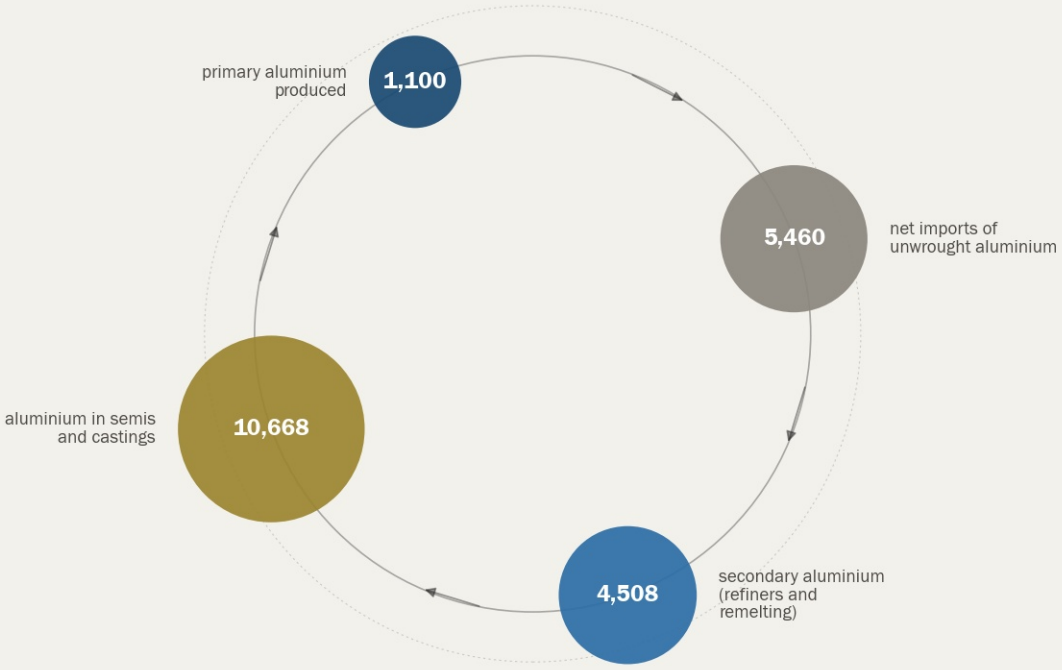
IGMNiR
Economic Chamber of Non-Ferrous Metals and Recycling

Aluminium in the EU-27, 2024 (kt; circle area ∝ tonnes)



IGMNIR REPORT · NOVEMBER 2026

Aluminium in the EU-27 economy

Value, circularity and security of supply

An integrated assessment of the aluminium industry in the European Union (AL-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 AL-EU, an integrated model that estimates the economic, fiscal, environmental and strategic contribution of the aluminium 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 – bauxite mining and alumina refining (A0), collection and trading of aluminium scrap (A1), secondary refining of scrap into casting alloys (A2), primary smelting (A3), rolling, extrusion, wire and foil (A4) and aluminium castings (A5). A dynamic model links the industry to the aluminium stock in European vehicles, buildings, packaging 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:** AL-EU v1.1 (run ID ALEU-1.1-7e3c2686c5; random-number seed 20261118, a fixed numeric identifier). **Suggested citation:** IGMNiR (2026), *Aluminium in the EU-27 economy: value, circularity and security of supply. An integrated assessment of the aluminium industry in the European Union (AL-EU model)*, Economic Chamber of Non-Ferrous Metals and Recycling, November 2026.

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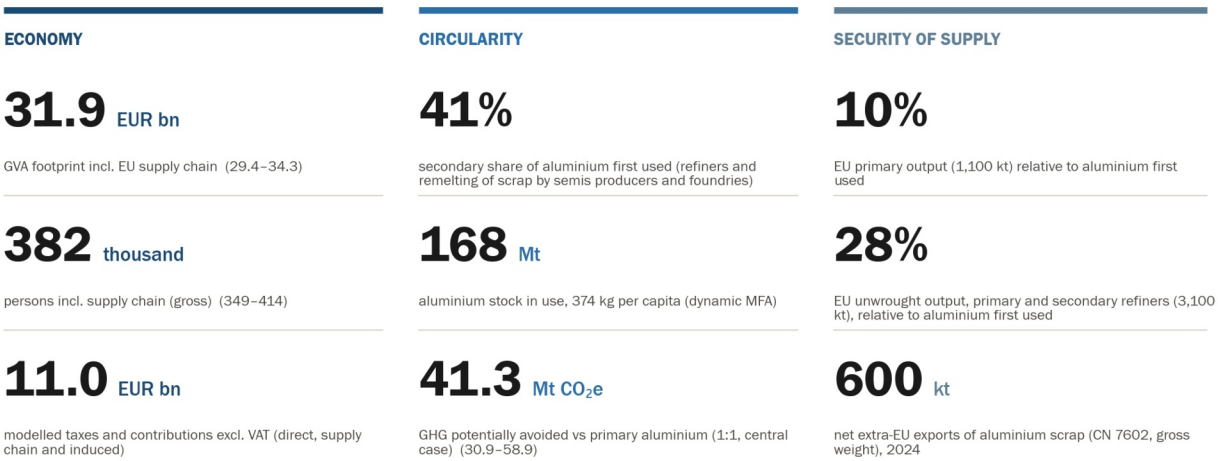
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How to read the numbers. *Observations* (O) are published statistics and company data – Eurostat structural business statistics (SBS), national accounts, input-output tables, PRODCOM and Comext, the EU emissions registry, the British Geological Survey and company reports. *Estimates* (E) combine observations with allocations or calibrated parameters – the aluminium shares of bauxite mining, scrap trading and castings, the split of NACE 24.42 into alumina refining, refiners, smelters and semis, and the aluminium from scrap remelted by semis producers and foundries, derived from an aluminium bridge. 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 aluminium stock in use, the emissions and other burdens potentially avoided and the scenarios. Economic results are gross contributions; value added is at factor cost. Tonnages are aluminium metal including alloying elements. Compensation of indirect emission costs is not deducted; taxes are model estimates, not a net fiscal balance.

Key findings

The EU-27 produced about 1,100 kt of primary aluminium in 2024 in nine smelters and about 4,510 kt of secondary aluminium – 2,000 kt at refiners and 2,510 kt remelted by semis producers and foundries – and imported, net of exports, 5,460 kt of unwrought aluminium from outside the EU. Of about 11,070 kt of aluminium first used in the EU, secondary aluminium supplied 41% and EU primary smelters 10%. The secondary share is set, through the scaling of PRODCOM semis volumes, to the 38–40% reported by European Aluminium; the model divides it between refiners and remelting.

FIGURE 1 The aluminium 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: bauxite mining and alumina refining, collection and trade of scrap, secondary refining, primary smelting, rolling, extrusion, wire and foil, aluminium castings. GHG: conditional, substitution-based estimate, largely outside the EU. Source: IGMNiR AL-EU v1.1.

SEVEN FINDINGS

- **Value.** The extended aluminium value chain generated about EUR 18.5 billion of gross value added in 2024 and employed about 220,000 people. Including the supply chain inside the EU the footprint is EUR 31.9 billion and about 382,000 jobs (90% band EUR 29.4–34.3 billion). These are gross contributions associated with the activity, not the effect of its loss. Rolling, extrusion, wire and foil (A4) and castings (A5) account for 84% of direct value added, primary smelting (A3) for 2%. A3 value added is the residual of a cost build-up: between EUR 100 million (electricity at EUR 65 per MWh) and EUR 680 million (EUR 30 per MWh) (central EUR 430 million at EUR 45), and zero at about EUR 71 per MWh.
- **Recycling.** The recycling chain – collection and trade of scrap (A1) and refining of scrap into casting alloys (A2) – generated EUR 2,240 million of direct value added and about 30,600 jobs; EUR 4,190 million with the supply chain. Attributing the value added of semis producers and foundries to remelted scrap in proportion to its share of their metal input would add EUR 3,660 million; this is an input-share attribution, not the value added of remelting.
- **Public finances.** Activity in the extended chain is associated with about EUR 11.0 billion of taxes and social contributions excluding VAT (90% band EUR 10.1–11.9 billion), most of it on labour. Aluminium production (NACE 24.42) is eligible for compensation of indirect emission costs; in Germany the primary aluminium benchmark

accounted for 6.8% of compensation for cost year 2024 (DEHSt 2025); known compensation to aluminium producers in Germany, Spain and France – about EUR 0.41 billion – is of the same order as the value added of primary smelting. Compensation is not deducted.

- **Aluminium in use.** The dynamic model estimates the aluminium stock in use in the EU-27 at about 168 Mt (374 kg per person; 90% band 324–441), against 260 kg for the EU-28 in 2013 (Passarini et al. 2018) and 290 kg for the EU-28 and EFTA (European Aluminium 2020). End-of-life products released about 4,510 kt of aluminium in 2024, of which about 2,970 kt was recovered (66%).
- **Environment.** Depending on the counterfactual, secondary aluminium produced in the EU potentially avoided between about 19.7 and 59.7 Mt CO_2e in 2024. With one-for-one replacement of primary aluminium at the footprint of the European consumption mix (10.1 t CO_2e per tonne) the value is 41.3 Mt in the central run and 43.4 Mt as the median of the draws (90% parameter band 30.9–58.9 Mt, which does not cover the choice of counterfactual); counting only aluminium from domestic old scrap, 22.1 Mt; the central value treats remelted fabrication scrap as displacing primary aluminium, a convention. Primary aluminium produced in Europe carries 6.6 t CO_2e per tonne, imported primary aluminium 13.2 t (European Aluminium 2025a) and the global average 14.4 t (International Aluminium Institute 2025a).
- **Security of supply.** Relative to aluminium first used in the EU (11,070 kt), EU bauxite corresponds to 1.9%, EU alumina to 19% and EU primary smelting to 10%; all unwrought aluminium produced in the EU, primary and from refiners, to 28% (refiners' output also counts in the secondary share); secondary aluminium supplies 41% of aluminium first used, aluminium from domestic old scrap 20–22% – against the CRMA reference values of 10% (extraction), 40% (processing) and 25% (recycling), which apply to strategic raw materials in general and to capacity in 2030. Unwrought aluminium imports come mainly from Norway (23%; HHI 985), bauxite from Guinea (72%). The EU exported 1,260 kt of aluminium scrap (gross weight) to countries outside the EU and imported 660 kt; 27% of exports went to India.
- **Outlook.** In the high-circularity scenario for 2035 secondary aluminium rises to 5,640 kt and direct value added to EUR 20.4 billion; the additional secondary feed exceeds the growth of domestic old scrap (dynamic model) and new scrap by about 215 kt of aluminium, and net imports of unwrought aluminium are about 5,200 kt.

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

Indicator (2024)	Status	Central	P5	P50	P95	Unit
Direct GVA – recycling chain (A1+A2)	E	2,243	1,780	2,269	2,768	EUR m
Direct GVA – aluminium industry (A0–A4)	E	13,670	13,251	13,699	14,163	EUR m
Direct GVA – extended value chain (A0–A5)	E	18,516	18,057	18,528	19,016	EUR m
GVA incl. supply chain (Type I)	M	31,880	29,441	31,898	34,331	EUR m
GVA incl. induced (Type II)	M	40,533	37,474	40,551	43,615	EUR m
Direct employment	E	219,800	212,500	219,600	226,600	persons
Jobs incl. supply chain	M	381,900	349,200	381,300	414,500	persons
Jobs incl. induced	M	495,200	452,100	494,300	538,900	persons
Taxes and contributions (attribution, not net balance)	M	11,031	10,112	11,020	11,940	EUR m
GHG potentially avoided – secondary aluminium produced	M	41,279	30,874	43,357	58,882	kt CO_2e
– of which remelting by semis producers and foundries	M	23,695	16,350	25,256	37,443	kt CO_2e
GHG potentially avoided – domestic old scrap only	M	22,133	15,974	22,813	31,691	kt CO_2e
GHG potentially avoided – substitution 0.5	M	19,700	14,489	20,660	28,348	kt CO_2e
Bauxite residue potentially avoided	M	10.1	7.5	10.4	13.7	Mt
Secondary aluminium (refined and remelted)	E	4,508	3,938	4,649	5,500	kt
Aluminium stock in use	M	168	146	171	199	Mt
Old scrap recovered from end-of-life products	M	2,972	2,543	3,016	3,598	kt
Balance residual of domestic scrap (residual less bottom-up)	M	507	−220	521	1,310	kt
Secondary share of aluminium first used	E	41	37	41	46	%

Indicator (2024)	Status	Central	P5	P50	P95	Unit
Coverage ratio: domestic scrap supply / scrap used	E	110	108	110	112	%

Source: IGMNiR AL-EU v1.1; 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 0.3%. Segments A0–A5: see Chapter 4. GVA, jobs and taxes are gross contributions; direct GVA is at factor cost from SBS, indirect and induced GVA at basic prices from FIGARO (valuing direct GVA at basic prices changes GVA including the supply chain by 0.6%). Type II effects assume that household spending responds to income at constant propensities without supply constraints. Taxes exclude VAT. Emissions potentially avoided compare secondary aluminium produced in the EU with 1:1 substitution of primary aluminium at 10.1 t CO_2e per tonne; they occur largely outside the EU and are not changes of the EU inventory; 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 scrap exports relative to scrap used.

01 Introduction

Aluminium is light, strong in its alloys, resistant to corrosion and a good conductor of electricity and heat, and it can be remelted repeatedly without loss of its properties. These properties make it a material of vehicles, buildings, packaging, electrical networks and machinery. The European Union both produces and uses aluminium on a large scale. In 2024 one bauxite mine in Greece produced 1,061 kt of bauxite, four alumina refineries in Ireland, Germany, Greece and Spain produced about 4.0 Mt of alumina, and the nine smelters in operation, mainly in France, Germany, Romania, Greece and Sweden, produced between about 1,010 kt (European Aluminium) and 1,188 kt (Idoine et al. 2026) of primary aluminium (AL-EU central value 1,100 kt). Recycling supplies 38–40% of EU aluminium (European Aluminium 2025b; 2026c), and net imports of unwrought aluminium from outside the EU were 5,460 kt (Eurostat Comext). Bauxite, alumina and aluminium are a strategic and a critical raw material under the Critical Raw Materials Act.

This report treats the EU-27 as one economy. Aluminium that moves between Member States – alumina from Ireland smelted in France or Germany, rolling slabs cast in one Member State and rolled in another, scrap collected in one Member State and refined in another – is a domestic flow; only trade with countries outside the EU is foreign trade. Earlier IGMNiR reports analysed aluminium in Poland and copper in the EU-27 (IGMNiR 2026a; 2026b); AL-EU applies the same integrated model to aluminium in the Union as a whole.

1.1 Questions addressed

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

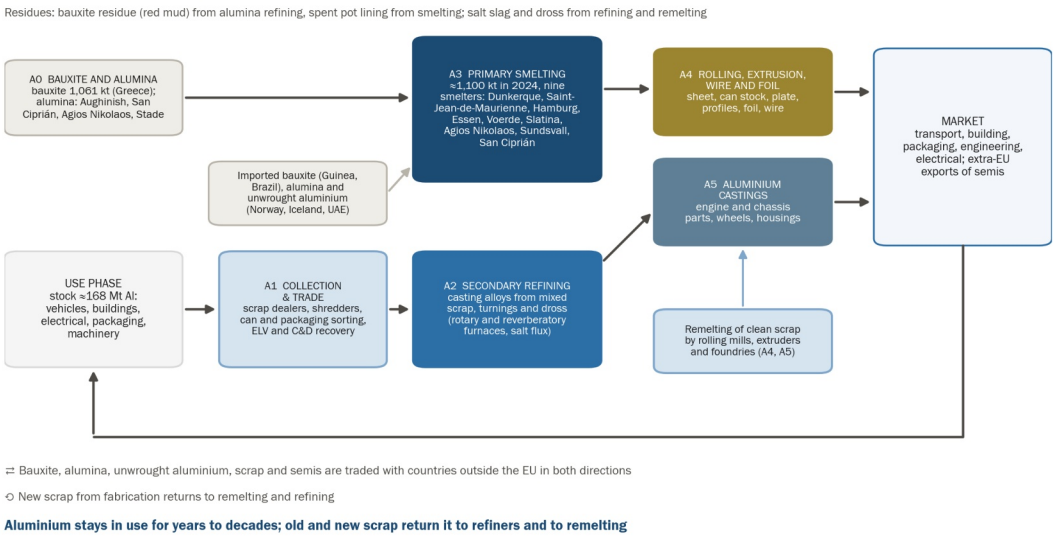
02 How much value added, employment and tax revenue does it support in the EU supply chain and through household spending?

03 How much aluminium is in use in the EU, how much scrap does it release, and how does this compare with the scrap used and traded?

04 Which emissions and other burdens does secondary aluminium produced in the EU potentially avoid compared with primary aluminium?

05 How dependent is the EU on imported bauxite, alumina and unwrought aluminium, how large are its scrap exports, and how might this change to 2035?

FIGURE 2 The aluminium value chain in the EU-27 and the six segments of the AL-EU model



Source: IGMNiR; Idoine et al. (2026); European Aluminium.

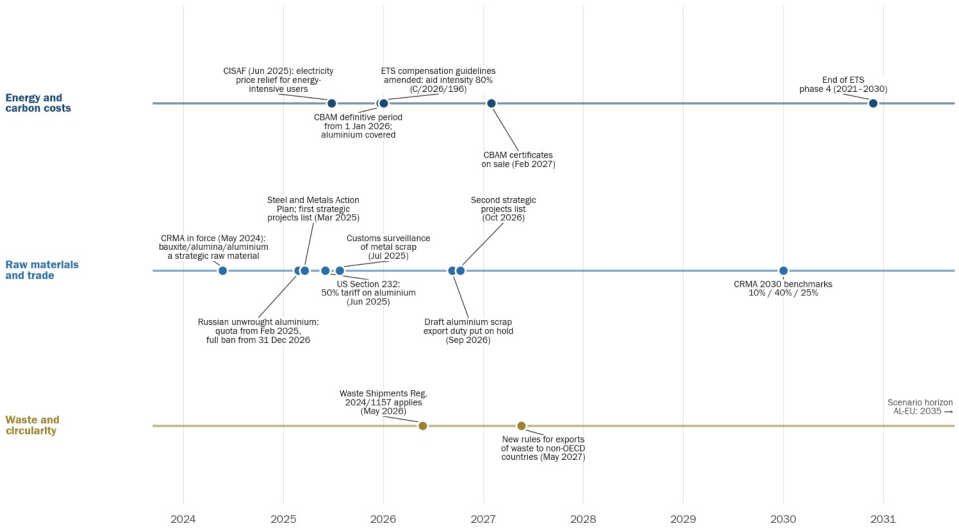
1.2 Structure of the report

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

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

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



Source: Regulation (EU) 2024/1252; Commission Decision C(2025)1904 and C(2026)8051 (strategic projects); COM(2025) 125; Council Regulation (EU) 2025/395; Communication C/2025/3602 (CISAF); US Proclamation 10947 (3 June 2025); DG TAXUD, news of 23 July 2025; Regulation (EU) 2023/956 and (EU) 2025/2083 (CBAM); Communication C/2026/196; Regulation (EU) 2024/1157; Directive 2003/87/EC; press reports on the aluminium scrap measure (September 2026). Legal status 10 November 2026.

2.1 Critical Raw Materials Act

Regulation (EU) 2024/1252 (Critical Raw Materials Act, CRMA) lists bauxite/alumina/aluminium both as a strategic raw material (Annex I, Section 1) and as a critical raw material (Annex II, Section 1). For strategic raw materials it sets benchmarks for 2030: EU capacity for extraction of at least 10%, for processing of at least 40% and for recycling of at least 25% of annual EU consumption, and no more than 65% of annual consumption of a strategic raw material at any relevant stage of processing from a single third country. Strategic projects receive faster permitting and may receive coordinated support. The first list of strategic projects of March 2025 and the second list of October 2026 include the following aluminium projects.

