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Solutions for CRitical Raw materials - a European Expert Network

1 OUTLOOK REPORT 1

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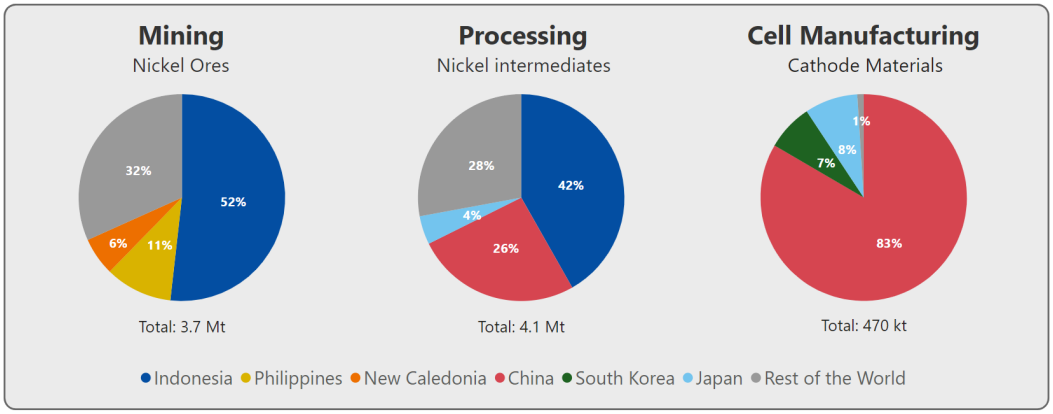
2 EXECUTIVE SUMMARY

This report presents the latest available commodity intelligence on nickel and tungsten, specifically focusing on the geopolitical dimension, i.e., market concentration, ownership, country risk, and supply chain bottlenecks. These market insights have been gathered from various publicly available and commercial or otherwise proprietary sources. The addition of the latter restricts this document to be **for internal use only**.

Nickel has been classed as a strategic raw material, alongside copper and others, by the European Commission in 2023. Its critical role in steel production and battery chemistry is undeniable, and although market concentration used to be at moderate levels, a recent boost in investments (primarily from Chinese investors) and project developments in Indonesia has severely impacted the market with an HHI (scale 1-10,000) of over 2900 for mine production and around 3000 for refined and processed Ni, indicating a moderately highly concentrated market. In 2023, Indonesia's mine production had reached over 2,030,000 metric tons, corresponding to around 55% of the global mine production. The low-cost Indonesian Ni has affected the profitability of many Ni mining projects and refineries globally. Indonesia is forecast to reach a Ni market share of between 44 and 60% in 2024, with projections that Indonesia could truly dominate the market and reach up to 75% market share by 2030. This has been facilitated by Chinese investments reflected in the ownership structure and several domestic factors, including Indonesian government policies that encourage domestic processing and refining, as well as HPAL technology to extract Ni from low-grade ores, often with significantly increased environmental impact. Indonesian Ni supplies predominantly come from laterites, and their production routes are more carbon-intensive as they rely heavily on a coal-based power grid. Future supply growth is also expected to come from Australia, Brazil, and the Philippines, as these countries have significant reserves. Still, energy prices and market evolution will strongly condition their emergence. Overall, 65 out of 115 operating and active Ni mining projects are located in the Asia-Pacific region. As the EU heavily relies on Ni imports from Russia, the current war on Ukraine and rising geopolitical tensions—with Norilsk Nickel being excluded from the LME and possible further trade restrictions being implemented—also exert pressure on the Ni market.

Nickel value chain country share for the top 3 producing countries



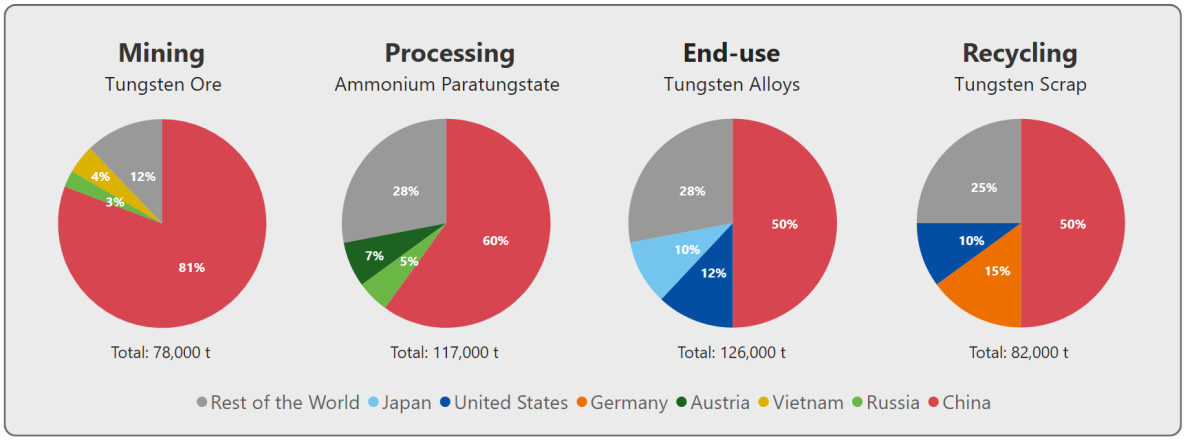
The bulk of the growth that the Ni sector is experiencing comes from EV battery demand, which is closely linked to EV sales and developments in battery chemistry. Although a huge trend to high-nickel chemistries (NMC 8-1-1) has dominated the development of Gigafactories projects within the

EU in recent years, a shift toward nickel-free batteries (especially LFP) has been observed in the past few months. The market repartition between these battery technologies is to be closely monitored, as it will be very dynamic. There could be a risk that the 2030 Ni supply may exceed overall demand, if the battery sector demand falls behind projections. Although EV sales have been lower than initial estimates, future Ni demand forecasts for EV and cleantech applications remain strong. At the same time, the Ni demand forecast for the steel and stainless steel sectors is fairly stable—with Nickel Pig Iron (NPI) and Electric Arc Furnaces (EAFs) in addition to the abovementioned geopolitical/market-concentration aspects, exerting the most pressure on this sector. If Ni and FeNi applications in the steel sector contract due to substitution with NPI or stainless steel scrap, further supplies for the battery sector may become available. Given its indispensable contribution to battery technology and, consequently, to sustainable transportation, the overall future trend points towards an increasing reliance on nickel. Therefore, in addition to supply diversification, further research into environmentally friendly methods of mining and recycling is imperative.

Tungsten is a conflict mineral and critical raw material with one of the highest geographic concentrations in terms of sourcing and refining, with an HHI of over 4,190. Mine production is particularly heavily concentrated in China (>80%). Additionally, the vertical integration of tungsten ores and concentrates into intermediary and finished products has made China the dominant player in the tungsten market. The automotive sector is the biggest market driver overall (25% of total consumption globally) but shows signs of decreasing growth since EVs require less tungsten than ICEVs—a negative growth rate of 2% is projected for the EV sector. Defence and the semiconductor sector are the main growth areas due to technological developments and geopolitical pressures. There is significant potential to source tungsten from outside China, and several players, such as Canada, have invested in tungsten projects that, if they successfully enter the market, could change the currently skewed tungsten market significantly. Still, China's control on prices may well limit such project developments should the economic context evolve. Despite a positive demand outlook fuelled by Europe's widely discussed plans to enhance its military capabilities and its raw materials strategies outlined in the CRMA, tungsten and ferro-tungsten prices have struggled to maintain their recent highs due to competitive pricing from Chinese exporters, exerting their market power. Furthermore, it is likely that tungsten could increasingly be on the list for export restrictions as a material for dual applications and strategic importance. While China is dominating the upstream tungsten sector with a 80+% market share, Russia and Vietnam are also significant players in producing tungsten ore and concentrates, albeit with a much lower overall market share.

Ammonium paratungstate (APT), the most important precursor material for the majority of tungsten products, is also heavily concentrated in China. Nevertheless, Austria, with its Sandvik-owned Wolfram mine and refinery also holds a 7% stake in this important market segment and is Europe principal ‘homegrown’ tungsten source. Furthermore, the Canadian mining company Almonty Industries claims their forthcoming mine in South Korea has the potential to produce 50% of the world's ex-China tungsten supply with the World’s largest tungsten mine. If successful, this could induce a significant shift in the highly concentrated tungsten market.

Tungsten value chain country share for the top 3 producing countries



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4 LIST OF ABBREVIATIONS AND ACRONYMS

APS – Announced Pledges Scenario

APT – Ammonium Paratungstate

CA – Consortium Agreement

CAM – Cathode Active Material

D – Deliverable

DDP – Delivered Duty Paid

DoA – Description of Action

EC – European Commission–

GA – General Assembly

H2020 – Horizon 2020 The 8th EU Framework Programme for Research and Innovation.

HDS – High Demand Scenario

HE or HEU - Horizon Europe – the 9th Framework Programme of the EC for research, technological development and innovation activities.

HHI – Herfindahl-Hirschman Index

IPR – Intellectual Property Right

LDS – Low Demand Scenario

LFP – Lithium Iron Phosphate

Li-NCA – Lithium Nickel Cobalt Aluminium

MHP – Mixed Hydroxide Precipitate

NCA – Nickel Cobalt Aluminium

NMC – Nickel Manganese Cobalt

NPI – Nickel Pig Iron

NZE – Net Zero Emissions

PC – Project Coordinator

pCAM – Precursor Cathode Active Material

SC – Steering Committee

SME – Small and Medium Enterprise

WP – Work package

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7 DISCLAIMER

The numbers and graphs in this report are an amalgamation of various data sources, including personal communication with nickel and tungsten experts. The complexity and often intransparency of the nickel and tungsten sector (similar to other commodity supply chains) makes it extremely difficult to arrive at commonly agreed numbers. This is evident in huge deviations among the various publicly available and commercial sources such as S&P Global, IEA, USGS and others. The reason for these differences is not a lack of diligence or insight, it is the convoluted nature of the commodity market where various sources are often lumped together, annual reports often only give bulk sums rather than granular numbers, and qualities and product codes are mixed or discarded. Additionally, the increasing importance of recycled material flows is differently accounted for in reports depending on the focus and perspective of the authors. We sought to strike a balanced approach and blended production numbers and projections with a strong contextual element to arrive at a robust representation of the market.

8 NICKEL

Nickel's critical role in the steel industry and renewable energy sector is undeniable. Here, we present the latest available data on Ni with a specific focus on market concentration, geopolitical risks, and supply and demand trends.

Figure 1: Nickel for the energy transition executive summary from the ETC Ni factsheet (Energy Transitions Commission, 2023).

The Ni market has recently focused on Indonesia and its dramatic increase in mining and processing activities that have a global impact (e.g., Figure 4). INSG data and forecasts (International Nickel Study Group, 2024) project a further steep increase in Indonesian production share in the coming years. IEA estimates Indonesia will account for 62% of global production in 2030. INSG data shows that it will be already at 60% in 2024, and trends indicate a possible concentration of >70% of mining production by 2030 in Indonesia (BRGM, 2024). INSG data for refined Ni production also illustrates the strong market concentration in Indonesia and China, with both countries accounting for 71% of global production in 2023 (compared to 66% in 2022 and a forecast of 73.5% for 2024). INSG data is generally considered the most granular and reliable source for Ni data; however, other sources, such as S&P Global (S&P Global Market Intelligence, 2024) put Indonesia's market share at around 44% for primary Ni production in 2027, indicating that the market is far from consensus on the impact of Indonesia's Ni production in the coming years. Several voices have also raised concerns about the feasibility of planned projects, as permitting issues may hamper the progress of projects that are in the queue and often already taken into consideration in some of these projections.

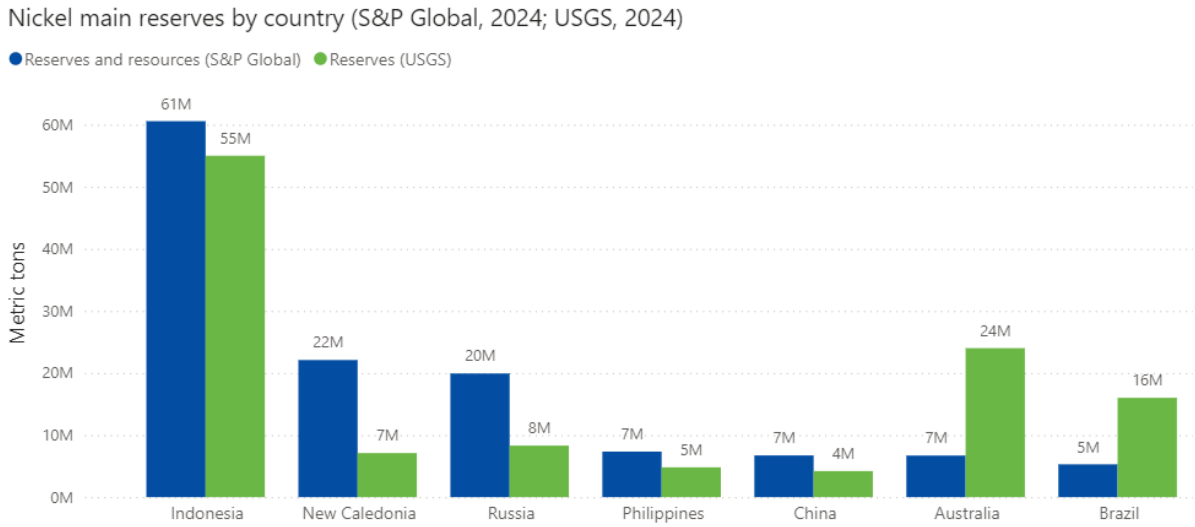
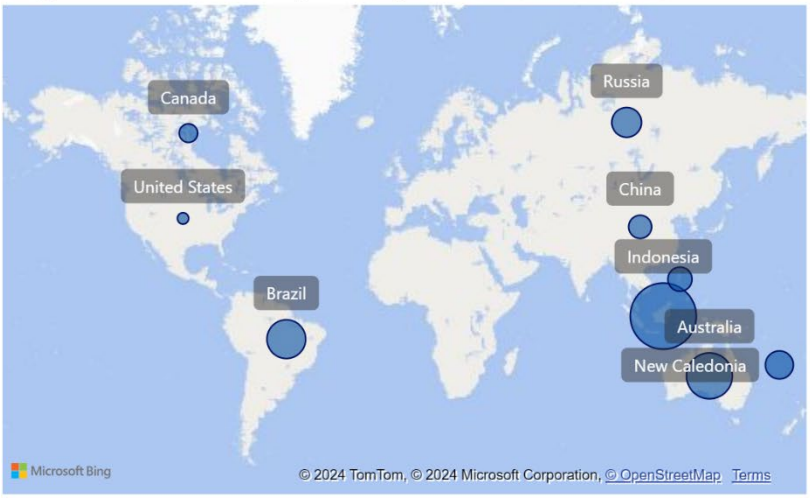


Figure 2: Reserves and resources data for nickel from S&P Global and the USGS. Australia and Brazil have significant potential but Indonesia is clearly dominating in terms of available reserves and Resources (USGS, 2024; S&P Global Market Intelligence, 2024).

Largest nickel reserves by country in 2023 (USGS, 2024)



Country	Reserves in metric tons
Australia	24,000,000
Brazil	16,000,000
Canada	2,200,000
China	4,200,000
Indonesia	55,000,000
New Caledonia	7,100,000
Other countries	9,100,000
Philippines	4,800,000
Russia	8,300,000
United States	340,000
World total	**131,040,000**

Figure 3: Global reserves of nickel by country in 2023 (USGS, 2024; EIT RawMaterials, 2024).

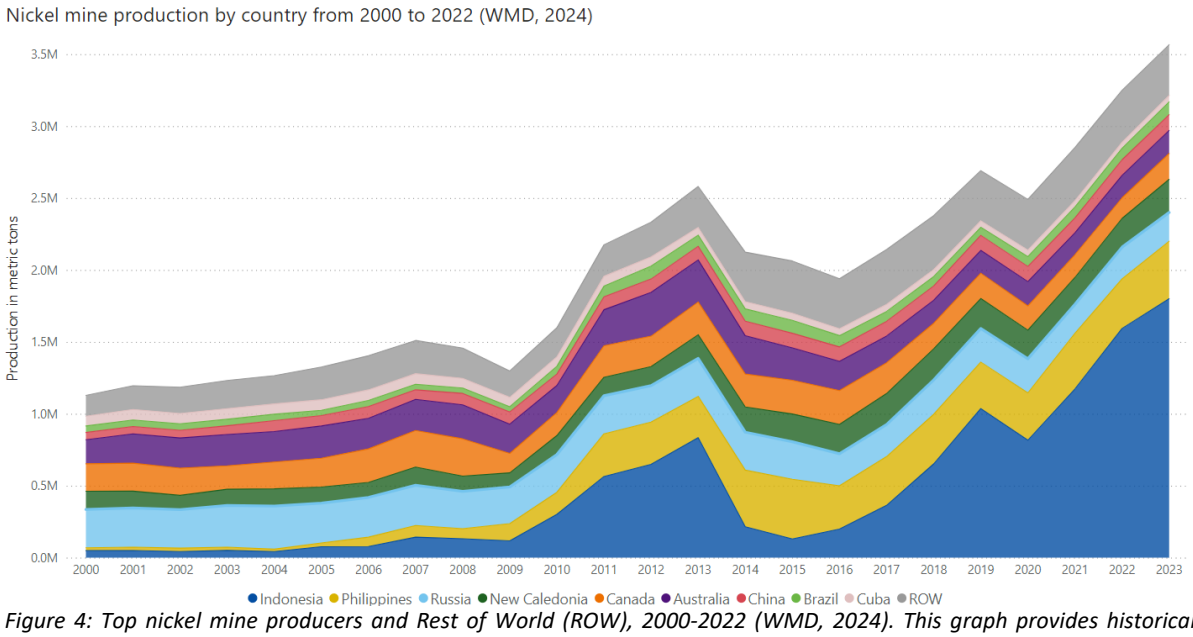


Figure 4: Top nickel mine producers and Rest of World (ROW), 2000-2022 (WMD, 2024). This graph provides historical context with production data dating back to 2000 and illustrating the ebb and flow of Indonesian Ni mine production from 2009 onward.

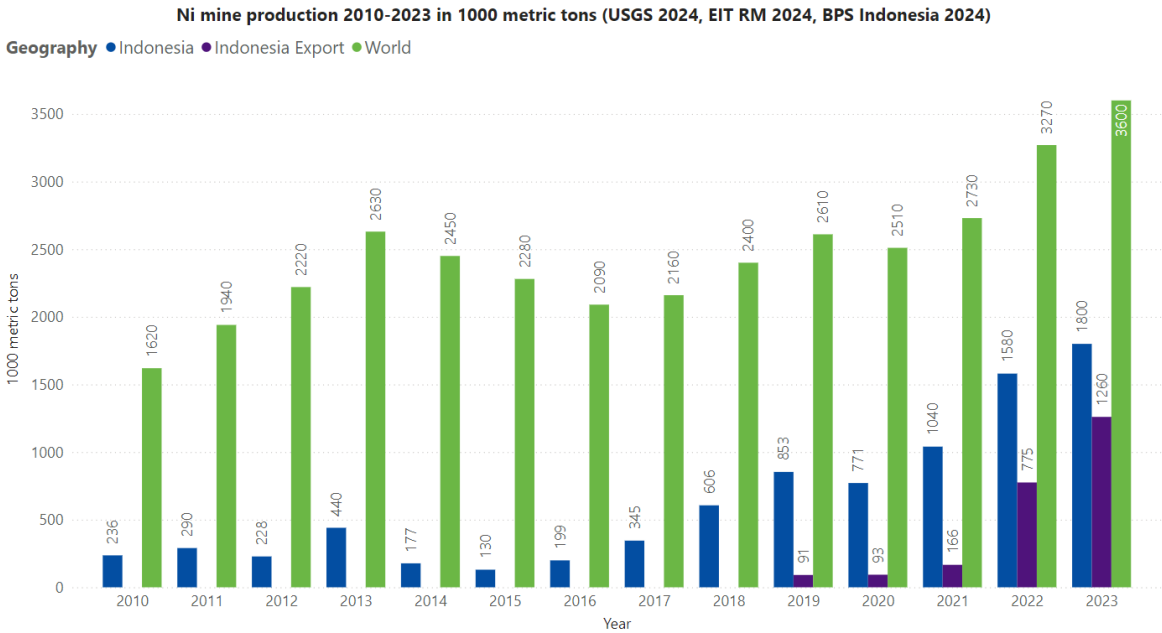


Figure 5: Nickel mine production globally and in Indonesia (2010-2023) showing a significant increase in production and exports over the last 6 years driven by Indonesia (US Geological Survey, 2024; BPS Statistics Indonesia, 2024; Anggi & and Robby, 2024; EIT RawMaterials, 2024). The recent peak of Indonesian production at around 2 million metric tons represents almost a doubling of the previous 2019 peak (see Figure 4), illustrating the current momentum of the Indonesian Ni market.

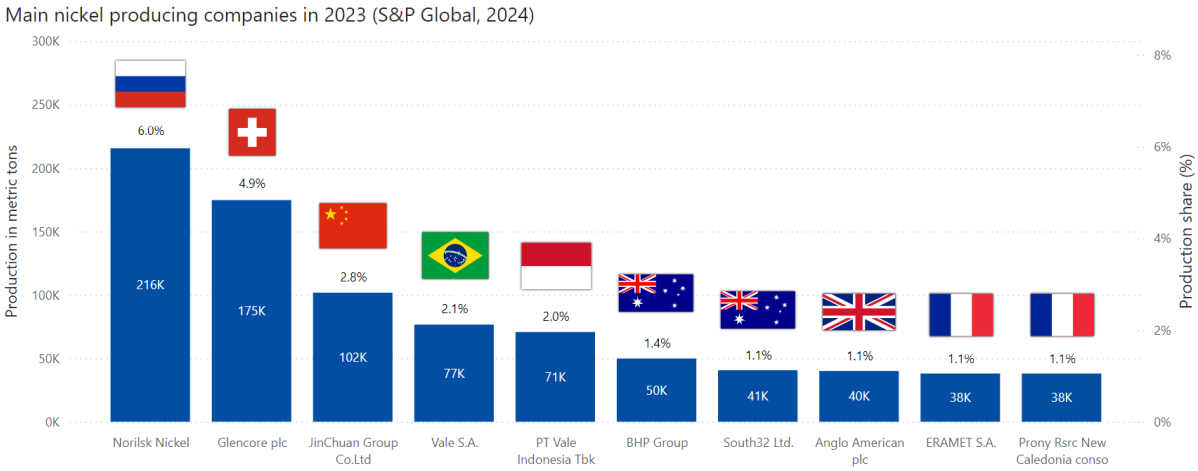


Figure 6: Top nickel-producing companies worldwide in 2023, including their production volume in metric tons, global production share %, and owner country (S&P Global, 2024; EIT RawMaterials, 2024).

A detailed overview of global Ni mining and processing companies and projects has been compiled in Appendix A. The tables illustrate the often-complex ownership structure and that especially Indonesian, Chines and Russian operations are owned, at least to a large share, by their corresponding governments or government-controlled organisations. Indonesian mining operations have a strong Chinese ownership and investment network behind them.

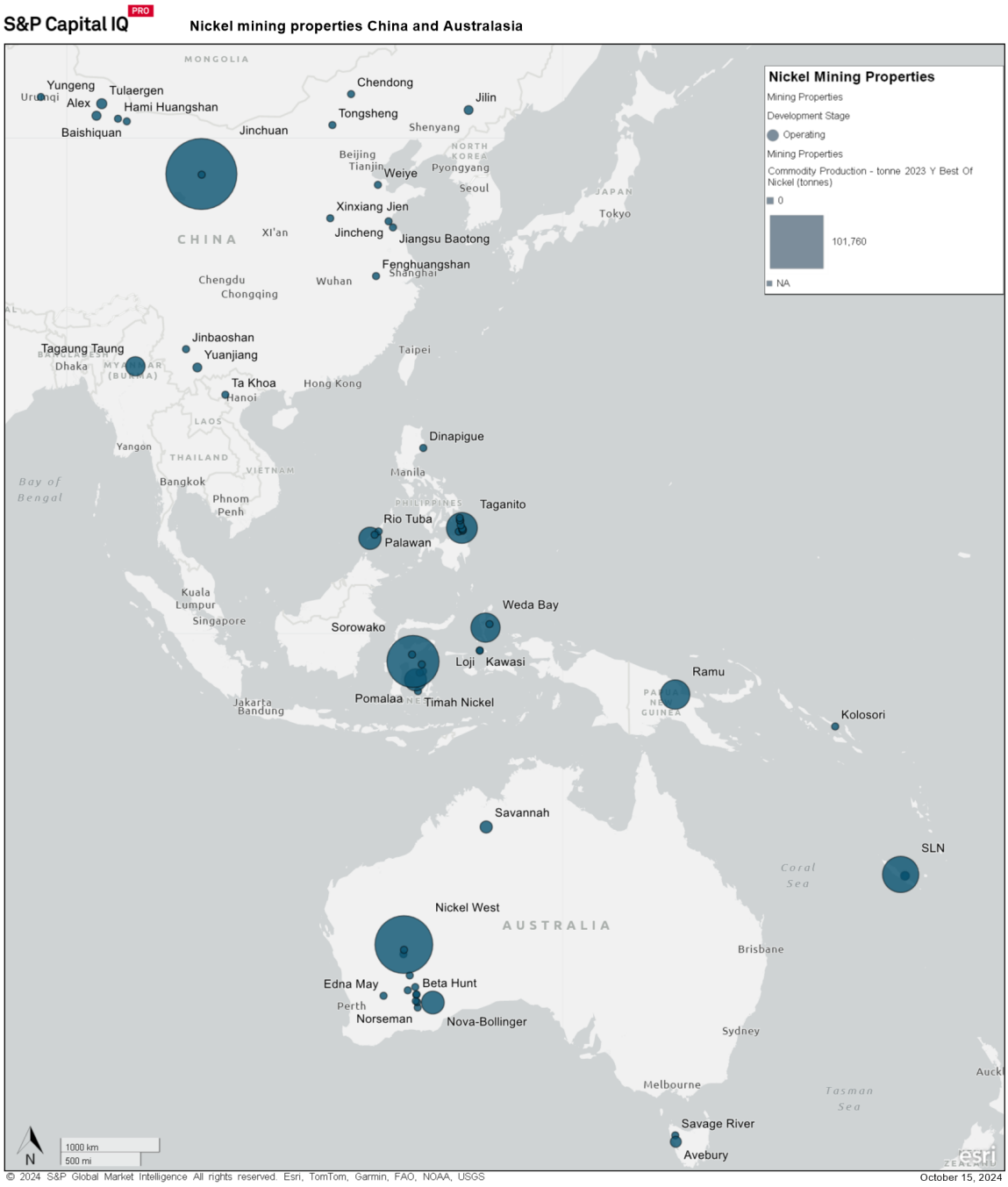


Figure 7: Location and size proportional to production (where available) for nickel mining properties in China and Australasia (S&P Global, 2024) illustrating the geographic concentration in this area. 65 out of 115 operating and active Ni mining projects are located in this area. The Appendix A – Nickel Ownership provides a comprehensive list of all properties, including their ownership details.

