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The economic and strategic importance of multi-metals processing

Commissioned by Nyrstar

MAY 2025

Contents

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Executive summary

Mandala was commissioned by Nyrstar to provide an independent summary of the significance of lead and zinc refining in Australia. This report finds that Australia's existing capabilities are a gateway to domestic critical minerals processing, but fundamental shifts in the global industrial policy landscape are undermining Australia's current and future processing capabilities.

Australia's existing lead and zinc capabilities are a gateway to critical minerals processing

Australia has the largest reserves of lead and zinc globally and an established refining capability, ranking as the third largest exporter of refined and intermediate lead and the second largest exporter of refined zinc in the world.

Nyrstar is Australia's major lead and zinc producer, with two multi-metals smelters: Nyrstar Port Pirie and Nyrstar Hobart. Both facilities are core pillars of the local industrial base and the Australian economy, contributing $1.7 billion gross value added in 2024 and supporting 6,648 full time equivalent jobs across the country.

Lead and zinc refining is an essential precursor to capturing and processing five critical minerals: antimony, bismuth, tellurium, germanium, and indium. Nyrstar Port Pirie is Australia's only producer of refined lead with critical minerals extraction capacity.

Securing a stable supply of critical minerals is increasingly important

Lead, zinc and critical minerals processing is concentrated in China. Australia has the opportunity to become a valuable trading partner in global supply chains as governments look to diversify critical mineral supplies and reduce vulnerabilities to market interventions, including China's recent ban on antimony and germanium exports to the US. For example, the European Union and other regions have introduced import guardrails for critical minerals to limit dependencies on single markets.

Fundamental shifts in global industrial policy have undermined domestic processing

Lead and zinc smelters around the world are operating in challenging economic conditions.

China's industrial policy interventions have established integrated supply chains across lead and zinc production and manufacturing, linking metals refining to the manufacture of finished goods. This downstream vertical integration allows for cross-subsidisation across the value chain, with additional government subsidies supporting loss-making activities. Overall, these policy interventions have supported China to capture a disproportionately high percentage of the minerals processing supply chain compared to their domestic mineral reserves.

Backed by strong government policy, Chinese smelters are refining more of the by-product metals available from feedstock and are driving competition for high quality feedstocks at higher payable rates. At the same time, declining treatment charges are further eroding smelter operating margins around the world.

Maintaining lead and zinc refining capabilities outside of China will become increasingly challenging. If other countries exit lead and zinc smelting, China could achieve monopoly power in this market and maintain majority control of the global supply of associated critical minerals.

Protecting Australia's minerals processing capability is in the national interest

Australia's lead and zinc smelting capabilities are fundamental to Australia's ambition to leverage its high-quality mineral deposits and become a leading exporter of value-added critical minerals. Maintaining a robust domestic industry has economic, strategic, security, industrial, and societal benefits.

Should Australia's existing multi-metals smelting capabilities falter or shut down, rebuilding this infrastructure would require impractical levels of cost and delay. This includes the likely collapse of local skills pipelines, particularly for metals manufacturing workers.

Government support is required to protect Australia's natural advantages in minerals processing and ensure lead, zinc, and associated critical minerals are refined and processed domestically, long into the future.

1 **Australia's existing zinc and lead capabilities are a gateway to critical minerals processing**

2 Securing a stable supply of critical minerals is increasingly important for Australia

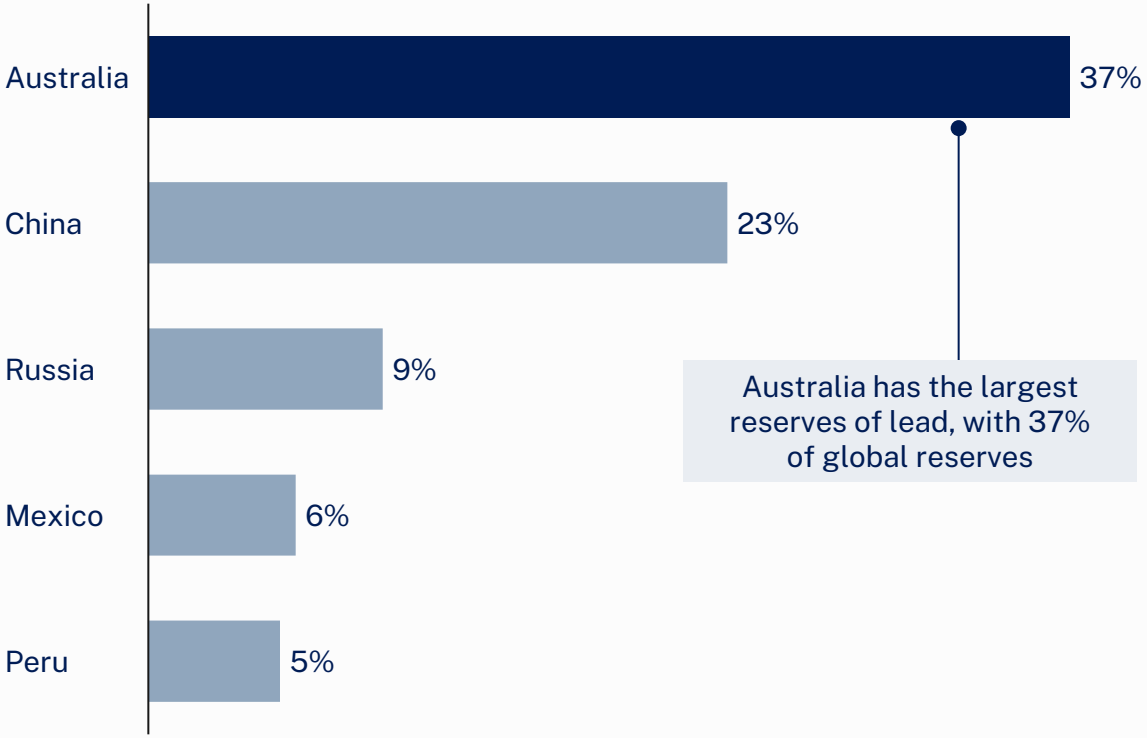
3 Fundamental shifts in global industrial policy have undermined the viability of domestic minerals processing

4 Appendix

Australia has the largest reserves of lead and zinc globally, providing a significant long-term opportunity to move downstream in both supply chains