TABLE 2 Strategic projects concerning aluminium under the CRMA

Project	Member State	Promoter	Raw material or stage	List
BAUX-EU, GALLANT and LEADER	Greece	Metlen; European Bauxites	Bauxite/alumina/ aluminium; gallium	First list, March 2025
Production of primary aluminium and product diversification	Slovakia	Slovalco	Processing (primary aluminium)	Second list, October 2026
New aluminium recycling hub in Greece	Greece	ElvalHalcor	Recycling	Second list, October 2026
Project Arctial	Finland	Arctial	Processing (primary aluminium)	Second list, October 2026

Source: European Commission (2025a), first list of strategic projects of 25 March 2025; European Commission (2026a), second list of 9 October 2026. Selection of projects that name aluminium, alumina or bauxite.

2.2 Scrap, waste and trade policy

The European Steel and Metals Action Plan of 19 March 2025 (COM(2025) 125) stated that EU production covers 46% of EU aluminium demand and that aluminium scrap exports were expected to exceed 1.3 Mt in 2024, and announced that the Commission would consider trade measures to ensure sufficient availability of scrap by the third quarter of 2025 at the latest; it also stated that the Commission stands ready to open a safeguard investigation for aluminium on a duly substantiated request (European Commission 2025b). Customs surveillance of exports and imports of ferrous, aluminium and copper scrap has applied since 23 July 2025 (European Commission 2025f). On 18 November 2025 the Commission announced preparatory work on a measure concerning aluminium scrap, and a call for evidence ran from 19 December 2025 to 31 January 2026. In September 2026 the measure, which in draft form provided for an export duty of 15% for three years, was reported to have been put on hold; under the Waste Shipment Regulation (EU) 2024/1157 exports of non-hazardous waste to non-OECD countries will from May 2027 be allowed only to countries on a list adopted by the Commission (Reuters 2026a). No export duty or quota on aluminium scrap had been adopted by 10 November 2026.

Since 25 February 2025 Regulation (EU) 2025/395 restricts imports of unwrought aluminium (CN 7601) from Russia: a quota of 275,000 t until 26 February 2026, then imports only under contracts concluded before 25 February 2025 and capped at 50,000 t until 31 December 2026, and a full ban thereafter (Council Regulation (EU) 2025/395; London Metal Exchange 2026). EU import duties on unwrought aluminium are 3% for unalloyed (CN 7601 10) and 6% for alloyed metal (CN 7601 20).

2.3 Emissions trading, carbon border adjustment and compensation

The production of primary aluminium or alumina (activity 26) and of secondary aluminium (activity 27) is covered by the EU Emissions Trading System; some alumina refineries are registered under combustion (activity 20). Aluminium production (NACE 24.42) is on the EU list of sectors exposed to a risk of carbon leakage for 2021–2030 (Commission Delegated Decision (EU) 2019/708). The free-allocation benchmark for primary aluminium falls from 1.464 t CO_2e per tonne in 2021–2025 (Regulation (EU) 2021/447) to 1.423 t in 2026–2030 (Implementing Regulation (EU) 2026/1412), that for pre-bake anodes from 0.312 to 0.290 t; there is no product benchmark for alumina. Verified emissions of the named installations are listed below; the activity of production of primary aluminium or alumina totalled 2.54 Mt CO_2e in 2024 (free allocation 2.10 million allowances) and that of secondary aluminium 1.10 Mt in 27 installations (free allocation 0.87 million allowances) (European Commission 2026c).

TABLE 3 Verified emissions of aluminium installations in the EU ETS, 2024 (t CO_2e)

Installation	Member State	t CO_2e
Aluminium of Greece / Metlen, Agios Nikolaos (alumina and smelter)	EL	1,188,253
Aughinish Alumina (alumina)	IE	1,125,955
Aluminium Dunkerque	FR	501,467
Alúmina Española, San Ciprián (alumina)	ES	399,403
Aluminium Oxid Stade (alumina)	DE	376,363
Trimet Saint-Jean-de-Maurienne	FR	258,927
Kubal, Sundsvall	SE	195,324
Alro, Slatina	RO	174,795
Trimet Voerde (incl. anode plant 20,859 t)	DE	185,479
Trimet Essen	DE	156,655
Trimet Hamburg (incl. anode plant 24,380 t)	DE	150,980
Alteo Gardanne (alumina)	FR	51,473
Talum, Kidričevo	SI	41,217

Installation	Member State	t CO_2e
Slovalco, Žiar nad Hronom	SK	37,882
Alcoa San Ciprián (smelter)	ES	13,088
Speira Rheinwerk, Neuss	DE	0
Aldel, Delfzijl	NL	10
Total of the installations listed		**4,857,271**

Source: European Commission (2026c), Union Registry, verified emissions 2024 (extraction of 1 April 2026); selection of installations by name. Aughinish and Aluminium of Greece are registered under combustion (activity 20). Activity 26 (production of primary aluminium or alumina, incl. the alumina refineries of Stade, San Ciprián and Gardanne and the anode plants) in the EU-27: 2,543,063 t; activity 27 (secondary aluminium): 1,101,576 t in 27 installations. Speira Rheinwerk emitted 91,496 t in 2023 and Alcoa San Ciprián 103,324 t in 2025.

Compensation of indirect emission costs is governed by the Guidelines on State aid in the context of the ETS (2020/C 317/04); aluminium production (NACE 24.42) is eligible; in primary smelters electricity accounts for about 70% of the footprint of primary aluminium (European Aluminium 2025a). 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 sector or firm are published only in some Member States. In Germany, of EUR 2,783.65 million for cost year 2024, the primary aluminium benchmark accounted for 6.8% (≈EUR 189 million) and the fallback approach for aluminium for 2.3%; beneficiaries included TRIMET Aluminium (EUR 192.44 million), Aluminium Norf (EUR 25.19 million), Aluminium Oxid Stade (EUR 8.75 million), Speira (EUR 8.72 million) and Novelis Koblenz (EUR 3.55 million) (DEHSt 2025; 2026). In Spain Aluminio Español received EUR 4.98 million and Alúmina Española EUR 4.82 million of EUR 597.92 million for costs of 2024 (Ministerio de Industria y Turismo 2025).

Smelters in the EU compete in a global market. An OECD study of the aluminium value chain found that government support is common throughout the chain and especially heavy in China and the countries of the Gulf Cooperation Council, that it appears to explain part of the recent increases in smelting capacity, and that support to upstream producers also confers significant support to downstream activities such as semi-finished products (OECD 2019). The EU applies definitive anti-dumping duties to imports from China of aluminium extrusions (Commission Implementing Regulation (EU) 2021/546), aluminium flat-rolled products (Commission Implementing Regulation (EU) 2021/1784; suspended for nine months by Commission Implementing Decision (EU) 2021/1788 and applied again from 12 July 2022 under Commission Implementing Decision (EU) 2022/1178) and aluminium converter foil (Commission Implementing Regulation (EU) 2021/2170).

TABLE 4 **Compensation of indirect emission costs paid in 2024 (costs of 2023), all eligible sectors**

Member State	EUR million	Installations
DE	2,395.0	707
FR	908.8	293
PL	614.6	97
EL	287.0	57
ES	282.8	191
BE	249.9	56
IT	165.5	252
NL	147.3	48
FI	143.2	55
RO	116.7	31
CZ	60.4	23
SK	58.3	9
LU	37.6	4
SI	25.4	16
PT	25.0	23

Member State	EUR million	Installations
Total	**5,517.5**	**1,862**

Source: European Commission (2025d), Carbon Market Report, COM(2025) 735, Table 6.

Aluminium (Chapter 76) is covered by the Carbon Border Adjustment Mechanism (Regulation (EU) 2023/956). The definitive period began on 1 January 2026; certificates are sold from 1 February 2027 (Regulation (EU) 2025/2083) and the first surrender is due on 30 September 2027. Default values for unwrought aluminium (CN 7601) set by Implementing Regulation (EU) 2025/2621, as corrected by 2026/1740, range from 1.870 t CO_2e per tonne for India, the United Arab Emirates and Bahrain to 3.198 t for Mozambique (Russia 2.160, Canada 1.960, China 3.000, other origins 2.203), against a CBAM benchmark of 1.423 t (Regulation (EU) 2025/2620). A proposal to extend the mechanism to about 180 downstream products and to address circumvention (COM(2025) 989; European Commission 2025e) was adopted by the European Parliament at first reading on 15 September 2026 and is in trilogue.

2.4 Energy and State aid

Primary smelting uses about 14–16 MWh of electricity per tonne (International Aluminium Institute 2025b: world 14,004 kWh, Europe 15,619 kWh in 2024), and European smelters drew 78% of their electricity from renewable sources in 2023 (European Aluminium 2025a). 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, applicable from 25 June 2025 to 2030) 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. European Aluminium reports that the EU lost about 30% of its primary capacity since 2008 and that the number of operating smelters fell from 13 in 2019–2021 to 9 in 2023–2025 (European Aluminium 2026c); the table lists the main closures and restarts.

TABLE 5 Closures, curtailments and restarts of EU primary smelters, 2021–2026

Smelter	Capacity, kt	Event
Aldel, Delfzijl (NL)	110	Primary production halted October 2021; care and maintenance from September 2022
Alcoa San Ciprián (ES)	228	Stopped 2022; restart 2024–2026; completion announced 8 April 2026
Speira Rheinwerk, Neuss (DE)	–	Output cut by half from October 2022; fully curtailed March 2023; primary production ended end-2023
Slovalco, Žiar nad Hronom (SK)	–	Curtailed 2022; last cells shut early 2023; restart 31 August 2026
Talum, Kidričevo (SI)	–	Output cut to about 20% in 2022; remaining pots shut April 2023
Trimet (DE, FR)	–	Curtailments 2022–2023; ramp-up from the start of 2024

Source: Alcoa (2026); Speira (2022); U.S. Geological Survey (2026); company and press reports compiled by IGMNiR; European Aluminium (2026c) for the number of smelters.

2.5 External trade: US Section 232 tariffs

The United States raised its Section 232 tariff on aluminium from 10% to 25% and ended country exemptions and quota arrangements from 12 March 2025 (Proclamation 10895; White House 2025) and raised the tariff to 50% from 4 June 2025 (Proclamation 10947; Federal Register 2025); in August 2025 more than 400 tariff codes of derivative products were added (U.S. Geological Survey 2026). EU exports of aluminium and aluminium articles (HS 76) to the United States were 334.7 kt (EUR 2.60 billion) in 2024, 8.8% of extra-EU exports of these goods by weight. The table compares them with exports to all other destinations outside the EU.

TABLE 6 EU-27 exports of aluminium and aluminium articles (HS 76) to the United States and to other destinations outside the EU

Period	United States, kt	United States, EUR m	Other extra-EU, kt	Other extra-EU, EUR m
2024, full year	334.7	2,602.1	3,475.5	15,826.3
August–December 2024	137.1	1,064.3	1,392.5	6,501.4
August–December 2025	149.6	1,063.3	1,425.4	6,547.4
January–August 2025	223.0	1,710.7	2,325.0	11,032.1
January–August 2026	347.2	2,291.3	2,354.9	11,836.4

Source: Eurostat Comext (DS-045409), monthly data, extraction of 10 November 2026; IGMNiR aggregation. Exports to the United States by weight: August–December 2025 +9.1% against the same period of 2024; January–August 2026 +55.7% against January–August 2025. Exports to other extra-EU destinations: +2.4% and +1.3%. The composition by CN heading is shown in the next table.

TABLE 7 EU-27 exports of aluminium products to the United States by CN heading (kt)

Product	2024	June–Dec. 2024	June–Dec. 2025	Jan.–Aug. 2025	Jan.–Aug. 2026
Unwrought aluminium (7601)	13.3	6.7	15.7	9.4	32.2
Waste and scrap (7602)	9.4	6.3	5.1	12.4	12.4
Bars, rods and profiles (7604)	33.1	19.4	15.6	19.6	17.6
Wire (7605)	5.9	3.4	3.9	4.7	3.4
Plates, sheets and strip (7606)	143.3	84.3	90.8	93.9	205.6
Foil (7607)	63.5	38.1	38.8	41.6	34.7
Other HS 76 (7603, 7608–7616)	66.2	38.8	35.0	41.4	41.2
HS 76 total	**334.7**	**196.9**	**205.0**	**223.0**	**347.2**

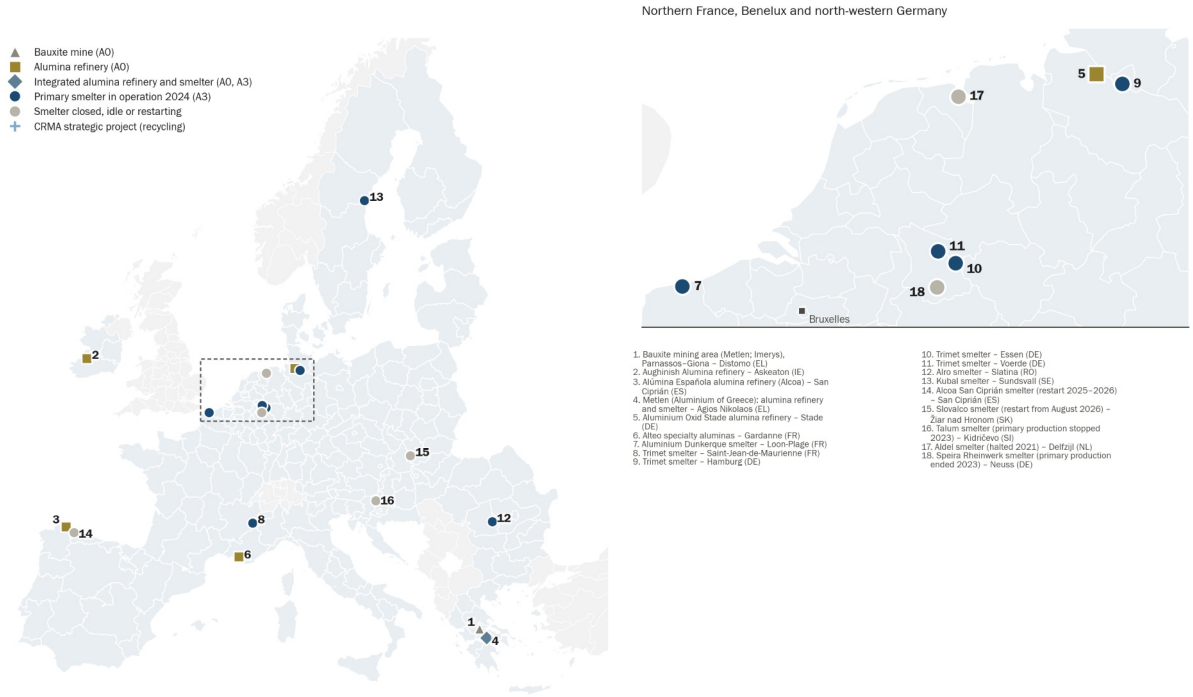
Source: Eurostat Comext (DS-045409), monthly data, extraction of 10 November 2026; IGMNiR aggregation.

The increase comes almost entirely from plates, sheets and strip (7606: +111.7 of +124.3 kt, 90%), whose exports to the United States more than doubled under the 50% tariff. Exports of bars and profiles (7604), wire (7605) and foil (7607) fell by 10%, 28% and 17%, and all exports other than 7606 and 7601 by 9%; scrap exports were unchanged. The rise in sheet exports came after the fires: +8% in June–December 2025 against June–December 2024 and +119% in January–August 2026 against January–August 2025. In the United States, fires in September and November 2025 stopped the hot mill of the Novelis plant in Oswego, a major supplier of automotive sheet, until production restarted in June 2026 (Reuters 2026b); the trade data do not show how much of the increase in EU exports of sheet this explains.

03 The aluminium industry in the EU-27

The EU aluminium value chain runs from one bauxite mine in Greece and four alumina refineries, through nine primary smelters, secondary refiners that turn scrap into casting alloys, and rolling mills, extruders and foundries that also remelt scrap, to the users in transport, construction, packaging and engineering; Alteo Gardanne (FR) produces specialty aluminas and is not counted in the alumina output of the BGS. NACE 24.42 (aluminium production), which covers alumina refining, smelting, refining and the production of semis, employed 117,216 persons in 2024 and NACE 24.53 (casting of light metals) 82,900 (Eurostat 2026b). European Aluminium reports more than 1 million direct and indirect jobs, about EUR 40 billion of annual turnover and about 600 plants in 30 European countries (European Aluminium 2024).

FIGURE 4 Bauxite mine, alumina refineries and primary smelters in the EU-27



Source: IGMNiR; Idoine et al. (2026); European Aluminium; company reports (Metlen, Alcoa, Trimet, Alro, Speira); EU ETS registry; European Commission, second list of strategic projects (9 October 2026); GISCO boundaries. Locations approximate; projects shown only where a location is published. Numbers refer to Annex C.

3.1 Bauxite and alumina

TABLE 8 Bauxite and alumina production in the EU-27 by Member State (kt)

Member State and product	2023	2024	Note
Greece (bauxite)	974.9	1,061.3	one mine in operation
France (bauxite)	≈120	≈120	non-metallurgical uses
Croatia (bauxite)	14.7	15.0	
Ireland (alumina)	1,380.3	1,740.0	Aughinish
Germany (alumina)	452.0	1,030.0	Stade; U.S. Geological Survey ≈450
Spain (alumina)	716.0	800.0	San Ciprián
Greece (alumina)	712.6	709.3	Agios Nikolaos; U.S. Geological Survey 865

Member State and product	2023	2024	Note
Alumina, EU-27	**3,261**	**4,279**	

Source: Idoine et al. (2026), British Geological Survey, World Mineral Production 2020–24; U.S. Geological Survey (2026). France and Romania produced no alumina in 2023–2024. AL-EU uses 4,000 kt of alumina, between the British Geological Survey and U.S. Geological Survey totals, and 1,061.3 kt of metallurgical bauxite.

The EU imported 10,470 kt of bauxite from outside the EU in 2024, mainly from Guinea (72%; HHI 5,449), and was a net exporter of alumina (CN 2818 20: imports 730 kt, exports 1,890 kt). With about 1.93 t of alumina per tonne of aluminium, EU alumina output corresponds to 2,070 kt of aluminium, more than EU primary output; EU bauxite corresponds to about 210 kt of aluminium.

3.2 Primary smelting

Primary aluminium production in the EU-27 is published by the British Geological Survey by country (1,188 kt in 2024; 1,102 kt in 2023; about 1,988 kt in 2021) and by European Aluminium as an EU total (about 1,010 kt in 2024). In Romania, Greece and Sweden one smelter accounts for national output. AL-EU uses 1,100 kt with a range of 1,010–1,190 kt. EU primary capacity is about 2.1 Mt a year (Joint Research Centre 2026).

TABLE 9 Primary aluminium production in the EU-27 by smelter, 2024 (kt)

Smelter	kt	Grade	Source
Aluminium Dunkerque; Trimet Saint-Jean-de-Maurienne (FR)	429.2	A	Idoine et al. (2026), France
Alro, Slatina (RO)	248.1	A	Idoine et al. (2026), Romania
Trimet Hamburg, Essen, Voerde (DE)	220.0	A	Idoine et al. (2026), Germany
Metlen, Agios Nikolaos (EL)	182.0	A	Idoine et al. (2026), Greece
Kubal, Sundsvall (SE)	109.0	A	Idoine et al. (2026), Sweden
Alcoa San Ciprián (ES)	0.0	B	restart 2024–2026 (completed 8 April 2026)
Slovalco (SK), Talum (SI), Aldel (NL), Speira Rheinwerk (DE)	0.0	B	closed or curtailed 2021–2023
Total	**1,188.3**		

Source: Idoine et al. (2026), British Geological Survey, national totals, which equal the output of the single smelter in Romania, Greece and Sweden; IGMNiR compilation. The model uses 1,100 kt (range 1,010–1,190 kt). Grades: A official statistics or company financial statements, B company data, C derived.