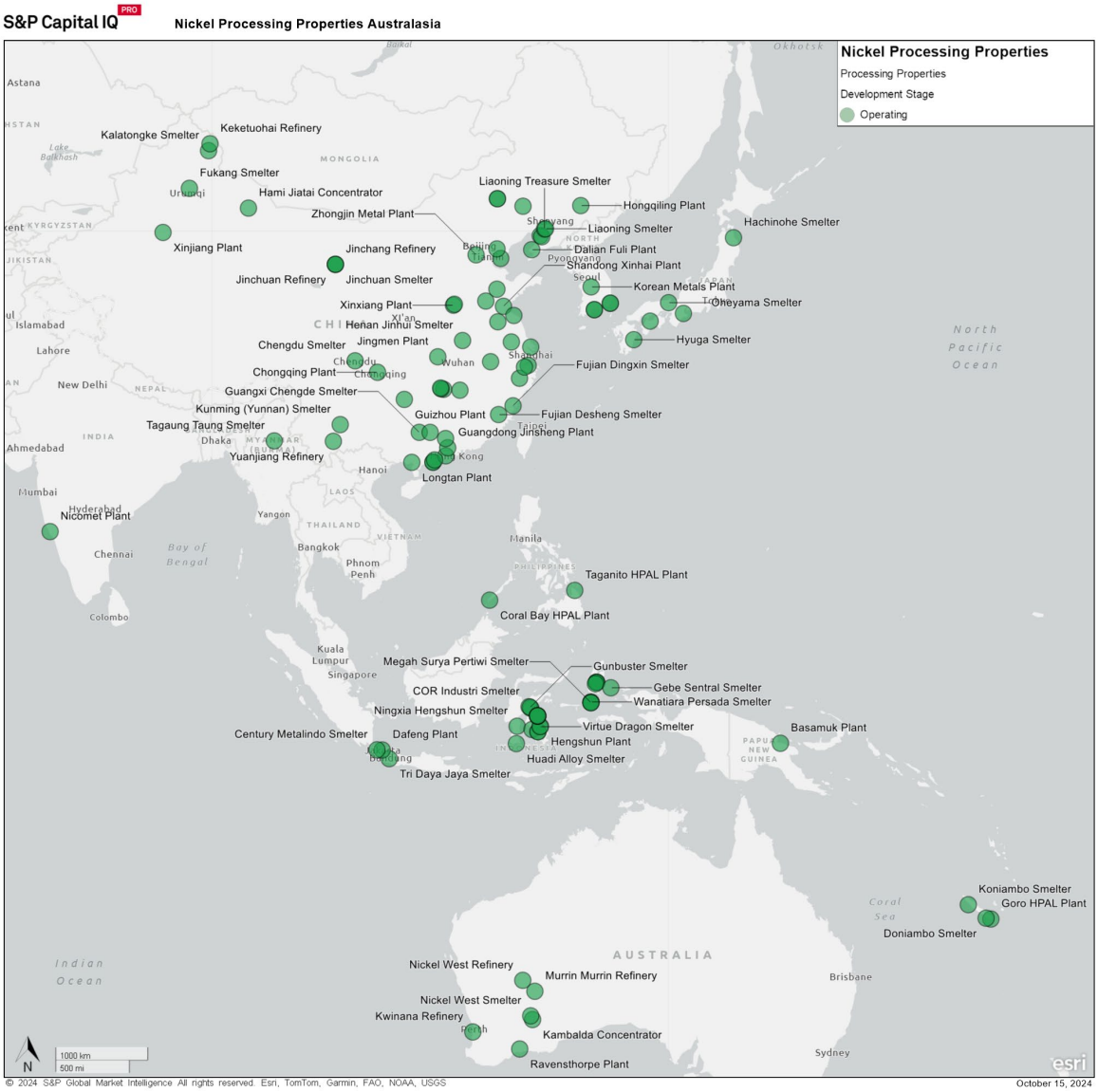


Figure 8: Location of nickel processing properties in China and Australasia (S&P Global, 2024) illustrating the geographic concentration in this area. 116 of 164 active and operating processing facilities are located in the Asia-Pacific region. Although this is not a direct correlation with production output, it clearly indicates the geographic concentration of the sector, specifically the processing stage. A comprehensive list of all properties, including their ownership details, can be found in the Appendix A.

8.1 Nickel products and applications

The global nickel market can be roughly divided into three product areas: high-purity nickel metal (>99 % nickel, Class I nickel), nickel chemicals (particularly nickel sulphate), and Class II nickel (<99 % nickel), such as ferro-nickel and nickel pig iron (NPI). Low-purity nickel (Class II) as well as ferro-nickel and NPI are mostly used for steel production. High-purity (Class I) nickel, with a purity of about 99.8%, is primarily used for batteries. Nickel and FeNi for steel production is, and for the foreseeable future will be the largest share of Ni-demand.

However, battery precursors are demanding an ever-increasing market share with forecasts seeing a growth factor of 5-6 (between 2021-2040) (see Figure 9 and Figure 10).

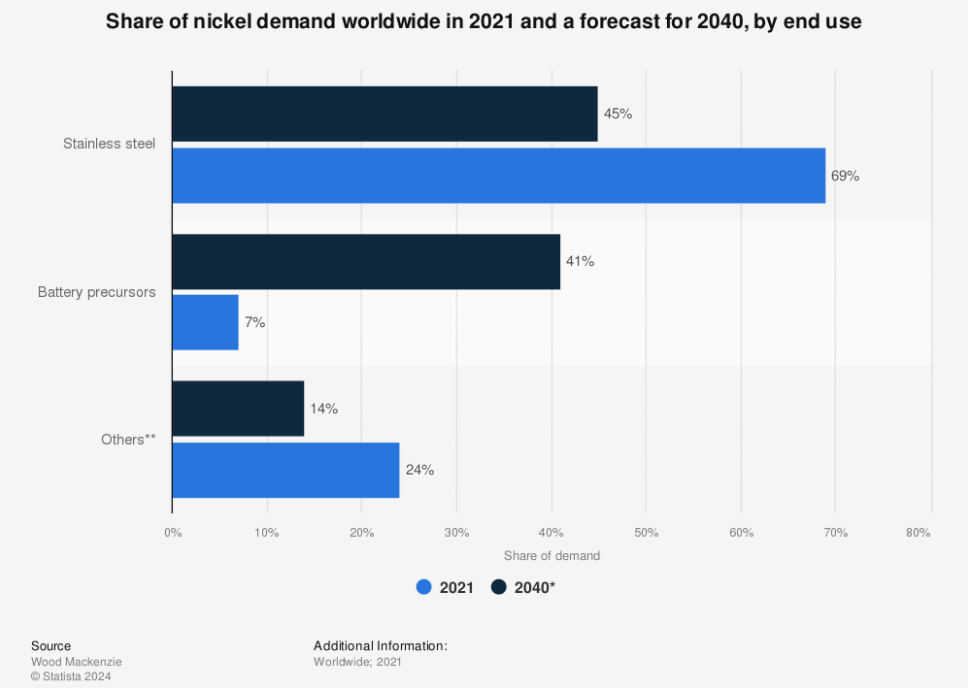


Figure 9: Share of Ni-demand by sector, 2021 and 240 forecast (Wood Mackenzie, 2022).

Battery technology pathways (e.g., LFP or sodium batteries), socio-economic and (geo)-political contexts (i.e., how will demand for EVs evolve in Europe over the next few years, and to what extent can this be politically stimulated?) are variables that are very difficult to predict, and often numbers as these presented in Figure 9 are based on assumptions that are very favourable to EVs and NMC batteries.

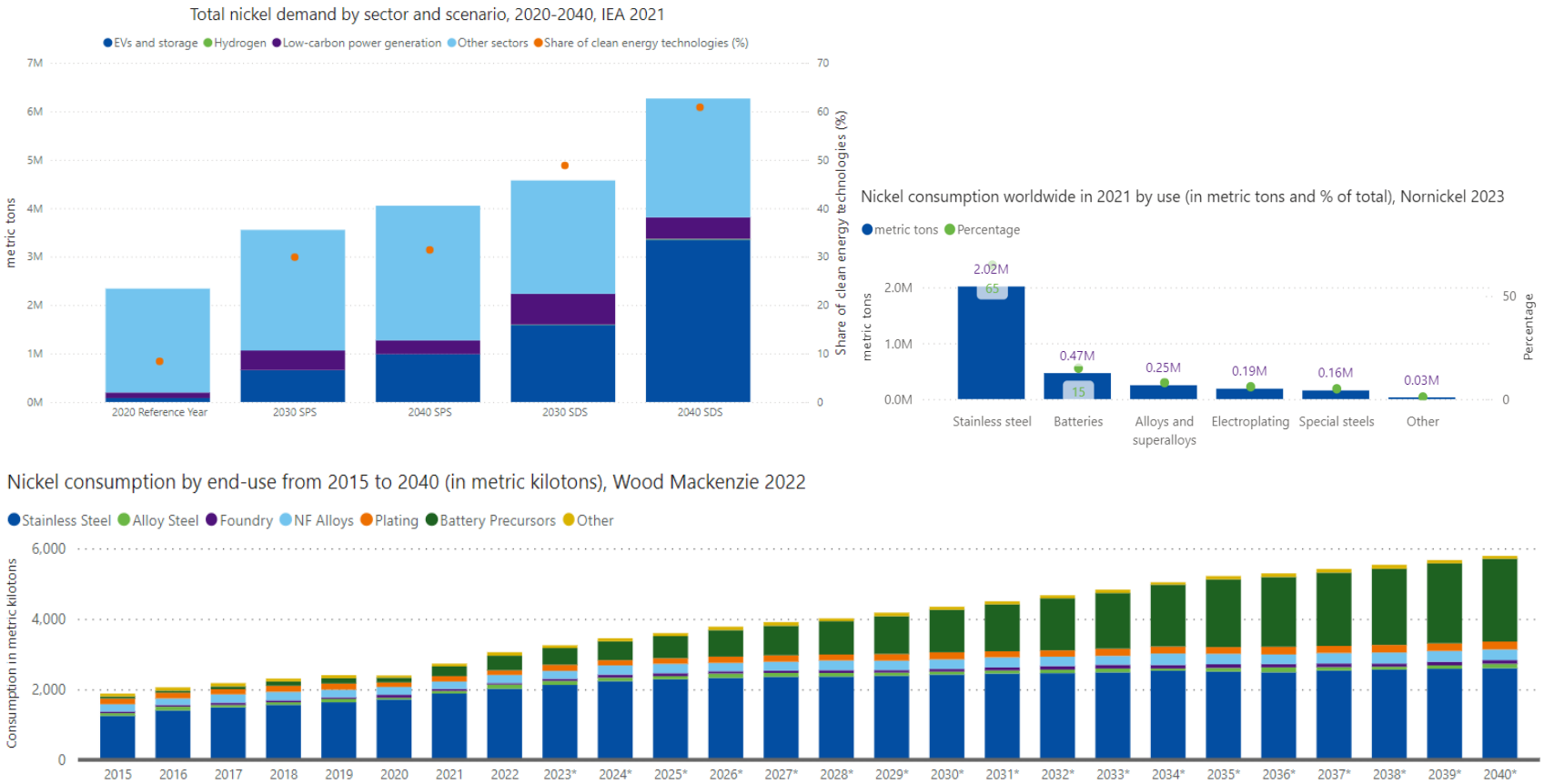


Figure 10: (top-left) Ni-demand forecast for Stated Policy Scenario (SPS) and Sustainable Development Scenario (SDS) in metric tons with overall share of clean energy Ni demand in percent. (top-right) Ni consumption in 2021 by use/sector in metric tons. (bottom) Ni consumption forecast to 2040 by use/sector in metric kilotons. Sources: (Nornickel, 2022) (Nickel Institute, 2022) (Wood Mackenzie, 2022) (IEA, 2021)

8.1.1 Steel sector

The production of stainless steel (Ni – Cr – Fe alloy typically containing around 8 wt.% Ni and 11 wt.% Cr) is the most important application, accounting for 69% of world primary nickel usage in 2022 (stainless-steel-world.net). Ferronickel is commonly produced by a pyrometallurgical process using oxidised nickeliferous ores (mostly laterites) containing 20-40 wt.% Ni (Zevgolis & Daskalakis, 2021). It is a key raw material for the stainless steel industry. The increased use of nickel pig iron (NPI) as a cheap alternative for FeNi has caused market disruptions and is one of the current key drivers of the market. The production of stainless steel is crucial for many industries, including green energy transition applications such as wind turbines, structures for solar panels, and tidal power generation. However, the main applications of stainless steel lie elsewhere, e.g., in transport, machinery, etc. Nickel-copper alloys are used for constructions requiring high corrosion resistance.

8.1.2 Other uses

The main application of pure nickel is as an anode for the electroplating of metallic objects. Nickel anode material has a 99.6 % purity. Pure metallic nickel is also used in the construction of chemical industry plants due to its corrosion resistance, particularly to alkalis. It is also applied for electromagnetic radiation shielding. High-purity ultrafine nickel powder with high surface activity and a large specific surface area is used as a catalyst for pre-reforming processes (methanation and reverse reaction) in hydrogen production plants (Sperle, Chen, Lødeng, & & Holmen, 2005). In case of applications requiring the use of high-purity nickel (99.90 to 99.99 %), the Mond carbonyl refining process is followed (Zumdahl, Zumdahl, & DeCoste, 2020), while electrowinning is sufficient for lower-purity nickel products.
Nickel sulfate solution is used as an electrolyte in nickel electroplating. Nickel oxide (NiO) is used as a p-type semiconductor in electronic devices (Carbone, 2022).

8.1.3 Batteries

Nickel's importance in the battery sector is growing (see also Figure 9 and Figure 10), especially high-grade nickel sulphate, due to its role in clean energy and electric mobility. With the global increase in electric mobility, the demand for nickel, particularly for battery production, is expected to rise significantly. Forecasts by Wood Mackenzie (2022) see the Ni-battery market on equal footing with the Ni-steel market by 2040. Most new nickel projects are focused on supplying the battery industry, highlighting the critical role of nickel in enhancing battery performance and energy density.

8.1.3.1 Nickel compounds

Nickel-containing matte (Ni_3S_2) can be produced through pyrometallurgical processing of nickel sulfide ores or NPI. Nickel-cobalt oxide and hydroxide mixtures are produced by hydrometallurgical processing of laterite ores and are the intermediate products for the synthesis of nickel end products. Lithium nickel manganese cobalt oxides (NMC), mixed metal oxides of lithium, nickel, manganese and cobalt with the general formula $LiNi_xMn_yCo_{1-x-y}O_2$ and lithium nickel cobalt aluminium oxides (Li-NCA) (chemical formula: $LiNi_xCo_yAl_zO_2$ x+y+z=1) are the most significant nickel-containing compounds used for the construction of

cathodes in batteries applied in mobile devices and electric vehicles (Nickel Institute, 2023). Nickel sulfate solution is used as an electrolyte in nickel electroplating. Nickel oxide (NiO) is used as p-type semiconductor in electronic devices (Carbone, 2022).

8.1.3.2 Outlook

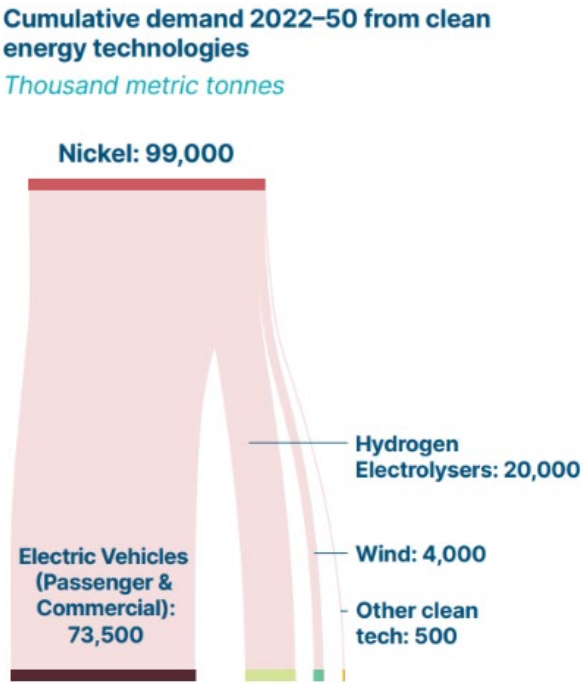


Figure 11: Nickel demand (2022-2050) for the clean energy sector (Energy Transitions Commission, 2023).

The clean energy demand for Ni is primarily driven by the EV sector, accounting for around 74% of the overall cumulative 2022-2050 demand (see also Figure 10). Hydrogen electrolysers are another growth market, but projections see it only at approximately 20% of the cumulative demand of the overall clean energy sector (see Figure 11) and IEA projections are even lower (Figure 10). It is important to note that the EV market growth has lagged behind expectations, especially in recent months. EU car sales were at a 3-year low in August 2024, with EV sales plunging by 44% (Reuters, 2024). These market adjustments can lead to oversupply and further price pressure on an already volatile Ni sector. However, strong EV demand in Asia will certainly be a driver for continued Ni demand (see Figure 12).

The Ni market transformation has been facilitated by the significant growth in large-scale NPI (nickel pig iron) production since the late 2000s. More recently, HPAL (High-Pressure Acid Leach) plants have started to process nickel (and to a lesser extent, cobalt) from often low-grade laterite-type and limonite deposits through a hydrometallurgical processes to convert them into intermediate-type products such as MHP – Mixed Hydroxide Precipitate. The resulting acidic solution is then processed to convert the Ni content into nickel sulfate, a crucial material in manufacturing NMC-type lithium-ion batteries (Transport & Environment, 2023). Since 2022, China has also developed a process to convert NPI into mattes, which can then be converted into Class I products and nickel sulfate. Indonesian

nickel production has traditionally been Class II nickel. However, with Chinese investments, the HPAL route is being employed to produce Class I nickel with a 99.8% purity from laterite-type deposits. Today, Indonesian nickel is almost exclusively exported to China (Benchmark Minerals, 2023; Mining.com, 2024).

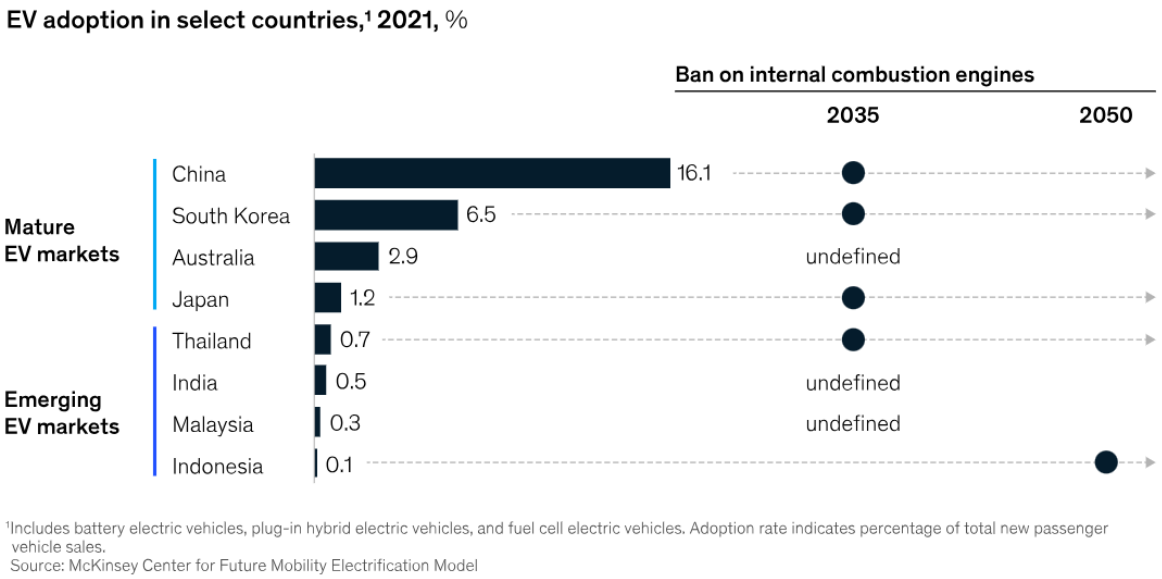


Figure 12: EV adoption rates are strong in mature Asian markets such as China and South Korea and will be a key driver for Ni demand (McKinsey Center for Future Mobility Electrification Model, 2022).

8.1.4 Secondary Production & Recycling

Nickel can be recovered from its two main applications: lithium-ion batteries and stainless steel scrap. Around 68% of all nickel available from consumer products is recycled and begins a new product life cycle (reference year 2010); another 15% enters the carbon steel loop (Joint Research Centre, 2020). Stainless steels, which account for two-thirds of nickel consumption, are extensively recycled. Most of the collected waste comes from the demolition of obsolete factories, machinery, equipment, and consumer goods. However, around 17% still end up in landfills, i.e., by disposing of metal goods and electrical and electronic equipment. The proportion of recycled nickel in total global consumption remains low due to current consumption volumes being much higher than in the past and the emergence of new uses (such as sulfates for batteries). According to the INSG, it reaches approximately a quarter (25%) of total demand (International Nickel Study Group, 2024; BRGM, 2024).

Recycling is an important factor in nickel's life cycle and an important contributor to increasing the sustainability of nickel-containing products. The durability and long lifetime of EV batteries and stainless steel are challenges for recycling since it takes time to build up a significant feedstock of secondary materials, particularly in emerging markets. Overall, the demand for recycled nickel is growing; it is part of the solution complementing primary production (Nickel Institute, 2023).

As nickel recycling is a well-established route for the steel industry it provides an increasingly important input stream. Forecasts, however, also project a significant recycling input for the battery sector. As a growing number of batteries reach end-of-life status due to widespread usage in EVs and other applications, efficient methods for recovering nickel become critical from an environmental conservation and resource management standpoint. Nickel recycling could cover between 67.7 % and 96.6 % of demand for EV batteries in 2050 (Hongyan, et al., 2023). Recycling of Ni waste and scrap is one of the areas where European players and other Western nations are still competitive if not leading (see Figure 13). Germany and Sweden have been among the top 5 global importers of Ni waste and scrap in recent years (Drive Sustainability, 2023).

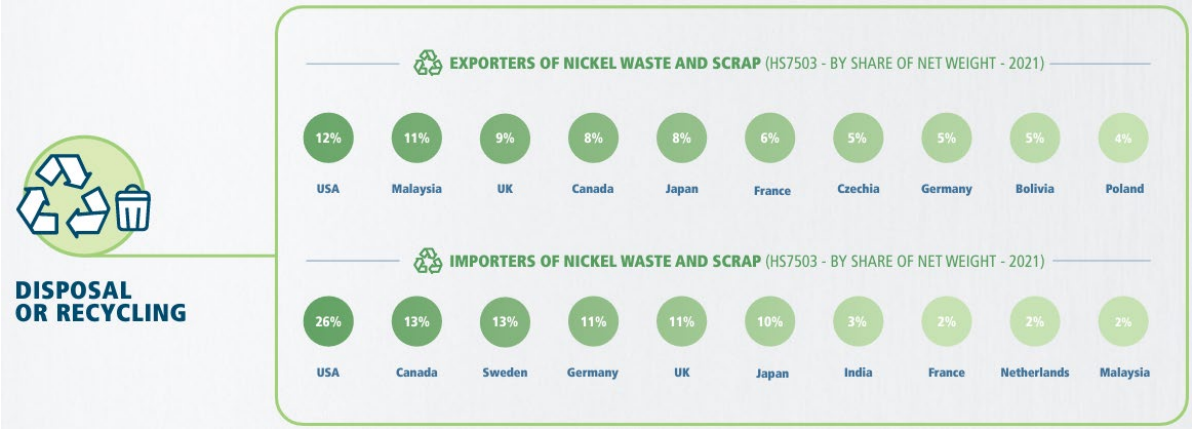


Figure 13: Nickel waste and scrap (HS7503) trade leaders globally by share of net weight – 2021 data (Drive Sustainability, 2023).

8.2 Material Flow Analysis

Tracing material flows has increasingly become critical to inform high-level decisions, geopolitical strategies, and innovation schemes. The difficulty arises from a complex and often intransparent network of stakeholders and production (e.g., Figure 14, Figure 15) and trade flows (Figure 14) linked to an often opaque ownership structure. An analysis of trade flows can be seen across the different Ni products in Figure 14, highlighting the upstream concentration in Indonesia and the amount of imports of material into China. The data also show that the EU is a net-exporter for scrap, which sends valuable raw material input for the steel sector overseas at a time where EAF become more prevalent. The data in Figure 14, however, are in parts already outdated as the represent 2019 numbers and do not show the increasing move towards Class I Ni by Indonesia with a strong domestic focus and most exports directed to China (see also 8.4). Figure 15 , taken from a recent publication, illustrates the Ni material flow across the different supply chain stages (Sun, Jiao, Hao, Liu, & Zhao, 2024). The numbers represent 2021 data and we have updated them in the corresponding graphs in Figure 16 and Figure 17. A great graphical abstract of 2021 data for the different supply chain stages for Ni can also be found on the Drive Sustainability Raw Material Outlook page (Drive Sustainability, 2023). One example, for Ni waste material and scrap trade flows, is shown in Figure 13.