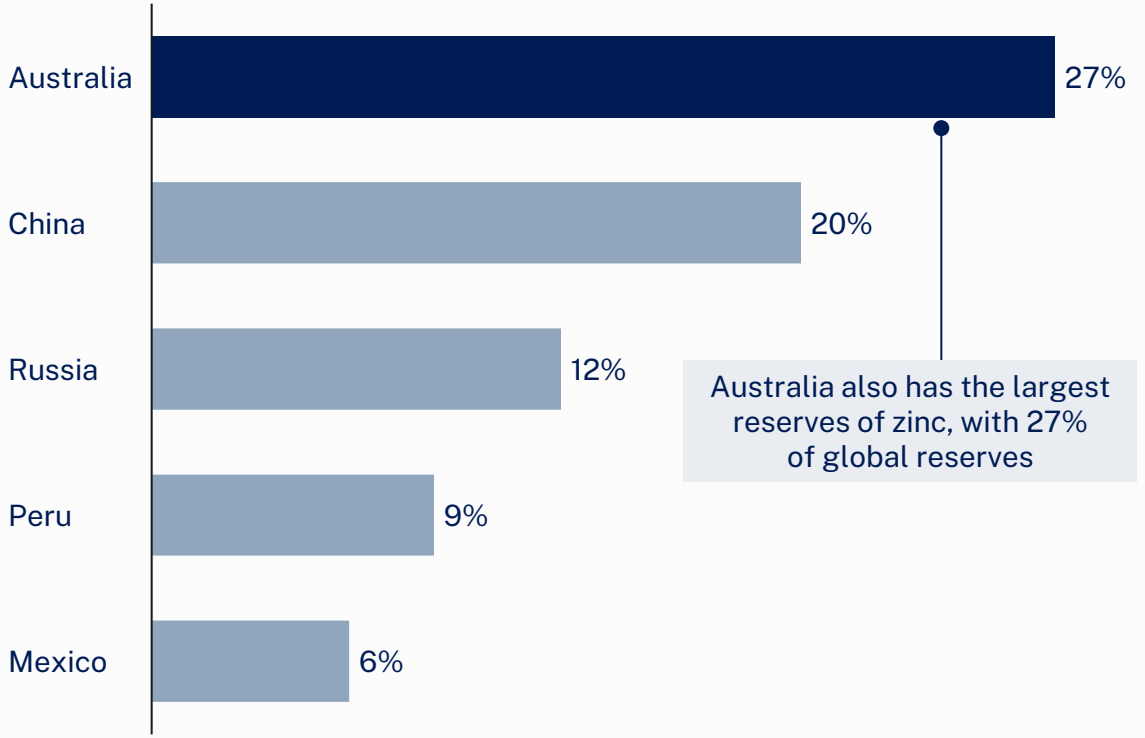
Top five countries for lead reserves by volume

% of global reserves, 2024



Top five countries for zinc reserves by volume

% of global reserves, 2024



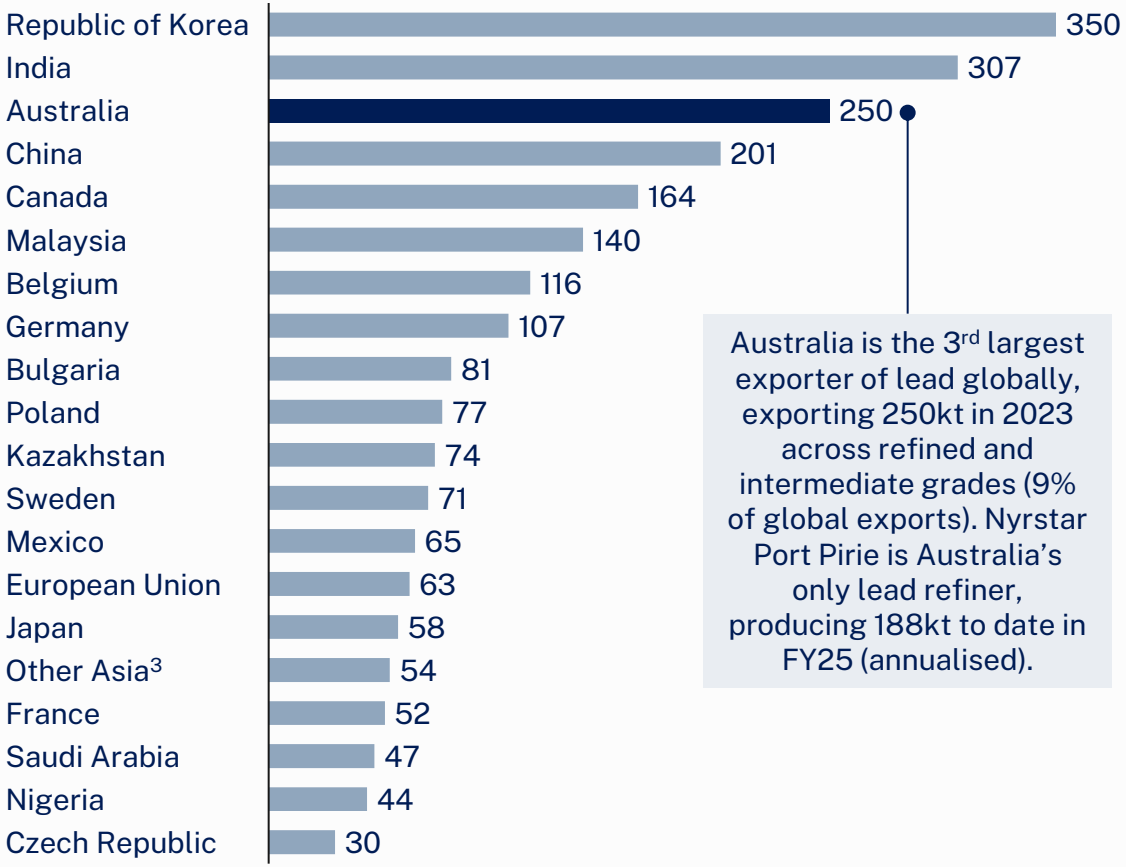
Australia has some of the richest mineral resources in the world – providing a strong foundation to move downstream in mineral supply chains and a significant long-term opportunity to protect and develop sovereign capability in processing and manufacturing

Source: Department of Industry, Science and Resources (2023), *Critical Minerals Strategy;* Department of Industry, Science and Resources (2025), *Minerals;* USGS (2025) Zinc, (2025) Lead, (2025) Antimony, (2025) Bismuth, (2025) Germanium; (2025) Tellurium, (2025) Indium; Mandala analysis.

Moving down the value chain, Australia is the third largest exporter of lead and second largest exporter of refined zinc globally