3.3 Semis and castings

TABLE 10 Production of unwrought aluminium, semis and light-metal castings in the EU-27 (PRODCOM)

PRODCOM	Product	2023, kt	2024, kt	2024, EUR m
24421130	Unwrought non-alloy aluminium	400.0	300.0	1,200
24421154	Unwrought aluminium alloys	5,131.4	6,000.0	10,633
24421200	Aluminium oxide (alumina)	1,200.0	1,800.0	900
24422100	Powders and flakes	80.0	80.0	240
24422230	Bars, rods and profiles, non-alloy	478.7	570.0	2,040
24422250	Bars, rods and profiles, alloy	2,959.9	2,841.5	13,408
24422330	Wire, non-alloy	80.0	60.0	210
24422350	Wire, alloy	210.0	100.0	800
24422430	Plates, sheets and strip > 0.2 mm, non-alloy	400.0	440.0	1,120
24422450	Plates, sheets and strip > 0.2 mm, alloy	4,000.0	5,000.0	15,000
24422500	Foil ≤ 0.2 mm	966.2	1,050.0	5,000
24422630	Tubes and pipes, non-alloy	16.0	16.0	80
24422650	Tubes and pipes, alloy	161.3	137.4	720
24422670	Tube or pipe fittings	126.1	19.0	221

PRODCOM	Product	2023, kt	2024, kt	2024, EUR m
24531010	Light-metal castings for land vehicles	1,500.0	1,028.9	6,900
24531020	Castings for transmission shafts, crankshafts	18.0	16.3	115
24531040	Other parts of piston engines and machinery	360.0	320.0	2,000
24531050	Castings for machinery and appliances	360.0	400.0	1,243
24531090	Castings for other uses	325.3	326.3	1,800

Source: Eurostat PRODCOM (DS-059358), EU27_2020, production quantity and value. Many EU totals are rounded estimates of Eurostat; rolled products and foil may count foil stock twice, and unwrought alloys include primary and secondary alloys. AL-EU scales the semis quantities in the bridge by pc_scale (Annex B).

Semis producers in the EU recorded on average about 10.4 Mt a year of rolled, extruded, drawn and foil products in 2022–2024 (10,410 kt; 2024 alone 10,310 kt; PRODCOM, status E because EU cells are rounded estimates) and foundries about 2.3 Mt of light-metal castings (mean of 2022–2024). European foil deliveries, a wider region than the EU, were 892.5 kt in 2024, 7.3% more than in 2023 (EAFA 2025).

3.4 Official statistics

TABLE 11 Structural business statistics for the activities of the aluminium value chain, EU-27, 2024

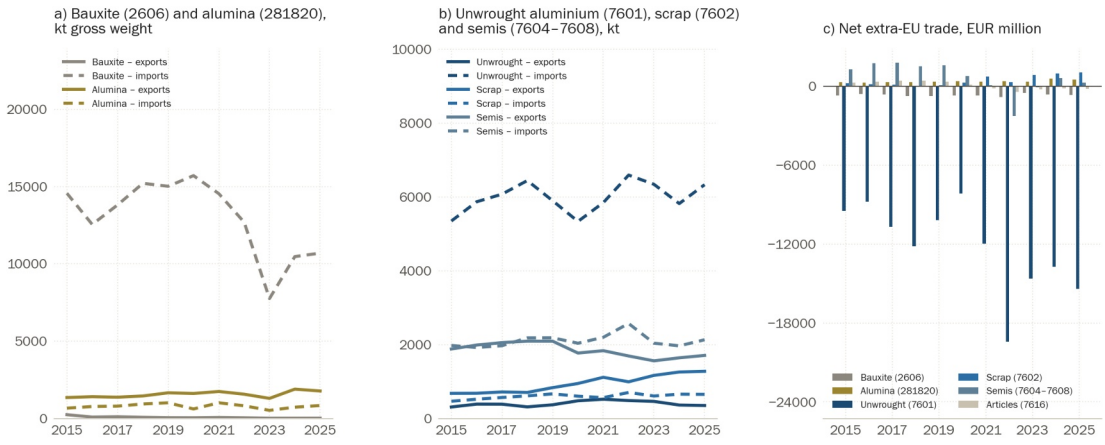
NACE	Activity	Turnover, EUR m	Output, EUR m	Value added, EUR m	Persons employed	Personnel costs, EUR m
B 07.29	Mining of other non-ferrous ores	12,686	11,740	6,586	43,634*	2,123*
G 46.77	Wholesale of waste and scrap	68,196	16,023	7,688	120,000	3,737
E 38.3	Materials recovery	90,000	80,000	18,000	273,002	10,668*
C 24.42	Aluminium production	58,513	55,590	11,848	117,216	6,676
C 24.53	Casting of light metals	17,300	16,400	5,210	82,900	3,970

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 24.53 output EUR 16,400 million and value added EUR 5,210 million, 46.77 employment 120,000). NACE 24.42 recorded value added of EUR 11,850 million on output of EUR 55,590 million; in 2023 it employed 119,094 persons.

3.5 Trade with countries outside the EU

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



Source: Eurostat Comext DS-045409, EU-27 extra-EU trade (gross weight); IGMNiR AL-EU.

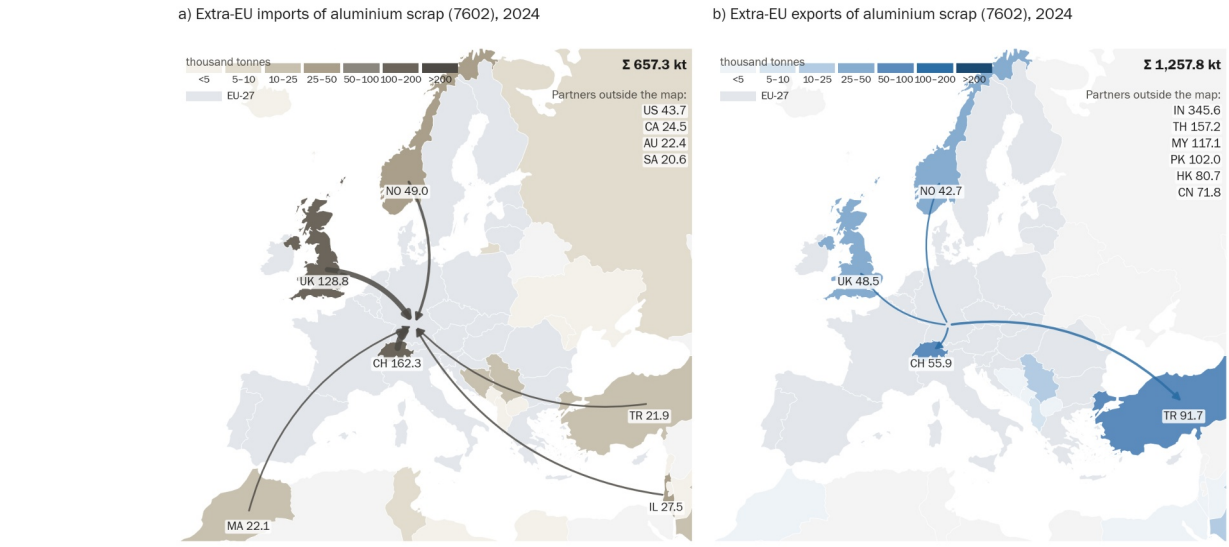
TABLE 12 Extra-EU trade in aluminium by product, 2024

CN	Product	Imports, kt	Exports, kt	Imports, EUR m	Exports, EUR m	Balance, EUR m
2606	Aluminium ores and concentrates (bauxite)	10,469.2	16.6	635	10	−626
281820	Aluminium oxide (alumina)	726.9	1,894.5	455	1,048	593
7601	Unwrought aluminium	5,822.5	362.7	14,702	980	−13,722
760110	– of which not alloyed	2,608.6	13.8	6,306	43	−6,263
760120	– of which alloys	3,213.9	348.9	8,395	936	−7,459
7602	Aluminium waste and scrap	657.3	1,257.7	1,181	2,165	984
7603	Powders and flakes	16.1	13.1	61	93	31
7604	Bars, rods and profiles	391.8	312.7	1,939	2,084	145
7605	Wire	311.2	50.1	880	208	−672
7606	Plates, sheets and strip > 0.2 mm	969.6	978.1	3,495	4,135	640
7607	Foil ≤ 0.2 mm	265.1	275.4	1,203	1,667	464
7608	Tubes and pipes	29.2	26.3	173	246	72
7609	Tube or pipe fittings	10.4	3.5	181	115	−66
7610	Structures and parts	258.4	202.3	1,450	2,428	978
7611	Reservoirs and tanks > 300 l	0.7	6.4	7	60	53
7612	Casks, drums, cans, boxes	57.8	96.9	520	957	436
7613	Containers for compressed gas	10.3	6.6	121	71	−49
7614	Stranded wire and cables, not insulated	55.9	13.2	182	79	−103
7616	Other articles of aluminium	226.0	130.4	2,607	2,463	−144

Source: Eurostat Comext (DS-045409), reporter EU27_2020, partner extra-EU; gross weight; intra-EU trade is not shown. Unit values: bauxite imports EUR 61/t; alumina imports EUR 626/t; unwrought aluminium imports EUR 2,525/t; scrap imports EUR 1,797/t and exports EUR 1,721/t, against an LME aluminium price of USD 2,419/t (EUR 2,235/t) in 2024 (World Bank 2025; European Central Bank 2026).

The EU is a large net importer of unwrought aluminium (EUR 13,720 million in 2024) and of bauxite (EUR 630 million), and a net exporter of alumina (EUR 590 million) and of scrap (EUR 980 million). Imports of unwrought aluminium came mainly from Norway, Iceland and the United Arab Emirates (largest partner 23%; HHI 985); Norway and Iceland belong to the European Economic Area. Russia supplied 323 kt in 2024 (5.5%). The EU exported 1,260 kt of aluminium scrap in 2024 and imported 660 kt (net exports 600 kt); exports were 834.5 kt in 2019 and 1,277.3 kt in 2025. 27% of exports went to India, followed by Thailand and Malaysia; European Aluminium reports that about 80% of exports go to Asia (European Aluminium 2026b). The unit value of exported scrap (EUR 1,721 per tonne) was close to that of imported scrap (EUR 1,797 per tonne).

FIGURE 6 Origins of extra-EU aluminium scrap imports and destinations of exports, 2024



Source: Eurostat Comext (DS-045409), CN 7602, EU-27 extra-EU trade, gross weight; GISCO boundaries; IGMNiR AL-EU. EU-27 shown in light grey-blue; partners outside the map are listed at the right.

3.6 Secondary aluminium and recycling

Secondary aluminium in the EU has two routes. Refiners turn mixed and contaminated scrap, turnings and dross into casting alloys (2,000 kt in AL-EU, range 1,600–2,400 kt); remelters – rolling mills, extruders and foundries – melt sorted wrought scrap and their customers process scrap into slabs, billets and castings. Neither route is reported separately by statistics. European Aluminium reports that about 40% (around 5 Mt) of EU aluminium consumption comes from recycling and that EU recycling furnace capacity is 12 Mt, of which about 15% is idle (European Aluminium 2025b); this furnace capacity also melts internal scrap and primary metal, whereas the ceilings used in the AL-EU scenarios and stress tests (2,600 kt of refiners' output and 3,800 kt of remelted aluminium) are IGMNiR estimates for scrap-based output only. AL-EU derives remelting from a bridge: aluminium in semis and castings less the unwrought aluminium that enters them.

TABLE 13 Bridge from semis and castings to aluminium from remelted scrap, EU-27, 2024 (kt)

Item	kt	Status
Semis (PRODCOM, codes 2442 21–26, mean 2022–2024)	10,412.5	E
× scaling pc_scale (0.82)	8,538.3	E
Light-metal castings × aluminium share (93%)	2,129.7	E
Aluminium in semis and castings	**10,668.0**	E
less: primary aluminium produced in the EU	−1,100.0	O/E
less: secondary aluminium of refiners	−2,000.0	E
less: net extra-EU imports of unwrought aluminium (CN 7601)	−5,459.8	O
plus: unwrought aluminium in other uses (deoxidation, powders, chemicals)	400.0	E
plus: bridge term d_ref (stock changes, uses not covered); central	0.0	E
Aluminium from scrap remelted by semis producers and foundries	**2,508.2**	E

Source: Eurostat PRODCOM 2024 and Comext; IGMNiR AL-EU. Status: O observation, E estimate. The result is a residual of quantities of about 10 Mt and inherits their uncertainty.

TABLE 14 Aluminium flows by node, EU-27, 2024 (kt)

Node and flow	kt	Status
1. Unwrought aluminium		

Node and flow	kt	Status
Primary aluminium produced	1,100.0	O/E
Secondary aluminium of refiners	2,000.0	E
Net extra-EU imports of unwrought aluminium	5,459.8	O
Apparent use of unwrought aluminium	8,559.8	E
2. Semis and castings		
Aluminium from remelted scrap (bridge)	2,508.2	E
Aluminium in semis and castings	10,668.0	E
Aluminium first used (unwrought use plus remelted scrap)	11,068.0	E
3. Scrap		
Aluminium in secondary feed (refining and remelting)	4,651.9	E
Net extra-EU imports of scrap, aluminium content (CN 7602)	−477.5	O/E
Domestic scrap supply, residual	5,129.4	E
Old scrap recovered (dynamic model)	2,971.8	M
New scrap (15% of aluminium in semis used in the EU and castings)	1,650.3	E
Domestic scrap supply, bottom-up	4,622.1	M
Balance residual (residual less bottom-up)	**507.3**	M
4. Aluminium in use		
Inflow to use	8,851.8	M
End-of-life outflow	4,510.8	M
Stock in use, Mt	168.4	M

Source: IGMNiR AL-EU v1.1, modules M2 and M2b. Status: O observation, E estimate, M model result. Metal yield 88% in refining and 95% in remelting; virgin alloying elements 8% of refiners' and 3% of remelters' output, not counted in the feed; aluminium content of scrap 90% in imports and 85% in exports.

The residual estimate of domestic scrap supply exceeds the bottom-up estimate by 507 kt (residual less bottom-up 507 kt; 90% band −220 to 1,310 kt). The difference is not an independent confirmation of the model: the bottom-up estimate rests on calibrated parameters – the end-of-life collection rates of the JRC aluminium flow analysis scaled by coll_scale (1.00) and the new-scrap rate (15%) – and the residual estimate on the bridge, whose inputs are rounded statistics. With a new-scrap rate of 22%, new scrap would be about 2,420 kt instead of 1,650 kt and the residual would be −28 kt; the balance would close with a collection scaling of 0.99 and an end-of-life recycling rate of about 65%. The data used do not discriminate between these pictures; the residual is not distinguishable from zero within its band; its sign is not interpreted. The table below shows how far the residual moves across the parameter ranges.

TABLE 15 Reconciliation of the scrap balance residual: change by parameter (kt)

Parameter	Range	At low value	At high value
the scaling of PRODCOM semis volumes	0.74–0.95	−509.8	828.4
the rate of new scrap	0.10–0.22	382.5	−535.4
product lifetimes	0.80–1.20	−476.7	379.3
the bridge term for remelting	−300–300	−306.3	306.3
net imports of aluminium in finished products	−1,500–500	304.7	−304.7
the past per-capita inflow	0.68–0.85	201.1	−287.3
end-of-life collection rates	0.93–1.05	208.0	−148.6
the metal yield of refiners	0.82–0.95	153.0	−154.1

Source: IGMNiR AL-EU v1.1; one parameter at a time, other parameters central (central residual 507.3 kt). Not covered by parameters: aluminium exported in used vehicles and goods, aluminium in shredder fractions classified outside CN 7602, and stock changes at scrap dealers.

TABLE 16 AL-EU and published aluminium flow studies for the EU

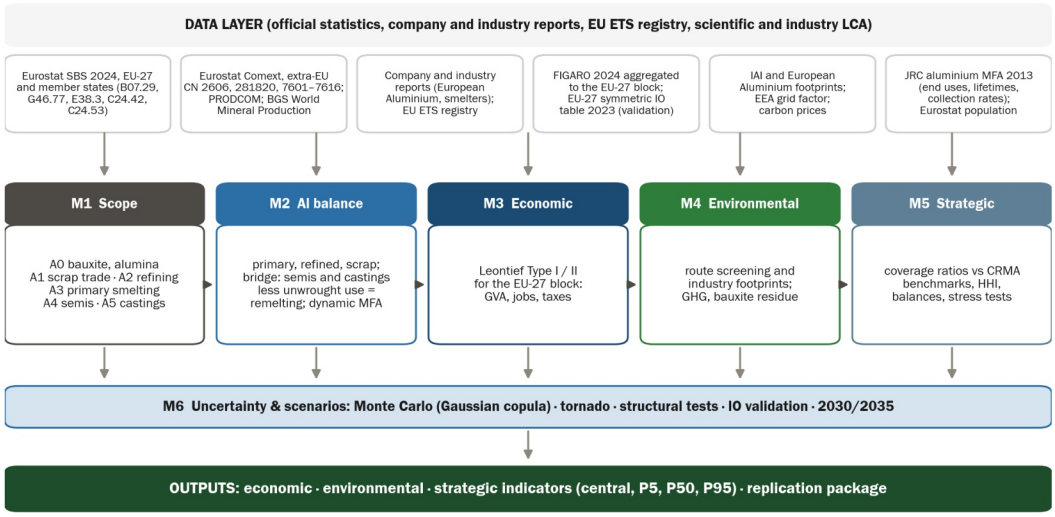
Indicator	AL-EU	Published value	Source
Inflow to use, 2013, kt	6,516	7,683 (EU-28; Table S8; text: ≈5,464)	Passarini et al. (2018)
End-of-life outflow, 2013, kt	3,299	4,338 (EU-28)	Passarini et al. (2018)
Stock in use, 2013, kg per person	285	≈260 (EU-28)	Passarini et al. (2018)
Stock in use, 2024, kg per person	374	290 (EU-28 and EFTA)	European Aluminium (2020)
End-of-life recycling rate, %	66	69 incl. exported scrap; 51 excl. (EU-28, 2013)	Passarini et al. (2018)
Old scrap in aluminium first used (EoL-RIR), %	20–22	12; 16 if exported scrap were processed in the EU (2013); 32 (CRM study)	Passarini et al. (2018); European Commission (2023)
Secondary share of aluminium first used, %	41	36 (20 post-consumer, 16 pre-consumer); ≈38–40	European Aluminium (2020; 2025b; 2025c)

Source: IGMNiR AL-EU v1.1 and the studies named. The JRC analysis refers to the EU-28 (with the United Kingdom) and to 2013; definitions of first use and recycling input differ between studies. The agreement is not an independent validation: the dynamic model of AL-EU takes its end-use shares, lifetimes and collection rates from the JRC analysis (which takes the collection rates from the World Aluminium mass-flow model), and its historical inflow path is calibrated to the JRC inflow and stock of 2013. The JRC report gives an inflow to use of about 5,464 kt in its text and 7,683 kt as the sum of its Table S8; the Table S8 sum is consistent with the reported net addition to stock (3,361 kt) plus the end-of-life outflow (4,338 kt) and is used here.

04 The AL-EU model

AL-EU combines six modules: allocation of structural business statistics to the aluminium value chain (M1), a mass balance of aluminium with a bridge from semis production to remelted scrap (M2) and a dynamic model of aluminium 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 7 Architecture of the AL-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. **A0** combines the bauxite share (0.4%) of NACE 07.29 (mining of other non-ferrous metal ores) with alumina refining, whose value added, employment and personnel costs are a share (2.0%) of NACE 24.42 (aluminium production) and whose output is valued at 4,000 kt of alumina times the unit value of extra-EU alumina exports (EUR 553/t). **A1** is the aluminium share of wholesale of waste and scrap (NACE 46.77; 14% of value, 12% of employment) and of materials recovery (NACE 38.3; 4% and 4%). **A2** (refiners of secondary casting alloys) and **A3** (primary smelters with anode plants and casthouses) take their employment from NACE 24.42 by employment keys (4.5% and 5.5%) at the personnel cost per person of 24.42; their output is valued physically and their value added follows from a cost build-up. A2: 2,000 kt of casting alloys valued at the LME aluminium price of EUR 2,235/t; scrap and alloying metals (80% of output) and other inputs such as natural gas, salt and services (10%) leave value added of 10% of output. A3: 1,100 kt of primary aluminium at the 2024 LME price of EUR 2,235/t plus 15% for regional premiums and value-added products; less alumina (1.93 t per tonne at EUR 553/t) and anode carbon (EUR 230/t) as chain inputs, electricity (16,500 GWh at EUR 45/MWh) and other inputs (8% of

output); value added is the residual. **A4** is the rest of NACE 24.42 (88% of employment): rolling, extrusion, wire, foil and the remelting of scrap in their casthouses. **A5** is the aluminium share (93%) of NACE 24.53 (casting of light metals). The recycling chain is A1+A2, the aluminium industry A0–A4 and the extended value chain A0–A5. Segments are synthetic: they are built from statistics, not from lists of companies.