	Ores & concentrate		Matte		MSP/MHP/Ni ox.		FeNi/NPI		Class I		Nickel sulpate		First-use products		End-use products		Scrap	
	Import	*Export*	*Import*	*Export*	*Import*	*Export*	*Import*	*Export*	*Import*	*Export*	*Import*	*Export*	*Import*	*Export*	*Import*	*Export*	*Import*	*Export*
Indonesia		39%		28%			0%	38%			1%		2%	10%	2%	1%	2%	1%
Philippines		32%				15%					2%				2%			1%
Russian Fed.		1%		23%						21%			1%		2%	1%		2%
Australia		6%		6%		0%				20%	4%				2%		0%	1%
Canada		5%	2%	32%	1%	8%				13%	7%		2%		5%	1%	3%	3%
Norway			33%			0%				13%					1%			
Rep. of Korea					2%	0%	4%	1%	6%		7%	8%	5%	7%	1%	4%	4%	2%
Japan	5%		32%		15%	0%	1%	5%	6%	2%	44%	6%	2%	5%	2%	3%	1%	4%
India						0%	6%		3%		1%		4%	3%	2%	6%	18%	
USA						0%	2%		11%		1%	3%	5%	4%	17%	6%	3%	8%
EU28	5%	0%	27%	9%	14%	10%	15%	4%	31%	16%	20%	43%	44%	42%	29%	32%	54%	58%
China	80%		3%		67%	0%	65%		25%	2%	3%	1%	6%	14%	3%	24%	2%	
Total	90%	82%	97%	98%	99%	34%	94%	48%	82%	87%	89%	61%	70%	86%	66%	77%	86%	80%

Figure 14: Import and exports of nickel products in different stages of the supply chain in 2019 (Cormery, 2022). Master Thesis on global nickel cycles at NTNU, 2022: https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/3023798

Albeit based on 2019 data, Cormery (2022) show quite a comprehensive overview of trade flows for the various supply chain segments and illustrate the dominance of Indonesia for the most upstream segments and China's hunger for imports. The table (Figure 14) does not yet reflect the more recent shift of Indonesia to produce increasingly more intermediate and high-purity products.

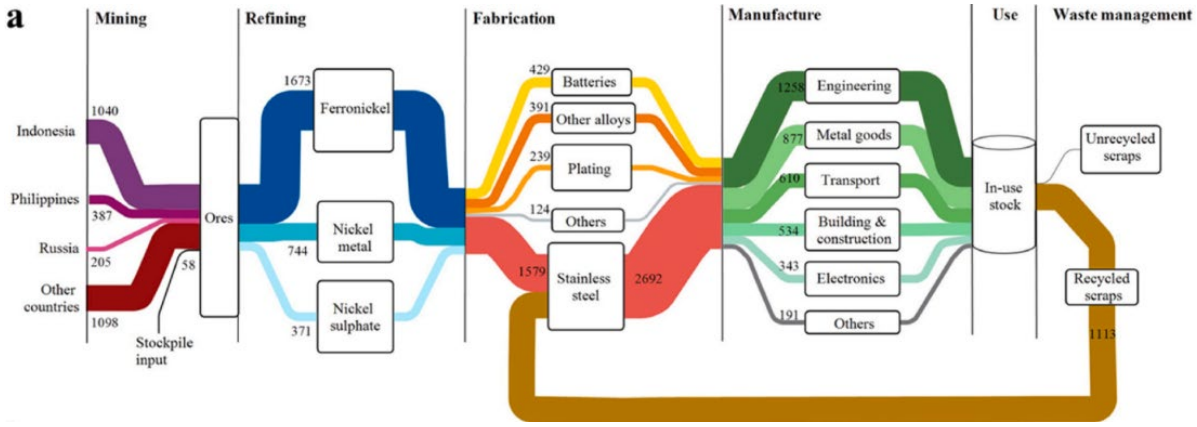


Figure 15: Material Flow Analysis for Ni along the supply chain (left to right, 2021 values in kt) (Sun, Jiao, Hao, Liu, & Zhao, 2024).

Figure 16 and Figure 17 illustrate the global distribution of Ni production along the supply chain, showing the top 3 countries and the rest of the World (ROW) for every stage and their corresponding percentage share, including the materials and the overall production in million metric tons. Indonesia, the Philippines and Russia are the leading source countries for nickel ore, whereas China dominates the downstream stages, especially for the battery material pathway. Further insight on battery grade Ni material flows comes from IEA (Figure 16) indicating that the Class I Ni supply is dominated by Indonesia whereas Ni-sulfate and cathode material is heavily concentrated in China. This market concentration is further illustrated in Chapter 8.3 and Figure 19.

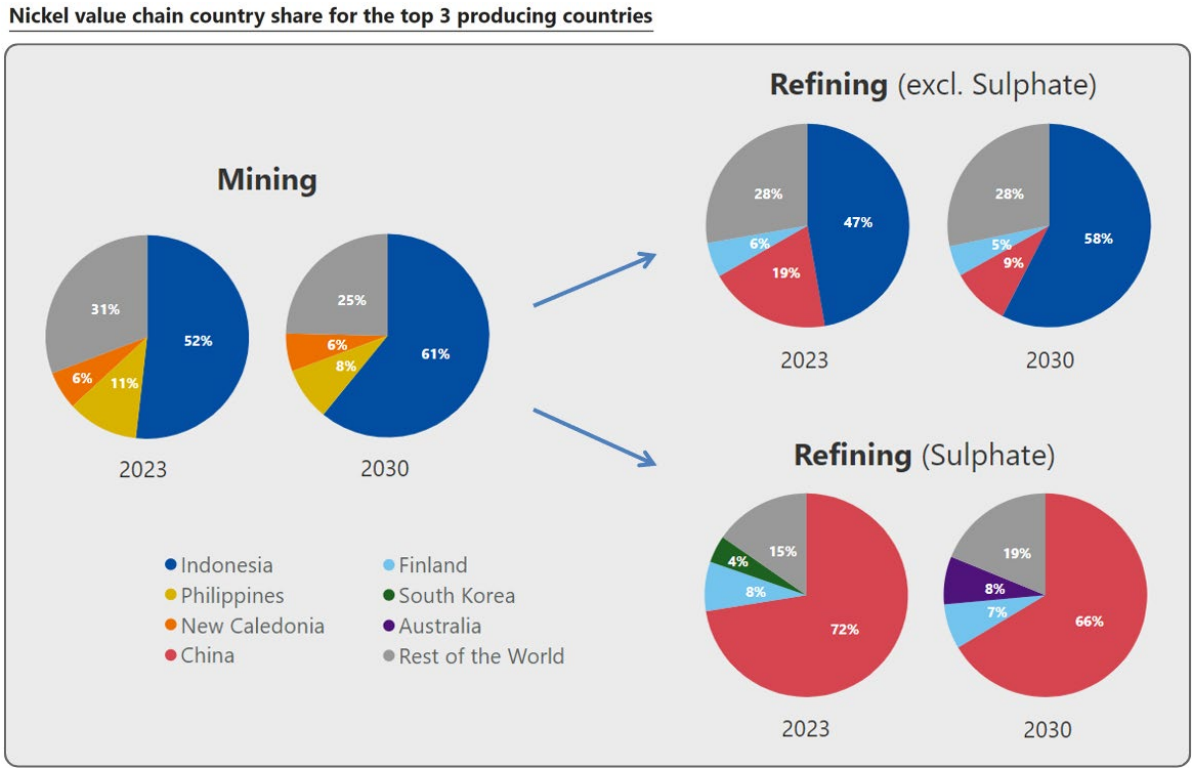


Figure 16: Nickel production share for mining and refining for the top 3 companies and the rest of the World (ROW) in 2023 and projected for 2030 (IEA, Global Critical Minerals Outlook 2024, 2024; EIT RawMaterials, 2024).

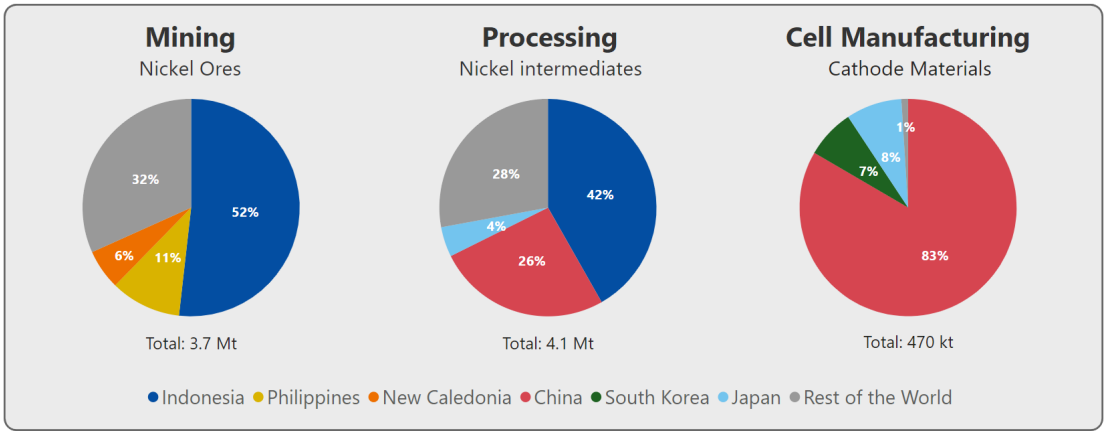


Figure 17: Nickel value chain production share for the top 3 companies and the rest of the World (ROW) in 2023. NPI: Nickel Pig Iron. FeNi: Ferro-nickel (EIT RawMaterials, 2024; International Nickel Study Group, 2024; USGS, 2024; WMD, 2024).

8.3 Market concentration

The market has shifted from moderately concentrated to highly concentrated in recent years. Anything above an HHI of 2,500 is considered a highly concentrated marketplace, and Ni mine production has a value of 2,922 (EIT RawMaterials, 2024) (see Figure 18). The driving force behind this is the Indonesian government's decision to restrict the export of nickel ore

in 2014 and massive Chinese investments in Indonesian mining and refining operations, which has led to market volatility from the early 2010s onwards. This topic is discussed further in Chapter 8.4.

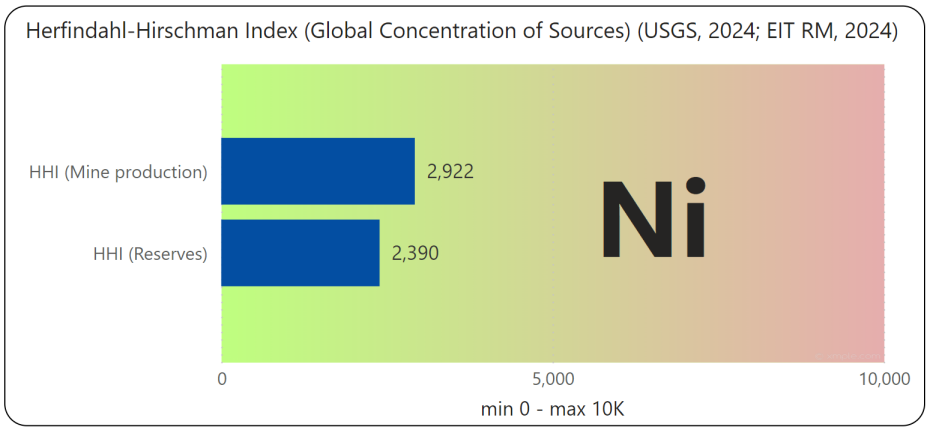


Figure 18: HHI for Ni, based on the most recent mine production data, shows that Ni is relatively highly concentrated, with indices of 2,922 for mine production and 2,390 for reserves. However, as discussed above, the coming years will see further market concentration focused mainly on Indonesia (EIT RawMaterials, 2024; USGS, 2024).

An extensive overview of active and operating nickel mining and processing projects, including their location and ownership details, can be found in Appendix A – Nickel Ownership . The table also illustrates that many Indonesian projects are indeed owned by Chinese investors/companies. Western investors, primarily from Australia are also operating in Indonesia. Most recently, BASF and Eramet have cancelled plans to invest up to $2.6 billion in building a high-pressure acid leach (HPAL) operation in Weda Bay, Indonesia. The project had been set to become the first and only nickel plant in Indonesia with 100% Western ownership. While BASF listed *'alternative supply options'* as a main reason for not going through with the investment, ERAMET states they remain focused on *'sustainably optimizing the resource potential of Weda Bay mine to supply ore to local nickel producers'*.
Will Talbot, Benchmark Principal Analyst, summarises (Benchmark Minerals, 2024) *cancellation of BASF and Eramet's project demonstrates the pressures faced by HPAL operators today, particularly for those owned by Western companies, both in Indonesia and outside of the region."*

8.3.1 World

Global Ni resources in active and operating mines are predominantly concentrated in Indonesia, New Caledonia, Russia, and the Philippines. Additionally, Indonesia has a large number of SE Asian projects that are often owned by Chinese companies, leading to a high upstream concentration of Ni mining. However, other players have significant potential to reduce the market concentration, namely Canada, with almost 14 billion metric tons of Ni earmarked for production in exploration projects. Indonesian nickel is almost entirely exported to China, and vice versa. China imports 97%, 94% and 83% of its NPI, matte and MHP, respectively, from Indonesia, and those volumes are still growing (ArgusMedia, 2024; BRGM, 2024).

IEA provides a comprehensive analysis of the EV battery supply chain (IEA, 2022) and critical minerals, which also include nickel (IEA, 2024) (see Figure 19). As illustrated in Figure 19 Indonesia is dominating the upstream part of the Ni for the EV battery supply chain, whereas China dominates the downstream part of that supply chain. Only Russia and Japan have significant stakes in the material processing stage.

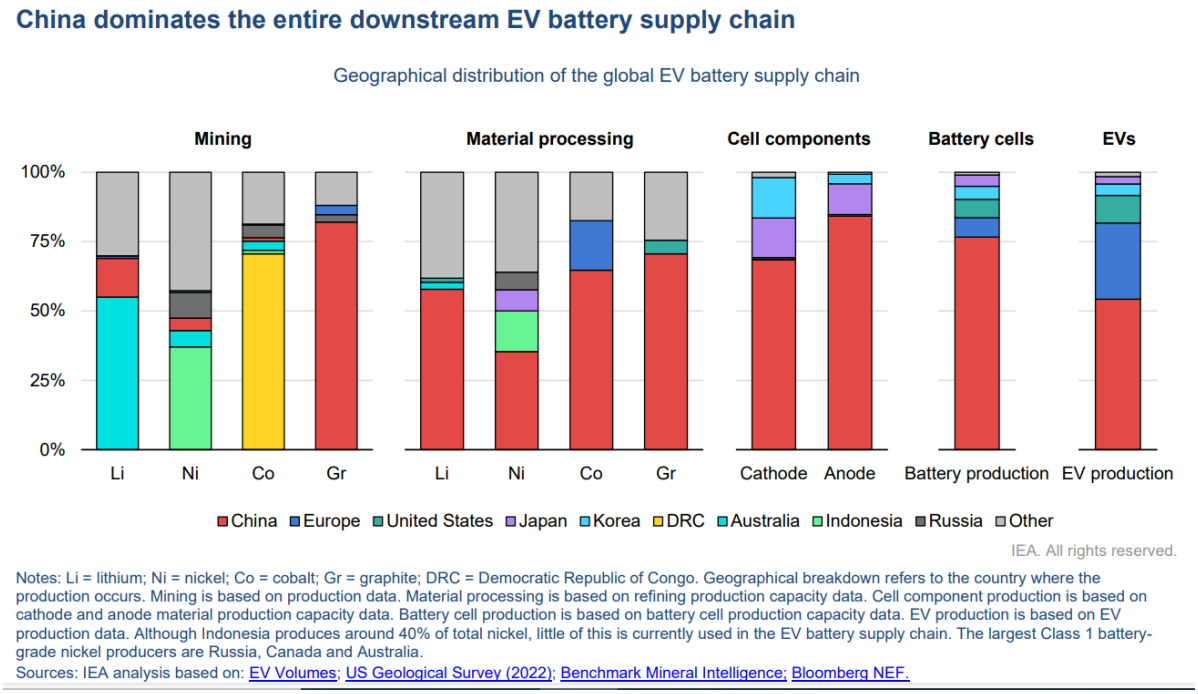


Figure 19: Production concentration in the different supply chain steps for EV Production. Figure is published originally in IEA (2022) EV battery supply chain report.

8.3.2 EU

The European Union hosts diversified industries within nickel-based value chains from upstream to downstream. Especially the steel sector is economically very important for the EU. A battery-value chain is currently developing within the EU and substantial investments have been made to establish a number of Gigafactories and other production facilities. At the same time, EU car sales were at a 3-year low in August 2024, with EV sales plunging by 44% (Reuters, 2024). In the upstream production of nickel (mining, smelting, refining) Finland, France, Greece, and Poland are the most important producing countries within EU (Nickel Institute, 2024; SCRREEN, 2023). The JRC presented an Outlook for EU27 supply in a 2021 commissioned report delivered by Roskill (European Commission: Joint Research Centre, 2021):

Mined production of nickel ore from the EU27 in 2019 accounted for 2.1% of global mine supply. The only producing countries were Finland and Greece. Finland produced 39kt Ni-in-ore in 2019 with two companies, Terrafame and Boliden operating mines. Nickel mine supply in the EU27 is forecast to increase by 0.5%py, which will be solely driven by increased output from Terrafame in for its integrated nickel sulphate production.

Total intermediate production from EU27 countries is forecast to total 62kt Ni in 2020, which represents 5.7% of global intermediate supply. This is expected to rise by 2.2%py to 2030 and 1.1%py to 2040. Finland is responsible for the vast majority of intermediate nickel production in the EU27 (95% in 2020), which is forecast to remain the case over the outlook period. Nickel intermediate production in Finland comes from operations at Boliden in Harjavalta, Terrafame in Talvivaara, and to a much lesser extent, crude nickel sulphate from Mondo Minerals in Vuonos.

Primary refined nickel production (including Class I metal and primary nickel sulphate) in the EU27 totalled 71.8kt Ni in 2019. As with intermediate production, Finland makes up the bulk of refined nickel production from the EU27 bloc and is expected to account for 76% of refined output in 2020. Other refined nickel producing countries in the EU27 include France, Austria, Belgium and Germany. Roskill forecast 85% of EU27 refined nickel production is made up by Class I metal in 2020, with the remaining 15% primary nickel sulphate. By 2040, this share is expected to narrow to 54% for Class I metal and 44% primary nickel sulphate. This change is the result of Terrafame's nickel sulphate plant coming online in H1 2021 and ramping up to full capacity. Total Class I metal production from EU27 countries is estimated at 59kt Ni in 2020, which represents 7.2% of global Class I supply. This is expected to rise by 1.5%py to 2030 and 0.7%py to 2040.

EU27 market balance**:** There are two distinct and independent market balances to consider within the EU27 bloc. The first is domestic supply against that of total demand from EV sales (end-use). On this front, Roskil forecast a period of structural deficits post2024 owing to limited scope for new primary supply being developed. This highlights the EU27's need for domestic investment in new nickel supply and/or the requirement for sourcing additional units from outside the EU27. Post-2030, however, rapid growth in EOL battery availability and nickel units within such could have a 'flattening effect' on the overall market balance deficit growth. Secondly, is domestic supply against that of physical demand from domestic precursor/cathode makers (first use). Roskil forecast domestic nickel production to adequately supply EU27 cathode makers until 2026. Post 2027, deficits could form when only considering primary refined supply. Such deficits could be mitigated if the EU27 utilises nickel available from EOL battery recycling, in turn generating a circular economy of nickel supply for EU27 cathode industry demand.

The downstream production for battery value-chain (pCAM, CAM, cells, battery manufacturing) is currently building up in several European Union countries, especially in Poland, France, Finland, Germany and Sweden. The activities in the battery value-chain tend to be vertically integrated, and several value-chain steps could be included at the same industrial site, especially in facilities called Gigafactories. A comprehensive analysis of the European current and expected gigafactories is presented in the recent report by the Faraday Institution (2024). The following analysis focuses on upstream production for nickel

in relation to the battery production value-chain: mining, smelting, refining, and precursor chemical (pCam) production and related value-chains within EU.

The current low prices of nickel and Russian sanctions most probably influence companies operating in the nickel-value chain within EU. Especially this brings pressure to the companies operating in the upstream and the steel sector as Russian nickel is a major raw material source for them. However, this far there has not been any official statements regarding this item. If Russia begins to restrict nickel exports as stated in September 2024 (Reuters, 2024) that would most probably have effect also on European nickel-based value-chains.

Read more on:

Tighter sanctions target Nornickel as pressure mounts – Eye on the Arctic (rcinet.ca)
Russia's Nornickel examining impact of latest US sanctions (msn.com)
Russian freight trains still passing through Finnish border checkpoints | Yle News | Yle
Chemicals Producer BASF Freezes New Russia and Belarus Business (wsj.com)

8.3.2.1 FINLAND

Finland is the largest producer of mined nickel in the EU, with over 60% share of the annual EU production (SCRREEN2, 2023). The country´s aggregated reserves of nickel were 1,5 Mt, and resources 4,7 Mt in 2024 (Eilu & Eloranta, 2022). Finland hosts two nickel mines, Boliden Kevitsa and Terrafame Sotkamo. The Terrafame Sotkamo site also includes chemical manufacturing facilities (Långbacka, Bertelli, Friedrichs, & Kivinen, 2025). Downstream facilities include Boliden’s Harjavalta nickel smelter and the Nornickel Harjavalta nickel refinery. Several new nickel-producing mines are at the feasibility and/or authorisation procedure stage (Tuomela, Törmänen, & Michaux, 2021). BASF has constructed a pCAM factory in Harjavalta, however, the opening of the factory has been delayed due to permitting issues (BASF, 2024).

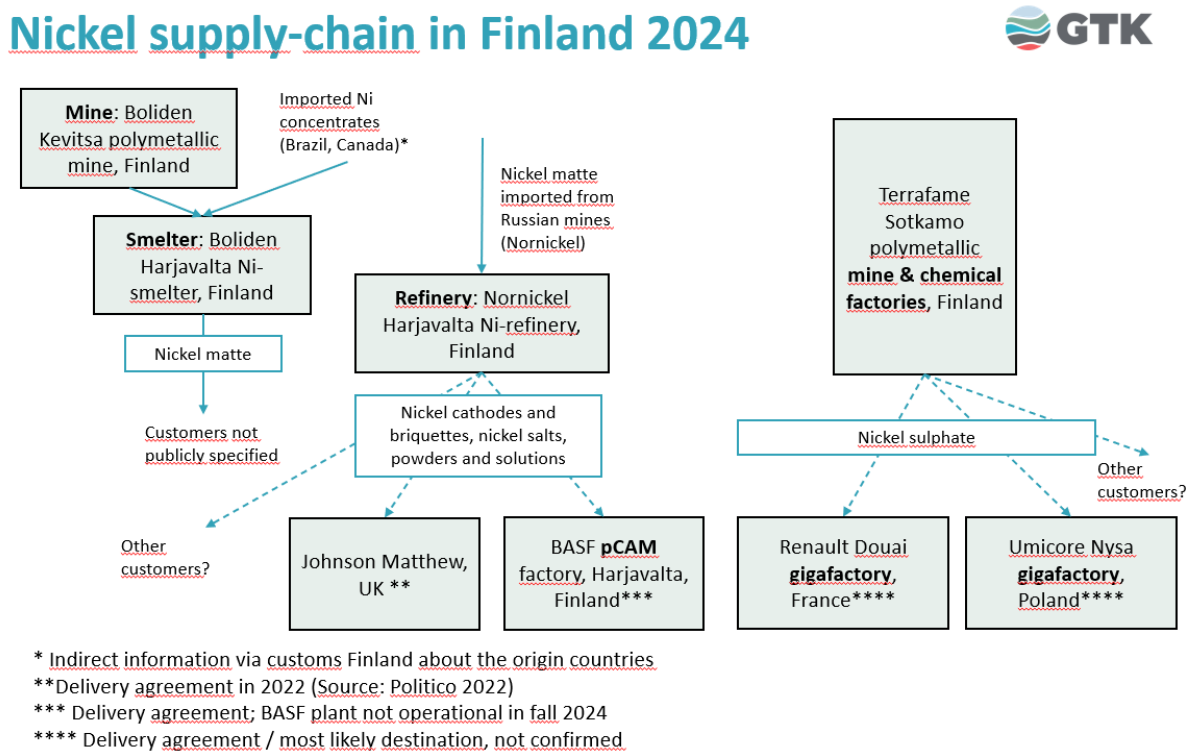


Figure 20 The nickel-based value chain in Finland illustrates that Europe has an existing capacity on which to build. However, it also is evident that this supply chain relies on Russian Ni supplies by Norilsk-Nornickel (see text below). Provided by GTK, 2024.

Boliden is a Sweden based metals and mining company. Boliden´s nickel operations in Finland are vertically integrated, including mining and smelting activities. According to the company annual report 2023, Kevitsa polymetallic mine in Sodankylä Finland, supplies nickel concentrate to the Harjavalta smelter. This mine provides ~50% of the smelted raw materials in Boliden Harjavalta smelter. In addition, nickel ore concentrates are imported to Finland from Brazil, Canada and Australia. Most probably, these concentrates are processed in the Boliden Harjavalta smelter, although this information is not confirmed.

According to Boliden, their Harjavalta plant does not use Russian nickel raw materials. Imports from Russia are nickel matte, which is further processed in the Nornickel refinery at Harjavalta (see below). Boliden also confirmed in a personal communication that Harjavalta´s product, also nickel matte, is not further processed at the Nornickel refinery even though they are very closely situated.

Nornickel (Norilsk Nickel) is a vertically integrated, giant Russian mining and metals company. Nornickel has nickel operations, especially in the Norilsk region in Russia, and is one of the leading World producers of battery-grade Class I nickel. Nornickel operates a nickel refinery in Harjavalta for which the nickel raw material is imported from the company´s mine facilities in Russia. Nornickel has agreements at least with BASF and Johnson Matthew for nickel product deliveries (Politico E&E News, 2022; Tuomela P. T., 2021).

Terrafame is a Finland based mining and chemical company that operates Sotkamo polymetallic mine in Eastern Finland. The Sotkamo site hosts mining and processing activities and produces nickel sulphate which is the most important Ni-precursor chemical for the battery value chain. Production at the Sotkamo site is based on bioleaching with integrated chemical factories. In the European market, Terrafame has agreements for nickel sulphate deliveries with Umicore (Umicore, 2023), Stellantis (Terrafame, 2023) and Renault (Terrafame, 2022).

BASF is a German-based chemical company. It has constructed a battery materials plant for precursor cathode active material (PCAM) production at Harjavalta, Finland. The plant is completed, but unfinished permitting issues prevent the company from beginning production. The factory will use nickel sulphate, cobalt sulphate, and manganese sulphate, which will be processed into a metal alloy (pCAM). (Source: BASF webpage and environmental permit).