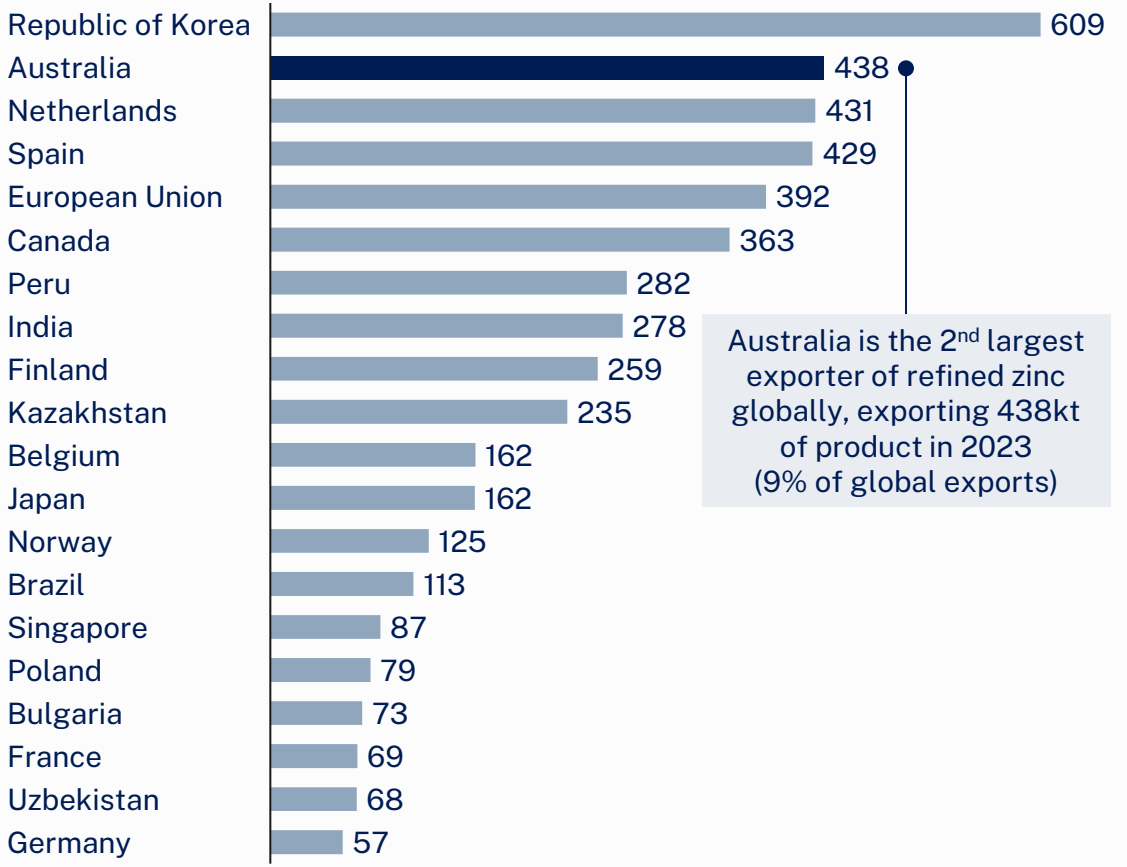
Lead exports by country

Kilotonnes (kt), top 20 exporters of refined and intermediate lead,[1] 2023



Zinc exports by country

Kilotonnes (kt), top 20 exporters of refined and intermediate zinc,[2] 2023



1 Refined lead defined as WITS product codes relating to unwrought lead: 780110, 780199, 780191; 2 Refined zinc defined as WITS product codes relating to unwrought zinc: 790111, 790112, 790120; 3 Other Asia not elsewhere specified (nes) as defined by the World Bank.
Source: World Bank WITS (World Integrated Trade Solution) (2023) *Trade Statistics by Product (HS 6-digit);* Nyrstar data.

Valuable critical minerals can be extracted as by-products from lead and zinc refining

Lead and zinc are core inputs into many products we rely on daily. Zinc is required to galvanise (protect) steel, which is used in the production of wind turbines, cars, electrical appliances, and buildings. Lead is widely used in car batteries, ammunition, and electrical cables.

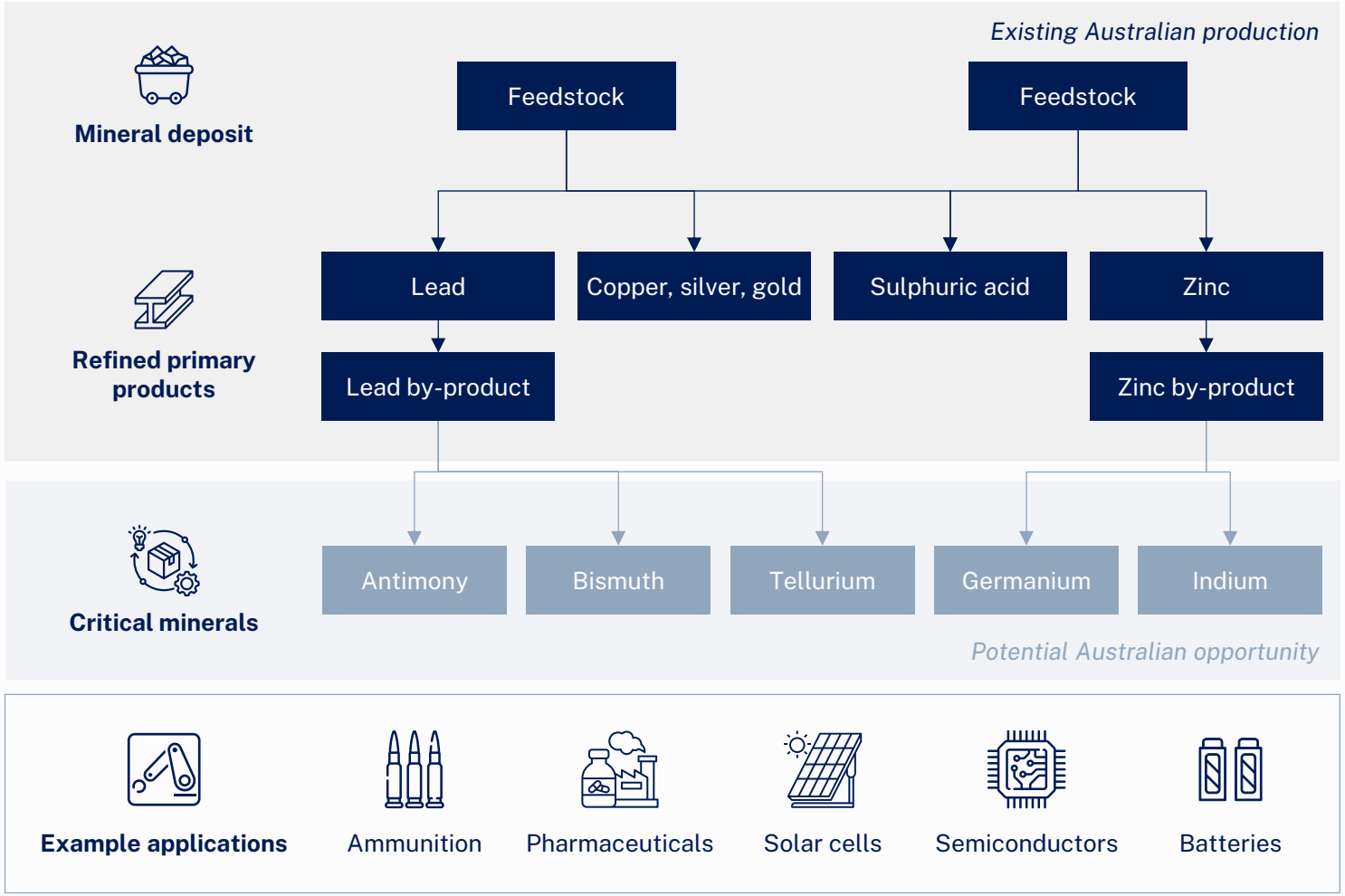
Australia has an established lead and zinc refining capability. Recently, the value of by-products from this refining process has been recognised. In fact, five of Australia's registered critical minerals are produced as by-products of lead and zinc. These critical minerals are antimony, bismuth, tellurium, germanium, and indium.

Strategically important sectors like energy, transport, defence, and advanced manufacturing rely on the critical minerals derived from zinc and lead refining. For example, antimony is required to make ammunition and flame retardants, and germanium is a key input into semiconductor manufacturing. Other critical minerals are essential for the net-zero transition, including indium for batteries and tellurium for solar cells.

Australia currently has limited refining capabilities for critical minerals but could leverage existing lead and zinc refining facilities, with investment in proven engineering, to bring forward this capability. For example, lead processing is an essential precursor to extracting and refining antimony. Australia could acquire an antimony refining capability quickly through the upgrade of existing lead smelters.