TABLE 17 Segments of the AL-EU model, 2024 (central estimate)

Segment	Basis	Output, EUR m	GVA, EUR m	Persons	GVA per person, EUR k
A0 Bauxite mining and alumina refining	SBS 07.29 × al_mine + 24.42 × aa_share; alumina output valued physically	2,259	263	2,520	104.5
A1 Collection and trade of aluminium scrap	SBS 46.77, 38.3 × aluminium shares	5,443	1,796	25,320	70.9
A2 Secondary refining (casting alloys)	SBS 24.42 × ref_share; output valued physically	4,470	447	5,270	84.7
A3 Primary smelting	SBS 24.42 × prim_share; output valued physically	2,827	432	6,450	66.9
A4 Rolling, extrusion, wire and foil	SBS 24.42, rest	46,081	10,732	103,150	104.0
A5 Aluminium castings	SBS 24.53 × al_cast	15,252	4,845	77,100	62.8

Source: IGMNiR AL-EU v1.1; Eurostat SBS (sbs_ovw_act) 2024, EU27_2020. GVA at factor cost. 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 turnover of NACE 24.53 – are used as published. The output of A4 is the output of NACE 24.42 less the physically valued output of alumina refining, refiners and smelters; it is therefore sensitive to the prices used for these three activities.

4.2 Aluminium mass balance

The physical module works in kilotonnes of aluminium, including alloying elements, as is customary in the industry. Primary output of the EU-27 (1,100 kt in 2024; range 1,010–1,190 kt) lies between the European Aluminium estimate and the sum of the country data of the BGS (Chapter 3). Refiners produced an estimated 2,000 kt of secondary casting alloys (1,600–2,400 kt), because the split of recycled aluminium between refiners and remelters is not published. Apparent use of unwrought aluminium is primary output plus refiners' output plus net extra-EU imports of unwrought aluminium (CN 7601; 5,460 kt), 8,560 kt. Aluminium from scrap remelted by semis producers and foundries (S_dm, 2,508 kt) is derived in every Monte Carlo draw from a bridge: aluminium in semis (8,538 kt; PRODCOM volumes, mean of 2022–2024 per product, of 10,413 kt scaled by pc_scale 0.82 (0.74–0.95), because EU cells are rounded Eurostat estimates that change by steps of 1,000 kt and foil stock is counted both with strip and with foil; the central value gives a secondary share of first use close to the 38–40% reported by European Aluminium) and in aluminium castings (2,130 kt) less unwrought aluminium entering them (apparent use less 400 kt of other uses such as steel deoxidation and chemicals) plus a term d_ref of −300 to +300 kt for stock changes. Secondary aluminium is the sum of refiners' output and remelting, 4,508 kt. The bridge is sensitive to single PRODCOM cells: the EU cell for alloy plates, sheets and strip was 4,000 kt in 2023 and 5,000 kt in 2024, a difference of about 1,000 kt that the three-year mean halves. Scrap feed C (aluminium in the scrap melted) follows from metal yields of 88% in refining and 95% in remelting, net of virgin alloying elements added by refiners (8% of output; 5–11%) and remelters (3%; 1–5%); extra-EU trade in scrap (CN 7602) is converted at 90% aluminium for imports and 85% for exports.

$$S_{dm} = \text{Al in semis} + \text{Al in castings} - (P_{prim} + R_{sec} + \text{net imports of 7601} - \text{other uses}) + d_{ref} \qquad C = R_{sec}(1 - a_{ref})/y_{ref} + S_{dm}(1 - a_{dm})/y_{dm} \qquad A_{res} = C - al_{imp} \cdot M_{7602} + al_{exp} \cdot X_{7602} \qquad A_{bu} = \text{old scrap recovered} + r_{new} \cdot (\text{Al in semis} - \text{net exports} + \text{Al in castings})$$

4.3 Dynamic model of aluminium in use

The dynamic model follows aluminium entering use in the EU-27 from 1960 to 2035 (with a spin-up from 1900) and releases it at end of life with normally distributed product lifetimes (standard deviation 0.3 × mean). End-use shares, mean lifetimes and collection rates are those of the JRC material-flow analysis of aluminium in the EU-28 for 2013 (Passarini et al. 2018, Tables S8 and S10; the collection rates come from the World Aluminium mass-flow model); consumer durables include the JRC category of other uses. The 2024 inflow (8,852 kt) is derived from the AL-EU balance: aluminium in semis used in the EU (production less net extra-EU exports of semis) and in castings, less new scrap (15%), plus net imports of aluminium in finished products (−500 kt). The per-capita inflow rises linearly from r60 (0.12 of the 2024 level) in 1960 to 2024; k_in (0.75) sets the 2013 level relative to 2024. With these values the model gives an inflow of 6,516 kt and a stock of 126 Mt (285 kg per person) in 2013, against the JRC values for the EU-28 of 7,683 kt and 132 Mt (260 kg per person) and 290 kg per person for Europe estimated by European Aluminium (2020). The level and path of inflow were set with these values in view; the agreement is therefore a calibration, not a validation. Collection rates are scaled by coll_scale (1.00) to the metal recovered from collected scrap.

TABLE 18 Parameters of the dynamic model of aluminium in use: end uses

End use	Share of inflow, %	Mean life, years	Collection and recovery, %
Transport	34.2	22	80
Building and construction	27.7	60	95
Packaging	12.4	1	59
Electrical engineering	10.8	40	70
Consumer durables and other	8.4	20	45
Industrial machinery	4.0	40	80
Dissipative uses	2.9	1	0

Source: Passarini et al. (2018), Tables S8 (inflow 2013, lifetimes) and S10 (collection rates), scaled by coll_scale; IGMNiR AL-EU v1.1.

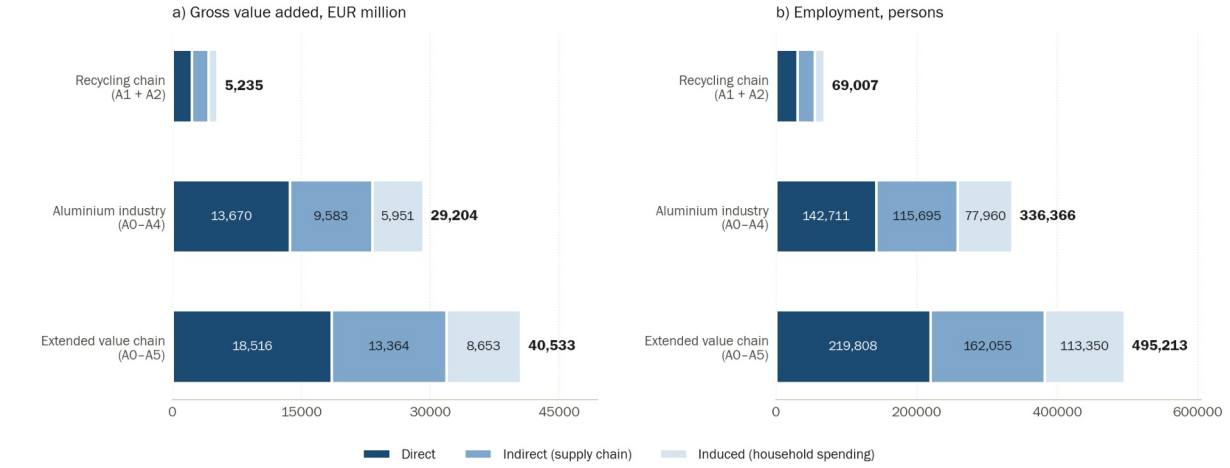
4.4 Economic, fiscal, environmental and strategic modules

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. First-round demand of each segment excludes purchases within the aluminium chain (basic metals, mining products, wholesale and waste services), which are counted in the segments themselves; non-chain inputs enter the first round with the input structure of the parent product. For primary smelters electricity is costed explicitly and enters the first round as a purchase of electricity (CPA D35) at the domestic share of the basic-metals column; together with the electricity bought by the other segments at the input structure of basic metals, electricity is the largest supplying product of the chain. This broad exclusion makes the first round conservative. 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 (21.8% statutory average × taxable share of operating surplus) and net taxes on production and products from FIGARO. The environmental module compares secondary aluminium produced in the EU with displaced primary aluminium; the strategic module compares EU output with EU use and measures concentration of extra-EU trade. Monte Carlo draws (47 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 aluminium value chain in the EU-27 generated EUR 18,520 million of direct gross value added and employed about 219,800 persons. Domestic suppliers in the EU added EUR 13,360 million and 162,100 jobs (Type I: EUR 31,880 million, 90% band 29,440–34,330; 382,000 jobs), and household spending a further EUR 8,650 million (Type II: EUR 40,530 million and 495,000 jobs). The aluminium industry A0–A4 accounts for EUR 13,670 million of direct value added and the recycling chain A1+A2 for EUR 2,240 million.

FIGURE 8 Economic footprint of the aluminium value chain in the EU-27, 2024



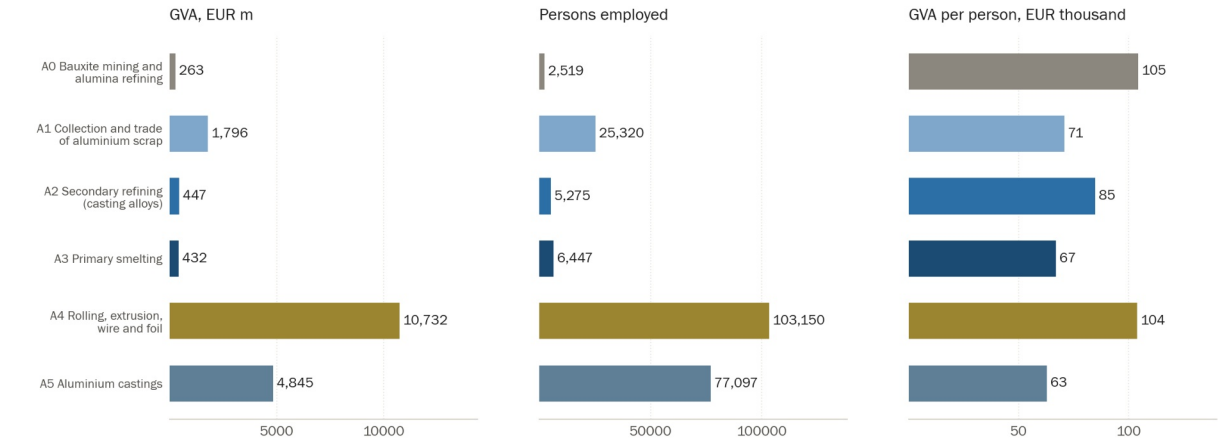
Source: IGMNiR AL-EU v1.1; Eurostat SBS 2024, PRODCOM 2024, FIGARO 2024 (EU-27 block), Comext; central estimate.

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
A0 Bauxite mining and alumina refining	263	1,111	1,390	2,520	12,920	370
A1 Collection and trade of aluminium scrap	1,796	3,427	4,252	25,320	46,160	1,151
A2 Secondary refining (casting alloys)	447	762	983	5,270	9,130	293
A3 Primary smelting	432	1,153	1,468	6,450	12,670	378
A4 Rolling, extrusion, wire and foil	10,732	16,800	21,111	103,150	177,530	5,595
A5 Aluminium castings	4,845	8,627	11,329	77,100	123,460	3,244
Extended value chain A0–A5	**18,516**	**31,880**	**40,533**	**219,810**	**381,860**	**11,031**

Source: IGMNiR AL-EU v1.1. Attribution of A4 and A5 to remelted scrap in proportion to its share of their aluminium input (24%): EUR 3,660 million of GVA and about 42,400 persons; this is an input-share attribution, not the value added of remelting itself. Taxes exclude VAT.

FIGURE 9 Direct GVA, employment and productivity by segment, 2024



Source: IGMNiR AL-EU v1.1; Eurostat SBS 2024, PRODCOM 2024, FIGARO 2024 (EU-27 block), Comext; central estimate.

Value added per person ranges from EUR 63 thousand to EUR 105 thousand. Rolling, extrusion, wire and foil (A4) and castings (A5) account for 84% of direct value added and 82% of employment; primary smelting (A3) for 2.3% and 2.9%. Employment of A2 and A3 follows from employment keys and their value added from cost build-ups; the employment keys are not checked against company data. The cost build-up of smelters values electricity before compensation of indirect emission costs, whereas SBS value added of NACE 24.42 is at factor cost and includes operating subsidies; compensation received by smelters (in Germany TRIMET EUR 192.4 million for cost year 2024; DEHSt 2026) therefore remains in the A4 residual. A3 value added is between EUR 100 million (electricity at EUR 65 per MWh) and EUR 680 million (EUR 30 per MWh) and EUR 320–540 million for premiums of 10–20%; it is zero at about EUR 71 per MWh. The electricity cost of EUR 45 per MWh is an IGMNiR assumption (range 30–65). It is below the Eurostat average of EUR 113 per MWh for non-household consumers above 150 GWh, which includes network charges and levies, because smelters buy mainly under long-term contracts and from own or captive generation, and in France had regulated access to historical nuclear electricity (ARENH) at EUR 42 per MWh until the end of 2025. Known compensation of indirect emission costs to aluminium producers – EUR 238.6 million for the German companies listed (cost year 2024; DEHSt 2026), EUR 9.8 million in Spain (costs of 2024; Ministerio de Industria y Turismo 2025) and EUR 158.9 million for sector 24.42 in France (cost year 2022; Ministère de la Transition écologique 2024), together about EUR 0.41 billion – is of the same order as the whole A3 value added.

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

Item	Persons	Status	Source
SBS NACE 24.42, EU-27 (persons employed)	117,216	O	Eurostat SBS
Model: A0 alumina part + A2 + A3 + A4 (in 24.42)	117,220	E	AL-EU
Model: refiners and smelters (A2 + A3)	11,720	E	AL-EU
Model: aluminium castings (A5) vs SBS 24.53	77,100 / 82,900	E/O	AL-EU; Eurostat SBS
Germany: SBS 24.42 + 24.53 (persons employed) vs industry statement	55,850 / >60,000	O	Eurostat SBS; Aluminium Deutschland (2025)
Model: extended value chain A0–A5, direct and Type I	220,000 / 382,000	E/M	AL-EU
European aluminium industry: direct and indirect jobs (industry statement)	>1,000,000	O	European Aluminium (2024)

Source: IGMNiR AL-EU v1.1; Eurostat SBS 2024; industry statements as stated. NACE 24.53 includes magnesium castings. The European Aluminium figure covers Europe beyond the EU-27 and indirect jobs, and 89% of those jobs are downstream (Metal Packaging Europe et al. 2025); it is not comparable with the direct segments of AL-EU.

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
A0 Bauxite mining and alumina refining	2,259	263	791	1,205	1,053	848
A1 Collection and trade of aluminium scrap	5,443	1,796	1,574	2,073	1,928	1,630
A2 Secondary refining (casting alloys)	4,470	447	3,576	447	391	315
A3 Primary smelting	2,827	432	1,427	969	928	722
A4 Rolling, extrusion, wire and foil	46,081	10,732	26,727	8,622	7,536	6,068
A5 Aluminium castings	15,252	4,845	5,033	5,374	4,697	3,782
Total	76,332	18,516	39,127	18,689	16,534	13,364

Source: IGMNiR AL-EU v1.1. Chain inputs = metal (or alumina, scrap) share of output (m0, m2, m4, m5); for A3 alumina and anode carbon; for A1 intermediate consumption less non-chain inputs of the parent FIGARO column. Electricity of smelters is a non-chain input entering the first round as CPA D35.

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	1,726	12.9
M69_70 Legal, accounting and management consultancy services	916	6.9
H49 Land transport and pipelines	850	6.4
C25 Fabricated metal products	785	5.9
L Real estate services	643	4.8
N80-82 Security, building and office support services	582	4.4
H52 Warehousing and transport support	565	4.2
K64 Financial services	487	3.6
G46 Wholesale trade	471	3.5
C33 Repair and installation of machinery	460	3.4
Other products	5,879	44.0

Source: IGMNiR AL-EU v1.1; FIGARO 2024, EU block.

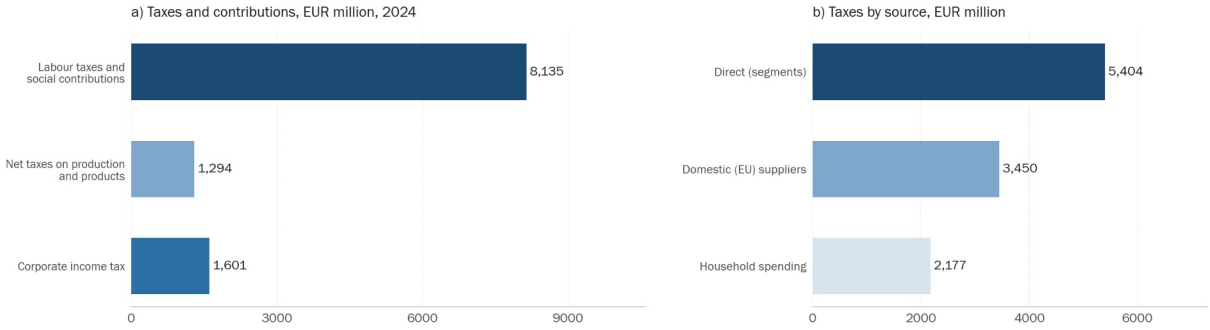
All economic results are gross contributions: they describe the value added and employment linked to the activity in 2024, not what would be lost if the activity stopped, since part of the labour, capital and demand would move to other uses and part of the supply would be replaced by imports. The model 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 11,030 million of taxes and social contributions excluding VAT (90% band 10,110–11,940): EUR 5,400 million in the segments, EUR 3,450 million at domestic suppliers and EUR 2,180 million from household spending. Labour taxes and contributions account for EUR 8,140 million. The implicit tax rate on labour (37.09%) and the statutory corporate tax rate (21.8%) are EU-27 values (DG TAXUD 2026); they are not weighted by the distribution of employment of the aluminium chain across Member States. The figures attribute public revenue to the activity; they are not a net fiscal balance. On the side of public support, aluminium installations received free allocation of emission allowances – 2.10 million allowances for the production of primary aluminium or alumina (activity 26) and 0.87 million for secondary aluminium (activity 27) in 2024 (European Commission 2026c); alumina refineries registered under combustion (activity 20) are not included, about EUR 190 million at the 2024 average auction price of EUR 64.74 – and compensation of indirect emission costs. Compensation for aluminium is published only in some Member States: in Germany for cost year 2024 TRIMET received EUR 192.44 million, Aluminium Norf EUR 25.19 million, Aluminium Oxid Stade EUR 8.75 million, Speira EUR 8.72 million and Novelis Koblenz EUR 3.55 million, and the primary aluminium benchmark accounted for 6.8% of EUR 2,783.65 million paid to all sectors (DEHSt 2025,

2026); in Spain Aluminio Español received EUR 4.98 million and Alúmina Española EUR 4.82 million for 2024 costs (Ministerio de Industria y Turismo 2025); in France sector 24.42 received EUR 158.85 million for cost year 2022 (Ministère de la Transition écologique 2024).