CNGR Finland's Hamina Plant: This plant is set to produce pCAM, which is crucial for lithium-ion batteries. The facility aims to supply materials for approximately 500,000 fully electric cars per year.

8.3.2.2 FRANCE

Nickel mining is a significant part of New Caledonia's economy. The island holds about 7.1 million tonnes of nickel reserves, which is roughly 10% of the world's total. In 2020, New Caledonia produced 200,000 tonnes of nickel, making it the fourth-largest producer globally. Nickel mining accounts for 6% of the island's GDP and 24% of private employment. The sector is dominated by major companies like Vale, Eramet, Glencore, and Sumitomo Metal Mining. New Caledonian nickel production has suffered from the low nickel prices and civil unrest in the area.

The battery supply chain in mainland France is currently building up:

Sibanye-Stillwater's GalliCam Project: Located in France, this project plans to repurpose the Sandouville nickel refinery to produce pCAM. According to the company, production is expected to start in 2027, contributing to the European EV battery value chain (Sibanye-Stillwater, 2024).

Renault is planning to construct an EV battery Gigafactory in Douai as part of the new ElectriCity industrial hub (Renault, 2024). The Douai Gigafactory would include CAM production. Renault has an agreement with Terrafame in Finland for nickel sulphate deliveries (Terrafame, 2022).

8.3.2.3 POLAND

Umicore has launched Europe's first battery materials gigafactory in Nysa, Poland. The facility started CAM production in July 2022 and aims to reach an annual production capacity of 40 GWh by the end of 2024. Umicore has an agreement with Terrafame in Finland for nickel sulphate deliveries (Umicore, 2022; Umicore, 2023).

Umicore and PowerCo Joint Venture (IONWAY): Umicore and Volkswagen Group-backed battery company PowerCo have recently announced their joint venture - IONWAY - meant for large-scale industrial production of sustainable battery materials for electric vehicles such as CAM and pCAM in Europe. Moreover, the battery materials company has also chosen to build its first CAM production plant in Nysa, Poland, adjacent to Umicore's existing CAM plant. It is said that the facility will benefit from Umicore's CAM know-how and easy access to raw materials from Umicore's refining operations in Finland. IONWAY: Umicore-PowerCo JV aims sustainable CAM, pCAM production in Europe - (etn.news)

8.3.2.4 GERMANY

Germany has an established nickel industry especially in steel and alloys production with first use production totalling €9,501M in 2014 (Nickel Institute). The nickel raw material is largely imported from Russia (Deutsche Welle, 2022).

Nickelhütte Aue GmbH: This company specializes in recovering metal concentrates, including nickel, from various industrial processes. They further process these materials to produce basic chemicals, including nickel sulphate.

Umicore: Although headquartered in Belgium, Umicore has significant operations in Germany. They have agreements to supply high-grade nickel sulphate for battery materials in Europe.

8.4 Commodity market summary and outlook

Although global primary nickel production has increased by around 40% during the last years (2019-2023: 41%; 2020-2023: 35%), the additional capacity mostly comes from Indonesia (Figure 4, Figure 5, Figure 17, Figure 23). Indonesia has seven-folded its nickel production in the last 10 years (USGS mineral commodity summaries) largely with Chinese investments, and in 2023, the country produced between 50-55% of global nickel supplies (International Nickel Study Group, 2024; USGS, 2024). Indonesia has the capacity to increase the global share of nickel production to >70% by the end of the decade due to an expected structural change in the nickel market: while Indonesia is increasing its capacities, refineries but also mines outside of Indonesia and China face increasing cost-curve pressure and may be forced to or are closing their production (SMM, 2023) (see also S&P Global projection in (S&P Global Market Intelligence, 2024) in Figure 21).

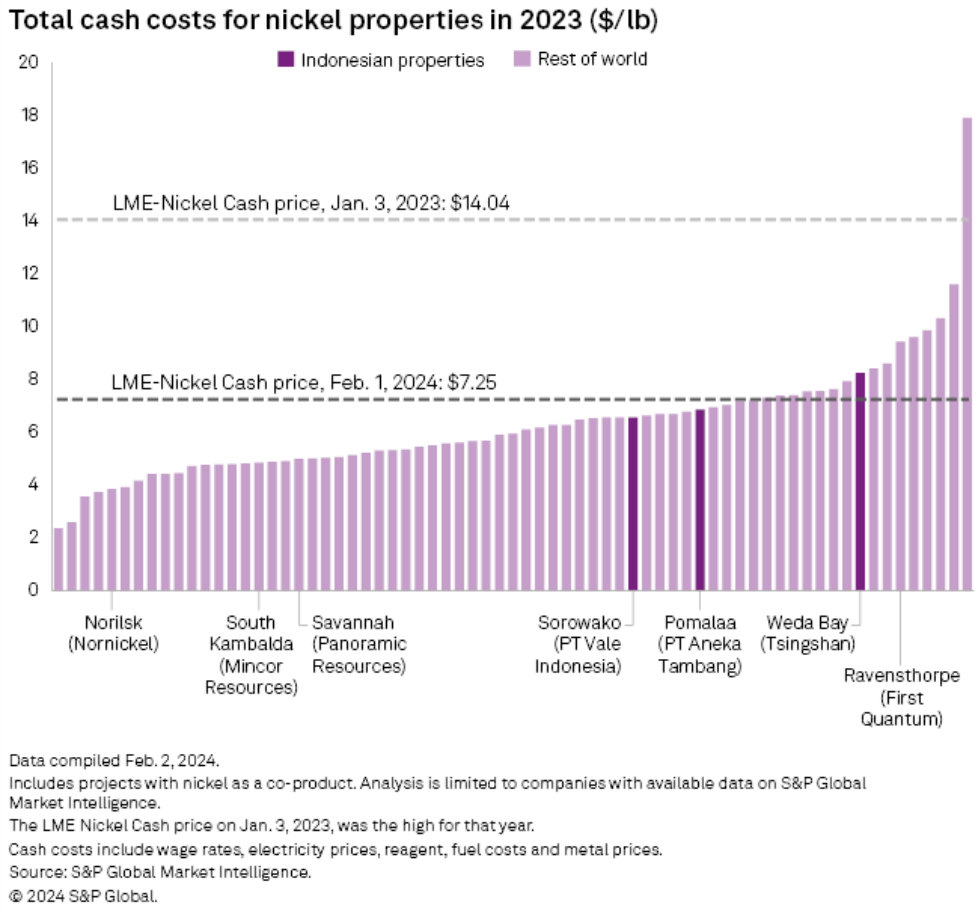


Figure 21: Cash cost curve for Ni properties in 2023 with LME-Nickel Cash Price levels (S&P Global Market Intelligence, 2024)

Furthermore, Indonesia's export restrictions (also illustrated in Figure 5 and Figure 22) and its continued investment in value-added downstream activities have made the country the nexus for the global Ni market. Driven by increased Indonesian production, Ni prices dropped by 45% during the year 2023 and are currently around 17,800 USD/t - Nickel LME cash official prompt price, USD/t, in warehouse (Miningweekly.com). This has created profitability problems for most of the nickel-producing companies worldwide. At 18,000 USD, about 35% of global nickel production is unprofitable, and at 15,000 USD, about 75%. The average production cost in Australia is currently 17,000 USD/t. Consequently, despite the future need for more nickel, operations are closing, which will further increase Indonesia's market share (S&P Global Market Intelligence, 2024).

Figure 22: Countries with nickel export restrictions in 2021. Indonesia's nickel export prohibition applies for a concentration level above 93% Ni. (OECD, 2021)

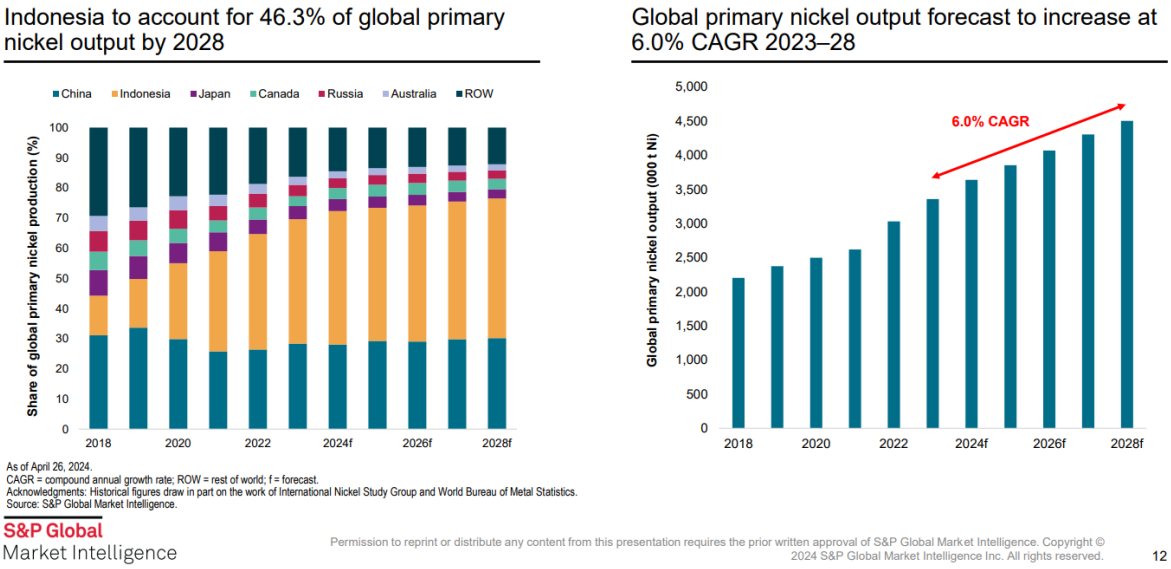


Figure 23: The rise of Indonesian Ni production. Left: Share of global primary Ni production in % (2018-2028). Right: Global primary Ni output compound annual growth rate is projected to be at around 6%. (S&P Global Market Intelligence, 2024).

Indonesia aims to strengthen its position in the global nickel market and maximise the economic benefits of its resources. This aim has been supported by several domestic factors, including government policies that encourage domestic processing and refining, and a

strategic focus on meeting the rising global demand for EV batteries with raw materials supply and efforts towards an integrated domestic EV battery supply chain (Centre for Strategic and International Studies, 2021). More specifically, Indonesia banned the export of raw nickel ore from January 2014 (with a temporary exception for ores from low nickel deposits in January 2017 and December 2019). The country also issues production quotas, known by the Indonesian acronym RKAB (Rencana Kerja dan Anggaran Biaya). Recently, Indonesia extended the validity of these production permits from one year to three years to reduce bureaucracy and provide some stability to mining companies in planning their long-term operations. Indonesian export restrictions on nickel were subject to a WTO complaint by the EU initiated in 2019. (World Trade Organization, 2022; Centre for Strategic and International Studies, 2021) In October 2019, Indonesia updated their regulations on nickel exports to boost domestic value-addition. Effective January 1, 2020, the export of low-grade nickel (below 1.7% Ni) was banned. Companies must now establish smelters in Indonesia, with stringent penalties for non-compliance. This is part of Indonesia's broader goal to foster domestic processing industries and support its electric vehicle ambitions (Norton Rose Fullbright, 2019).

Secondly, low energy prices in Indonesia provide the country with a cost advantage, although Indonesian nickel is primarily found in low-concentration deposits beneath the rainforest floor, requiring large amounts of energy for extraction, which involves crushing the mined ore, converting it into a slurry, and treating it with acid under high pressure. Much of this nickel (i.e., NPI) is produced using coal-powered energy, resulting in higher carbon emissions per metric ton than other methods. Producing one metric ton of Class I nickel in Indonesia creates six times more emissions than nickel production in Australia (Figure 24) and is responsible for further severe environmental impacts (Horner & Hool, 2024; IEA, 2021).

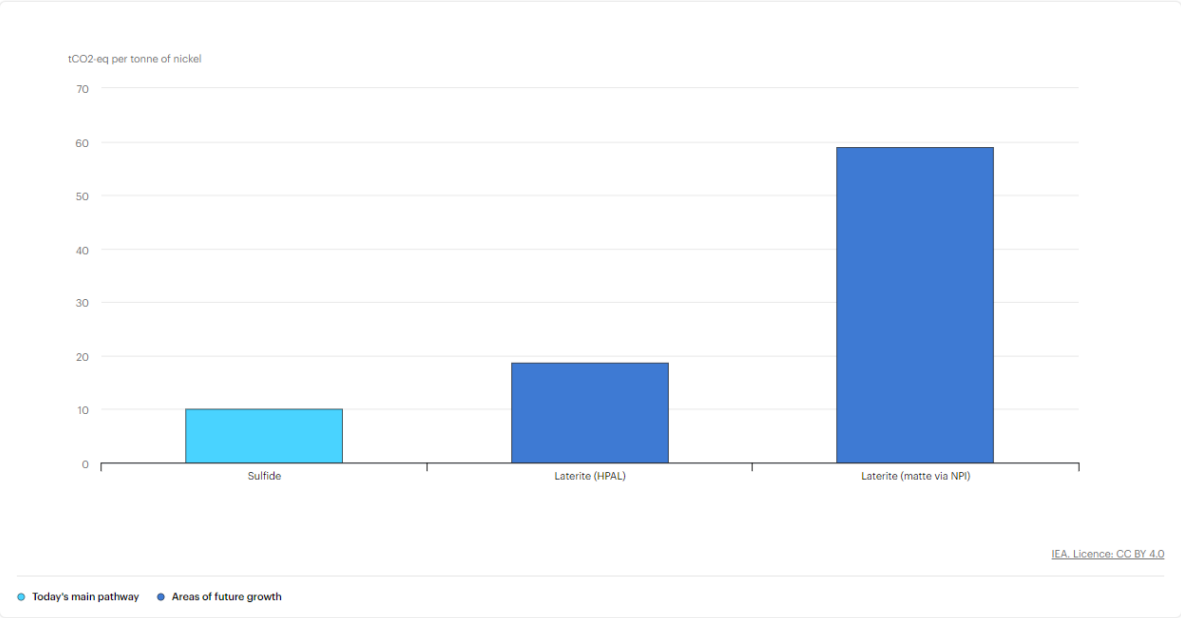


Figure 24: Total CO_2 eq. Per tonne of Ni by production pathway (IEA, 2021).

Indonesia's high-emission nickel output is currently pricing out low-emission metal, which has failed to command a market premium so far. There have been calls for the London Metal Exchange by miners outside Indonesia to expand its responsible sourcing policy to include environmental due diligence. However, the LME believes there are currently not enough buyers to support a green premium. Moreover, defining the criteria for "green" nickel remains challenging due to the lack of standardised methods for measuring emissions across the industry (Horner & Hool, 2024). Finally, with demand growth in electric vehicles worldwide slower than projected, current market prices do not reflect nickel's (future) economic importance. However, there still seems to be a consensus that the battery and electric vehicles sector (Figure 26) will be a further and increasingly relevant driver for Ni prices (USGS, 2023) (S&P Global Market Intelligence, 2024).

Although a significant increase in demand is projected, numbers vary between 20% to over 70% increase (see source below), depending on the scenario and the reference year. One controlling factor is the development of Ni-free batteries which would affect the energy transition demand for Ni drastically (Figure 27). The IEA projects an almost 73% increase (APS) in total Ni demand between 2021 and 2030 (Table 1) and puts the overall supply risk for Ni at a low 6% (IEA, Nickel, IEA, Paris , 2024).

Table 1: IEA nickel demand forecast up to 2030 and 2040, based on the announced pledges scenario (APS), for cleantech applications and other uses (including the steel sector). The share of the top three mining and refining countries' value refers to the countries listed in Figure 25.

Milestones (APS)	2021	2023	2030	2040
Cleantech demand (kt)	**240**	**478**	**1 953**	**3 381**
Other uses (kt)	2 519	2 627	2 802	2 857
Total demand (kt)	**2 759**	**3 104**	**4 754**	**6 238**
Secondary supply and reuse (kt)	10	43	139	613
Primary supply requirements (kt)	**2 749**	**3 061**	**4 615**	**5 625**
Share of top three mining countries	60%	69%	76%	83%
Share of top three refining countries	66%	71%	71%	73%

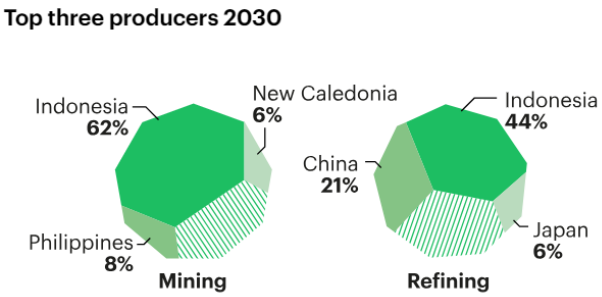


Figure 25: Top three mining and refining producers 2030, as projected by IEA (IEA, Nickel, IEA, Paris , 2024).

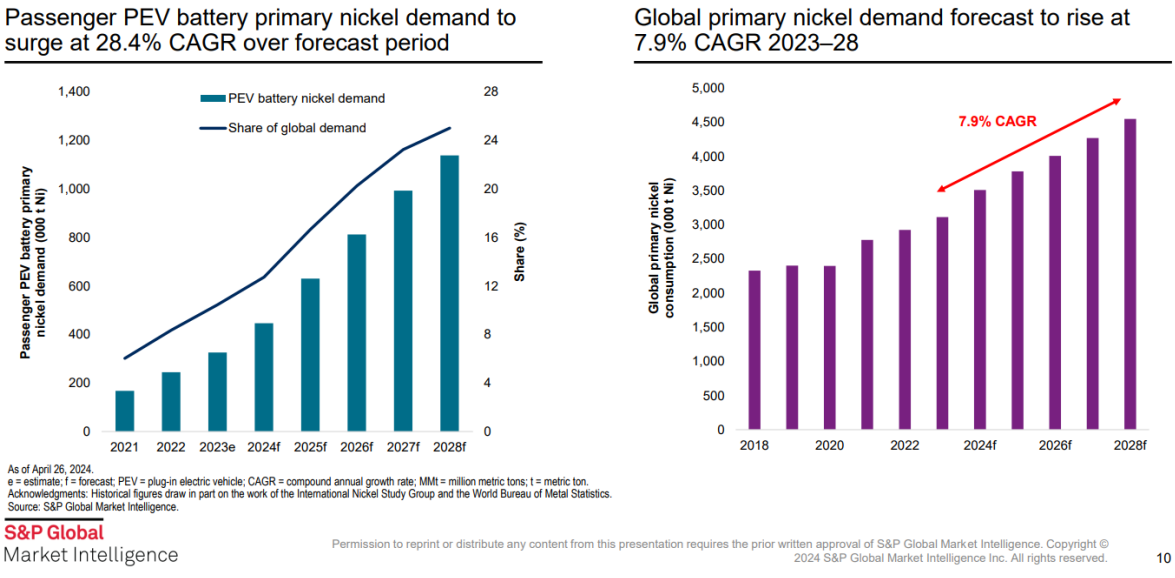


Figure 26: Demand forecast for battery-grade Ni and global primary consumption in 1000 metric tons (S&P Global Market Intelligence, 2024). Although various sources agree that a significant demand increase is eminent, this surge is largely driven by the EV sector and recent projections have been a bit more conservative than initial forecasts (see 8.4).

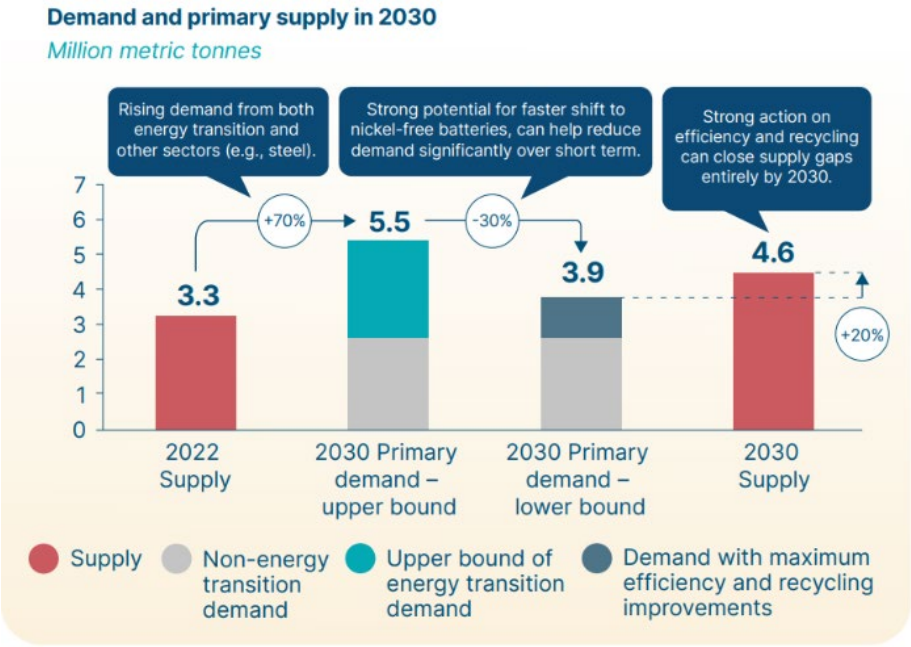


Figure 27: The Energy Transition Commission projects a similar Ni demand increase to numbers reported by the IEA (Energy Transitions Commission, 2023). If a faster shift toward nickel-free batteries is achieved, 2030 Ni supply will exceed overall Ni demand due to the reduced demand by the battery sector.

8.5 Country risk scores

Table 2: Risk scores for the main nickel-producing countries in 2022 and 2023. Risk level: 0.1-0.7: Low, 0.8-1.5: Moderate, 1.6-2.3: Elevated, 2.4-3.1: High, 3.2-4.3: Very high, 4.4-6.4: Severe, 6.5-10: Extreme. Production numbers for 2023, as well as the 2022 figures for the Philippines and Russia, are estimated (WMD, 2024; S&P Global, 2024; USGS, 2024).

Country	Production 2022 WMD (t)	Production 2023 USGS (t)	Economic	Legal	Operational	Political	Security	Tax	Overall
Australia	155,007	160,000	1.10	1.10	1.40	1.50	1.20	1.60	1.30
Brazil	79,370	89,000	2.10	1.90	2.90	2.00	1.80	2.80	2.30
Canada	143,266	180,000	1.50	1.10	1.50	1.30	1.20	1.40	1.30
China	109,400	110,000	1.30	2.30	2.40	1.80	1.70	2.00	1.90
Indonesia	1,593,400	1,800,000	1.80	2.30	2.70	1.90	2.40	1.90	2.20
New Caledonia	199,951	230,000							
Philippines	345,200	400,000	1.60	2.30	2.70	2.00	2.60	2.10	2.20
Russia	220,000	200,000	5.20	5.20	4.00	2.70	2.60	4.00	4.00
United States	17,500	17,000	0.80	1.20	1.60	1.70	2.20	1.50	1.50

A recent paper by (Sun, et al., 2024) quantifies the number of mined materials owned by foreign direct investment (FDI) for four critical materials, including Nickel. A supply risk index (SRI), which allocates 'production' of materials to the origin of investors, is proposed, composed of three sub-indicators: import dependency, the share of national imports in global imports, and the likelihood of supply disruption. For the case of Nickel, some interesting data is shown in Figure 1c, where we see a large portion of Nickel mined in Indonesia run by operators (such as Tsingshan) from China. From a global perspective, considering the country of the origin of FDI as the owner of a material production site leads to lower supply concentration measured using

the Herfindahl–Hirschman Index (HHI). For individual countries, adjusting for FDI can reduce the supply risk, although the likelihood of supply disruption (which considers political stability in addition to HHI) usually increases when considering the impact of FDI. In Europe, the main country assessed for supply risk is Finland, and in this case, supply risk increases after adjusting for FDI, mainly due to increased national imports as a share of global imports. Similar results are seen for Germany, Italy, and Cyprus.

8.6 EU trade flows

This chapter presents EU trade data maps by HS code for the following products.

Table 3: HS codes and product descriptions for the presented trade data.

HS Code	Product description
750110	Nickel mattes
750120	Nickel oxide sinters and other intermediate products of nickel metallurgy
750210	Nickel, unwrought, not alloyed
750220	Nickel, unwrought, alloyed
750400	Nickel powders and flakes
720260	Ferro-Nickel

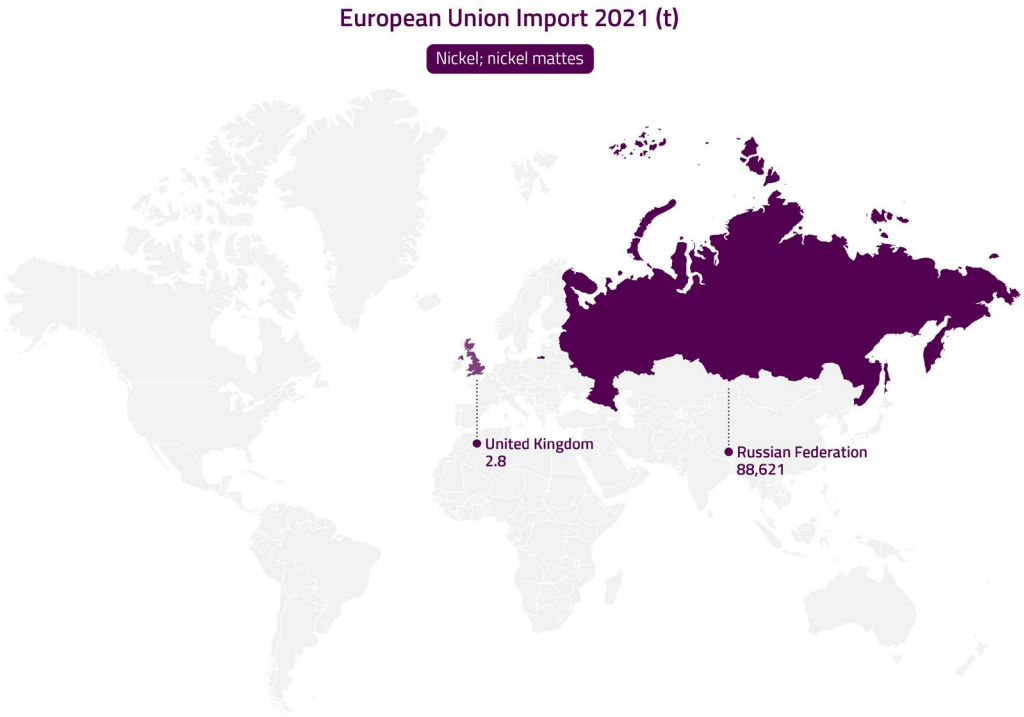


Figure 28: EU imports of 750110 ((EIT RawMaterials, 2023).