Source: Geoscience Australia (2024) *Critical Mineral By-product potential.*

Illustrative overview of lead and zinc processing outputs

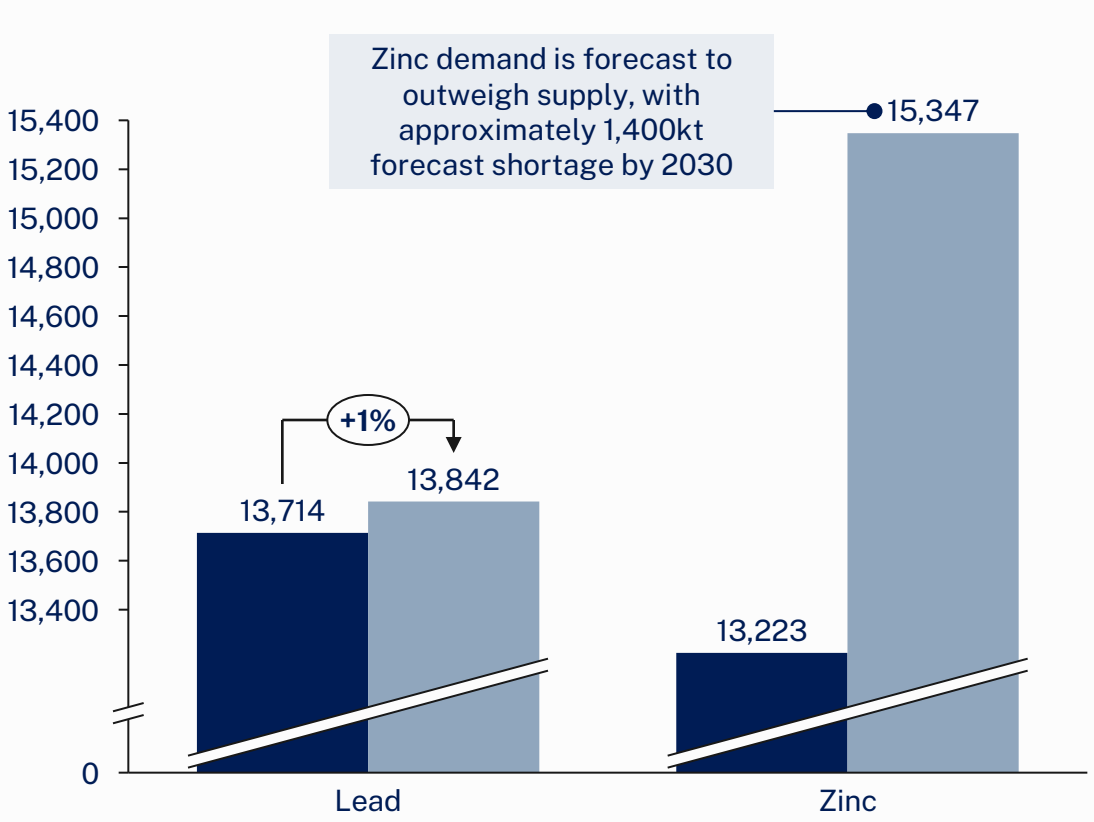


Source: European Commission (2023) *Study on the Critical Raw Materials for the EU 2023*; SCRREEN (2023) *Critical Raw Materials 2023*; Patel & Karamalidis (2021) *Germanium: A review of its US demand, uses, resource, chemistry, and separation technologies*; Perpetua Resources (2021) *Antimony: A Critical Metalloid for Manufacturing, National Defence and the Next Generation of Energy Generation and Storage Technologies;* IEA (2021) *The Role of Critical Minerals in Clean Energy Transitions*; Mandala analysis.

Strong growth fundamentals in lead, zinc, and associated critical minerals markets are supporting demand including 130% growth in antimony demand by 2030

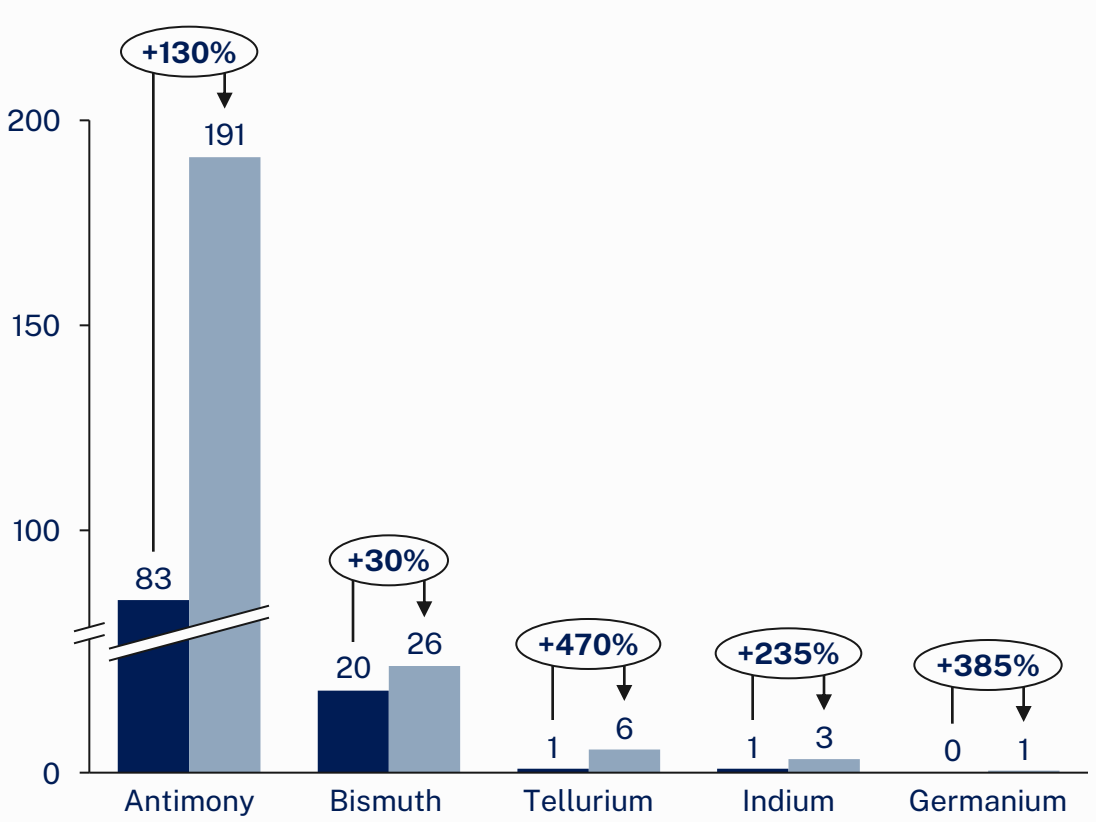
Refined lead and zinc forecast demand

Kilotonnes (kt), global demand, latest available data[1]



Critical minerals forecast demand

Kilotonnes (kt), global demand, latest available data[1]



1 Current 2023 or 2024 mine production for antimony and refinery production for indium, tellurium, and bismuth from USGS. Current germanium refinery production based on a 2016-2020 average from SCRREEN. Bismuth demand forecasted with a historical 2016-2020 growth rate of 4-5%. Antimony demand forecasted as an additional 18kt per year to 2030. Tellurium, indium, and germanium based on an average of forecasts for all applications from Watari et al. 2 USD converted to AUD.

Source: Nyrstar market data; USGS (2024) *Antimony*, (2024) *Bismuth*, (2024) *Indium*, (2024) *Tellurium*; SCRREEN (2023) *Germanium Factsheet;* Watari et al. (2020) *Review of critical metal dynamics to 2050 for 48 elements*; SCRREEN (2023) *Antimony Factsheet*; Perpetua Resources (2021) *Antimony: A Critical Metalloid for Manufacturing, National Defence and the Next Generation of Energy Generation and Storage Technologies;* SCRREEN (2020) *Bismuth Factsheet;* Mandala analysis.