FIGURE 10 Taxes and contributions linked to the aluminium value chain, 2024



Source: IGMNiR AL-EU v1.1; 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	8,135	M	37.09% × labour cost (SBS, FIGARO)
(ii) Corporate income tax	1,601	M	21.8% × taxable share of operating surplus
(iii) Net taxes on production and on products used, net of other subsidies	1,294	M	FIGARO coefficients
Total (excl. VAT)	11,031	M	
Free allocation of allowances, activities 26 (primary aluminium or alumina) and 27 (secondary aluminium), 2024, at EUR 64.74	192	E	European Commission (2026c); not netted
Indirect emission cost compensation, all sectors, paid by 15 Member States in 2024 (costs of 2023)	5,520	O	European Commission (2025d); not netted
For comparison: named aluminium companies in Germany, cost year 2024	239	O	DEHSt (2026)
For comparison: aluminium companies in Spain, costs of 2024	9.8	O	Ministerio de Industria y Turismo (2025)

Source: IGMNiR AL-EU v1.1; DG TAXUD (2026); European Commission (2025d, 2026c); DEHSt (2025, 2026); Ministerio de Industria y Turismo (2025). Aluminium production (NACE 24.42), including semis producers, is eligible for the compensation of indirect emission costs under the Guidelines 2020/C 317/04. Free allocation and compensation are public support and are not deducted from the taxes; row (iii) uses FIGARO net taxes on production, which are net of other subsidies at the average rate of basic metals; the value of free allocation is an attribution at the average auction price, not a cash flow.

5.2 Split keys and boundaries with other IGMNiR reports

Four keys allocate the statistics of NACE 24.42: the employment shares of alumina refining (2.0%), refiners (4.5%) and primary smelters (5.5%), and the residual for semis producers; in addition, physical outputs and prices determine the output of A0, A2 and A3. The keys move value added between segments rather than in or out of the chain. The table shows their effect.

TABLE 24 Alternative split keys, 2024

Key	GVA A1+A2	GVA A2	GVA A3	GVA A4	GVA A0 –A5	Jobs A2	Jobs A3	Jobs A4
Central keys	2,243	447	432	10,732	18,516	5,300	6,400	103,200
Smelters 4.5% of 24.42	2,243	447	432	10,732	18,516	5,300	5,300	104,300
Smelters 7.0% of 24.42	2,243	447	432	10,732	18,516	5,300	8,200	101,400
Refiners 3.0% of 24.42	2,243	447	432	10,732	18,516	3,500	6,400	104,900

Key	GVA A1+A2	GVA A2	GVA A3	GVA A4	GVA A0 –A5	Jobs A2	Jobs A3	Jobs A4
Refiners 6.0% of 24.42	2,243	447	432	10,732	18,516	7,000	6,400	101,400
Refiners output 1,600 kt	2,154	358	432	10,822	18,516	5,300	6,400	103,200
Refiners output 2,400 kt	2,333	536	432	10,643	18,516	5,300	6,400	103,200
Scrap trade valued with the employment key	2,090	447	432	10,732	18,362	5,300	6,400	103,200

Source: IGMNiR AL-EU v1.1. GVA in EUR million, jobs in persons. The employment keys of refiners and smelters move jobs between A2, A3 and A4; their value added follows from the cost build-ups.

AL-EU covers the whole EU-27 and therefore contains the activities analysed in the IGMNiR report on aluminium in Poland and the aluminium part of the report on non-ferrous scrap in Poland. Within AL-EU each activity is counted once: alumina refining only in A0, refiners only in A2, smelters only in A3, semis producers only in A4 and foundries only in A5. National reports and AL-EU are alternative perspectives and are not additive. The AL-EU chain ends at semis and castings, whereas CU-EU (IGMNiR 2026b) also included wires and cables; direct value added of the two reports is therefore not directly comparable.

5.3 Comparison with other studies of aluminium in the EU

Several public studies describe aluminium flows, stocks and recycling in the EU; they differ in geography (EU-28, EU-27 or Europe including EFTA and the United Kingdom), year, unit and method. The matrix below 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 supply-security indicators for aluminium in the EU-27 was identified in the search for this report.

TABLE 25 Studies of aluminium in the EU: scope, methods, results and data access

Study	Scope	Method	Key results	Data access
Passarini et al. (2018), JRC	EU-28, 2013	Static MFA	Stock 132 Mt (260 kg/person); inflow to use 7.7 Mt; EoL-RR 69% (51% excl. exports); EoL-RIR 12%; new scrap >70% of secondary input	Public report
European Aluminium (2020), Circular Aluminium Action Plan	EU-28 + EFTA, 2019	Industry synthesis (CRU, Material Economics)	Demand 13.5 Mt; recycled 36% of supply (20% post-consumer); post-consumer scrap 3.6 Mt; stock 290 kg/person	Public report
International Aluminium Institute (2020)	World, Europe	Global mass-flow model	Recycling efficiency 76% (world); Europe recovers 81% of scrap available	Public summary
Gregoir and Van Acker (2022), KU Leuven	Europe, 2020–2050	Scenario study	Demand 14 → 21 Mt; recycling 42% → 53% of supply	Public report
European Commission (2023), CRM study	EU, 2016–2020	Criticality assessment	Aluminium/bauxite import reliance 89% (extraction), 58% (processing); EoL-RIR 32%	Public report
European Aluminium (2026c), industry statistics	EU-27, 2024–2025	Industry statistics	Supply ≈11.1 Mt (2024); 2025: net imports 52%, recycling 38%, primary 10%	Public charts
AL-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-RR: end-of-life recycling rate; EoL-RIR: end-of-life recycling input rate (definitions differ between studies).

5.4 Comparison with economic contribution studies

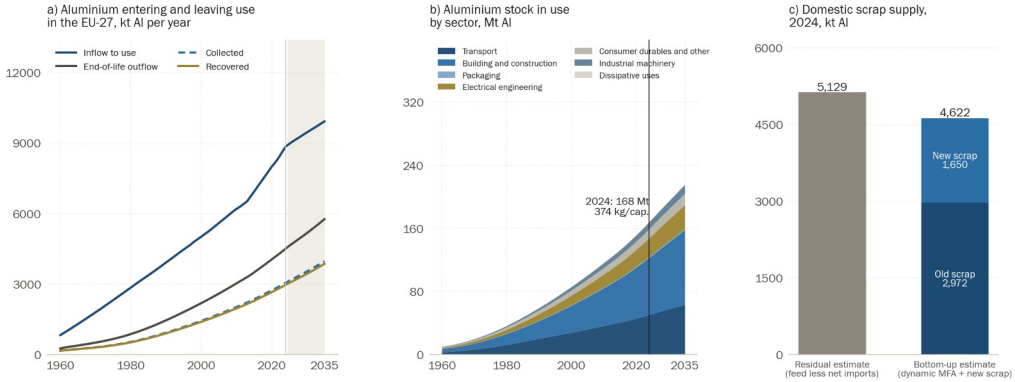
Economic contribution studies of metal industries use the same accounting but define the industry and the multiplier differently. For the US aluminium industry, a study prepared for the Aluminum Association reports 165,354 direct jobs and 871,464 jobs including supplier and induced effects, a ratio of about 5.3 (The Aluminum Association 2026). For the EU-28 steel industry in 2017, Oxford Economics (2019) reports ratios of 5.8 for value added and 7.9 for jobs. European Aluminium states that the European aluminium industry supports more than one million direct and indirect jobs (European Aluminium 2024), 89% of them downstream (Metal Packaging Europe et al. 2025). The corresponding ratios of AL-EU are 1.72 (Type I) and 2.19 (Type II) for value added and 1.7 and 2.3 for jobs. The ratios are not fully comparable: AL-EU counts six segments from bauxite to castings as direct activity, removes purchases within the aluminium chain from first-round demand and counts only effects inside the EU, each of which lowers the ratio; downstream users of aluminium (vehicles, construction products, packaging) are outside the chain, while the direct employment of the US study includes downstream fabrication and distribution. The conventional FIGARO multipliers of basic metals (CPA C24), computed without these exclusions, are 3.60 (Type I) and 4.57 (Type II) for value added and 3.83 (Type I) for jobs, close to the ratios of the other studies; the gap is a matter of method, not of the economy.

Industry statements provide a check of orders of magnitude. Aluminium Deutschland states more than 60,000 employees in the German aluminium industry (Aluminium Deutschland 2025); SBS gives 55,850 persons employed in NACE 24.42 and 24.53 in Germany in 2024 (29,128 and 26,722), the latter including magnesium castings. European Aluminium reports an annual turnover of about EUR 40 billion and around 600 plants in 30 European countries (European Aluminium 2024); the sum of segment outputs of the extended chain in AL-EU is EUR 76.3 billion for the EU-27 alone; this is a gross sum that counts deliveries within the chain (alumina to smelters, metal to semis producers, alloys to foundries) more than once, while the turnover of NACE 24.42 was EUR 58.5 billion.

06 Aluminium in use and scrap supply

The dynamic model estimates that about 168 Mt of aluminium was in use in the EU-27 in 2024, or 374 kg per person (90% band 324–441). Buildings hold 43% of the stock and transport 30%. In 2024 about 8,850 kt of aluminium entered use and 4,510 kt reached end of life, of which 2,970 kt was recovered as old scrap (66%). Packaging, with a lifetime of about one year, accounts for 24% of the end-of-life flow; its inflow is calibrated to the 1,100 kt of aluminium packaging waste generated in the EU-27 in 2024, of which 650 kt was recycled (Eurostat 2026b), and the other end-use shares of the JRC are rescaled. Collection of transport is set at 80%, between the 67% of end-of-life vehicles collected in the EU (Passarini et al. 2018) and the 92% of the World Aluminium mass-flow model for vehicles reaching treatment; recovered metal is 97% of collected metal. With the inflow growth assumed in the central case the stock reaches 216 Mt in 2035 and recovered old scrap 3,870 kt.

FIGURE 11 Aluminium in use in the EU-27, 1960–2035, and domestic scrap supply in 2024



Source: IGMNiR AL-EU v1.1, module M2b; inflow-driven stock model 1960–2035; end-use shares, lifetimes (Table S8) and collection rates (Table S10, World Aluminium mass-flow model) from the JRC aluminium MFA for 2013 (Passarini et al. 2018), packaging calibrated to Eurostat packaging waste generated (env_waspac) and transport collection set at 80%; lifetimes normal, SD = 0.3 × mean; per-capita path anchored on the AL-EU balance for 2024 and calibrated to the JRC inflow and stock of 2013; population Eurostat (demo_gind, EUROPOP2023). Model estimates; 2025–2035 under the central inflow growth of 1.0% a year.

TABLE 26 Aluminium stock in use and end-of-life flows by end use, 2024 and 2035

End use	Stock 2024, Mt	End of life 2024, kt	Stock 2035, Mt	End of life 2035, kt
Transport	50.7	1,801	63.5	2,308
Building and construction	72.2	446	94.6	696
Packaging	1.1	1,067	1.2	1,217
Electrical engineering	23.8	357	30.4	489
Consumer durables and other	11.6	461	14.4	592
Industrial machinery	8.8	131	11.2	179
Dissipative uses	0.3	247	0.3	281
Total	168.4	4,511	215.6	5,762

Source: IGMNiR AL-EU v1.1, module M2b. Model results (status M).

TABLE 27 Sensitivity of the dynamic model

Case	Stock 2024, kg/person	End of life 2024, kt	Recovered 2024, kt	EoL-RR 2024, %	Recovered 2035, kt
Central	374	4,511	2,972	66	3,867
Lifetimes −20%	331	5,108	3,448	68	4,469
Lifetimes +20%	409	4,023	2,592	64	3,378

Case	Stock 2024, kg/person	End of life 2024, kt	Recovered 2024, kt	EoL-RR 2024, %	Recovered 2035, kt
Inflow 2013 at 0.68 of 2024	350	4,234	2,771	65	3,649
Inflow 2013 at 0.85 of 2024	408	4,906	3,259	66	4,177
Inflow 1960 index 0.08	369	4,406	2,886	66	3,804
Inflow 1960 index 0.18	383	4,668	3,100	66	3,960
Collection scaling 0.93	374	4,511	2,764	61	3,596
Collection scaling 1.05	374	4,511	3,120	69	4,060
No inflow growth after 2024	374	4,511	2,972	66	3,796
Inflow growth 2% a year	374	4,511	2,972	66	3,943
Inflow 1998–2008 +25%	395	4,882	3,236	66	4,027
Flat per-capita inflow from 1990	529	6,623	4,538	69	5,262
Log-normal lifetimes	376	4,510	2,973	66	3,875
Half of end-of-life vehicles collected	374	4,511	2,269	50	2,966
Higher building share	356	4,671	3,005	64	3,869
New-scrap rate 22%, balance closed by recovery (collection scaling 0.99)	337	4,169	2,709	65	3,515

Source: IGMNiR AL-EU v1.1, module M2b.

Recycling indicators differ in definition. In AL-EU 66% of aluminium in end-of-life products is recovered as scrap, within the EU or for export – close to the 69% estimated by the JRC for 2013, including exported scrap (51% without it), because the collection rates are taken from the same source. By product, the EU recycling rate of aluminium packaging was 59.3% in 2024 (Eurostat 2026b) and that of beverage cans in Europe 76.3% in 2023 (European Aluminium and Metal Packaging Europe 2026). Input-based rates are different: old scrap used in the EU is about 22% of aluminium input to refining and fabrication (EoL-RIR) at a new-scrap rate of 15% and about 20% at 22%, and old and new scrap together 41% (RIR). The JRC reports an EoL-RIR of 12% for 2013 (16% if exported scrap had been processed in the EU) and the Commission's critical raw materials study 32%; European Aluminium reports that recycling supplies 38–40% of EU aluminium (European Aluminium 2025b, 2026c).

TABLE 28 **Aluminium recycling indicators: AL-EU and published values for the EU**

Indicator and definition	AL-EU 2024	Published	Source
End-of-life recycling rate (recovered / end-of-life outflow)	66%	69% incl. exports; 51% excl. (EU-28, 2013)	Passarini et al. (2018)
Recycling rate of aluminium packaging, EU-27, 2024	–	59.3%	Eurostat (2026b)
Recycling rate of beverage cans, Europe, 2023	–	76.3%	European Aluminium and Metal Packaging Europe (2026)
End-of-life recycling input rate (old scrap in input)	20–22%	12% (2013); 32%	Passarini et al. (2018); European Commission (2023)
Recycled aluminium, share of supply / first use	41%	36% (2019); 38–40% (2024–2025)	European Aluminium (2020, 2025b, 2026c)
Stock in use, kg per person	374	260 (EU-28, 2013); 290 (Europe)	Passarini et al. (2018); European Aluminium (2020)

Source: IGMNiR AL-EU v1.1 and as stated. The EoL-RIR range corresponds to new-scrap rates of 22% and 15%. The end-of-life recycling rate and the stock depend on parameters taken from the JRC and calibrated to its values, so their agreement is not an independent validation.

The residual estimate of domestic scrap supply (5,129 kt) – aluminium in the scrap feed of refiners and remelters less net extra-EU imports of aluminium in scrap – differs from the bottom-up estimate (4,622 kt: 2,972 kt of old scrap recovered and 1,650 kt of new scrap) by 507 kt, with a 90% band of −220 to 1,310 kt. The difference is not distinguishable from zero within its band; its sign is not interpreted. Its size is not an independent confirmation of the model, because the bottom-up estimate rests on calibrated collection rates and on the new-scrap rate: at a rate of 22% instead of 15% new scrap would be 2,420 kt instead of 1,650 kt,

and the share of aluminium first used that comes from domestic old scrap (old scrap recovered less net scrap exports, after melt losses) would fall from 22% to 20%. Internal scrap that semis producers remelt in their own casthouses is outside both estimates. Aluminium also leaves the EU in forms not classified as aluminium scrap, for example in used vehicles and in shredder fractions; these flows are not observed. The parameters that move the difference most are listed in the table.

The parameters that move the difference most are listed in the reconciliation table of Chapter 3.

The dynamic model has three limitations. Its end-use structure, lifetimes and collection rates are those of 2013 and of the EU-28; the path of inflow before 2024 is a calibrated assumption rather than a time series of consumption; and it was not validated against administrative data on end-of-life vehicles, packaging waste or construction and demolition waste beyond the packaging recycling rate.

07 Environmental contribution

Primary aluminium is energy-intensive. According to European Aluminium, a tonne of primary aluminium produced in Europe (EU, EFTA and the United Kingdom) carried a cradle-to-gate footprint of 6.6 t CO_2e in 2023, a tonne of imported primary ingot 13.2 t and the primary aluminium used in Europe – the consumption mix of European and imported metal – 10.1 t (European Aluminium 2025a); the difference reflects the electricity used by smelters, at 105 g CO_2e/kWh in Europe against 492 g/kWh for imports, with smelting electricity accounting for about 70% of the European primary footprint. The global average in 2024 was 14.4 t, of which 8.5 t from electricity (International Aluminium Institute 2025a). Secondary aluminium produced in the EU – 2,508 kt remelted by semis producers and foundries and 2,000 kt of refiners' alloys – carries screening footprints of 0.35 t and 0.50 t CO_2e per tonne, based on the European gate-to-gate values for remelting (0.26 t) and refining (0.41 t; 0.37 t with a salt-slag credit) plus scrap preparation. Only the aluminium content of secondary output displaces primary aluminium; the virgin alloying elements are added on both routes and are not credited. Compared with one-for-one substitution of primary aluminium in the European consumption mix it potentially avoided about 41,280 kt CO_2e in 2024 (90% band 30,870–58,880); with the global average primary footprint the result would be 59,650 kt and with European primary aluminium only 26,320 kt.

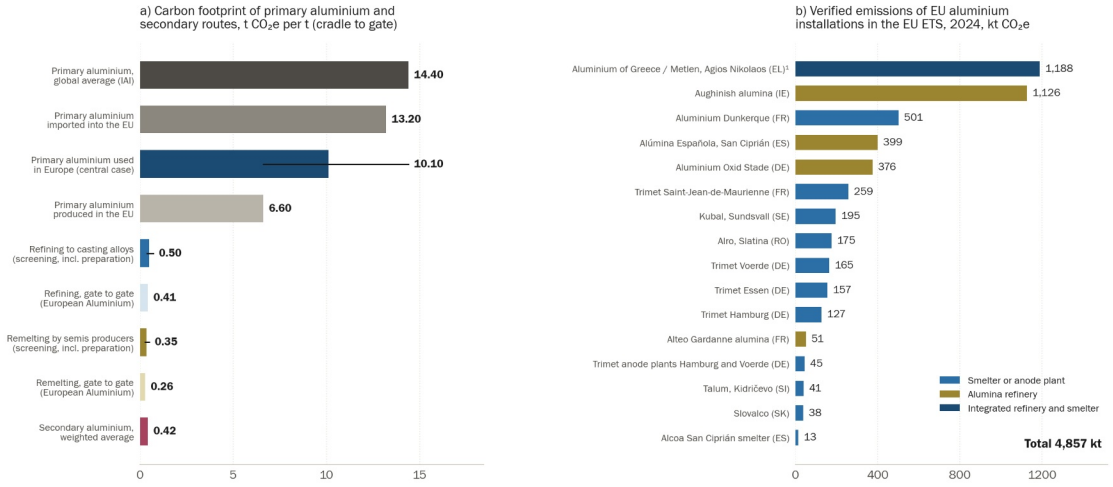
TABLE 29 Screening and published footprints for aluminium routes, t CO_2e per t (cradle to gate)

Route	t CO_2e/t	Range	Basis
Remelting by semis producers and foundries, incl. scrap preparation	0.35	0.26–0.50	European remelting gate to gate 0.26 (2021 data) + scrap preparation
Refining of scrap to casting alloys, incl. scrap preparation	0.50	0.37–0.70	European refining gate to gate 0.41 (0.37 with salt-slag credit; 2017–2019 data) + scrap preparation
Secondary aluminium, weighted by output	0.42		weights 2,508 kt and 2,000 kt
Primary aluminium used in Europe (consumption mix; central)	10.1	6.6–14.4	European Aluminium (2025a)
Primary aluminium produced in Europe	6.6		European Aluminium (2025a)
Primary ingot imported into Europe	13.2		European Aluminium (2025a)
Primary aluminium, global average (2024 data)	14.4		International Aluminium Institute (2025a)

Source: IGMNiR AL-EU v1.1; European Aluminium (2025a), Environmental Profile Report 2024 V2.0, geography EU, EFTA and United Kingdom, 2023 model year; International Aluminium Institute (2025a). The secondary values are screening values per tonne of metal and include scrap preparation; dross and salt-slag treatment are not credited. The secondary route has its own residues: refining in rotary furnaces produces about 0.3–0.5 t of salt slag per tonne of aluminium (United Nations Environment Programme 2013) and remelting produces dross; these are not deducted from the burdens potentially avoided.