Figure 29: EU imports of 750110 (EIT RawMaterials, 2023).

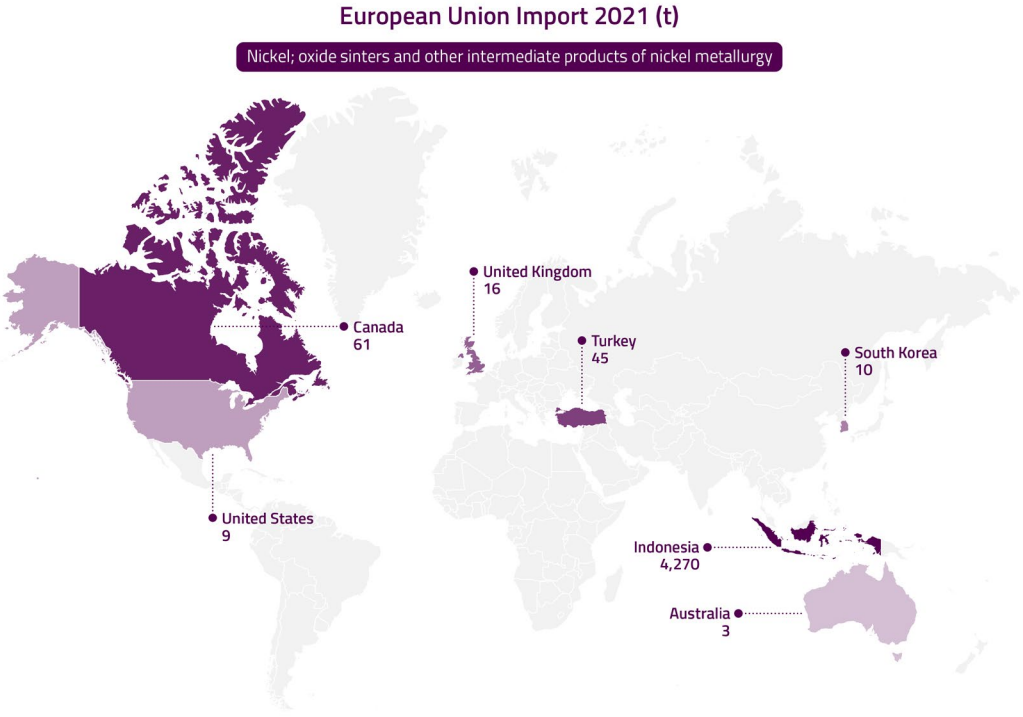


Figure 30: EU imports of 750120 (EIT RawMaterials, 2023).

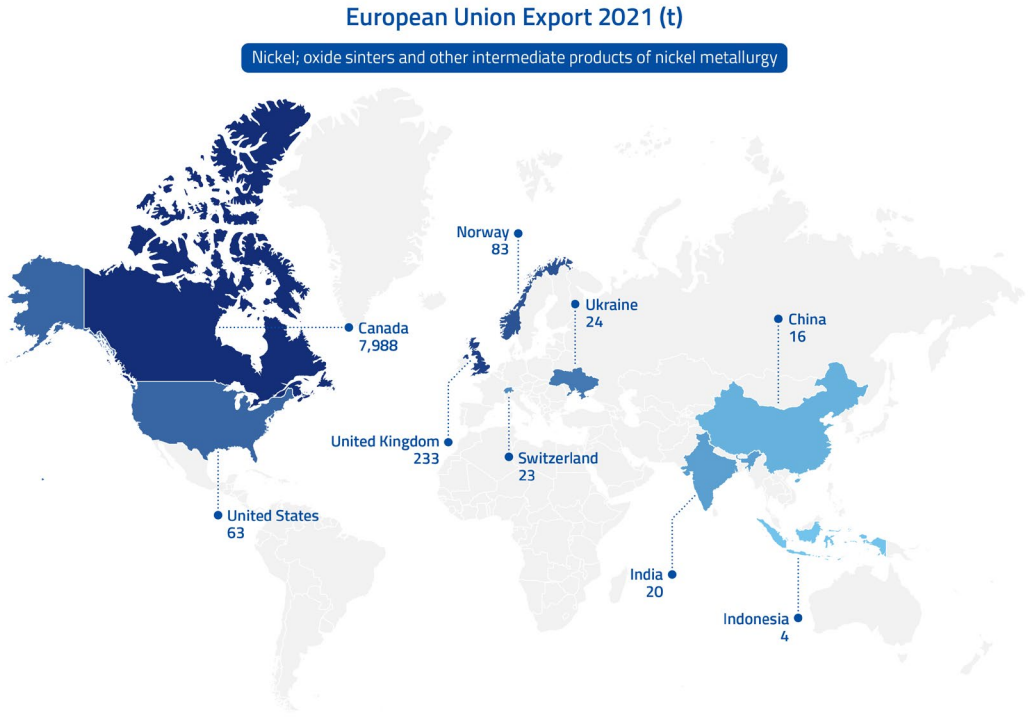


Figure 31: EU exports of 750120 (EIT RawMaterials, 2023).

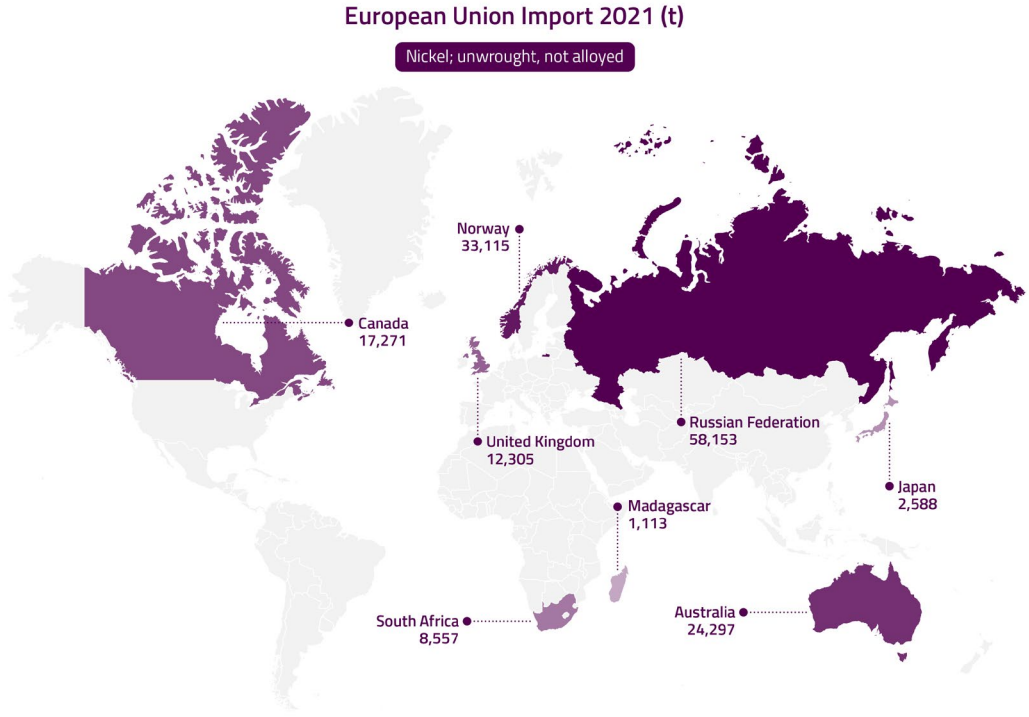


Figure 32: EU imports of 750210 (EIT RawMaterials, 2023).

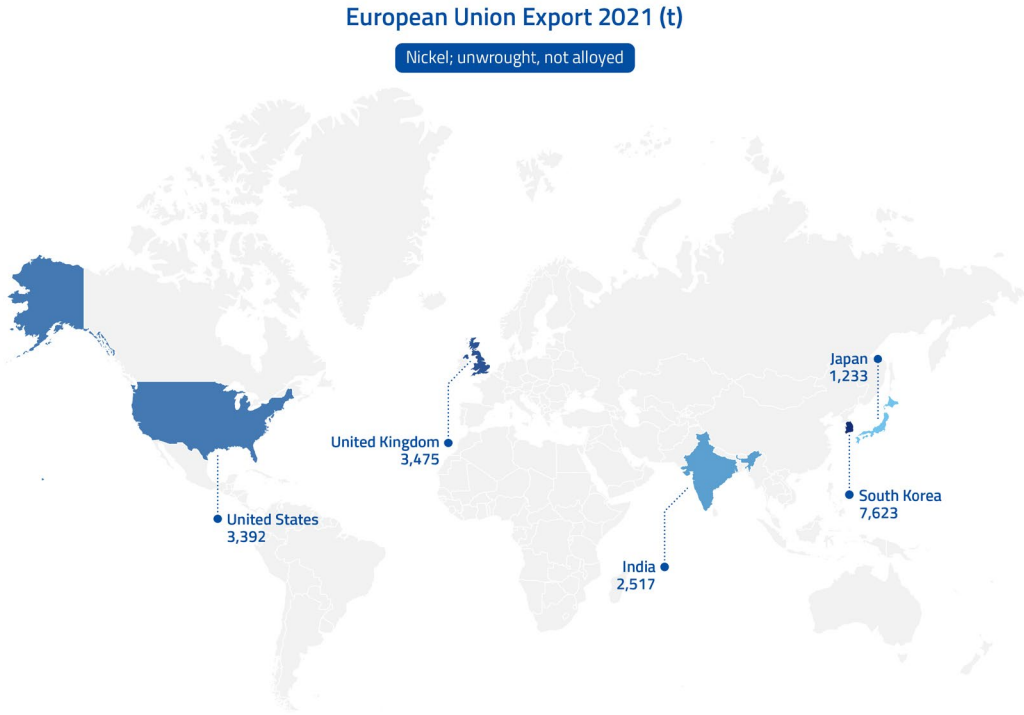


Figure 33: EU exports of 750210 (EIT RawMaterials, 2023).

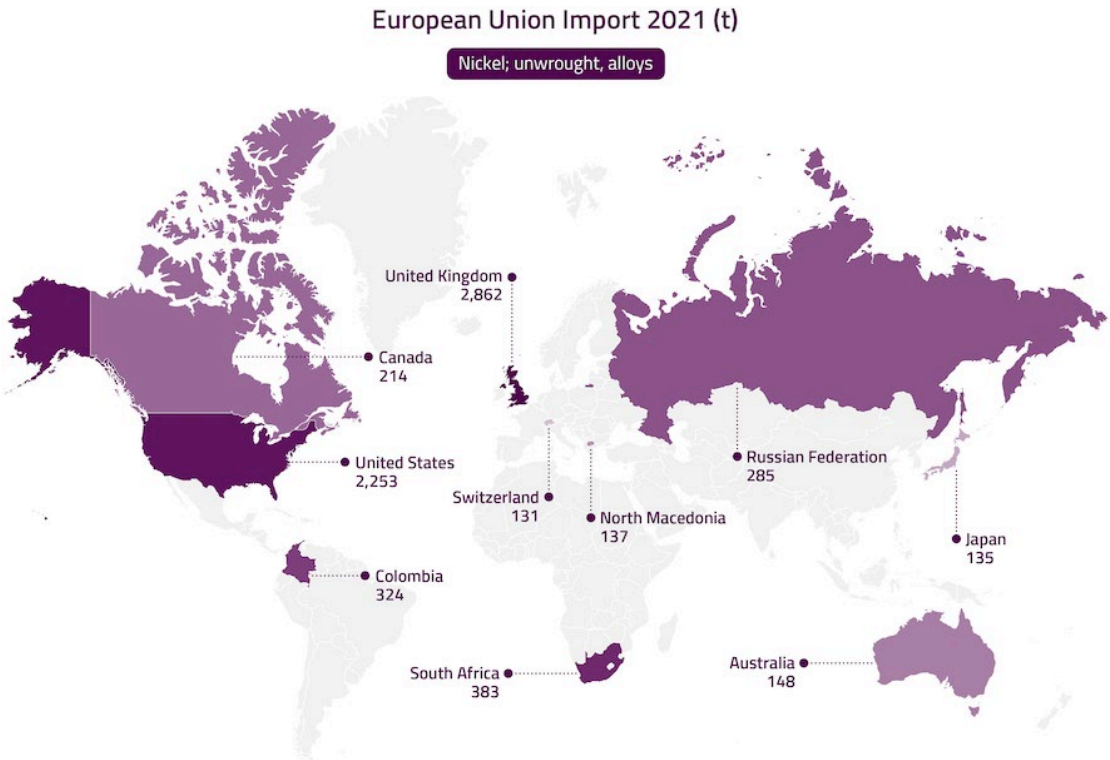


Figure 34: EU imports of 750220 (EIT RawMaterials, 2023).

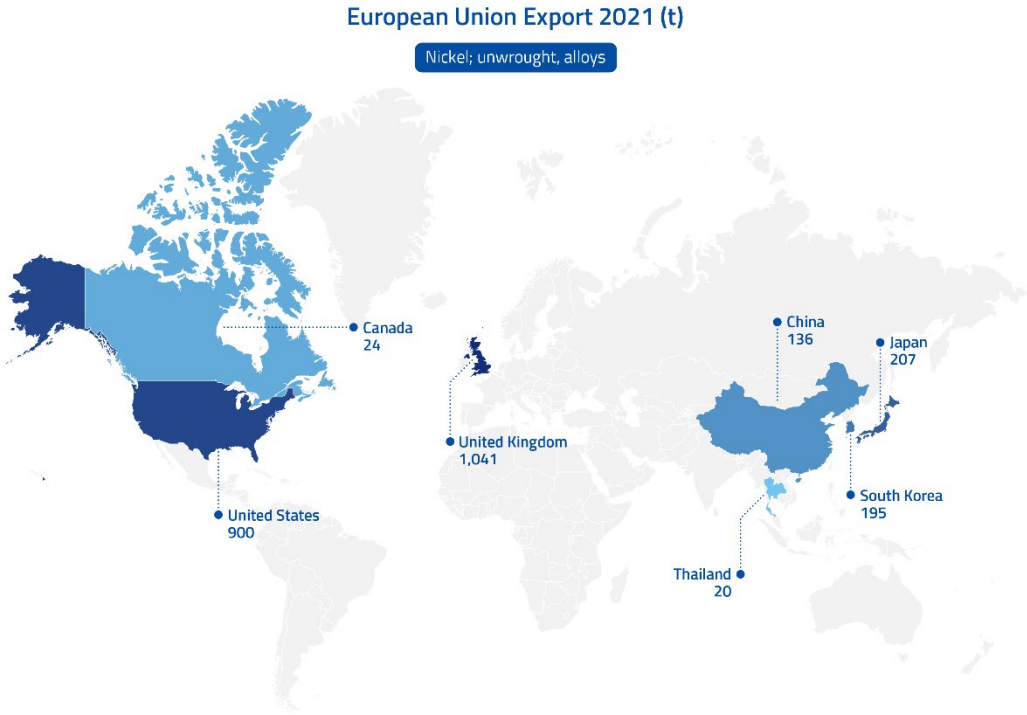


Figure 35: EU exports of 750220 (EIT RawMaterials, 2023).

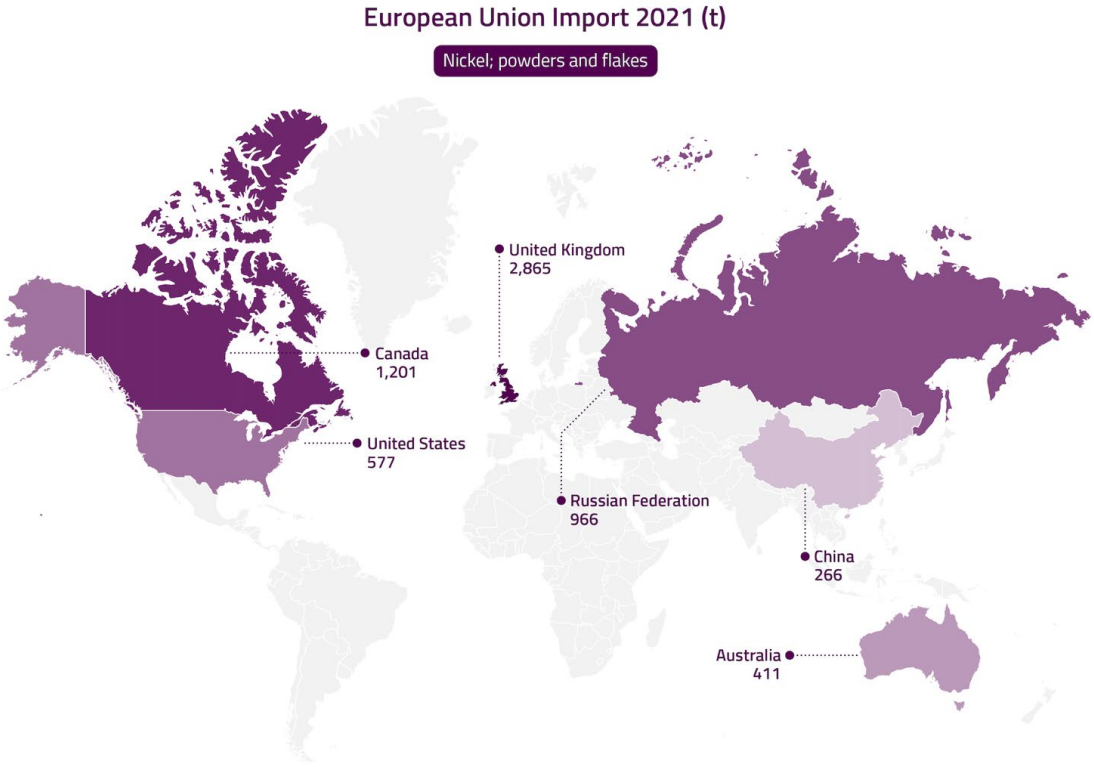


Figure 36: EU imports for 750400 (EIT RawMaterials, 2023).

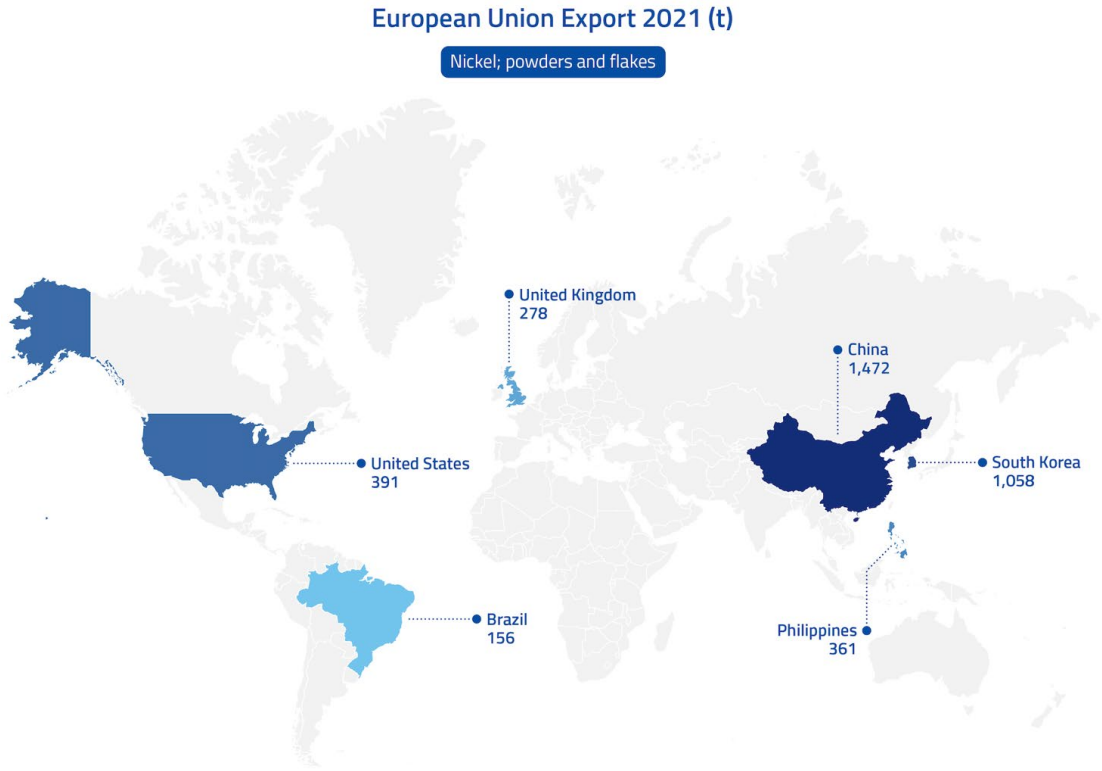


Figure 37: EU exports for 750400 (EIT RawMaterials, 2023).

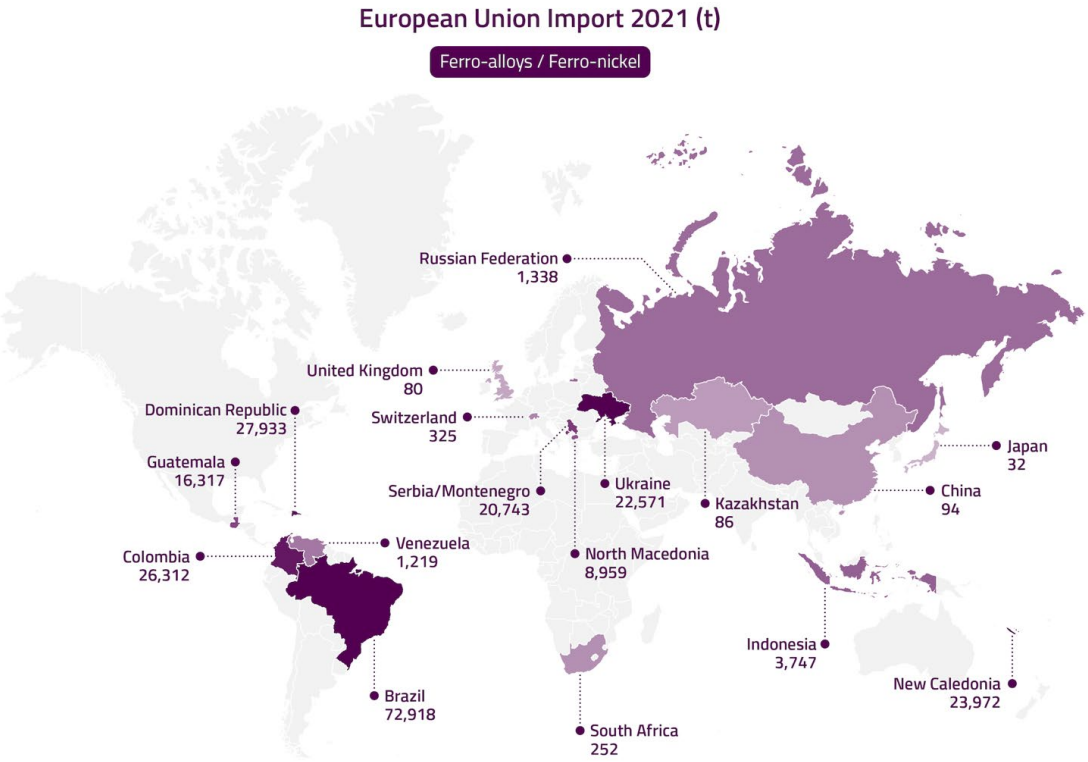


Figure 38: EU imports for Ferronickel by quantity (EIT RawMaterials, 2023).

Figure 39: EU exports for Ferronickel by quantity (EIT RawMaterials, 2023).

9 TUNGSTEN

9.1 Commodity assessment and outlook

Tungsten is a highly critical material that is also classed as a conflict mineral as part of the 3TGs (European Commission, 2021). Its applications range from cemented carbide parts for cutting and wear-resistant applications, metalworking, mining, and oil- and gas-drilling industries to various alloys and specialty steels; electrodes, filaments, wires, and other components for electrical, electronic, heating, lighting, and welding applications; and chemicals for various applications (USGS, 2024). The automotive sector is currently the largest consumer of tungsten products (25% of total consumption globally). However, Argus Media forecasts a negative growth rate of 2% in the years ahead for tungsten in the automotive sector because electric vehicles use significantly less tungsten than combustion engine cars. Currently, it is the defence sector that has the highest growth in terms of demand due to geopolitical issues in Eastern Europe and the Middle East (Argus Media, 2024). Additionally, semiconductor producers such as TSMC and NVIDIA use tungsten, adding supply chain pressure to highly strategic technology, Artificial Intelligence and computing power.

Tungsten and ferro-tungsten prices were at 6-year highs, correlated to supply issues in China. However, Argus Media report that the medium-term supply picture is likely to be boosted by new projects coming on-stream in 2024 and 2025. Also, more recent assessments by MetalsHub (2024) state that despite a positive outlook fuelled by Europe's widely discussed plans to enhance its military capabilities, ferro-tungsten prices have struggled to maintain their recent highs. The competitive pricing from Chinese exporters has prompted certain European traders to adopt aggressive pricing strategies once again. As a result, most transactions are currently occurring at $42-43/kg W DDP, with higher prices achievable in smaller lot deals (2-3 tonnes). Since the beginning of June, prices have seen a decrease of at least $1.5/kg W, settling now at $42-44/kg W DDP (MetalsHub, 2024).

9.2 Secondary production

Tungsten and ferrotungsten already have a comparatively high recycling rate of 30 to 40% (Joint Research Centre, 2023; Hool, et al., 2022; ITIA, 2024) and scrap, i.e., secondary sources, will likely play an increasingly important supply role. Tungsten scrap, due to its high tungsten content in comparison to ore, is a valuable raw material (International Tungsten Industry Association, 2023). Recycling contributes 25 to 30% of meeting the overall global demand for tungsten. The recycling rates for hard metal tools and heavy metal parts range from 50 to 75%. There is potential to further increase recycling rates in energy, lighting, and chemical applications.