1 Australia’s existing zinc and lead capabilities are a gateway to critical minerals processing

2 **Securing a stable supply of critical minerals is increasingly important for Australia**

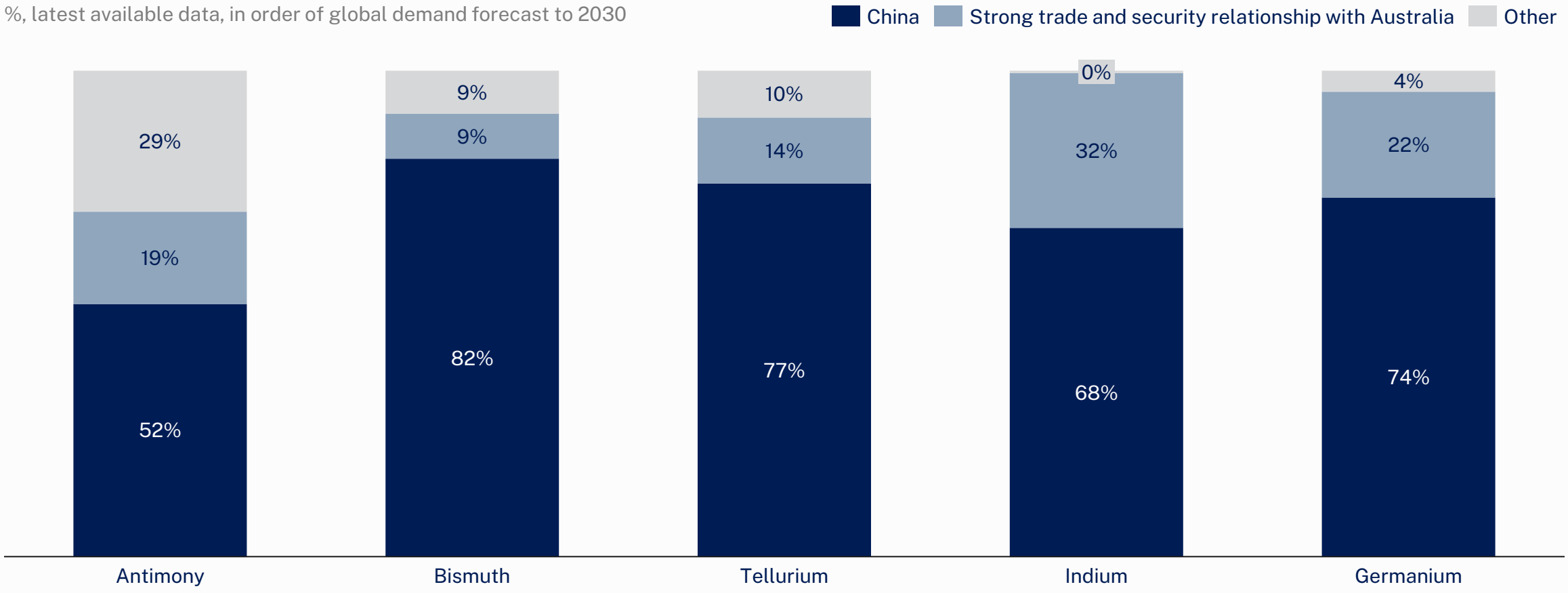
3 Fundamental shifts in global industrial policy have undermined the viability of domestic minerals processing

4 Appendix

Critical minerals processing is highly concentrated, with China producing between 52% to 82% of the global supply

Proportion of global production by source region

%, latest available data, in order of global demand forecast to 2030



Notes: 2023 production for germanium, bismuth, indium, and tellurium, 2016-2020 average production for antimony. Countries or regions defined as having a strong trade and security relationship with Australia: Belgium, Canada, Europe, France, Japan, South Korea, Sweden, Thailand, and the United States. Other includes Bolivia, Bulgaria, Kazakhstan, Laos, Myanmar, Russia, South Africa, and Uzbekistan, and Vietnam.
Sources: Nyrstar market data; USGS (2025) Bismuth, (2025) Indium, (2025) Tellurium; SCRREEN (2023) Factsheet Antimony; World Bank WITS (World Integrated Trade Solution) (2023) *Trade Data*; Mandala analysis.

Australia could become a valuable trading partner in diverse supply chains

Australia and other nations are highly reliant on China for refined critical minerals and are vulnerable to supply chain disruption. For example, 100% of Australia's tellurium imports were sourced from China in 2023. Tellurium is used to manufacture metals, glass and ceramics, electronic products, and solar cells.

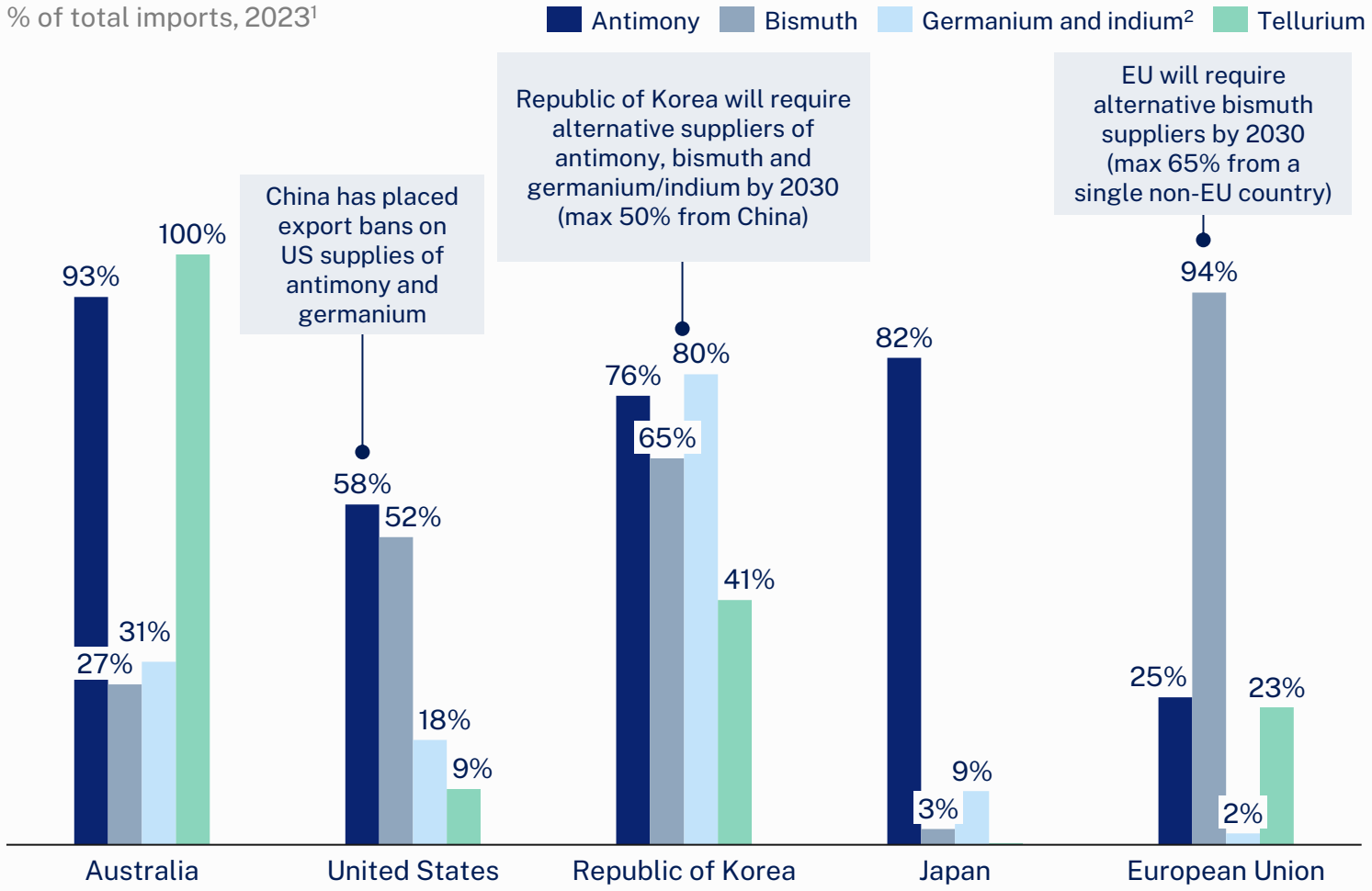
The US placed restrictions on the export of semiconductors to China in 2024. In response, China banned antimony exports to the US – affecting 58% of the US' antimony imports (based on 2023 data). Antimony has key defence applications, particularly in ammunition manufacturing. Given the US has limited domestic capabilities (one smelter and no operational mining), it will have to source antimony from multiple smaller producers. The second and third largest suppliers of antimony to the US in 2023 were Thailand and Belgium (9% and 8% of imports respectively). The second largest antimony producer globally is Tajikistan (25% of production).