Direct emissions of the installations themselves are reported in the EU Emissions Trading System. In 2024 installations for the production of primary aluminium or alumina (activity 26) verified 2.54 Mt CO_2e and installations producing secondary aluminium (activity 27, 27 installations) 1.10 Mt (European Commission 2026c). The installations named in Section 2.3, including alumina refineries and anode plants, verified 4.86 Mt CO_2e. Activity 26 includes the alumina refineries of Stade, San Ciprián and Gardanne and the anode plants; the smelters with their anode plants verified about 1.72 Mt, a total that includes Slovalco, Talum and the San Ciprián smelter, which emitted 92 kt in 2024 without primary output. The seven smelters producing in 2024 other than Metlen – whose smelter is registered together with its alumina refinery – emitted 1.58 Mt, or 1.57 t CO_2e per tonne of their output of 1,006 kt (Idoine et al. 2026), and 1.61 t including the Trimet anode plants of Hamburg and Voerde; the free-allocation benchmarks are 1.464 t per tonne of aluminium and 0.312 t per tonne of pre-bake anode for 2021–2025. These are on-site emissions (Scope 1); the electricity of smelters, the largest part of the primary footprint, is outside the EU ETS for the installations and enters the system through power generation. For 2026–2030 the aluminium benchmark is 1.423 t; there is no product benchmark for alumina.

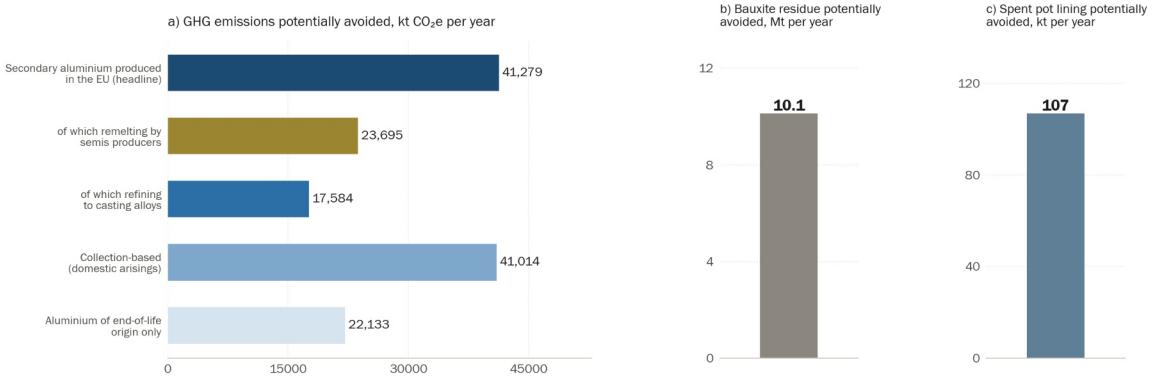
FIGURE 12 Carbon footprints of primary and secondary aluminium routes and verified emissions of EU installations



Source: IAI (2024 data); European Aluminium, Environmental Profile Report 2024 (2025); IGMNiR screening values for refining and remelting incl. scrap preparation (Chapter 7); EU ETS verified emissions (Union Registry, extraction 1 April 2026). Not ISO 14044 comparative LCAs; lines show ranges in Annex B. ¹ Integrated alumina refinery and smelter, registered under combustion (activity 20). EU-27 totals 2024: activity 26 production of primary aluminium or alumina 2,543 kt, activity 27 secondary aluminium 1,102 kt (27 installations).

Counting only aluminium from domestic old scrap – old scrap recovered in the EU less net scrap exports, after melt losses – the emissions potentially avoided are 22,130 kt CO_2e. Based on the aluminium collected from EU arisings rather than on the aluminium produced, the result is 41,010 kt. The primary production potentially displaced would also have caused other burdens, which are potentially avoided: about 10.1 Mt of bauxite residue (1.23 t per tonne of alumina, global average; International Aluminium Institute 2022) and 110 kt of spent pot lining (about 25 kg per tonne of primary aluminium; International Aluminium Institute 2024a). Most of these burdens would arise outside the EU. At the 2024 auction price the emissions potentially avoided correspond to EUR 2,670 million and at the EIB shadow cost of carbon to EUR 8,570 million; these are valuations, not cash flows.

FIGURE 13 Emissions and other burdens potentially avoided by secondary aluminium produced in the EU-27, 2024



Source: IGMNiR AL-EU v1.1, module M4; 1:1 substitution of primary aluminium (central case, Annex B) by secondary aluminium produced in the EU; avoided burdens arise largely outside the EU. Bars in a) are alternative attributions and are not additive, except the two sub-items of the headline.

7.1 Structural sensitivity

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

TABLE 30 Structural sensitivity of the emissions and bauxite residue potentially avoided (2024)

Case	Headline, kt CO_2e	Remelting	Refining	Collection-based	Secondary footprint, t/t	Bauxite residue, Mt
Central case: European consumption mix (10.1 t)	41,279	23,695	17,584	41,014	0.42	10.1
Substitution 0.8	32,647	18,780	13,867	32,438	0.42	8.1
Substitution 0.5	19,700	11,408	8,292	19,574	0.42	5.1
Aluminium from domestic old scrap only	22,133	12,704	9,428	41,014	0.42	5.4
Displaced: primary produced in Europe (6.6 t)	26,323	15,179	11,144	26,155	0.42	10.1
Displaced: imported primary ingot (13.2 t)	54,525	31,237	23,288	54,175	0.42	10.1
Displaced: global average (14.4 t)	59,652	34,156	25,496	59,270	0.42	10.1
Displaced: EU primary and net imports of 7601, weighted (10.1 t)	41,393	23,759	17,633	41,127	0.42	10.1
Grid factor 2023 (205.7 g/kWh)	41,262	23,678	17,584	40,998	0.42	10.1
Refining 0.37 t	41,539	23,695	17,844	41,273	0.36	10.1
Refining 0.70 t	40,879	23,695	17,184	40,617	0.51	10.1
Remelting 0.26 t	41,504	23,920	17,584	41,239	0.37	10.1
Remelting 0.50 t	40,902	23,318	17,584	40,640	0.50	10.1
Bridge term d_ref −300 kt	38,444	20,860	17,584	38,444	0.42	9.4
Bridge term d_ref +300 kt	44,113	26,529	17,584	41,122	0.41	10.8
Refiners output 1,600 kt	41,541	27,473	14,067	41,361	0.40	10.2
Refiners output 2,400 kt	41,017	19,916	21,101	40,669	0.43	10.1

Source: IGMNiR AL-EU v1.1. In the weighted case net extra-EU imports of unwrought aluminium have a weight of 83% and EU primary production of 17% at 6.6 t. The imports carry 10.8 t: imports from Norway and Iceland (36% of extra-EU imports of CN 7601) at the footprint of primary aluminium produced in Europe (6.6 t; the European Aluminium geography includes EFTA), the rest at that of imported primary ingot (13.2 t); the weighted footprint is 10.1 t.

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 aluminium from scrap add to the emissions of the EU aluminium industry, compared with the primary tonne it may displace? Secondary aluminium is not burden-free – scrap collection, sorting, de-coating, melting and the treatment of dross and salt slag cause emissions – and it is not always a full substitute for primary metal, because alloy composition limits the use of mixed scrap in wrought products. The substitution cases address this. The emissions potentially avoided occur mainly at smelters and power plants outside the EU and are not changes of the EU greenhouse gas inventory; they are not additive to the ETS emissions shown in Section 2.3 shown above.

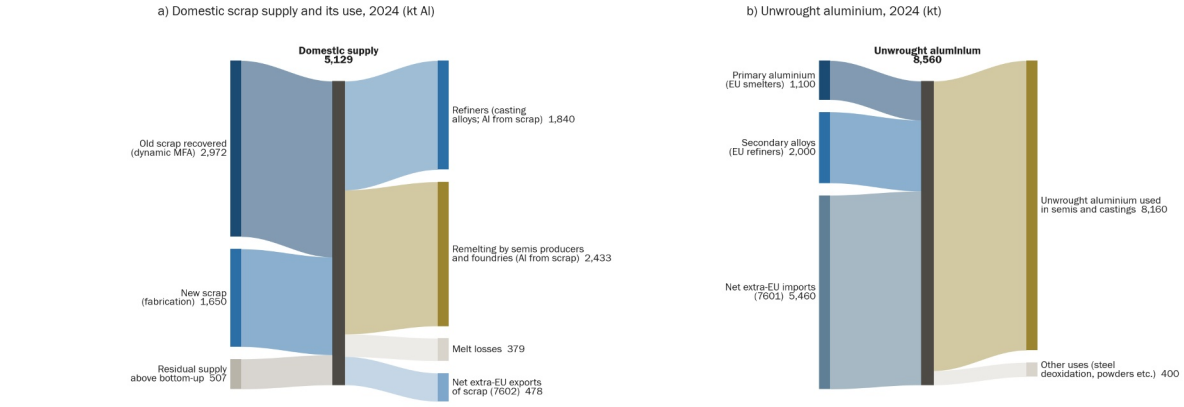
7.3 Uncertainty from the counterfactual

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 19,700 to 59,650 kt CO_2e; the Monte Carlo band (30,870–58,880 kt) covers the parameter ranges, including the displaced footprint between 6.6 and 14.4 t, but not the choice of substitution. The two ranges are not combined.

08 Strategic contribution

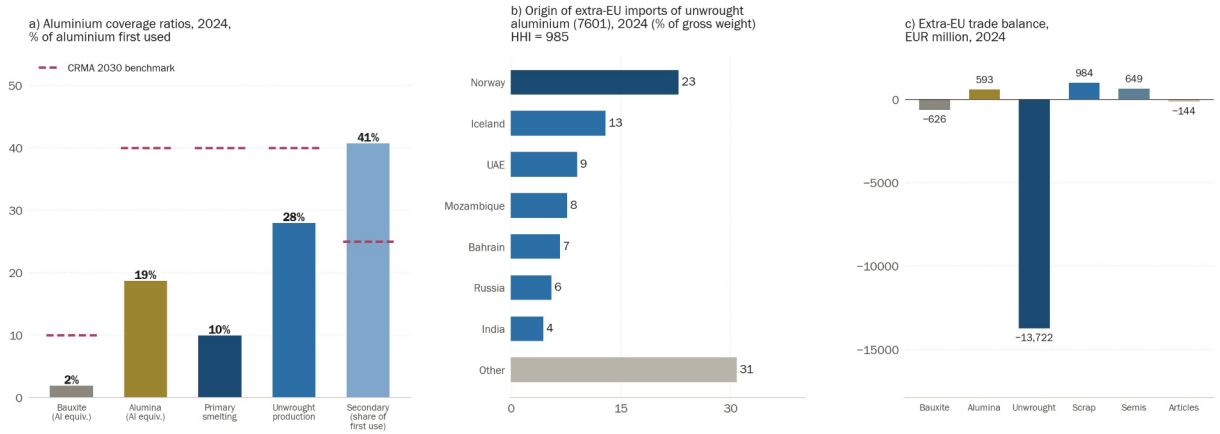
The EU-27 mined 1,061 kt of bauxite in 2024, produced about 4,000 kt of alumina and 1,100 kt of primary aluminium, and its refiners produced about 2,000 kt of secondary casting alloys. Apparent use of unwrought aluminium was 8,560 kt; semis producers and foundries remelted about 2,508 kt of aluminium in scrap. In extra-EU trade the EU imported 10,469 kt of bauxite and 727 kt of alumina while exporting 1,894 kt of alumina, imported 5,823 kt of unwrought aluminium and exported 363 kt, and exported 1,258 kt of aluminium scrap while importing 657 kt. In semis (CN 7604–7608) imports exceeded exports by 324 kt.

FIGURE 14 **Aluminium flows in the EU-27, 2024**



Source: IGMNiR AL-EU v1.1 mass balance (M2) and dynamic MFA (M2b); Idoine et al. (2026); Eurostat PRODCOM and Comext 2024 (CN 7602 at 90% Al in imports and 85% in exports). Remelting is derived from the aluminium bridge. In a), refiners and remelting show aluminium from scrap; in b), refiners' alloys include virgin alloying elements (8% of output). The difference between the residual and the bottom-up estimate of domestic scrap supply is a balance residual.

FIGURE 15 **Supply security indicators for aluminium, 2024**



Source: IGMNiR AL-EU v1.1; Eurostat Comext (DS-045409; extra-EU trade, imports by country of origin); Idoine et al. (2026); Regulation (EU) 2024/1252, Art. 5(1). The CRMA benchmarks refer to EU capacity for strategic raw materials as a whole and are shown for orientation only; the secondary share relates secondary aluminium to aluminium first used, not to the CRMA definition of recycling capacity. Unwrought production includes refiners, whose output also counts in the secondary share. HHI: Herfindahl–Hirschman index of partner countries (0–10,000).

Bauxite/alumina/aluminium is a strategic and critical raw material under the Critical Raw Materials Act, which sets benchmarks for strategic raw materials as shares of annual EU consumption: extraction at least 10%, processing at least 40%, recycling at least 25%, and no more than 65% from a single third country at any processing stage. Applied to aluminium as coverage ratios of 2024, all relative to aluminium first used (11,070 kt), EU bauxite output equals 1.9% (in aluminium equivalent), EU alumina output 19%, EU primary output 10%

and all unwrought aluminium produced in the EU, primary and refiners' output, 28%; secondary aluminium equals 41%, and aluminium from domestic old scrap alone 22%. Refiners' output counts both in unwrought production and in the secondary share; the two ratios are not additive. The benchmarks are defined for the whole set of strategic raw materials and on a capacity basis for 2030; the aluminium ratios are shown for orientation only. Primary output covers a small share of use; the processing ratio for alumina reflects refineries supplied with imported bauxite, whose output is partly exported.

TABLE 31 Aluminium coverage ratios and concentration compared with the CRMA benchmarks, 2024

Indicator	Aluminium 2024	CRMA benchmark 2030
Extraction: bauxite (Al equivalent) / aluminium first used	2%	≥10%
Processing: alumina (Al equivalent) / aluminium first used	19%	≥40%
Processing: primary aluminium / aluminium first used	10%	≥40%
Processing: primary and refiners output / aluminium first used	28%	≥40%
Recycling: secondary aluminium / aluminium first used	41%	≥25%
Largest supplier of bauxite imports (Guinea), share of extra-EU imports	72%	≤65%
Largest supplier of unwrought aluminium imports (Norway), share of extra-EU imports; share of EU use	23%; 16%	≤65%

Source: IGMNiR AL-EU v1.1; Regulation (EU) 2024/1252, Art. 5 and Annex I; Comext. Coverage ratios use output in 2024, the benchmarks refer to capacity in 2030 relative to annual EU consumption; the 65% limit refers to EU consumption, and shares of extra-EU imports are shown as upper values of exposure. Al equivalent: 2.6 t bauxite per t alumina and 1.93 t alumina per t aluminium.

TABLE 32 Concentration of extra-EU aluminium trade by partner country, 2024

Flow	kt, gross weight	HHI	Largest partner	Top 1, %	Top 5, %
Bauxite imports (2606)	10,469.2	5,449	Guinea	72	97
Alumina imports (2818 20)	726.9	3,321	Jamaica	52	94
Unwrought aluminium imports (7601)	5,841.0	985	Norway	23	59
– of which not alloyed (7601 10)	2,608.6	858	Mozambique	17	54
Scrap imports (7602)	657.3	1,193	Switzerland	25	63
Scrap exports (7602)	1,257.8	1,251	India	27	65
Plate, sheet and strip exports (7606)	978.2	1,844	the United Kingdom	38	73

Source: Eurostat Comext (DS-045409), EU27_2020 reporter, extra-EU partners; IGMNiR AL-EU v1.1. Totals are sums over identified partners and differ slightly from the Comext totals of Section 3.5. HHI: Herfindahl–Hirschman index (0–10,000). Totals are sums of partner-level data; for unwrought aluminium (7601) they exceed the extra-EU total of the trade table in Chapter 3 by 18.5 kt (5,841.0 against 5,822.5 kt).

Unwrought aluminium comes from a broader set of countries than bauxite. In 2024 Russia supplied 323 kt of extra-EU imports of unwrought aluminium (5.5%); under Council Regulation (EU) 2025/395 these imports are limited by a quota of 275,000 t until 26 February 2026 and by 50,000 t under earlier contracts until 31 December 2026, after which they are banned. Stress tests show first-order exposures; they keep prices, other suppliers and stocks unchanged and are not forecasts.

TABLE 33 Stress indicators for the EU aluminium value chain, 2024 basis

Test	Size	Relative to
Electricity +EUR 50/MWh for smelting and for rolling, extrusion and casting	EUR 1,225 m a year	10.6% of GVA of A2–A4; smelters alone 191% of GVA of A3
Loss of the largest bauxite supplier (Guinea)	7,500 kt bauxite	72% of EU alumina output (alumina equivalent)
Loss of the largest alumina supplier (Jamaica)	375 kt alumina	18% of EU primary output (Al equivalent); the EU is a net exporter of alumina
Loss of the largest supplier of unwrought aluminium (Norway)	1,334 kt	15.6% of unwrought aluminium used; Norway is in the European Economic Area
One-month outage of the largest smelter (Alro, 248 kt a year)	20.7 kt	1.9% of annual EU primary output

Test	Size	Relative to
Doubling of net scrap exports (aluminium content)	478 kt Al	10.3% of aluminium in the scrap feed
Halving of gross scrap exports (aluminium content) retained in the EU	535 kt Al	11.5% of aluminium in the scrap feed; unused capacity for scrap feed ≈2,040 kt Al
US tariff of 50%: EU exports of HS 76 to the US, 2024	334.7 kt (EUR 2,600 m)	8.8% of extra-EU exports of HS 76
Aluminium price +30% against the 2024 average (EUR 2,235/t), margins unchanged	EUR 10,600 m of metal value bought by A2, A4 and A5	15.4% of output of A2–A5; one month of this metal throughput is worth EUR 880 m

Source: IGMNiR AL-EU v1.1; Comext; Idoine et al. (2026) for Alro; Federal Register (2025) for the US tariff (50% from 4 June 2025, extended to derivative products). Electricity use of smelting (16,500 GWh, ≈15.0 MWh per tonne) and of semis and casting (8,000 GWh) is an IGMNiR estimate; refining and remelting use mainly natural gas and are not included. The energy test is related to A3 value added, which is a residual of the cost build-up. Unused capacity: refiners up to 2,600 kt and remelting up to 3,800 kt of aluminium (IGMNiR estimate), converted to feed with the yields of the model. The price test changes the value of metal priced off the LME in A2, A4 and A5 only (alumina and carbon of smelters and the purchases of scrap traders are not included); smelters would gain on their output; value added in SBS reflects the margins of 2024, and the model has no margin response.

