business statistics; Waste statistics; Comext DS-045409; FIGARO inter-country input–output tables (naio_10_fcp_ip4); National accounts (nama_10_a64); GISCO NUTS 2021.

Fraser of Allander Institute (2024), The Aluminium Industry in the UK. University of Strathclyde for ALFED.

Gregoir L. (KU Leuven) (2022), Metals for Clean Energy: Pathways to solving Europe's raw materials challenge. Eurometaux.

IGSMiE PAN – Lewicka E., Szlugaj J. (eds.) (2025), Gospodarka surowcami mineralnymi w Polsce w latach 2015–2024. Kraków.

International Aluminium Institute (2023), Aluminium recycling factsheet; GHG emissions data.

International Copper Association (2023), Copper environmental profile.

International Zinc Association (2023), Life cycle assessment of special high grade zinc.

KGHM Polska Miedź S.A. (2025, 2026), Strategy summary for 2024; Q4/FY2025 results presentation.

KOBiZE (2025), Wskaźniki emisyjności CO_2 dla energii elektrycznej (2024 data); National inventory report.

Miller R.E., Blair P.D. (2022), Input–Output Analysis: Foundations and Extensions, 3rd ed. Cambridge University Press.

Nuss P., Eckelman M.J. (2014), Life Cycle Assessment of Metals: A Scientific Synthesis. PLoS ONE 9(7): e101298.

OECD (2025), Taxing Wages 2025. Paris: OECD Publishing.

Regulation (EU) 2023/956 (CBAM); Regulation (EU) 2024/1157 (waste shipments); Regulation (EU) 2024/1252 (CRMA); Regulation (EU) 2026/1738 (ELV).

Stalprodukt S.A. (2024, 2025, 2026), Sprawozdanie Zarządu z działalności Grupy Kapitałowej Stalprodukt za lata 2023, 2024 i 2025, wraz z oświadczeniem o zrównoważonym rozwoju (ESRS) oraz skonsolidowanymi sprawozdaniami finansowymi; raporty kwartalne 2024–2025. Bochnia.

Rothgang M., Dehio J., Janßen-Timmen R. (RWI) (2025), Economic Significance of the Steel Scrap Recycling Industry. Study for BDSV, Essen.

Uchwała nr 39 Rady Ministrów z dnia 1 marca 2022 r. w sprawie przyjęcia polityki surowcowej państwa, M.P. 2022 poz. 371.

World Bank (2026), Commodity Price Data (The Pink Sheet), annual and monthly series.

IGMNiR

Economic Chamber of Non-Ferrous Metals and Recycling

Economic Chamber of Non-Ferrous Metals and Recycling

Izba Gospodarcza Metali Nieżelaznych i Recyklingu

NF-REC-PL is an open, reproducible model linking official Polish and EU statistics with the process metallurgy of recycling. It estimates the gross economic contribution of non-ferrous scrap collectors, processors and secondary smelters, the greenhouse-gas emissions and energy their activity avoids, and its importance for the supply of strategic metals.

SUGGESTED CITATION

IGMNiR (2026), The value of non-ferrous scrap recycling to the Polish economy. NF-REC-PL integrated impact model, November 2026.