Supply chain diversification has become a priority for governments around the world, with many countries introducing maximum import guardrails to limit dependencies on a single market. Australia is well placed to meet global demand for value-added critical minerals given its high mineral reserves and existing processing capabilities, including a lead refinery with critical minerals extraction capacity.

Note: Listed policies as of March 2025.
Source: Australian Government (2023) *Critical Minerals Strategy 2023* – 2030; Center for Strategic and International Studies (2024) *China's Antimony Export Restrictions: The Impact on U.S. National Security*; IEA (2024) *European Critical Raw Materials Act*; Department of Health and Aged Care (2024) *Tellurium and its inorganic compounds: Evaluation statement*.

Proportion of refined critical mineral imports sourced from China

% of total imports, 2023[1]



1 Data refers to the following International Harmonized System product codes: Unwrought antimony and powders (811010), antimony oxides (282580), Bismuth above and below 99.99% (810601, 810690), Germanium, indium and others (811292, 811299), Tellurium and boron (280450). Imports with data gaps aligned with USGS. 2 Germanium and indium grouped as minerals are grouped in WITS data.
Source: World Bank WITS (World Integrated Trade Solution) (2023) *Trade Data*; S&P Global (2025) *China responds to US restrictions with export ban on select critical minerals;* USGS (2025) *Bismuth*; Mandala analysis.

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3 Fundamental shifts in global industrial policy have undermined the viability of domestic minerals processing

4 Appendix

Nyrstar is one of Australia's major lead and zinc producers and a key local employer

Nyrstar owns and operates two multi-metals smelters in Australia: Nyrstar Port Pirie, a multi-metals recovery plant producing refined lead and silver and Nyrstar Hobart, which primarily produces refined zinc. Both facilities are core pillars of the local industrial base and some of the few remaining employers of metals manufacturing trades. For example, Nyrstar employs almost 20% South Australia's engineering production workers (who refine, treat, and produce metal) and 25% of engineering production workers in Tasmania.

Nyrstar Port Pirie produces all of Australia's refined lead exports and half of Australia's total lead exports. The smelter is one of the world's largest primary lead smelting facilities, and the third largest silver producer. Nyrstar Port Pirie is also Australia's only producer of refined lead with critical minerals extraction capacity. The smelter employs 909 full time equivalent employees (FTE) workers and spent $351 million in South Australia in 2024, generating $682 million of gross value added.

Nyrstar Hobart produces 60% of Australia's refined zinc exports. The smelter employs 566 FTE workers and spent $293 million in Tasmania in 2024, generating $514 million of gross value added.

Overall, Nyrstar generated $1.7 billion in gross value added across the Australian economy in 2024 and supported 6,648 jobs.

Source: Nyrstar (2023) *Australia's opportunity in the energy transition;* Lawrence Consulting (2025) *Economic Impact of Nyrstar Australia 2024*; Lightcast (2024) *Labor Insights*, ABS (2021-22) *Input-Output tables,* ABS (2021) *Census;* Mandala analysis.

Nyrstar's economic impact in 2024

Total impact of Nyrstar Australia

$1.7b	Gross value added across the economy (0.1% of Gross National Product)
6,648	Full time equivalent jobs supported nationwide (0.05% of total employment)

Nyrstar Port Pirie

100% of Australia's refined lead exports

909	Full time equivalent employees
449	Suppliers in South Australia
$682m	Annual gross value added in South Australia

Nyrstar Hobart

60% of Australia's refined zinc exports

566	Full time equivalent employees
304	Suppliers in Tasmania
$514m	Annual gross value added in Tasmania

Source: Lawrence Consulting (2025) *Economic Impact of Nyrstar Australia 2024.*

Protecting Australia's minerals processing capability is in the national interest

Domestic lead and zinc smelting capabilities are fundamental to Australia's ambition to become a leading exporter of value-added critical minerals and metal compounds. This is because lead and zinc smelting is an essential precursor to processing critical minerals.

Fundamental shifts in global industrial policies have undermined the earnings viability of Australian smelting activities, delaying or deterring investment decisions in new processing activities. This is driven by a deterioration of operating margins and the markets' failure to price in the value of national security and sovereignty.

Australia's smelters play an important role in the domestic industrial base as a customer of domestic mines, a supplier of high-quality refined products to downstream manufacturers, and a key pillar of local economies. Maintaining and developing Australia's minerals processing capability has nationwide benefit – supporting local communities while unlocking opportunities in global supply chains. This is a core component of Australia's economic resilience.

Should Australia's capabilities falter or shut down, rebuilding would require impractical levels of cost and delay. This includes the likely collapse of local skills pipelines, particularly for metals manufacturing workers. A lack of alternative employment opportunities would likely force workers to exit the industry.

The role of lead, zinc, and associated critical minerals processing in Australia's national interest

Economic	Australia has a world-leading resources industry and the opportunity to provide a stable source of in-demand minerals, but the viability of domestic operations is being affected by external market failures
Strategic	Australia has high levels of reserves, but critical minerals are mainly processed overseas, with processing heavily concentrated in a single market
Security	Lead and zinc smelting is an essential precursor to capturing and processing five critical minerals used in defence, energy, transport, and advanced manufacturing
Industrial	Domestic smelters play an important role as a customer of Australian mines, a supplier of high-quality refined products to downstream manufacturers, and a key pillar of the local industrial base
Societal	Domestic processing supports local jobs, businesses and supply chains in major regional centres such as Hobart and industrial areas such as Port Pirie

Source: Mandala analysis.

Chinese industrial policy is reshaping global smelting economics

As smelters around the world face declining profitability and challenging market conditions, maintaining smelting capabilities outside of China will become increasingly challenging without deliberate investment. This is because Chinese smelters can withstand loss-making activities longer than their peers.