In Germany, H.C. Stark Tungsten, which was acquired by Japanese multinational Mitsubishi Materials earlier this year (2024), engages in recycling of two primary types of tungsten carbide scrap: hard scraps from tools used in various industries and soft scraps such as

grinding sludges. Their recycling methods include both direct physical recycling and holistic chemical recycling, allowing the breakdown of hard metal into its individual components for processing diverse types of scrap. (Hool, et al., 2022)

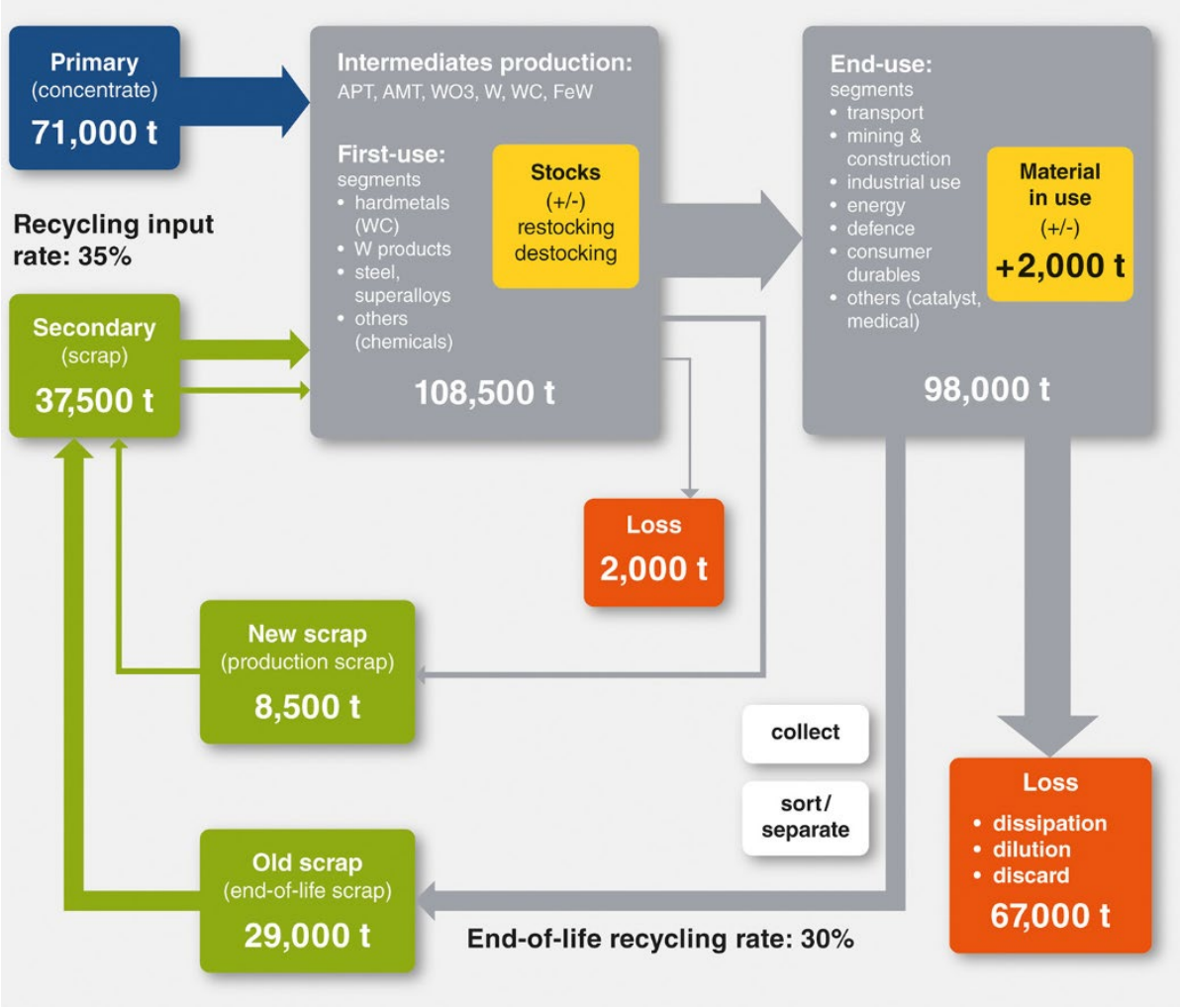


Figure 40: Material flow chart for tungsten and its various product streams. The numbers represent 2016 data based on an ITIA publication from 2018 (Zeiler, Bartl, & Schubert, 2021). Considering that the current (2023) primary tungsten concentrate production is at around 80,000 metric tons, this graph can still give an adequate overview.

9.3 Market concentration

Tungsten has one of the highest HHI, only exceeded by niobium and REE on the HHI scale. Anything above 2,500 is considered a highly concentrated marketplace, and based on our own calculations and USGS data, tungsten mine production and reserves sit at 4,190 and 3,795, respectively. Other sources report even higher indices, e.g., 6,000 (WMD, 2024).

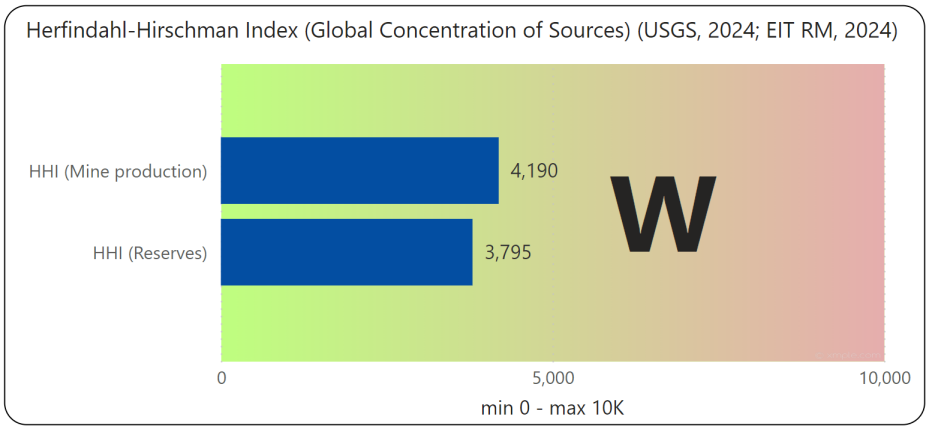


Figure 41: Tungsten HHI indices for mine production and reserves (EIT RawMaterials, 2024; USGS, 2024).

Tungsten mining is heavily concentrated in China, with over 80% of global mine production and close to 50% of global reserves (see also Figure 45) located in China (ITIA, 2024). Recent USGS data (Figure 44) indicate a market share of almost 84% for mine production (USGS, 2024) (see also Figure 44). A recent study by Liang et al. (2022) sheds light on the internal Chinese tungsten cycle (including production volumes in kt) from mining through to beneficiation and recycling, highlighting significant resource inefficiencies (see Figure 42). Liang et al. (2022) also report that 84% of tungsten concentrates within China are produced in the Jiangxi, Hunan and Henan provinces.

Figure 42: China's domestic tungsten cycle in metric kilotons (Jing-Jing Liang, 2022).

The dominant role of China in the tungsten market along the entire supply chain is illustrated in Figure 43. China rose to its current position from around 35% market share up until the 1980s and has steadily increased its output and market share since then. In addition to Russia, whose share has dropped in recent years, new players supplying tungsten in the mining and processing stages have emerged, including Vietnam, Rwanda, and, within Europe, Austria, Spain and the UK (see also 9.3.1).

Tungsten value chain country share for the top 3 producing countries

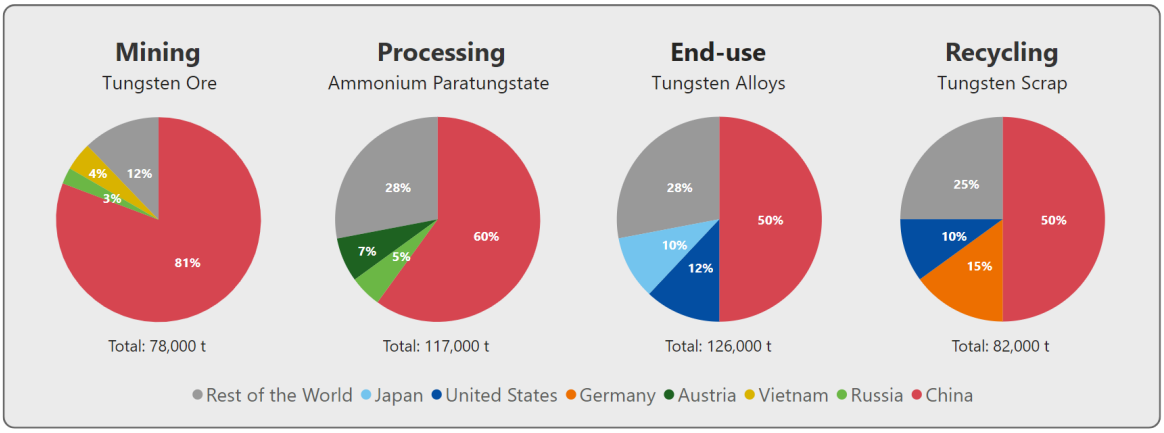


Figure 43: Tungsten supply chain production share for the top 3 companies and the rest of the World in 2023 (EIT RawMaterials, 2024; USGS, 2024).

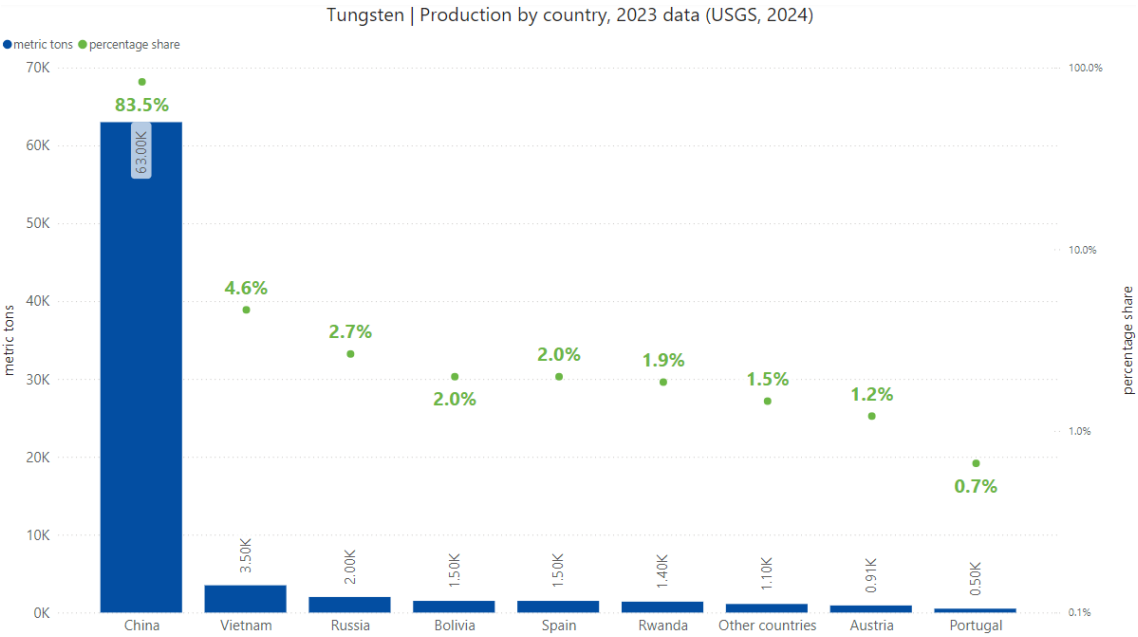


Figure 44: Tungsten production by country in 2023 and corresponding overall percentage share (USGS, 2024). China dominates the output, accounting for nearly 84% of mine production.

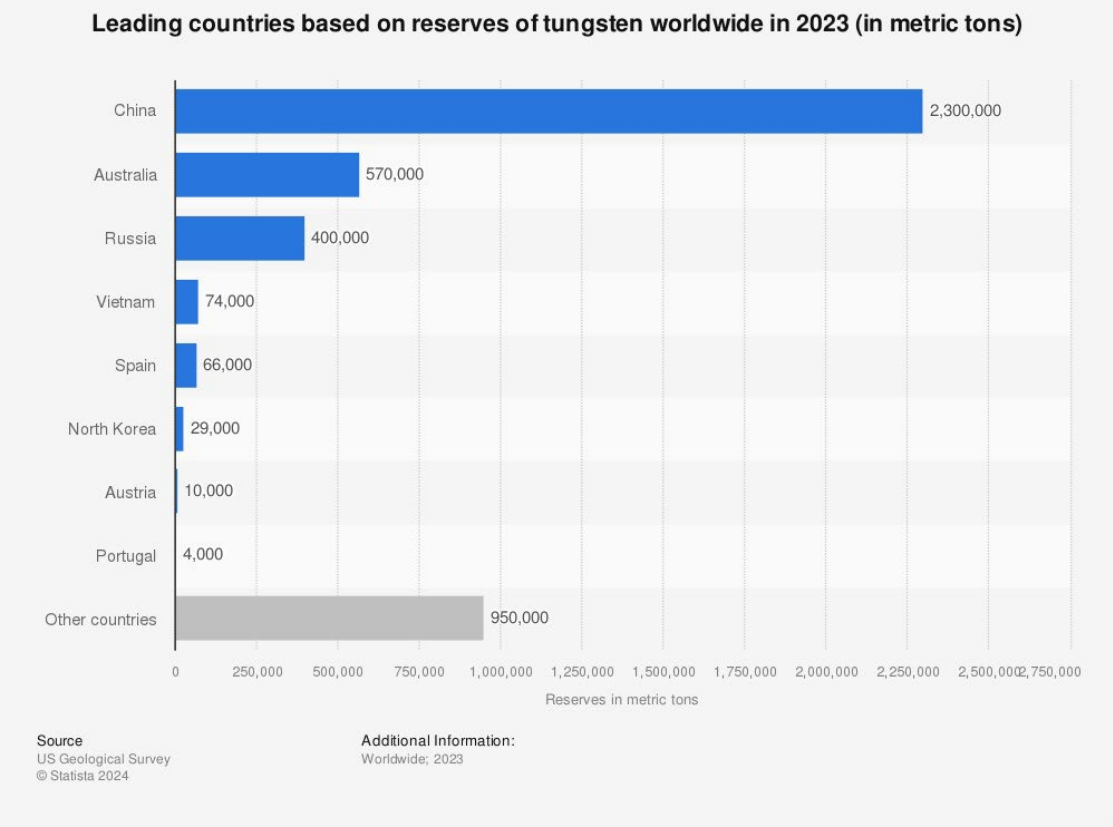


Figure 45: Global tungsten reserves, similar to the production values, are dominated by China. Australia and also Canada (not listed here) see significant potential to develop its tungsten reserves as a counterpoint to Chinese dominance.

According to a recent research article coming out of Russia, Russia is, in contrast to what is shown by other references, not a significant producer of ferrotungsten (Boyarko, Khatkov, & Bolsunovskaya, 2021). They also reported (before the invasion of Ukraine!) that *'the problematic Russian tungsten industry is unattractive for investors'*. The same authors expand on the topic in more recent papers (Boyarko G. , 2023; Boyarko G. , 2023; Boyarko G. , 2023).

9.3.1 Ownership Structure

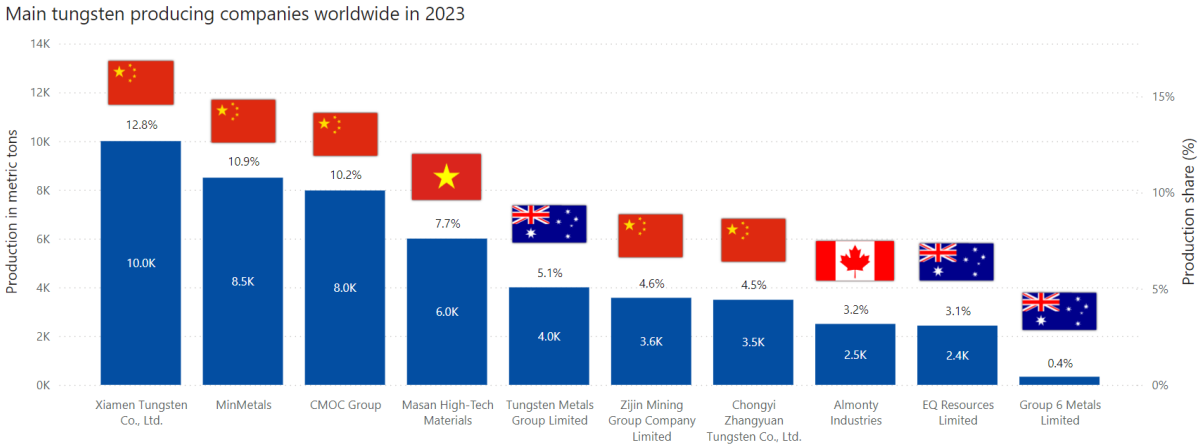


Figure 46: Top tungsten-producing companies worldwide in 2023, including their production volume in metric tons, global production share %, and owner country (EIT RawMaterials, 2024; USGS, 2024). This is, unfortunately, not a comprehensive list due to market intransparency and lack of reported numbers, especially from China. However, more detail on the ownership structure can also be found in Table 4 and Appendix B – Tungsten Ownership Table.

Demand for tungsten from outside of China is already on the rise. Kazakhstan, Canada and Australia have significant mining potential but are still in pre-production, i.e., exploration or advanced exploration stages. EQ Resources Limited, an Australian mining company with Cronimet (Germany) as a 7% shareholder, runs the Saloro-Barruecopardo mine in Spain and the Mt Carbine project in Australia, which both can become strategic suppliers for the EU. Vietnam is a further significant player, behind China and the UK. Almonty Industries, a Canadian mining company, claims their forthcoming mine in South Korea has the potential to produce 50% of the world's ex-China tungsten supply with the world's largest tungsten mine (Almonty Industries, 2024).

In Europe, Spain, Portugal and Austria produce tungsten and have resource potential. Wolfram (Wolfram Bergbau und Hütten AG), an Austrian company owned by the Sandvik Group (Sweden), operates the Mittersill mine in Austria. Their processing facility is also based in Austria, while their recycling branch is located in India (Figure 47). Their operations put them in the top 3 producers of ammonium paratungstate (see Figure 43). The UK also has a relevant stake in terms of global market share with Tungsten West PLC (Figure 46).

Table 4: Countries and owner names of operating and active tungsten mines (where tungsten is the primary commodity), including owner share (S&P Global, 2024).

Property	Owner 1 Name	Owner 1 Country	Owner 1 Share	Owner 2 Name	Owner 2 Country	Owner 2 Share
ATC Smelter	Tungsten Metals Group Limited	Australia	60	Boundary Gold and Copper Mining Ltd.	Canada	40.00
Barruecopardo	Oaktree Capital Management, L.P.	Australia	100			
Dajishan	Jiangxi Tungsten Industry Group Co. Ltd.	China	100			
Dangping	Jiangxi Tungsten Industry Group Co. Ltd.	China	100			
Dolphin	Group 6 Metals Limited	Australia	100			
Drakelands	Tungsten West PLC	United Kingdom	100			
Duchangyang Chushan	Xiamen Tungsten Co. Ltd.	China	100			
Gifurwe	Wolfram Mining and Processing Ltd.	Rwanda	100			
Hengyang Yuanjing	Hunan Nonferrous Metals Corporation Limited	China	100			
Luoyang Yulu Hui	Xiamen Tungsten Co. Ltd.	China	60	CMOC Group Limited	China	40.00
Malipo Nanwenhe	Zijin Mining Group Company Limited	China	100			
Mittersill	Wolfram Bergbau und Hütten AG (Sandvik Group)	Austria	100			
Mt Carbine	EQ Resources Limited	Australia	100	CRONIMET Holding GmbH	Germany	0.00
Nui Phao	Masan High-Tech Materials Corporation	Vietnam	100			
Panasqueira	Almonty Industries Inc.	Canada	100			
Pangushan	Jiangxi Tungsten Industry Group Co. Ltd.	China	100			
Shizhuyuan	Hunan Nonferrous Metals Corporation Limited	China	100	Unnamed Owner	USA	0.00
St Martin Refinery	Wolfram Bergbau und Hütten AG	Austria	100			
Xintianling	Hunan Nonferrous Metals Corporation Limited	China	100			
Zhuying Smelter	Hunan Nonferrous Metals Corporation Limited	China	100			

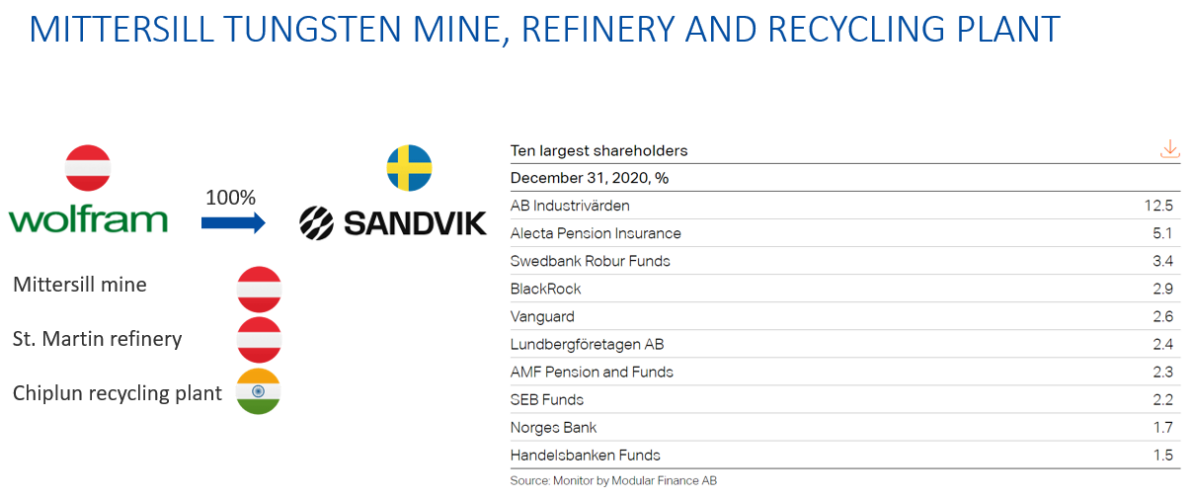


Figure 47: Ownership-distribution for the Mittersill tungsten mine, refinery and recycling plant.

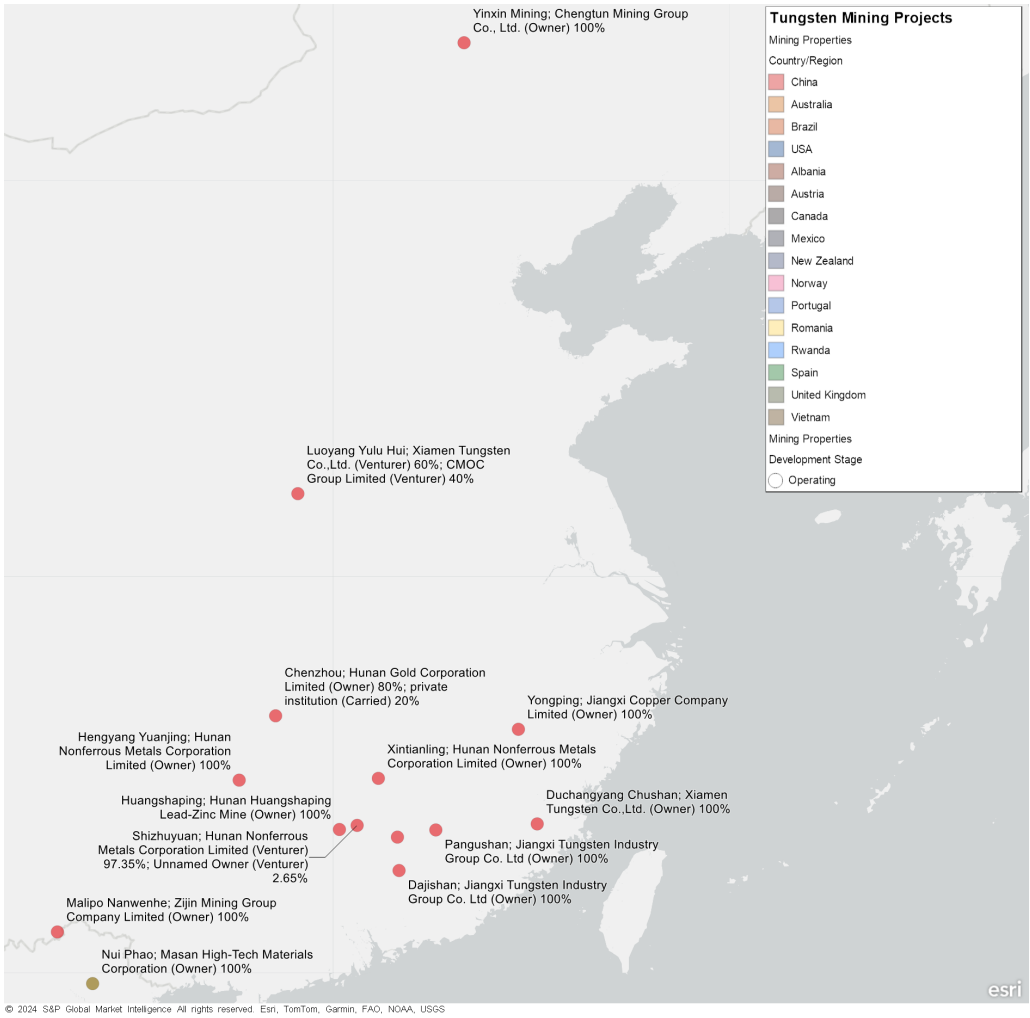


Figure 48: Location and ownership details of operating and active tungsten mining projects in China and Vietnam as available on S&P Global (S&P Global, 2024).

Figure 49: Australian and New Zealand operating and active tungsten mining projects, including ownership information, as available on S&P Global (S&P Global, 2024).