TABLE 34 Strategic indicators for the EU aluminium value chain, 2024

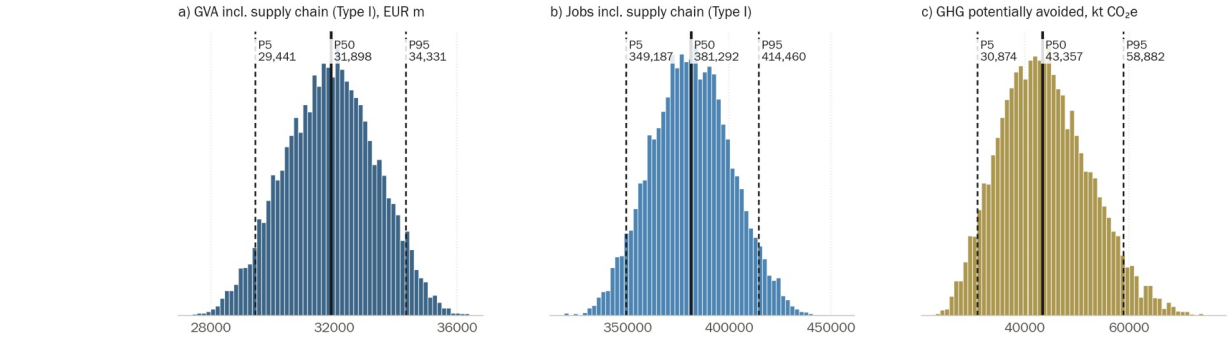
Indicator	Value	Source
Bauxite output, kt	1,061	Idoine et al. (2026)
Alumina output, kt	4,000	Idoine et al. (2026); U.S. Geological Survey (2026)
Primary aluminium output, kt	1,100	compiled (Chapter 3)
Unwrought aluminium used, kt	8,560	AL-EU
Secondary aluminium (refining and remelting), kt	4,508	AL-EU
Coverage ratio: domestic scrap supply / scrap used (residual; bottom-up)	110%; 99%	AL-EU
Trade balance, bauxite (2606) / alumina (2818 20), EUR m	−626 / 593	Comext
Trade balance, unwrought aluminium (7601), EUR m	−13,722	Comext
Trade balance, scrap (7602), EUR m	984	Comext
Trade balance, semis (7604–7608) / other articles (7616), EUR m	649 / −144	Comext

Source: IGMNiR AL-EU v1.1; Eurostat Comext (extra-EU trade); Idoine et al. (2026); U.S. Geological Survey (2026).

09 Uncertainty, checks and limitations

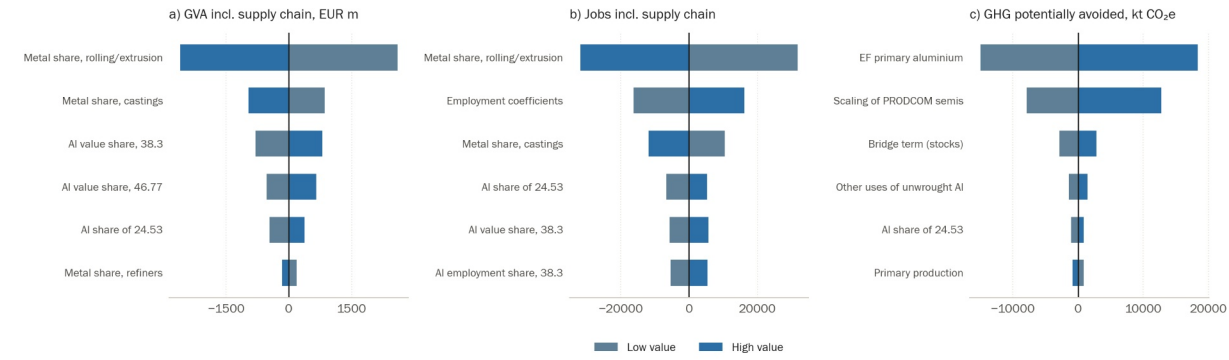
The 90% band of GVA including the supply chain is EUR 29,440–34,330 million, of jobs including the supply chain 349,000–414,000 and of the emissions potentially avoided 30,870–58,880 kt CO_2e. The economic results depend mainly on metal share of semis output, metal share of castings output and aluminium value share of materials recovery; the emissions potentially avoided on footprint of primary aluminium displaced and scaling of PRODCOM semis volumes. The central run uses the modal values; because several ranges are asymmetric, the median of the draws can differ from it.

FIGURE 16 Monte Carlo distribution of key results



Source: IGMNiR AL-EU v1.1, 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 17 Sensitivity of results to individual parameters



Source: IGMNiR AL-EU v1.1, module M6; one-at-a-time sensitivity on Annex B ranges; extended value chain.

TABLE 35 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)	29,410–34,260	350,000–413,000	31,260–58,810
No correlation	29,870–33,840	355,000–408,000	31,250–58,810
Correlation 0.95 in all groups	29,290–34,540	347,000–416,000	31,260–58,780
PERT distributions	29,620–34,080	353,000–411,000	31,220–56,040

Source: IGMNiR AL-EU v1.1, 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 0.5%.

TABLE 36 Structural tests of the economic and fiscal results

Case	GVA A1+A2	GVA A0–A5	GVA Type I	Jobs Type I	Taxes
Central case	2,243	18,516	31,880	382,000	11,031
Supply-chain effects −20%	2,243	18,516	29,207	349,000	10,176
Supply-chain effects +20%	2,243	18,516	34,553	414,000	11,886
EU-27 symmetric IO table 2023	2,243	18,516	31,974	381,000	10,775
Conservative first round	2,243	18,516	30,112	357,000	10,410
Smelters share of 24.42, low	2,243	18,516	31,880	382,000	11,031
Smelters share of 24.42, high	2,243	18,516	31,880	382,000	11,034
Refiners share of 24.42, low	2,243	18,516	31,880	382,000	11,031
Refiners share of 24.42, high	2,243	18,516	31,880	382,000	11,031
Premium on primary output 10%	2,243	18,516	31,830	381,000	11,019
Premium on primary output 20%	2,243	18,516	31,930	382,000	11,048
Metal share of semis, low	2,243	18,516	34,475	414,000	11,870
Metal share of semis, high	2,243	18,516	29,286	350,000	10,192
Aluminium share of castings, low	2,243	18,255	31,416	375,000	10,857
Aluminium share of castings, high	2,243	18,724	32,251	387,000	11,171
Scrap trade with employment key	2,090	18,362	31,619	381,000	10,978
Basic prices for all segments	2,279	18,722	32,086	382,000	11,031
Joint low (all allocation keys low, supply chain −20%)	1,352	17,575	24,519	289,000	8,610
Joint high (all allocation keys high, supply chain +20%)	3,256	19,495	41,191	498,000	14,071

Source: IGMNiR AL-EU v1.1; EUR million and persons.

TABLE 37 Parameter-uncertainty band and range of structural cases

Result	P5	P95	Structural minimum	Structural maximum
GVA Type I, EUR m	29,440	34,330	24,520	41,190
Jobs Type I	349,000	414,000	289,000	498,000
GHG potentially avoided, kt CO_2e	30,870	58,880	19,700	59,650

Source: IGMNiR AL-EU v1.1. 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 38 Consistency checks of the AL-EU model

Check	AL-EU value	Reference	Reference source	Independent of calibration
Primary output: sum of listed smelters (Idoine et al. 2026) vs model central value (range), kt	1,100	1,188 (1,010–1,190)	Idoine et al. (2026)	no
Primary output 2024: model vs European Aluminium, kt	1,100	≈1,010	European Aluminium (2026c)	yes
Aluminium first used (model) vs EU supply, kt	11,068	≈11,100	European Aluminium (2026c)	no
Secondary share of first use vs recycling share of EU supply	41%	38–40%	European Aluminium (2025b, 2026c)	no
Old scrap recovered 2024 (model) vs post-consumer scrap available in Europe 2019, kt	2,972	3,600	European Aluminium (2020)	yes
Aluminium packaging recycled 2024: model (packaging waste × recovery rate) vs Eurostat, kt	608	649.8	Eurostat (2026b)	yes
Inflow to use 2013 (EU-27 model) vs JRC (EU-28), kt	6,516	7,683	Passarini et al. (2018)	no
Stock in use 2013, kg per person, vs literature	285	260; 290	JRC; European Aluminium (2020)	no

Check	AL-EU value	Reference	Reference source	Independent of calibration
End-of-life recycling rate vs JRC (incl. exports)	66%	69%	Passarini et al. (2018)	no
Germany: SBS 24.42 + 24.53 persons employed vs industry statement	55,850	>60,000	Aluminium Deutschland (2025)	yes
Employment of the total EU-27 economy reproduced by FIGARO coefficients, million (construction check)	219.4	219.4	nama_10_a64_e	construction
GVA Type I with the EU-27 SIOT vs FIGARO, %	0.3	0	naio_10_cp1700	yes
Monte Carlo convergence, max. change of percentiles, %	0.5	–	seeds 1, 2, 3; 20,000 draws	–
Replication from package files, max. absolute difference	0.012	0	replication script	–

Source: IGMNiR AL-EU v1.1. “No” marks comparisons with data that were used to set the model parameters: primary output is set between the sum of listed smelters and the European Aluminium estimate; the scaling of PRODCOM semis in the bridge is set so that the secondary share falls in the 38–40% range of European Aluminium; the packaging inflow is calibrated to packaging waste generated, while the amount recycled is compared independently; the dynamic model takes its end-use shares, lifetimes and collection rates from the JRC and its inflow path is calibrated to the JRC inflow and stock of 2013, so agreement confirms the implementation, not the values. The JRC values refer to the EU-28 (with the United Kingdom); European Aluminium values partly refer to Europe beyond the EU-27. NACE 24.53 includes magnesium castings.

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); cells published in rounded form are used as published.
- **Allocation keys.** The aluminium shares of NACE 07.29, 46.77, 38.3 and 24.53 and the employment keys of alumina refining, refiners and smelters in 24.42 are assumptions (class C) that are not checked bottom-up against company accounts. The employment keys assume equal personnel cost per person within 24.42. The value added of alumina refining follows its employment key (equal value added per person), that of refiners and smelters a cost build-up, and rolling, extrusion, wire and foil (A4) take the residual of 24.42, so an error in the cost build-ups of A2 and A3 moves value added between them and A4 without changing the total.
- **Physical valuation.** The output of A0, A2 and A3 is valued at 2024 prices (extra-EU export unit value of alumina, LME price for secondary alloys, LME plus premium for primary aluminium); the output of A4 is the residual of 24.42 and absorbs any error in these prices and the compensation received by smelters.
- **Primary and secondary output.** EU primary output differs between the BGS (1,188 kt) and European Aluminium (≈1,010 kt); the split of recycled aluminium between refiners and remelters is not published and is an estimate.
- **Remelting.** Aluminium remelted by semis producers and foundries is derived from the bridge; it depends on rounded PRODCOM cells and possible double counting of foil stock and was not confronted with external data on scrap use by fabricators.
- **Scrap balance.** The residual and bottom-up estimates of domestic scrap supply differ by 507 kt in the central case, with a 90% band of −220 to 1,310 kt; the split of secondary aluminium into old and new scrap depends on the new-scrap rate (share of domestic old scrap in first use 20–22% for rates of 22% and 15%); aluminium leaving the EU in forms other than CN 7602 and stocks of scrap are not observed.
- **Dynamic model.** End-use shares, lifetimes and collection rates are those of 2013 for the EU-28; the inflow path before 2024 is calibrated.
- **Prices and margins.** Value added reflects the aluminium price, energy prices and margins of 2024; the model has no price or margin response. Regulated access to nuclear electricity in France (ARENH) ended with 2025, so smelter conditions after 2024 differ from the base year.
- **Fiscal and environmental modules.** Labour taxes use the EU-27 implicit tax rate on labour (DG TAXUD) and corporate tax a statutory average; footprints are screening values for the EU, EFTA and the United Kingdom, and the result depends on the displaced primary aluminium.

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 in the scenario (so in S3 lower activity meets an unchanged supply of old scrap), and unwrought aluminium used follows the bridge from semis and castings; a scenario at 2024 activity reproduces 2024. S1 (2030) assumes moderate growth of recycling and of semis; S2 (2035) assumes high circularity – more refining and remelting of scrap, a partial recovery of primary smelting and cleaner routes; S3 (2030) is a stress case with lower activity across the chain, including primary smelting −25%.

TABLE 39 Scenario assumptions (change versus 2024)

Driver	S1 2030	S2 2035	S3 2030
Refiners output (A2)	+10.0%	+25.0%	−10.0%
Remelting of scrap	+10.0%	+25.0%	−10.0%
Scrap collection and trade (A1)	+8.0%	+18.0%	−10.0%
Bauxite and alumina (A0)	0%	0%	−20.0%
Primary smelting (A3)	0%	+10.0%	−25.0%
Rolling, extrusion, wire and foil (A4)	+5.0%	+10.0%	−8.0%
Aluminium castings (A5)	+3.0%	+6.0%	−8.0%
Footprint of primary aluminium	−5.0%	−15.0%	−5.0%
Footprint of secondary aluminium	−15.0%	−30.0%	−5.0%

Source: IGMNiR AL-EU v1.1. Refiners are limited to 2,600 kt and remelting to 3,800 kt of aluminium. Additional scrap feed has a lower yield and a higher footprint.

TABLE 40 Aluminium balance in the scenarios (kt Al)

Item	2024	S1 2030	S2 2035	S3 2030
Refiners output	2,000	2,200	2,500	1,800
Remelting	2,508	2,759	3,135	2,257
Unwrought aluminium used	8,560	8,800	8,914	7,957
Unwrought aluminium produced (primary and refiners)	3,100	3,300	3,710	2,625
Net imports of unwrought aluminium (use less production)	5,460	5,500	5,204	5,332
Old scrap recovered (dynamic model)	2,972	3,440	3,867	3,440
Additional aluminium in scrap feed vs 2024	0	503	1,257	−465
Additional domestic scrap vs 2024	0	542	1,042	340
Additional feed not covered by additional domestic scrap	0	−39	215	−805
For comparison: net extra-EU exports of aluminium in scrap, 2024	478	478	478	478
For comparison: gross extra-EU exports of aluminium in scrap, 2024	1,069	1,069	1,069	1,069

Source: IGMNiR AL-EU v1.1. Negative values of the uncovered feed mean that additional domestic scrap exceeds the additional feed.

In S1 direct value added rises to EUR 19,390 million and in S2 to EUR 20,360 million; in S3 it falls to EUR 16,880 million. Employment including the supply chain, adjusted for productivity, is about 376,000 in S1, 375,000 in S2 and 326,000 in S3 (without the productivity adjustment 419,000 in S2). The emissions potentially avoided are 43,260 kt in S1 and 43,930 kt in S2. In S2 the additional scrap feed is larger than the growth of domestic old scrap (dynamic model) and new scrap, by about 215 kt (S1: 39 kt); for comparison, net

extra-EU exports of aluminium in scrap were 478 kt and gross exports 1,069 kt in 2024. Unwrought aluminium used rises from 8,560 kt to 8,800 kt in S1 and 8,914 kt in S2, while production of unwrought aluminium reaches 3,710 kt in S2; net imports of unwrought aluminium change from 5,460 kt to 5,204 kt and the coverage of use by EU production from 36% to 42%. The scenarios assume that the remaining use is covered by imports.

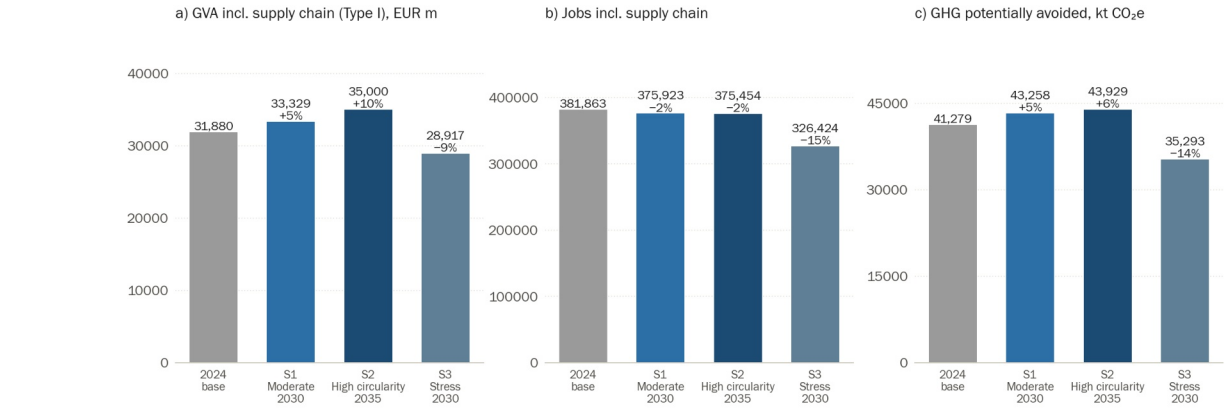
Published outlooks place these assumptions in context. European Aluminium (2020) projects European demand rising from 13.5 Mt to 16 Mt in 2030 and 18 Mt in 2050 and post-consumer scrap available rising from 3.6 Mt (2019) to 6.6 Mt in 2030 and 8.6 Mt in 2050; its action plan of January 2026 expects demand 30% above 2022 by 2040 (European Aluminium 2026a). KU Leuven (Gregoir and Van Acker 2022) estimates European demand rising from 14 Mt in 2020 to 21 Mt in 2050 and recycling rising from 42% to 53% of supply. Globally, the International Aluminium Institute and CRU project demand almost 40% higher in 2030 than in 2020 (International Aluminium Institute, CRU 2022). In AL-EU unwrought aluminium used rises by 3% to 2030 in S1 and by 4% to 2035 in S2, and old scrap recovered by 30% to 2035. The scenarios assume that primary metal and scrap remain available on 2024 terms; they do not represent changes in global supply or prices.

TABLE 41 **Decomposition of the change in emissions potentially avoided from 2024 to scenario S2, kt CO_2e**

Step	Result	Change
2024 base	41,279	
More secondary aluminium (volume)	51,598	10,320
Lower-grade marginal feed	51,457	−141
Cleaner secondary routes	52,021	563
Cleaner displaced primary aluminium	43,929	−8,092

Source: IGMNiR AL-EU v1.1; sequential decomposition, order as listed. A cleaner displaced primary aluminium lowers the emissions potentially avoided: the measure loses weight as primary production decarbonises.

FIGURE 18 **Scenario results: change versus 2024**



Source: IGMNiR AL-EU v1.1; 2024 prices; assumptions in the scenario table; labour productivity +1% a year; footprints of both routes decline over time.

The scenarios have no feedback between scrap prices, scrap quality, scrap exports and capacity use, and they do not show that the volumes are economically feasible. Not modelled are: the supply of scrap by alloy and grade, the cost of sorting and de-coating, the availability of electricity for smelters at competitive prices, and changes in trade policy. Mixed scrap is refined mainly into casting alloys, and wrought alloys need dilution with primary metal, so secondary aluminium does not replace primary metal one for one (Cullen and Allwood 2013); the main outlet of secondary casting alloys is castings for vehicles with combustion engines, so growth of the output of refiners as in S2 depends on demand for such castings (Modaresi and Müller 2012).

11 Summary

In 2024 the EU-27 produced about 1,100 kt of primary aluminium and about 4,510 kt of secondary aluminium and imported, net, 5,460 kt of unwrought aluminium. The extended aluminium value chain – from bauxite and alumina through scrap trading, refining, smelting, rolling and extrusion to castings – generated about EUR 18.5 billion of direct value added and employed about 220,000 people; with its EU supply chain it supported EUR 31.9 billion of value added and about 382,000 jobs, and about EUR 11.0 billion of taxes and contributions excluding VAT.

Secondary aluminium – about 2,000 kt from refiners and 2,510 kt remelted by semis producers and foundries – supplied 41% of aluminium first used in the EU, a share set through the scaling of PRODCOM semis volumes to the 38–40% reported by European Aluminium. Value added of primary smelting is the residual of a cost build-up and is between EUR 100 million (electricity at EUR 65 per MWh) and EUR 680 million (EUR 30 per MWh). The aluminium stock in use is about 168 Mt (374 kg per person); end-of-life products released about 4,510 kt of aluminium in 2024, of which about 2,970 kt was recovered. The EU exported 1,260 kt of aluminium scrap (gross weight) to countries outside the EU and imported 660 kt.

Depending on the counterfactual, secondary aluminium produced in the EU potentially avoided between about 19.7 and 59.7 Mt CO_2e in 2024; replacing primary aluminium at the footprint of the European consumption mix one-for-one, about 41.3 Mt, and about 22.1 Mt counting only aluminium from domestic old scrap; most of the burdens potentially avoided would have arisen outside the EU. EU primary smelting corresponds to 10% and all unwrought aluminium produced in the EU to 28% of aluminium first used in the EU. In scenario S2 (2035) net imports of unwrought aluminium are about 5,200 kt.