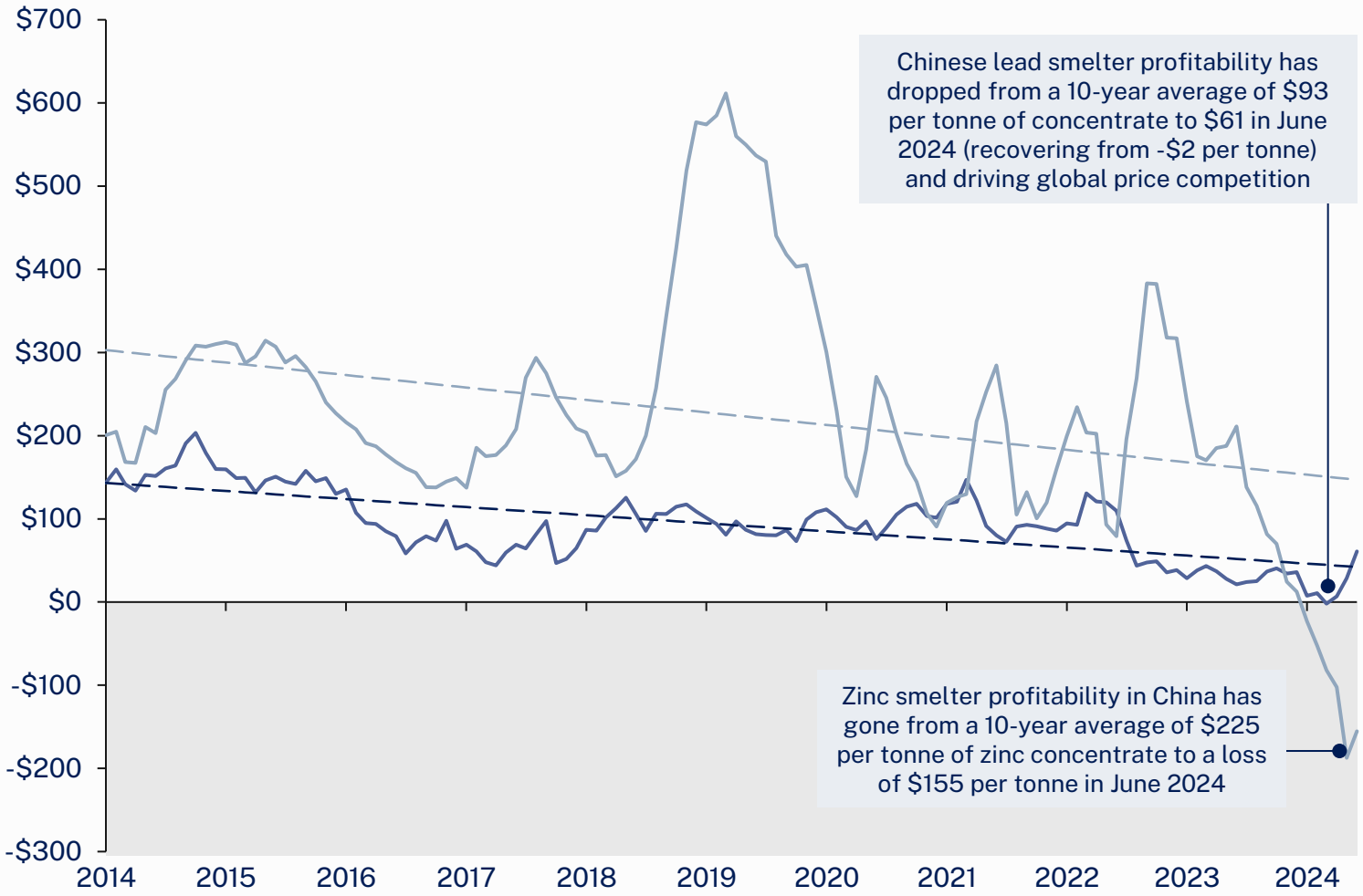
China's lead smelter profitability dropped to US$61 per tonne of concentrate in 2024 from a 10-year average of US$93, and zinc smelter profitability was negative at -US$155. However, Chinese smelters are increasing by-product processing which offsets eroded margins on primary metals and enables smelters to offer higher prices for feedstock. This increased competition for feedstock has driven treatment charges to their lowest in a decade, diminishing a key source of revenue. Australian smelters must match these terms but are technology-constrained in recovering by-product metals.

China's industrial policy has established vertically integrated value chains, enabling cross-subsidisation between smelting and manufacturing. China is also the largest producer of lead, zinc, and associated critical minerals globally. With unmatched economies of scale, Chinese smelters can invest in new technology and upgrades, creating a widening efficiency gap with the rest of the world.

Source: Nyrstar data; ILZSG (2024) *World Factbook 2024*; ILZSG (2025) *Review of Trends in 2024*; Nyrstar (2017) *Modeling Nyrstar*; Noranda (2021) *Zinc Smelter Revenue Model*; Wood Mackenzie (2024) *Zinc production cost trends and outlook*; Naughton (2021) *Industrial Policy in China;* Reuters (2022) *European smelter hits mean another year of zinc shortfall.*

China's smelter profitability

USD/tonne of concentrate, 2014 to 2024



Source: The foregoing chart was obtained from Global zinc and lead short-term outlook™ and Lead markets: Investment Horizon outlook™, a product of Wood Mackenzie; alongside Mandala analysis of Trafigura (2024) *The Future Outlook for World Zinc Demand.*

Government support will be required to protect Australia's current and future minerals processing capability

Policy enablers to improve competitiveness of domestic lead, zinc, and associated critical minerals processing

	Enabler	Description	Example application to zinc, lead, and by-product processing
HIGHER	**Finance**	The ability of firms to access sufficient volumes of capital with appropriate risk profile	Grants, loans, guarantees (for loans or contractual commitments), and tax incentives
Importance for sector development	**Feedstock**	The ability of firms to access key production feedstock and coordinate relationships with suppliers	Supporting access to domestic supplies of feedstock and coordinating relationships with suppliers (particularly in domestic value chain)
	Energy and infrastructure	The availability of connecting infrastructure including energy	Investments in supporting grid, port, and transport networks
	Coordination and regulation	The availability of coordinated and centralised support across the value chain	Coordinating supply and demand for a more integrated domestic value chain and developing regulation to accelerate ecosystem development
LOWER	**Workforce**	The availability of skilled employees and access to training facilities	Supporting ongoing operations to retain workers, local training programs, and pipeline development including apprenticeships

Source: Mandala analysis.

The Australian government has supporting industries that coincide with a strong economic, strategic, security, industrial, or societal need

Precedents of direct government intervention to support Australia's strategic mining and metallurgical assets

	GLENCORE	Alcoa	GFG ALLIANCE
	Copper smelting and refining[1]	**Aluminum smelting[2]**	**Steelmaking[3]**
Context	Glencore's copper smelting and refining assets in Mt Isa and Townsville faced significant economic pressures including high fixed operational costs and increasing energy costs which impeded competitiveness against international counterparts.	Alcoa was reviewing its international smelter fleet, leading to concerns about Portland's profitability. The smelter was losing production (and income) during summer shutdowns, particularly as the smelter was unable to re-supply the grid with energy during these periods.	Whyalla Steelworks is one of two steelworks in Australia. The steelworks was running at limited capacity due to a number of maintenance and repair issues while also operating at a loss, with outstanding debts of $1.3b.
Intervention	▪ **Incentive payment:** Government designed a support strategy with Glencore with a multi-million-dollar funding agreement (details not public) to offset operational costs and facilitate necessary maintenance, extending operational life. Glencore committed $500m towards continuing operations at these facilities. ▪ **Previous funding:** $15m funding in 2016 to extend operations to 2022.	▪ **Revenue underwriting:** Government agreed to underwrite the revenue earnt by the facility from resupplying energy to the grid if closed over summer. The smelter can draw on up to $19.2m per year in subsidies for four years (between 2020 and 2025).	▪ **Immediate support:** Government forced facility into administration with $484m in support for creditors, infrastructure upgrades and operating costs (including wages). ▪ **Upgrades and infrastructure:** Government committed $1.9b for upgrades to green steel production.