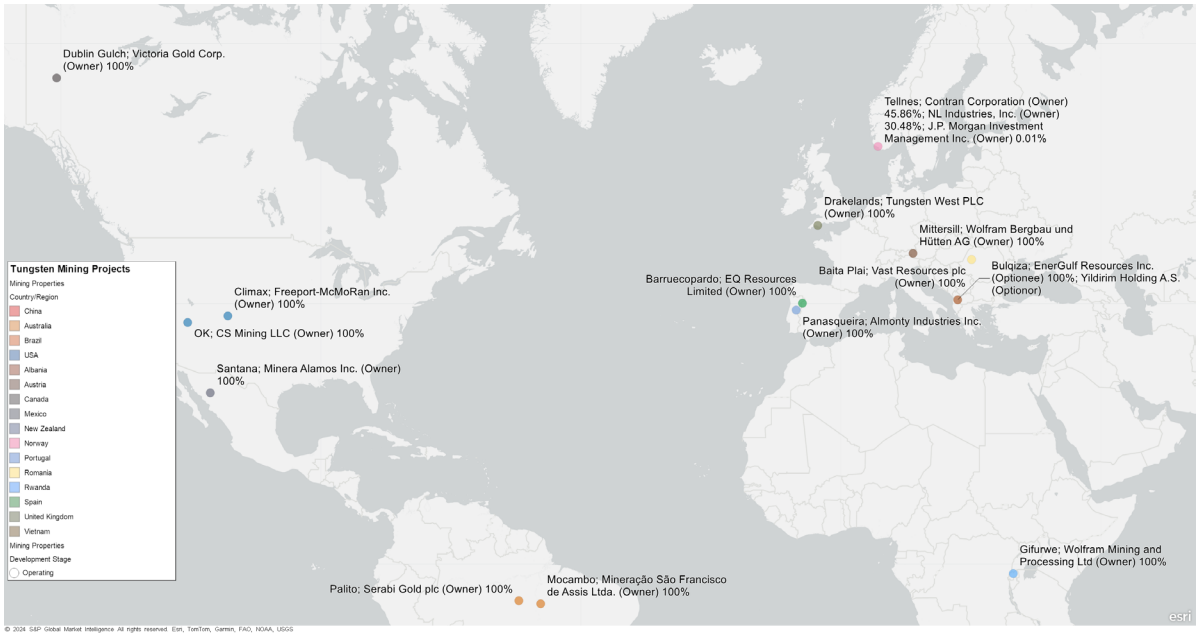


Figure 50: : Rest of the World operating and active tungsten mining projects, including ownership information, as available on S&P Global (S&P Global, 2024).

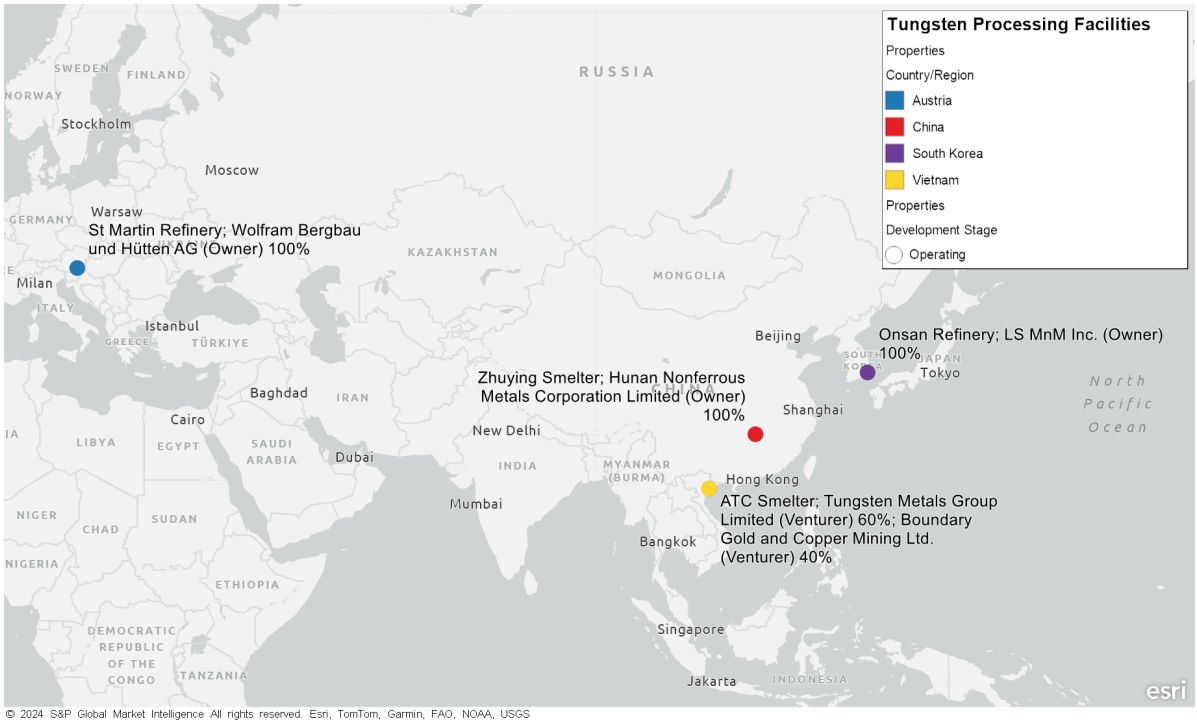


Figure 51: Location, name and ownership information of active and operating tungsten processing/refining projects as available on S&P Global (S&P Global, 2024).

9.4 Country risk scores

China and Vietnam have moderate risk scores but score higher than European sources or Australian producers. Russia, Congo, and North Korea have, by far, the highest associated risk scores. Although risk scores for China may be moderate, due to its dominance, there is a significant risk that it controls market prices and supply flows, leading to potentially strategically detrimental supply gaps for the EU and other parts of the World.

Table 5: Risk scores for the main tungsten-producing countries in 2022. Risk level: 0.1-0.7: Low, 0.8-1.5: Moderate, 1.6-2.3: Elevated, 2.4-3.1: High, 3.2-4.3: Very high, 4.4-6.4: Severe, 6.5-10: Extreme. Production numbers for 2023, as well as the 2022 figure for Russia, are estimated (S&P Global, 2024; WMD, 2024).

Country	Production 2022 WMD (t)	Production 2023 USGS (t)	Economic	Legal	Operational	Political	Security	Tax	Overall
Australia	180	800	1.10	1.10	1.40	1.50	1.20	1.60	1.30
Austria	910	910	1.90	1.30	1.50	1.60	1.50	1.20	1.50
Bolivia	1,358	1,500	3.00	3.40	3.60	3.00	2.10	3.10	3.00
China	65,620	63,000	1.30	2.30	2.40	1.80	1.70	2.00	1.90
North Korea	1,520	1,700	3.90	5.40	4.20	2.40	1.30	4.60	3.60
Portugal	448	500	2.00	1.50	1.80	1.90	1.10	1.70	1.70
Russia	2,000	2,000	5.20	5.20	4.00	2.70	2.60	4.00	4.00
Rwanda	1,610	1,400	2.50	2.00	1.70	1.70	1.70	1.90	1.90
Spain	396	1,500	2.00	1.70	2.10	2.00	1.60	2.10	1.90
Vietnam	10,817	3,500	2.10	1.90	2.60	1.30	1.50	2.00	1.90

9.5 Global trade

China has increasingly shifted from being the dominating exporter to also becoming the largest importer of tungsten concentrates (CNBC, 2024). The EU and other industrialised countries are critically dependent on tungsten imports. Leading importers of ferrotungsten are Germany, Japan, the Netherlands, and Austria; for metallic tungsten, the leading importers are Germany and the USA; and for tungsten carbide, the top importers are Germany, Japan, and the USA. The leading exporter of ferrotungsten is China, while China, the USA, and Germany are the main exporters of metallic tungsten. For tungsten carbide, China is the leading exporter.

Despite the war in Ukraine and the abovementioned assessment, the EU did import 753 metric tons of ferro-(silico)-tungsten from Russia in 2022, making it the 2nd largest contributor behind China (Figure 52).

The trade in ammonium paratungstate (APT), a stable intermediate tungsten product, has seen significant shifts, including high import growth rates. Political confrontations and trade restrictions, such as those imposed by the Eurasian Economic Union and Russia's export bans, also impact tungsten trade. Overall, tungsten's unique properties make it essential for a number of critical sectors, such as steel (ferro-alloys) (see Figure 52, Figure 53), electric vehicles (EVs) and aerospace industries. As production in these sectors grows, so does the demand for tungsten. This highlights the need for stable, diversified supply chains to mitigate geopolitical risks and ensure consistent supply.

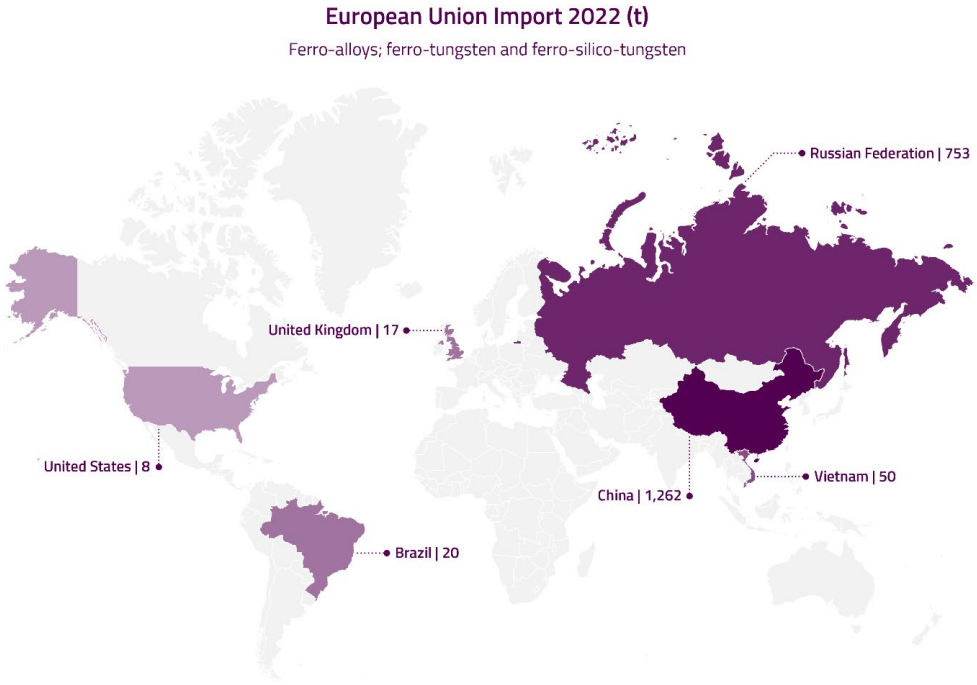


Figure 52: EU import streams for ferro-tungsten and ferrosilico-tungsten (720280), 2022 data (WITS, 2023; EIT RawMaterials, 2024).

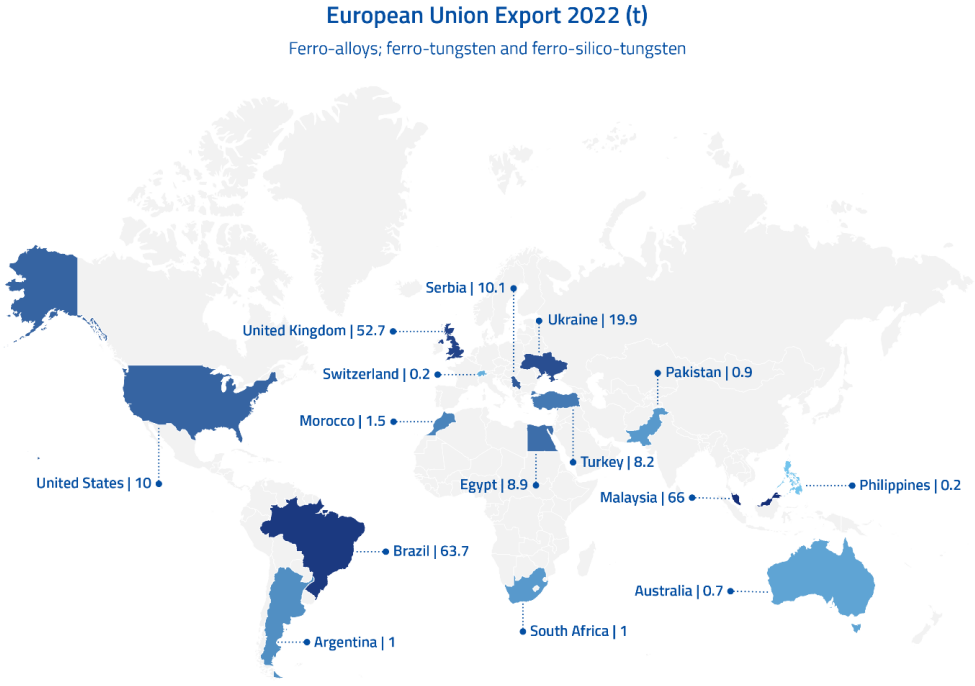


Figure 53: EU export flows for ferro-tungsten and ferrosilico-tungsten (720280), 2022 data (WITS, 2023; EIT RawMaterials, 2024).

10 DEVIATIONS

Not applicable.

11 REFERENCES

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12 APPENDIX

12.1 Appendix A – Nickel Ownership Tables

Table 6: Nickel companies in top-mining-production countries with top 3 shareholders and their countries of operation (EIT RawMaterials, 2024). A more comprehensive list of projects with corresponding companies and ownership information is shown in the table below.

Country	Company	Top 3 Shareholders	Countries of Operation
Indonesia	PT Vale Indonesia	1. Vale S.A. (Brazil) 2. Sumitomo Metal Mining Co., Ltd. (Japan) 3. Public Investors (Various)	Indonesia, Brazil, Canada, New Caledonia, Japan, UK
Indonesia	PT Aneka Tambang	1. Government of Indonesia (Indonesia) 2. Public Investors (Various) 3. PT Indonesia Asahan Aluminium (Indonesia)	Indonesia, Australia
Indonesia	PT Indonesia Morowali Industrial Park	1. Tsingshan Holding Group (China) 2. PT Bintangdelapan Group (Indonesia) 3. Public Investors (Various)	Indonesia
Philippines	Nickel Asia Corp.	1. Sumitomo Metal Mining Co., Ltd. (Japan) 2. Public Investors (Various) 3. Government Service Insurance System (Philippines)	Philippines
Philippines	Global Ferronickel Holdings	1. Public Investors (Various) 2. Platinum Group Metals Corp. (Philippines) 3. Government Service Insurance System (Philippines)	Philippines, Hong Kong
Philippines	DMCI Mining Corp.	1. DMCI Holdings, Inc. (Philippines) 2. Public Investors (Various) 3. Government Service Insurance System (Philippines)	Philippines
New Caledonia	Société Le Nickel	1. Eramet (France) 2. STCPI (New Caledonia) 3. Public Investors (Various)	New Caledonia
New Caledonia	Prony Resources	1. Trafigura Group (Singapore) 2. Agio Global (Australia) 3. Public Investors (Various)	New Caledonia

New Caledonia	Koniambo Nickel SAS	1. Glencore (Switzerland) 2. Société Minière du Sud Pacifique (New Caledonia) 3. Public Investors (Various)	New Caledonia
Russia	Norilsk Nickel	1. Interros (Russia) 2. UC Rusal (Russia) 3. Public Investors (Various)	Russia, Finland, South Africa
Russia	Ural Mining and Metallurgical Company	1. Iskander Makhmudov (Russia) 2. Andrei Bokarev (Russia) 3. Public Investors (Various)	Russia
Russia	Kola Mining and Metallurgical Company	1. Norilsk Nickel (Russia) 2. Public Investors (Various) 3. Government of Russia (Russia)	Russia
Canada	Vale Canada Limited	1. Vale S.A. (Brazil) 2. Public Investors (Various) 3. Government of Canada (Canada)	Canada, Brazil, Indonesia, New Caledonia, Japan, UK
Canada	Glencore Canada	1. Glencore (Switzerland) 2. Public Investors (Various) 3. Government of Canada (Canada)	Canada, Australia, New Caledonia, South Africa
Canada	Sherritt International	1. Public Investors (Various) 2. Government of Canada (Canada) 3. Government of Cuba (Cuba)	Canada, Cuba
China	Jinchuan Group	1. Government of China (China) 2. Public Investors (Various) 3. China Investment Corporation (China)	China, Zambia
China	China Molybdenum Co., Ltd.	1. Cathay Fortune Corporation (China) 2. Luoyang Mining Group Co., Ltd. (China) 3. Public Investors (Various)	China, DR Congo, Brazil, Australia
China	Tsingshan Holding Group	1. Xiang Guangda (China) 2. Public Investors (Various) 3. Government of China (China)	China, Indonesia, Zimbabwe

Table 7: Granular look at Ni mining and processing projects globally with their operator and ownership data and, where available, their 2023 Ni production. Compiled from the following sources (EIT RawMaterials, 2024; GTK, 2024; S&P Global Market Intelligence, 2024; International Nickel Study Group, 2024). Some of the listed properties, especially in China, Russia, and other nations, may not report transparently and comprehensively, may be offline, or may have closed.

Property Name	Country	Operator	Operator Country	Owner Share and Country	Ni production 2023
Nickel West (currently on hold)	Australia	BHP Group Limited	Australia	BHP Group Limited (Owner) 100%, Australia	80000
Nova-Bollinger		IGO Limited	Australia	IGO Limited (Owner) 100%, Australia	22915
Savannah		Panoramic Resources Limited	Australia	Panoramic Resources Limited (Owner) 100%; Ora Gold Limited (Fractional), Australia, Australia	5402
Avebury		Mallee Resources Limited	Australia	Mallee Resources Limited (Owner) 100%, Australia	3459
South Kambalda		Wyloo Pty Ltd	Australia	Wyloo Pty Ltd (Owner) 100%, Australia	
Savage River		Grange Resources Limited	Australia	Grange Resources Limited (Owner) 100%, Australia	
Ravensthorpe Plant		First Quantum Minerals Ltd.	Canada	First Quantum Minerals Ltd. (Venturer) 70%; POSCO Holdings Inc. (Venturer) 30%, Canada, South Korea	
North Kambalda		Wyloo Pty Ltd	Australia	Wyloo Pty Ltd (Owner) 100%, Australia	
Norseman		Pantoro Limited	Australia	Pantoro Limited (Owner) 100%; Mineral Resources Limited (Fractional), Australia, Australia	
Nickel West Smelter (on hold)		BHP Group Limited	Australia	BHP Group Limited (Owner) 100%, Australia	
Nickel West Refinery		BHP Group Limited	Australia	BHP Group Limited (Owner) 100%, Australia	
Murrin Murrin Refinery		Glencore plc	Switzerland	Glencore plc (Owner) 100%, Switzerland	
Kwinana Refinery (on hold)		BHP Group Limited	Australia		
Kambalda Concentrator		BHP Group Limited	Australia	BHP Group Limited (Owner) 100%, Australia	
Kalgoorlie Operations		Northern Star Resources Limited	Australia	Northern Star Resources Limited (Owner) 100%; FMR Investments Pty Ltd (Fractional); Franco-Nevada Corporation (Fractional); Horizon Minerals Limited (Fractional); Iondrive Limited (Fractional); Lefroy Exploration Limited (Fractional);	

				Metal Hawk Limited (Fractional), Australia, Canada, Australia, Australia, Australia	
Higginsville		Westgold Resources Limited	Australia	Westgold Resources Limited (Owner) 100%; Estrella Resources Limited (Fractional); Kalamazoo Resources Limited (Fractional); Liontown Resources Limited (Fractional); Minotaur Exploration Limited (Fractional); S2 Resources Ltd (Fractional), Australia, Australia, Australia, Australia, Australia	
Geko		Beacon Minerals Limited	Australia	Beacon Minerals Limited (Owner) 100%, Australia	
Edna May		Ramelius Resources Limited	Australia	Ramelius Resources Limited (Owner) 100%, Australia	
East Menzies		Resources & Energy Group Limited	Australia	Resources & Energy Group Limited (Owner) 100%, Australia	
Beta Hunt		Westgold Resources Limited	Australia	Westgold Resources Limited (Owner) 100%, Australia	
Bellevue		Bellevue Gold Limited	Australia	Bellevue Gold Limited (Owner) 100%, Australia	
Agnew/Lawlers		Gold Fields Limited	South Africa	Gold Fields Limited (Owner) 100%, South Africa	
Black Swan		Poseidon	Australia	Horizon Minerals (100%), Australia	
Treibach Smelter	Austria	Treibacher Industrie AG	Austria	Treibacher Industrie AG (Owner) 100%, Austria	
Phoenix	Botswana	Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel	Russia	Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel (Venturer) 85%; Botswana (Venturer) 15%, Russia, Botswana	
Barro Alto	Brazil	Anglo American plc	United Kingdom	Anglo American plc (Owner) 100%, United Kingdom	31800
Onca Puma		Vale S.A.	Brazil	Vale S.A. (Owner) 100%, Brazil	17000
Santa Rita		Appian Capital Advisory LLP	United Kingdom	Appian Capital Advisory LLP (Owner) 100%, United Kingdom	15998

Codemin		Anglo American plc	United Kingdom	Anglo American plc (Owner) 100%, United Kingdom	8200
Americano do Brasil		Prometálica Mineração Ltda	Brazil	Prometálica Mineração Ltda (Owner) 100%, Brazil	6000
Onca-Puma Refinery		Vale S.A.	Brazil	Vale S.A. (Owner) 100%, Brazil	
Onca Puma Smelter		Vale S.A.	Brazil	Vale S.A. (Owner) 100%, Brazil	
Fortaleza de Minas Smelter		Unnamed Owner	USA	Unnamed Owner (Owner) 100%, USA	
Codemin Smelter		Anglo American plc	United Kingdom	Anglo American Brasil Limitada (Codemin) (Owner) 100%, Brazil	
Barro Alto Smelter		Anglo American plc	United Kingdom	Anglo American plc (Owner) 100%, United Kingdom	
Barro Alto Refinery		Anglo American plc	United Kingdom	Anglo American plc (Owner) 100%, United Kingdom	
Ontario Division	Canada	Vale S.A.	Brazil	Vale S.A. (Owner) 100%, Brazil	38200
Lac des Iles		Impala Platinum Holdings Limited	South Africa	Impala Platinum Holdings Limited (Owner) 100%, South Africa	0
Sudbury Smelter		Glencore plc	Switzerland	Glencore plc (Owner) 100%, Switzerland	
Sudbury Operations		KGHM International Ltd.	Canada	KGHM Polska Miedz S.A. (Owner) 100%, Poland	
Port Colborne Refinery		Vale S.A.	Brazil	Vale S.A. (Owner) 100%, Brazil	
Long Harbour Refinery		Vale S.A.	Brazil	Vale S.A. (Owner) 100%, Brazil	
Copper Cliff Smelter		Vale S.A.	Brazil	Vale S.A. (Owner) 100%, Brazil	
Copper Cliff Refinery		Vale S.A.	Brazil	Vale S.A. (Owner) 100%, Brazil	
CCR Refinery		Glencore plc	Switzerland	Glencore plc (Owner) 100%, Switzerland	
Shandong Xinhai Plant	China	Shandong Xinhai Technology Co., Ltd.	China	Shandong Xinhai Technology Co., Ltd. (Owner) 100%, China	113701
Jinchuan		JinChuan Group Co.,Ltd	China	JinChuan Group Co.,Ltd (Owner) 100%, China	101760

Suqian Xiang-Xiang Smelter		Suqian Xiang-Xiang Industry Co., Ltd.	China	Suqian Xiang-Xiang Industry Co., Ltd. (Owner) 100%, China	15750
Inner Mongolia Shangtai Plant		Private Interest	China	Private Interest (Owner) 100%, China	5160
Yangzhou Yichuan Plant		Yangzhou Yichuan Nickel Industry Co., Ltd.	China	Yangzhou Yichuan Nickel Industry Co., Ltd. (Owner) 100%, China	3578
Tulaergen		China State-Owned Mining Enterprise	China	China State-Owned Mining Enterprise (Owner) 100%, China	2079
Alex		Xinjiang Xinxin Mining Industry Co., Ltd.	China	Xinjiang Xinxin Mining Industry Co., Ltd. (Owner) 100%, China	297
Yuanjiang		Sino-Platinum Metals Co.,Ltd	China	Yuanjiang Nickel (Owner) 100%, China	0
Jilin		Ji Lin Ji En Nickel Industry Co., Ltd.	China	Ji Lin Ji En Nickel Industry Co., Ltd. (Owner) 100%, China	0
Zhongjin Metal Plant		Private Interest	China	Private Interest (Owner) 100%, China	
Zhejiang Plant		Zhejiang Huayou Cobalt Co., Ltd	China	Zhejiang Huayou Cobalt Co., Ltd (Owner) 100%, China	
Zhejiang New Plant		Private Interest	China	Private Interest (Owner) 100%, China	
Yungeng					
Yuanjiang Refinery				Yuanjiang Nickel (Owner) 100%, China	
Yangjiang Yichuan Smelter		Guangdong Yangjiang Yichuan Metal Technology Co., Ltd .	China	Guangdong Yangjiang Yichuan Metal Technology Co., Ltd . (Owner) 100%, China	

Xinxiang Plant		Ji Lin Ji En Nickel Industry Co., Ltd.	China	Ji Lin Ji En Nickel Industry Co., Ltd. (Owner) 100%, China	
Xinxiang Jien		Ji Lin Ji En Nickel Industry Co., Ltd.	China	Ji Lin Ji En Nickel Industry Co., Ltd. (Owner) 100%, China	
Xinjiang Plant		Jingxiaogong Company, Xinjiang Non-Ferrous Metal Company	China	Jingxiaogong Company, Xinjiang Non-Ferrous Metal Company (Owner) 100%, China	
Weiye		Weiye Nickel Co Ltd	China	Weiye Nickel Co Ltd (Owner) 100%, China	
Tongsheng		Huade County Tongsheng Ferroalloy Co., Ltd.	China	Huade County Tongsheng Ferroalloy Co., Ltd. (Owner) 100%, China	
Tangshan Kaiyuan Smelter		Tangshan Kaiyuan Enterprise Group	China	Tangshan Kaiyuan Enterprise Group (Owner) 100%, China	
Shangtai Plant		Private Interest	China	Private Interest (Owner) 100%, China	
Shandong Sunyon Smelter		Private Interest	China	Private Interest (Owner) 100%, China	
Shandong Refinery		Yantai Cash Industrial Co., Ltd.	China	Yantai Cash Industrial Co., Ltd. (Owner) 100%, China	
Ningfeng Smelter		Yingkou Ningfeng Group Co., Ltd.	China	Yingkou Ningfeng Group Co., Ltd. (Owner) 100%, China	
Ningbo Changjiang Plant		Private Interest	China	Private Interest (Owner) 100%, China	
Longtan Plant		Yinyi Group Co., Ltd.	China	Yinyi Group Co., Ltd. (Owner) 100%, China	
Liaoning Treasure Smelter		Private Interest	China	Private Interest (Owner) 100%, China	