A Data sources

TABLE 42 Main data sources of the AL-EU model

Domain	Source	Use in AL-EU
Structural business statistics	Eurostat sbs_ovw_act, EU-27 and member states, 2021–2024	Output, value added, employment, labour costs, turnover (07.29, 24.42, 24.53, 46.77, 38.3); missing EU cells completed from member-state sums and earlier ratios
Production and trade	Eurostat PRODCOM (DS-059358), 2019–2024; Comext DS-045409, reporter EU27_2020, 2015–2025	Unwrought aluminium, alumina, rolled and extruded products, wire, foil, castings; extra-EU trade in CN 2606, 281820 and 7601–7616, partners, unit values
Input-output and national accounts	Eurostat 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
Bauxite, alumina and primary aluminium	Idoine et al. (2026), World Mineral Production 2020–24; U.S. Geological Survey (2026), Mineral Commodity Summaries; European Aluminium (industry statistics); company reports (Alro and others)	Bauxite, alumina and primary aluminium by member state and smelter; smelters in operation, closures and restarts
Recycling and markets	European Aluminium (2020, 2024, 2025a–c, 2026a–c); European Aluminium and Metal Packaging Europe (can recycling); Eurostat env_waspacr	Recycled share of supply, collection and recycling rates, scrap exports, demand outlooks
Policy, taxes and public support	EUR-Lex; European Commission (CRMA strategic projects, Steel and Metals Action Plan, Carbon Market Report); Council Regulation (EU) 2025/395; US Federal Register; DG TAXUD, Data on Taxation Trends 2026	Legal framework; trade measures; indirect-cost compensation; tax rate on labour
Energy and emissions	EEA (grid GHG intensity 2024); Union Registry verified emissions; European Aluminium Environmental Profile Report; International Aluminium Institute	Grid factor; footprints of primary and secondary aluminium; verified emissions of installations
Dynamic model of aluminium in use	Passarini et al. (2018, JRC MFA of aluminium for 2013); European Aluminium (2020); Eurostat demo_gind and proj_23np	End-use shares, lifetimes, collection rates; inflow and stock for calibration; population

Data as available on 31 October 2026.

TABLE 43 First-round demand within the EU by segment and product group, 2024 (EUR m)

Product group (CPA)	A0	A1	A2	A3	A4	A5
Electricity, gas, steam	191	90	71	735	1,364	850
Coke and refined petroleum	40	38	15	9	288	179
Chemicals	47	38	18	11	340	212
Rubber and plastics	19	24	7	4	133	83
Other non-metallic minerals	26	15	10	6	184	115
Transport and storage	144	310	53	32	1,030	642
Repair and installation	60	39	22	13	430	268
Fabricated metal, machinery	142	72	53	32	1,016	633
Professional and support services	147	577	54	33	1,051	655
Motor-vehicle trade and retail trade	48	79	18	11	342	213
Other products	190	647	70	42	1,360	847

Product group (CPA)	A0	A1	A2	A3	A4	A5
Total first-round demand within the EU	1,053	1,928	391	928	7,536	4,697
Non-chain intermediate consumption, all origins	1,205	2,073	447	969	8,622	5,374
First round within the EU relative to the row above	87%	93%	87%	96%	87%	87%

Source: IGMNiR AL-EU v1.1; FIGARO 2024 aggregated to the EU-27 block (intra-EU and all-origin coefficients). For A1 the first round equals the intra-EU input coefficients of the parent products (CPA_G46, CPA_E37-39), with purchases within the chain removed, times output; for A0 and A2–A5 purchases of metals, ores, alumina and scrap (the metal share of output) are removed and the remaining intermediate consumption is spread with the all-origin structure of CPA_C24. Electricity of smelters enters the first round as a non-chain input.

TABLE 44 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.
A1 first round	Intra-EU input coefficients of CPA_G46 (46.77) and CPA_E37-39 (38.3) excluding chain products, times the output of the aluminium share; structural test: all SBS intermediate consumption spread over the parent column
A0, A2, A4, A5 first round	Non-metal intermediate inputs = output – GVA – metal share × output; spread with the all-origin structure of CPA_C24 excluding metals, ores, alumina and scrap; the part produced in the EU enters the Leontief model
A3 first round	Alumina and anode carbon (chain inputs) excluded; electricity costed explicitly and entered as CPA_D35 at the EU-origin share of the CPA_C24 column; other inputs = output – GVA – alumina, carbon and electricity, spread with the CPA_C24 structure without D35
Value added	All segments from structural business statistics (value added at factor cost); output of A0, A2 and A3 valued physically (alumina at the 2024 unit value of extra-EU alumina exports, refined alloys and primary metal at the 2024 LME price); value added of A2 and A3 from cost build-ups, of A4 as the residual of NACE 24.42; 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 AL-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 aluminium bridge, Monte Carlo draws and percentiles, structural cases, scenario results and the stock model series. The run identifier (ALEU-1.1-7e3c2686c5) is a hash of the parameters, code and input data; the random-number seed is fixed.

TABLE 45 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 bauxite, alumina and aluminium	58	4468244bcb77f9b1
comext_eu_intra.csv	Comext, intra-EU trade in bauxite, alumina and aluminium	21	96cec956b5f01b6f
comext_eu_other_sec.csv	Comext, other secondary materials (extra-EU)	5	97f68cbdaa9c13df
comext_eu_partners.csv	Comext, trade by partner country	856	b6cdf04007f577e0
comext_us_monthly_hs76.csv		25	91fe1a9c56e812b7

File	Content	Size, KB	SHA-256 (first 16 characters)
eu_facilities.csv	Installations (Annex C)	2	22c9eae3267a8742
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, aluminium products, castings and cables, EU-27 (DS-059358)	18	9f743849143f14a0
sbs_eu.csv	Structural business statistics, EU-27 and member states (sbs_ovw_act)	400	8401704a8a6a4ce3
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 AL-EU v1.1, 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 ALEU-1.1-7e3c2686c5. **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.

TABLE 46 AL-EU parameters

Parameter	Central	Low	High	Class	Basis and source
Bauxite share of 07.29	0.004	0.002	0.008	A/C	bauxite share of NACE 07.29 (mining of other non-ferrous metal ores) in the EU-27: Greek bauxite 1,061 kt in 2024 (Idoine et al. 2026) at ≈EUR 30-50/t against 07.29 output of EUR 11.7 bn
Alumina refining share of 24.42 employment	0.020	0.015	0.030	C	alumina refining share of employment in NACE 24.42 (EU-27): Aughinish, San Ciprián, Agios Nikolaos, Stade ≈1,800-3,500 of 117,216 persons
Chain inputs, alumina refining	0.350	0.250	0.450	C	share of bauxite and other chain inputs in the output value of alumina refining
Aluminium value share, 46.77	0.140	0.100	0.190	C	aluminium share of the value of NACE 46.77 (wholesale of waste and scrap) in the EU-27: non-ferrous share ≈0.40 x aluminium share of non-ferrous scrap value ≈0.35
Aluminium employment share, 46.77	0.120	0.080	0.160	C	aluminium share of employment in NACE 46.77
Aluminium value share, 38.3	0.040	0.020	0.060	C	aluminium share of the value of NACE 38.3 (materials recovery of all waste streams): packaging sorting, ELV shredding, WEEE
Aluminium employment share, 38.3	0.040	0.020	0.060	C	aluminium share of 38.3 employment
Refiners, share of 24.42 employment	0.045	0.030	0.060	C	refiners of secondary casting alloys, share of persons employed in NACE 24.42: 2,000 kt at ≈300-800 t per person employed ≈2,500-6,500 persons of 117,216
Primary smelters, share of 24.42 employment	0.055	0.045	0.070	C	primary smelters incl. anode plants and casthouses, share of persons employed in NACE 24.42: nine smelters, ≈5,500-8,000 persons of 117,216
Metal share, secondary refining	0.800	0.740	0.850	C	scrap and alloying metals as share of the output value of secondary refiners
Other non-chain inputs, primary smelting	0.080	0.050	0.110	C	other non-chain inputs of primary smelters (maintenance, services, transport, fluxes) as share of output value; alumina, anode carbon and electricity are costed separately

Parameter	Central	Low	High	Class	Basis and source
Premium and value-added products, primary	0.150	0.100	0.200	C	regional duty-paid premium and value-added products (billets, slabs, rod) relative to the LME value of primary output
Other inputs, secondary refining	0.100	0.070	0.140	C	non-chain inputs of secondary refiners (natural gas, electricity, salt and fluxes, services) as share of output value
Electricity cost of smelters, EUR/MWh	45.0	30.0	65.0	C	average electricity cost of EU primary smelters 2024, EUR/MWh, before compensation of indirect emission costs
Anode carbon per t of primary aluminium, EUR	230	180	290	C	anode carbon and other carbon materials per t of primary aluminium, EUR/t: ≈0.42-0.45 t net carbon per t
Metal share, rolling, extrusion, wire and foil	0.580	0.500	0.660	A/C	metal share of output value of rolling, extrusion, wire and foil (PRODCOM 2024 unit values of rolled and extruded products against unwrought metal)
Metal share, aluminium castings	0.330	0.250	0.420	C	aluminium-alloy share of the output value of light-metal castings
Aluminium share of 24.53	0.930	0.880	0.970	C	aluminium share of NACE 24.53 casting of light metals (rest magnesium)
Primary aluminium produced in the EU-27, kt	1,100	1,010	1,190	A/B	primary aluminium produced in the EU-27 in 2024, kt: Idoine et al. (2026) 1,188 (France 429, Romania 248, Germany 220, Greece 182, Sweden 109); European Aluminium ≈1,010; nine smelters in operation
Secondary aluminium from refiners, kt	2,000	1,600	2,400	C	secondary aluminium produced by refiners (casting alloys), kt; total recycled aluminium in the EU ≈4.2-5 Mt (38-40% of EU supply; European Aluminium 2025b, 2026c); the split between refiners and remelters is not published
Bridge term: unwrought use not entering semis and castings, kt	0.000	−300.000	300.000	C	difference between apparent use of unwrought aluminium and metal entering semis and castings (stock changes, uses not covered), kt
Unwrought aluminium in other uses, kt	400	250	550	C	unwrought aluminium used outside semis and castings: steel deoxidation, chemicals, destructive uses; powders are in the semis sum, kt

Parameter	Central	Low	High	Class	Basis and source
Scaling of PRODCOM semis volumes	0.820	0.740	0.950	C	scaling of PRODCOM quantities of semis entering the bridge (mean of 2022-2024 per code): EU cells are rounded Eurostat estimates changing by steps of 1,000 kt, and foil stock is counted both with strip and with foil; central value gives a secondary share of first use consistent with the 38-40% reported by European Aluminium (2025b, 2025c)
Metal yield of refiners	0.880	0.820	0.950	B/C	aluminium recovered per t of aluminium in the scrap feed of refiners (dross, turnings and coated scrap, salt-slag losses); JRC 97% for secondary smelting of clean feed
Metal yield of remelting	0.950	0.900	0.980	B/C	aluminium recovered per t of aluminium in scrap remelted by semis producers and foundries: remelting losses 2-10% (European Aluminium 2020); JRC 99% applies to clean remelting
Virgin alloying elements in refiners' output	0.080	0.050	0.110	C	virgin alloying elements (silicon, copper, magnesium, zinc) in the output of refiners, share of casting alloy: secondary casting alloys contain ≈6-12% Si and up to ≈4% Cu
Virgin alloying elements in remelted output	0.030	0.010	0.050	C	virgin alloying elements in the output of remelters and foundries, share of metal remelted from scrap (wrought alloys ≈1-2%, foundry alloys more)
Aluminium content of scrap imports (CN 7602)	0.900	0.850	0.950	C	aluminium content of extra-EU imports of scrap CN 7602
Aluminium content of scrap exports (CN 7602)	0.850	0.780	0.920	C	aluminium content of extra-EU exports of scrap CN 7602
New scrap per t of aluminium in semis and castings used	0.150	0.100	0.220	A/C	new (fabrication) scrap from manufacturing of finished products per t of aluminium in semis used in the EU and in castings: JRC 15% for finished products (Passarini et al. 2018, Table S10); scrap arising inside semis plants is excluded from the bridge
Per-capita inflow 2013 relative to 2024	0.750	0.680	0.850	A/C	per-capita inflow in 2013 relative to 2024 (path piecewise linear through 1960, 2013 and 2024); the central value reproduces the JRC inflow to use of 2013 scaled to the EU-27 population (7,683 kt for the EU-28; Passarini et al. 2018, Table S8)
Net imports of aluminium in finished products, kt	−500	−1,500	500	C	net imports of aluminium contained in finished products into the EU-27, kt (negative: net exports, mainly vehicles and machinery); JRC 2013: imports in products 2,234 kt, exports not reported

Parameter	Central	Low	High	Class	Basis and source
Per-capita inflow 1960 relative to 2024	0.120	0.080	0.180	A/C	per-capita inflow in 1960 relative to 2024; with k_in the model gives a stock of ≈126 Mt (≈285 kg per person) in 2013, against 132 Mt and 260 kg per person for the EU-28 (Passarini et al. 2018)
Inflow growth 2025–2035, per year	0.010	0.000	0.025	C	annual growth of per-capita inflow 2025-2035
Scaling of product lifetimes	1.00	0.80	1.20	A/C	scaling of mean product lifetimes
Scaling of collection to recovered metal	1.00	0.93	1.05	A/C	scaling of end-of-life collection rates by end use (JRC Table S10, World Aluminium mass-flow model); recovered metal = collected x 0.97
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 (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
Footprint of displaced primary aluminium, t CO_2e/t	10.1	6.6	14.4	A/B	primary aluminium displaced, cradle to gate, t CO2e/t: primary aluminium used in Europe (consumption mix incl. imports, 2023) 10.1; EU-produced primary 6.6 (European Aluminium, Environmental Profile Report 2024 V2.0, 2025); global average 14.4 (International Aluminium Institute 2025a, 2024 data)
Remelting incl. scrap preparation, t CO_2e/t	0.350	0.260	0.500	B/C	remelting of scrap by semis producers and foundries incl. scrap preparation, t CO2e/t: European remelting gate to gate 0.26 (European Aluminium 2025a, 2021 data) plus scrap preparation
Refining incl. scrap preparation, t CO_2e/t	0.500	0.370	0.700	B/C	refining of scrap to casting alloys incl. scrap preparation, t CO2e/t: European refining gate to gate 0.41 (0.37 with salt-slag credit; European Aluminium 2025a, 2017-2019 data) plus scrap preparation
EU grid factor, t CO_2e/MWh	0.183	0.165	0.206	A	EU-27 electricity, t CO2e per MWh: EEA early estimate 2024 183.4 g/kWh (2023: 205.7)
Bauxite residue per t of primary aluminium, t	2.37	1.50	3.20	A/C	t of bauxite residue per t of primary aluminium: 1.23 t per t alumina (global average; range 0.55-2.21; IAI 2022b) x 1.93 t alumina per t aluminium

Parameter	Central	Low	High	Class	Basis and source
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)
Shadow cost of carbon, EUR/t	208	164	314	A	EIB shadow cost of carbon 2025 (European Investment Bank 2020), EUR 165/t (130-250) in 2016 prices, rebased to 2024 prices with the euro-area HICP

Correlated groups (Gaussian copula parameter): aluminium shares of scrap trade and recovery ($\rho = 0.8$); footprints of remelting and refining (0.6); metal shares of refining, smelting, semis and castings (0.6); lifetimes and per-capita inflow (−0.3). Aluminium from remelting is recomputed in each draw from the aluminium bridge, and the 2024 inflow to use from the balance.

C Installations of the aluminium value chain

Primary smelters and their output in 2024 are listed in the smelter table of Section 3.2; the table below lists the main installations of the aluminium value chain.

TABLE 47 Main aluminium installations in the EU-27

No.	Installation and activity	Location	Segment
1	Bauxite mining area (Metlen; Imerys), Parnassos–Giona	Distomo (EL)	A0
2	Aughinish Alumina refinery	Askeaton (IE)	A0
3	Alúmina Española alumina refinery (Alcoa)	San Ciprián (ES)	A0
4	Metlen (Aluminium of Greece): alumina refinery and smelter	Agios Nikolaos (EL)	INT
5	Aluminium Oxid Stade alumina refinery	Stade (DE)	A0
6	Alteo specialty aluminas	Gardanne (FR)	A0
7	Aluminium Dunkerque smelter	Loon-Plage (FR)	A3
8	Trimet smelter	Saint-Jean-de-Maurienne (FR)	A3
9	Trimet smelter	Hamburg (DE)	A3
10	Trimet smelter	Essen (DE)	A3
11	Trimet smelter	Voerde (DE)	A3
12	Alro smelter	Slatina (RO)	A3
13	Kubal smelter	Sundsvall (SE)	A3
14	Alcoa San Ciprián smelter (restart 2025–2026)	San Ciprián (ES)	not producing in 2024
15	Slovalco smelter (restart from August 2026)	Žiar nad Hronom (SK)	not producing in 2024
16	Talum smelter (primary production stopped 2023)	Kidričevo (SI)	not producing in 2024
17	Aldel smelter (halted 2021)	Delfzijl (NL)	not producing in 2024
18	Speira Rheinwerk smelter (primary production ended 2023)	Neuss (DE)	not producing in 2024

Locations at town level. The list covers the bauxite mine area, alumina refineries, primary smelters and selected large semi-fabricators and recyclers identified in company reports and EU documents of 2024–2026; it is not exhaustive.

D Glossary

- **Alumina** – aluminium oxide (Al_2O_3) refined from bauxite in the Bayer process; about 1.9 t of alumina are needed per t of primary aluminium.
- **Aluminium first used** – unwrought aluminium used in the EU plus aluminium from scrap remelted by semis producers and foundries (11,068 kt in 2024); the denominator of the secondary share. It differs from aluminium in semis and castings (10,668 kt) by other uses of unwrought metal and by the bridge terms.
- **Bauxite residue (red mud)** – the alkaline residue of alumina refining.
- **CBAM** – carbon border adjustment mechanism, Regulation (EU) 2023/956; aluminium (CN chapter 76) is covered; the definitive period began on 1 January 2026.
- **Casting alloys / wrought alloys** – alloys for shaped castings (mostly from refiners, higher silicon) / alloys for rolling, extrusion and drawing (mostly primary metal and clean scrap).
- **Compensation of indirect emission costs** – state aid for emission costs passed through in electricity prices (Directive 2003/87/EC, Art. 10a(6)).
- **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; bauxite/alumina/aluminium is a strategic and a critical raw material; 2030 benchmarks: extraction 10%, processing 40%, recycling 25% of EU consumption, at most 65% from one third country.
- **Dross and salt slag** – oxidised metal skimmed from melting furnaces / residue of refining dross and scrap in salt-covered rotary furnaces.
- **EoL-RR / EoL-RIR** – share of aluminium 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; AL-EU treats intra-EU deliveries as domestic.
- **FIGARO / SIOT** – EU inter-country input-output tables of Eurostat, aggregated in AL-EU to one EU-27 block / symmetric input-output table of the EU-27 (naio_10_cp1700), used for validation.
- **GVA** – gross value added: output minus intermediate consumption; from structural business statistics at factor cost.
- **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.
- **HHI** – Herfindahl–Hirschman index of concentration (0–10,000).
- **New and old scrap** – scrap from fabrication of semis and products / scrap from products at the end of their life. The new-scrap rate (r_new) is new scrap per tonne of aluminium in semis used in the EU and in castings.
- **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 aluminium** – aluminium smelted electrolytically from alumina / aluminium produced from scrap.
- **Refiners / remelters** – producers of casting alloys from mixed and contaminated scrap / producers of wrought-alloy ingots, slabs and billets from clean, sorted scrap, often integrated with rolling and extrusion.
- **Type I / Type II effects** – direct plus supply-chain effects / plus effects induced by household spending.

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AL-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 aluminium in use and the process metallurgy of aluminium. It estimates the gross economic and fiscal contribution of the aluminium industry in the European Union – bauxite mining and alumina refining, collection and trade of scrap, secondary refining, primary smelting, rolling, extrusion and castings – the emissions and other burdens potentially avoided by secondary aluminium, and the industry's importance for the security of supply.

SUGGESTED CITATION

IGMNiR (2026), Aluminium in the EU-27 economy: value, circularity and security of supply. An integrated assessment of the aluminium industry in the European Union (AL-EU model). Economic Chamber of Non-Ferrous Metals and Recycling, November 2026.

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