Source: 1 ABC (2020) *Mount Isa copper smelter gets three more years with 'one-off' incentive from Queensland Government*. 2 ABC (2020) *Alcoa's Portland aluminium smelter subsidy secures jobs, fails green energy test*; Australian Mining (2020) *Australian Government throws Portland smelter subsidy at Alcoa*. 3 Whyalla City Council (2025) *$2.4 billion plan to secure Whyalla's future.*

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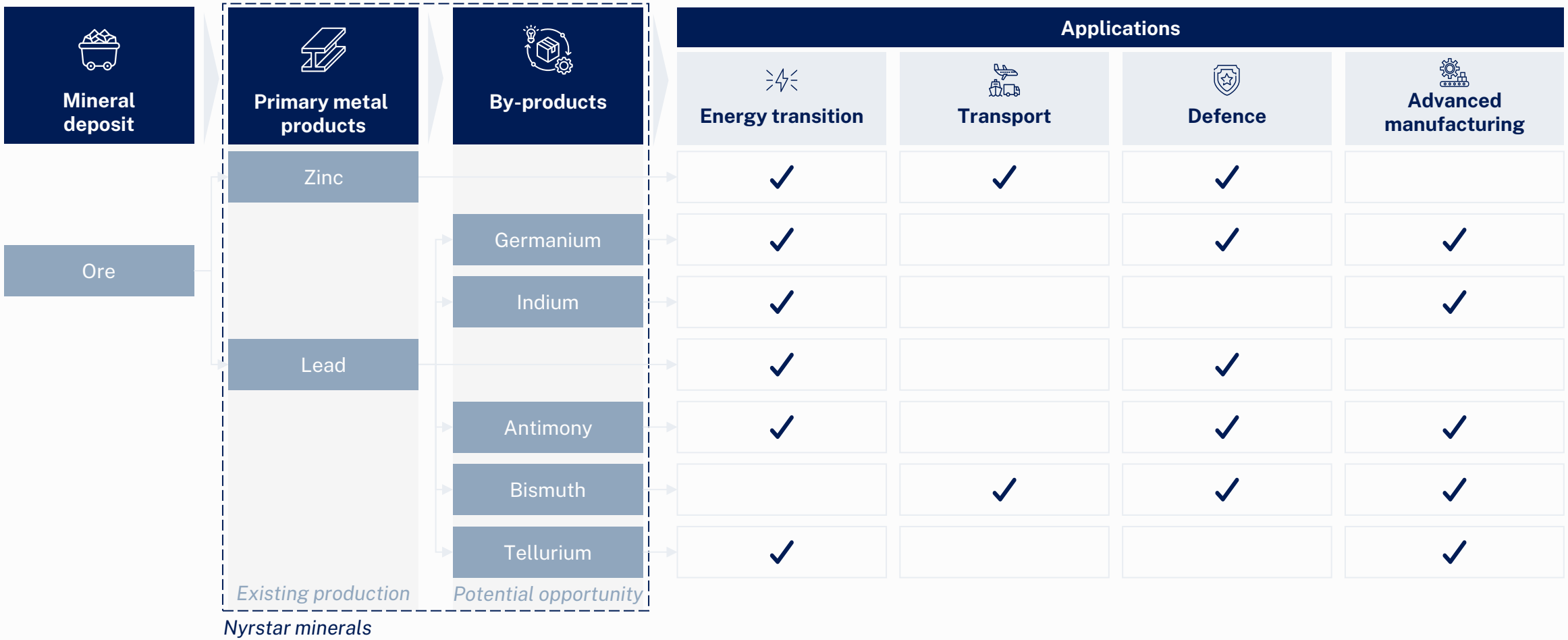
4 **Appendix**

Zinc and lead processing can unlock valuable by-products such as germanium and antimony, all of which are required in priority sectors

Illustrative overview of minerals processing outputs and applications



Source: Geoscience Australia (2024) *Critical Mineral By-product Potential*; European Commission (2023) *Study on the Critical Raw Materials for the EU 2023*; SCRREEN (2023) *Critical Raw Materials 2023*; Patel & Karamalidis (2021) *Germanium: A review of its US demand, uses, resource, chemistry, and separation technologies*; Perpetua Resources (2021) *Antimony: A Critical Metalloid for Manufacturing, National Defence and the Next Generation of Energy Generation and Storage Technologies;* IEA (2021) *The Role of Critical Minerals in Clean Energy Transitions*; Mandala analysis.

Illustrative use case examples by mineral

Mineral	Use cases: Energy	Transport	Defence	Advanced manufacturing
Zinc	▪ Wind, hydro, and solar ▪ Batteries	▪ Electric vehicles	▪ Defence vehicles	
Antimony	▪ Solar panels ▪ Wind turbines		▪ Detonators ▪ Smoke agents ▪ Primers	▪ Flame retardants
Germanium			▪ Thermal imaging	▪ Semiconductor ▪ Satellite solar cells ▪ Fibre and infrared optics
Bismuth		▪ Rocket propellant	▪ Ammunition ▪ Rocket propellant	▪ Pharmaceuticals
Tellurium	▪ Solar cells			▪ Chemical manufacturing
Indium	▪ Batteries			▪ Semiconductors ▪ LEDs
Lead	▪ Batteries		▪ Ammunition	

Source: European Commission (2023) *Study on the Critical Raw Materials for the EU 2023*; SCRREEN (2023) *Critical Raw Materials 2023*; Patel & Karamalidis (2021) *Germanium: A review of its US demand, uses, resource, chemistry, and separation technologies*; Perpetua Resources (2021) *Antimony: A Critical Metalloid for Manufacturing, National Defence and the Next Generation of Energy Generation and Storage Technologies;* IEA (2021) *The Role of Critical Minerals in Clean Energy Transitions*; Mandala analysis.

Zinc and associated minerals have been recognised as strategically important by governments around the world

Recognition of zinc and associated minerals as critical minerals by country

Critical minerals list[2] ✓

Mineral	Australia	United States	New Zealand	United Kingdom	Canada	Indonesia	Japan	India	South Korea	Germany[3] (EU)
Antimony	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Germanium	✓	✓	✓	✓	✓	✓	✓	✓		✓
Bismuth	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Indium	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Tellurium	✓	✓	✓	✓	✓	✓	✓	✓		
Zinc	*Strategic minerals list*	✓	✓	✓	✓	✓			✓	✓

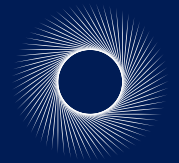
While there are variations between each country's definition of critical minerals, common criteria for all countries include:

- minerals are at risk of supply chain disruption; and
- minerals are an essential input for key priority technologies, especially those required in the energy transition.[1]

Australia also has strategic minerals which are important for key applications and technologies, but supply chains are not as vulnerable to the extent of critical minerals.

1 Some countries have additional criteria for a critical mineral. For example, it must be important for end-use applications and manufacturing value-add in Europe, have geological potential and be in-demand from strategic partners in Australia, or have production potential in Canada. 2 Australia's top 15 two-way trading partners for 2023 also include China, Singapore, Taiwan, Malaysia, Thailand, Vietnam, and Hong Kong but these countries do not have a critical minerals list. 3 Germany follows the EU critical minerals list.
Source: Australian Government DISR (2024) *Australia's Critical Minerals List and Strategic Minerals List*; Mandala analysis.


ARISTON BULKER



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