Liaoning Smelter		Liaoning Baoyu Special Steel Co., Ltd.	China	Liaoning Baoyu Special Steel Co., Ltd. (Owner) 100%, China	
Liaoning Shengyun Smelter		Private Interest	China	Private Interest (Owner) 100%, China	
Kunming (Yunnan) Smelter		Yunnan Copper Co.,Ltd	China	Yunnan Copper Co.,Ltd (Owner) 100%, China	
Keketuohai Refinery					
Kalatongke Smelter		Xinjiang Xinxin Mining Industry Co., Ltd.	China	Xinjiang Xinxin Mining Industry Co., Ltd. (Owner) 100%, China	
Jinzhou Plant		Guangdong Brunp recycling Technology Co., Ltd	China	Guangdong Brunp recycling Technology Co., Ltd (Owner) 100%, China	
Jingmen Plant		GEM Co., Ltd.	China	GEM Co., Ltd. (Owner) 100%, China	
Jinchuan Smelter		JinChuan Group Co.,Ltd	China	JinChuan Group Co.,Ltd (Owner) 100%, China	
Jinchuan Refinery		JinChuan Group Co.,Ltd	China	JinChuan Group Co.,Ltd (Owner) 100%, China	
Jincheng		Ganyu County Jincheng Nickel Industry Co., Ltd.	China	Ganyu County Jincheng Nickel Industry Co., Ltd. (Owner) 100%, China	
Jinchang Refinery		JinChuan Group Co.,Ltd	China	JinChuan Group Co.,Ltd (Owner) 100%, China	
Jinbaoshan		Yunnan Gold&Mineral Group Co., Ltd.	China	Yunnan Gold&Mineral Group Co., Ltd. (Owner) 100%, China	
Jiangxi Ruida Plant		Private Interest	China	Private Interest (Owner) 100%, China	
Jiangsu Refinery		Private Interest	China	Private Interest (Owner) 100%, China	
Jiangsu Delong Smelter		Jiangsu Delong Nickel Industry Co. Ltd	China	Jiangsu Delong Nickel Industry Co. Ltd (Owner) 100%, China	

Jiangsu Baotong		Jiangsu Baotong Nickel Industry Co., Ltd.	China	Jiangsu Baotong Nickel Industry Co., Ltd. (Owner) 100%, China	
Inner Mongolia Heyi Smelter		Private Interest	China	Private Interest (Owner) 100%, China	
Hunan Changyuan Plant		Hunan Changyuan Lico Co.,Ltd.	China	Hunan Changyuan Lico Co.,Ltd. (Owner) 100%, China	
Hongqiling Plant		Ji Lin Ji En Nickel Industry Co., Ltd.	China	Ji Lin Ji En Nickel Industry Co., Ltd. (Owner) 100%, China	
Henan Kelong Refinery		Henan Kelong New Energy Co., Ltd.	China	Henan Kelong New Energy Co., Ltd. (Owner) 100%, China	
Henan Jinhui Smelter		Henan Jinhui Stainless Steel Industry Group Co., Ltd.	China	Henan Jinhui Stainless Steel Industry Group Co., Ltd. (Owner) 100%, China	
Hami Jiatai Concentrator		Hami Jiatai Mineral Resource Exploiture Limited	China	Huili Resources (Group) Limited (Owner) 95%; Unnamed Owner (Owner) 5%, Hong Kong, USA	
Hami Huangshan		Xinjiang Yakesi Resources Co., Ltd.	China	Xinjiang Yakesi Resources Co., Ltd. (Owner) 100%, China	
Guizhou Plant		CNGR Advanced Material Co.,Ltd.	China	CNGR Advanced Material Co.,Ltd. (Owner) 100%, China	
Guangxi Yinyi Plant		Guangxi Yinyi Science and Technic Mine Metallurgy Co., Ltd	China	Guangxi Yinyi Science and Technic Mine Metallurgy Co., Ltd (Owner) 100%, China	
Guangxi Chengde Smelter		Private Interest	China	Private Interest (Owner) 100%, China	

Guangdong Jinsheng Plant		Guangdong Jinsheng New Energy Co., Ltd.	China	Guangdong Jinsheng New Energy Co., Ltd. (Owner) 100%, China	
Guangdong Guangxin Smelter		Guangdong Guangxin Shengte Investment Co., Ltd.	China	Guangdong Guangxin Shengte Investment Co., Ltd. (Owner) 100%, China	
Guangdong Fangyuan Plant		Guangdong Fangyuan New Materials Group Co., Ltd.	China	Guangdong Fangyuan New Materials Group Co., Ltd. (Owner) 100%, China	
Guangdong Century Smelter		Guangdong Century Tsingshan Nickel Co., Ltd.	China	Global Ferronickel Holdings, Inc. (Owner) 20%, Philippines	
Guangdong Centry Smelter		Private Interest	China	Private Interest (Owner) 100%, China	
Fukang Smelter		Xinjiang Xinxin Mining Industry Co., Ltd.	China	Xinjiang Xinxin Mining Industry Co., Ltd. (Owner) 100%, China	
Fujian Dingxin Smelter		Private Interest	China	Private Interest (Owner) 100%, China	
Fujian Desheng Smelter		Desheng Nickel Co., Ltd	China	Desheng Nickel Co., Ltd (Owner) 100%, China	
Fenghuangshan		Tongling Nonferrous Metals Group Co.,Ltd.	China	Tongling Nonferrous Metals Group Co.,Ltd. (Owner) 100%, China	
Dalian Fuli Plant		Dalian Fuli Investment Enterprise (Limited Partnership)	China	Dalian Fuli Investment Enterprise (Limited Partnership) (Owner) 100%, China	
Chongqing Plant		Ji Lin Ji En Nickel	China	Ji Lin Ji En Nickel Industry Co., Ltd. (Owner) 100%, China	

		Industry Co., Ltd.			
Chizhou Refinery		Private Interest	China	Private Interest (Owner) 100%, China	
Chengdu Smelter		China	China	Private Interest (Owner) 100%, China	
Chendong		Chendong Chemical Industry Co., Ltd.	China	Chendong Chemical Industry Co., Ltd. (Owner) 100%, China	
Changsha Plant		CNGR Advanced Material Co.,Ltd.	China	CNGR Advanced Material Co.,Ltd. (Owner) 100%, China	
Caofeidian Plant		China Metallurgical Group Corporation	China	China Minmetals Corporation (Owner) 100%, China	
Baishiquan		Timeless Resources Holdings Limited	Hong Kong	Timeless Resources Holdings Limited (Owner) 100%, Hong Kong	
Baijiazuizi		China State-Owned Mining Enterprise	China	China State-Owned Mining Enterprise (Owner) 100%, China	
Montelibano Refinery	Colombia	South32 Limited	Australia	South32 Limited (Owner) 99.94%; Mineworkers (Owner) 0.06%, Australia, Colombia	
Cerro Matoso Smelter		South32 Limited	Australia	South32 Limited (Owner) 100%, Australia	
Cerro Matoso Smelter		South32 Limited	Australia	South32 Limited (Venturer) 99.94%; Mineworkers (Venturer) 0.06%, Australia, Colombia	
Punta Gorda	Cuba	Cubaniquel	Cuba	Cubaniquel (Owner) 100%, Cuba	16000
Punta Gorda Smelter		Private Interest	China	Private Interest (Owner) 100%, China	
Ernesto Guevara HPAL Refinery		Sherritt International Corporation	Canada	General Nickel Company S.A. (Owner) 50%; Sherritt International Corporation (Owner) 50%, Canada, Cuba	
Skouriotissa Plant	Cyprus	Hellenic Minerals SA	Greece	Rockfire Resources plc (Owner) 100%, United Kingdom	

Falcondo Smelter	Dominican Republic	Falconbridge Dominican S.A.	Dominican Republic	Global Special Opportunities Ltd. (Venturer) 85.26%; Dominican Republic (Venturer) 9.98%; Private Interest (Venturer) 4.76%, Bahamas, Dominican Republic, China	
Falcondo Smelter		Global Special Opportunities Ltd.	Bahamas	Global Special Opportunities Ltd. (Owner) 100%, Bahamas	
Cerro de Maimon		Perilya Limited	Australia	Shenzhen Zhongjin Lingnan Nonfemet Co. Ltd. (Owner) 100%, China	
Sotkamo mine	Finland	Terrafame Oy	Finland	Terrafame Oy (Owner) 100%, Finland	30000
Sotkamo Plant		Terrafame Oy	Finland	Terrafame Oy (Owner) 100%, Finland	
Kevitsa mine & Harjavalta Smelter		Boliden AB (publ)	Sweden	Boliden AB (publ) (Owner) 100%, Sweden	
Harjavalta Refinery		Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel	Russia	Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel (Owner) 100%, Russia	
Sandouville Refinery	France	Sibanye Stillwater Limited	South Africa	Sibanye Stillwater Limited (Owner) 100%, South Africa	
Awaso	Ghana	Bosai Minerals Group Co., Ltd.	China	Ghana Bauxite Company Limited (Owner) 90%; Ghana (Carried) 10%, Ghana, Ghana	
Larco	Greece	Larco SA	Greece	Larco SA (Owner) 100%, Greece	0
Larymna Plant		Larco SA	Greece	Larco SA (Owner) 100%, Greece	
Fenix Smelter	Guatemala	Solway Investment Group Limited	Switzerland	Solway Investment Group Limited (Owner) 100%, Switzerland	
Fenix		Solway Investment Group Limited	Switzerland	Solway Investment Group Limited (Venturer) 98.2%; Guatemala (Venturer) 1.8%, Switzerland, Guatemala	
Nicomet Plant	India			Vedanta Limited (Owner) 100%, India	
Sorowako	Indonesia	PT Vale Indonesia Tbk	Indonesia	PT Vale Indonesia Tbk (Owner) 100%, Indonesia	70728

Weda Bay		PT Weda Bay Nickel	Indonesia	Tsingshan Holding Group Co., Ltd. (Venturer) 51.3%; ERAMET S.A. (Venturer) 38.7%; PT Aneka Tambang Tbk (Venturer) 10%, China, France, Indonesia	33400
Pomalaa		PT Aneka Tambang Tbk	Indonesia	PT Aneka Tambang Tbk (Owner) 100%; Hongkong CBL Limited (Fractional), Indonesia, Hong Kong	21473
Youshan Smelter		Chengtun Mining Group Co., Ltd.	China	Chengtun Mining Group Co., Ltd. (Owner) 35.8%; Tsingshan Holding Group Co., Ltd. (Owner) 35%; Zhejiang Huayou Cobalt Co., Ltd (Owner) 29.3%, China, China, China	
Westrong Metal Smelter		PT Harum Energy Tbk	Indonesia	PT Harum Energy Tbk (Owner) 80.7%; Private Interest (Owner) 19.3%, Indonesia, China	
Wanatiara Persada Smelter		Jinchuan Group International Resources Co. Ltd	Hong Kong	Jinchuan Group International Resources Co. Ltd (Venturer) 60%; Private Interest (Venturer) 40%, Hong Kong, China	
Walsin Smelter		Walsin Lihwa Corporation	Taiwan	Tsingshan Holding Group Co., Ltd. (Venturer) 50%; Walsin Lihwa Corporation (Venturer) 50%, China, Taiwan	
Virtue Dragon Smelter		Jiangsu Delong Nickel Industry Co. Ltd	China	Jiangsu Delong Nickel Industry Co. Ltd (Owner) 100%, China	
Tsingshan Steel Smelter		Tsingshan Holding Group Co., Ltd.	China	Tsingshan Holding Group Co., Ltd. (Venturer) 80%; Private Interest (Venturer) 20%, China, China	
Tsingshan Stainless Smelter		Tsingshan Holding Group Co., Ltd.	China	Tsingshan Holding Group Co., Ltd. (Venturer) 51%; Guangdong Ruipu Technology Co.Ltd. (Venturer) 19%; Hanwa Co., Ltd. (Venturer) 10%; Private Interest (Venturer) 10%; Pt. Indonesia Morowali Industrial Park (Venturer) 10%, China, China, Japan, China, Indonesia	
Tri Daya Jaya Smelter		PT Tri Daya Jaya	Indonesia	PT Tri Daya Jaya (Owner) 100%, Indonesia	
Timah Nickel		PT TIMAH Tbk	Indonesia	PT TIMAH Tbk (Owner) 100%, Indonesia	
Tapunopaka		PT Aneka Tambang Tbk	Indonesia	PT Aneka Tambang Tbk (Owner) 100%, Indonesia	
Sulawesi Mining Investment Smelter		Tsingshan Holding Group Co., Ltd.	China	Tsingshan Holding Group Co., Ltd. (Venturer) 46.55%; PT Bintang Delapan Resources (Venturer) 26.65%; Reed Limited (Venturer) 24%; Private Interest (Venturer) 3.8%, China, Indonesia, China, China	
Ranger RKEF Smelter		Nickel Industries Limited	Australia	Nickel Industries Limited (Venturer) 80%; Shanghai Decent Investment (Group) Co., Ltd. (Venturer) 20%, Australia, China	

PT Central Omega NPI Smelter		PT Central Omega Resources Tbk	Indonesia	PT Central Omega Resources Tbk (Venturer) 60%; Macrolink Holding Co.,Ltd. (Venturer) 40%, Indonesia, China	
PT Central Omega Mines		PT Central Omega Resources Tbk	Indonesia	PT Central Omega Resources Tbk (Venturer) 99%; Unnamed Owner (Venturer) 1%, Indonesia, USA	
Pomalaa Smelter		PT Aneka Tambang Tbk	Indonesia	PT Aneka Tambang Tbk (Owner) 100%, Indonesia	
Oracle		Nickel Industries Limited	Australia	Nickel Industries Limited (Venturer) 80%; Shanghai Decent Investment (Group) Co., Ltd. (Venturer) 20%, Australia, China	
NPI to Matte Plant		Tsingshan Holding Group Co., Ltd.	China	Tsingshan Holding Group Co., Ltd. (Owner) 100%, China	
Ningxia Hengshun Smelter		Ningxia Hengshun Smelting Co., Ltd.	China	Ningxia Hengshun Smelting Co., Ltd. (Owner) 100%, China	
Megah Surya Pertiwi Smelter		PT. Megah Surya Pertiwi	Indonesia	PT Trimegah Bangun Persada Tbk (Owner) 100%, Indonesia	
Loji		PT. Gane Permai Sentosa	Indonesia	PT Trimegah Bangun Persada Tbk (Venturer) 70%; Unnamed Owner (Venturer) 30%, Indonesia, USA	
Li Bai Plant		Tsingshan Holding Group Co., Ltd.	China	Tsingshan Holding Group Co., Ltd. (Owner) 100%, China	
Langit Refinery		Amperex Technology Limited	Hong Kong	TDK Corporation (Owner) 100%, Japan	
Kawasi		PT Trimegah Bangun Persada Tbk	Indonesia	PT Trimegah Bangun Persada Tbk (Owner) 100%, Indonesia	
Infei Metal Smelter		PT Infei Metal Industry	Indonesia	PT Tanito Harum Nickel (Owner) 99.58%, Indonesia	
Huadi Alloy Smelter		Shanghai Huadi Industry Co.,Ltd.	China	Shanghai Huadi Industry Co.,Ltd. (Owner) 100%, China	

HNC HPAL Smelter		Zhejiang Huayou Cobalt Co., Ltd	China	Zhejiang Huayou Cobalt Co., Ltd (Venturer) 57%; CMOC Group Limited (Venturer) 30%; Nickel Industries Limited (Venturer) 10%; Unnamed Owner (Venturer) 3%, China, China, Australia, USA	
HJF RKEF Smelter		PT Halmahera Jaya Feronikel	Indonesia	PT Trimegah Bangun Persada Tbk (Venturer) 63.1%; Lygend Resources & Technology Co., Ltd. (Venturer) 36.9%, Indonesia, China	
Hengshun Plant		Qingdao Zhongzi Zhongcheng Group Co.,Ltd.	China	Qingdao Zhongzi Zhongcheng Group Co.,Ltd. (Owner) 100%, China	
Hengjaya RKEF Smelter		Nickel Industries Limited	Australia	Nickel Industries Limited (Venturer) 80%; Shanghai Decent Investment (Group) Co., Ltd. (Venturer) 20%, Australia, China	
Hanking Group		Tuochuan Capital Limited	BVI	Tuochuan Capital Limited (Venturer) 70%; Evergreen Mining Limited (Venturer) 30%, BVI, BVI	
Halmahera Persada Lygend Plant		PT Halmahera Persada Lygend	Indonesia	PT Trimegah Bangun Persada Tbk (Venturer) 63.1%; Lygend Resources & Technology Co., Ltd. (Venturer) 36.9%, Indonesia, China	
Gunbuster Smelter		Jiangsu Delong Nickel Industry Co. Ltd	China	Jiangsu Delong Nickel Industry Co. Ltd (Owner) 100%, China	
Guang Ching Smelter		Guangdong Jeray Technology Group Co., Ltd.	China	Guangdong Jeray Technology Group Co., Ltd. (Venturer) 35%; Guangdong Guangxin Holdings Group Ltd. (Venturer) 25%; Pt. Indonesia Morowali Industrial Park (Venturer) 20%; Private Interest (Venturer) 15%; Hanwa Co., Ltd. (Venturer) 5%, China, China, Indonesia, China, Japan	
Gee Island		PT Aneka Tambang Tbk	Indonesia	PT Aneka Tambang Tbk (Owner) 100%, Indonesia	
Gebe Sentral Smelter		Zhenshi Group Eastern Special Steel Co., Ltd	China	Zhenshi Group Eastern Special Steel Co., Ltd (Owner) 100%, China	
Fujian Pan Plant		Private Interest	China	Private Interest (Owner) 100%, China	
Fengli Plant		Tsingshan Holding Group Co., Ltd.	China	Tsingshan Holding Group Co., Ltd. (Owner) 100%, China	

Dafeng Plant		Private Interest	China	Private Interest (Owner) 100%, China	
COR Industri Smelter		Macrolink Holding Co.,Ltd.	China	Macrolink Holding Co.,Ltd. (Venturer) 60%; PT Central Omega Resources Tbk (Venturer) 40%, China, Indonesia	
Century Metalindo Smelter		PT Century Metalindo	Indonesia	PT Century Metalindo (Owner) 100%, Indonesia	
Cahaya Sulawesi Smelter		Tsingshan Holding Group Co., Ltd.	China	Tsingshan Holding Group Co., Ltd. (Venturer) 49.9%; PT Merdeka Copper Gold Tbk (Venturer) 26.6%; Private Interest (Venturer) 23.5%, China, Indonesia, China	
Bukit Sulawesi Smelter		Tsingshan Holding Group Co., Ltd.	China	Tsingshan Holding Group Co., Ltd. (Venturer) 49.9%; PT Merdeka Copper Gold Tbk (Venturer) 26.6%; Private Interest (Venturer) 23.5%, China, Indonesia, China	
Blue Sky Plant		Tsingshan Holding Group Co., Ltd.	China	Tsingshan Holding Group Co., Ltd. (Owner) 100%, China	
Bintang Smelter		PT Bintang Smelter Indonesia	Indonesia	PT Bintang Smelter Indonesia (Owner) 100%, Indonesia	
ANI RKEF Plant		Nickel Industries Limited	Australia	Nickel Industries Limited (Venturer) 80%; Shanghai Decent Investment (Group) Co., Ltd. (Venturer) 20%, Australia, China	
Oheyama Smelter	Japan	Nippon Yakin Kogyo Co., Ltd.	Japan	Nippon Yakin Kogyo Co., Ltd. (Owner) 100%, Japan	
Niihama Refinery		Sumitomo Metal Mining Co., Ltd.	Japan	Sumitomo Metal Mining Co., Ltd. (Owner) 100%, Japan	
Matsusaka Refinery		Vale S.A.	Brazil	Vale S.A. (Venturer) 87.2%; Sumitomo Metal Mining Co., Ltd. (Venturer) 12.8%, Brazil, Japan	
Hyuga Smelter		Sumitomo Metal Mining Co., Ltd.	Japan	Sumitomo Metal Mining Co., Ltd. (Venturer) 60%; Nippon Steel Corporation (Venturer) 25%; Mitsui & Co., Ltd. (Venturer) 15%, Japan, Japan, Japan	
Hachinohe Smelter		Pacific Metals Co., Ltd.	Japan	Pacific Metals Co., Ltd. (Owner) 100%, Japan	
Ambatovy	Madagascar	Sumitomo Corporation	Japan	Sumitomo Corporation (Venturer) 54.17%; Korea Mine Rehabilitation and Mineral Resources Corporation (Venturer) 45.82%; Unnamed Owner (Venturer) 0.01%, Japan, South Korea, USA	40313

Ambatovy Refinery		Sherritt International Corporation	Canada	Sumitomo Corporation (Venturer) 47.67%; Korea Mine Rehabilitation and Mineral Resources Corporation (Venturer) 22.5%; Private Interest (Venturer) 12.83%; Sherritt International Corporation (Venturer) 12%; POSCO Holdings Inc. (Venturer) 2.93%; STX Corporation (Venturer) 1%; National Pension Service (Venturer) 0.22%, Japan, South Korea, China, Canada, South Korea	
Bou-Azzer	Morocco	Compagnie de Tifnout Tighanimine	Morocco	Managem S.A. (Venturer) 99.79%; Unnamed Owner (Venturer) 0.21%, Morocco, USA	0
Tagaung Taung	Myanmar	China Nonferrous Metal Mining (Group) Co., Ltd.	China	China Nonferrous Metal Mining (Group) Co., Ltd. (Optionee) 75%; Number Three Mining Enterprise Of The Muyanma (Optionor) 25%; Taiyuan Iron Steel Corp (Optionee), China, Myanmar, China	17111
Tagaung Taung Smelter		China Nonferrous Metal Mining (Group) Co., Ltd.	China	China Nonferrous Metal Mining (Group) Co., Ltd. (Venturer) 75%; Number Three Mining Enterprise Of The Muyanma (Venturer) 25%, China, Myanmar	
SLN	New Caledonia	ERAMET S.A.	France	ERAMET S.A. (Venturer) 56%; Société Territoriale Calédonienne de Participation Industrielle (Venturer) 34%; Nippon Steel Nisshin Co., Ltd. (Venturer) 10%, France, New Caledonia, Japan	44800
SMSP Operation		Societe Miniere du Sud Pacifique SA	New Caledonia	Societe Miniere du Sud Pacifique SA (Venturer) 51%; POSCO Holdings Inc. (Venturer) 49%, New Caledonia, South Korea	0
Koniambo Smelter		Glencore plc	Switzerland	Societe Miniere du Sud Pacifique SA (Venturer) 51%; Glencore plc (Venturer) 49%, New Caledonia, Switzerland	
Goro HPAL Plant		Prony Resources New Caledonia consortium	France	Prony Resources New Caledonia consortium (Owner) 95%; Societe de Participation Miniere du Sud Caledonia SAS (Venturer) 5%, France, France	
Figesbal		Figesbal	New Caledonia	Establissement Ballande Groupe (Venturer) 74.5%; Sumitomo Metal Mining Co., Ltd. (Venturer) 25.5%; Figesbal (Venture), New Caledonia, Japan, New Caledonia	
Doniambo Smelter		Société Le Nickel-SLN	New Caledonia	Société Le Nickel-SLN (Owner) 100%, New Caledonia	
Feni Smelter	North Macedonia	Global Special Opportunities Ltd.	Bahamas	Global Special Opportunities Ltd. (Owner) 100%, Bahamas	

Feni		Cunico Resources NV	Netherlands	BSG Resources Limited (Owner) 50%; IMR International Mineral Resources AG (Owner) 50%, United Kingdom, Switzerland	
Tellnes	Norway	Kronos Worldwide, Inc.	USA	Contran Corporation (Owner) 45.86%; NL Industries, Inc. (Owner) 30.48%; J.P. Morgan Investment Management Inc. (Owner) 0.01%, USA, USA, USA	240
Ramu	Papua New Guinea	Metallurgical Corporation of China Ltd.	China	Metallurgical Corporation of China Ltd. (Venturer) 56.97%; Ji Lin Ji En Nickel Industry Co., Ltd. (Venturer) 11.05%; JiuQuan Iron and Steel (Group) Co.,Ltd (Venturer) 11.05%; Jinchuan Group International Resources Co. Ltd (Venturer) 5.93%; Mineral Resources Development Corp (Venturer) 3.94%; Private Interest (Venturer) 2.5%; Nickel 28 Capital Corp. (Carried) 8.56%, China, China, China, Canada, Hong Kong	33604
Basamuk Plant		Metallurgical Corporation of China Ltd.	China	Metallurgical Corporation of China Ltd. (Venturer) 85%; Nickel 28 Capital Corp. (Venturer) 8.56%; Papua New Guinea (Carried) 6.44%, China, Canada, Papua New Guinea	
Yauli	Peru	Volcan Compañía Minera S.A.A.	Peru	Volcan Compañía Minera S.A.A. (Owner) 100%; Empresa Minera Mahr Tunel S.A. (Venture), Peru, Peru	
Taganito	Philippines	Taganito Mining Corporation	Philippines	Nickel Asia Corporation (Venturer) 65%; Pacific Metals Co., Ltd. (Venturer) 33.5%; Sojitz Corporation (Venturer) 1.5%, Philippines, Japan, Japan	36000
Rio Tuba		Rio Tuba Nickel Mining Corporation	Philippines	Nickel Asia Corporation (Venturer) 60%; Pacific Metals Co., Ltd. (Venturer) 36%; Sojitz Corporation (Venturer) 4%, Philippines, Japan, Japan	22000
Tubay		Sr Metals Inc.	USA	Sr Metals Inc. (Owner) 100%, USA	
Taganito HPAL Plant		Sumitomo Metal Mining Co., Ltd.	Japan	Sumitomo Metal Mining Co., Ltd. (Venturer) 75%; Mitsui & Co., Ltd. (Venturer) 15%; Nickel Asia Corporation (Venturer) 10%, Japan, Japan, Philippines	
Palhi		Unnamed Owner	USA	Unnamed Owner (Owner) 100%, USA	
Palawan		Oriental Peninsula Resources Group, Inc.	Philippines	Oriental Peninsula Resources Group, Inc. (Venturer) 99%; Unnamed Owner (Venturer) 1%, Philippines, USA	
Hinatuan		Hinatuan Mining Corporation	Philippines	Nickel Asia Corporation (Owner) 100%, Philippines	
Dinapigue		Dinapigue Mining Corporation	Philippines	Nickel Asia Corporation (Owner) 100%, Philippines	

Coral Bay HPAL Plant		Sumitomo Metal Mining Co., Ltd.	Japan	Sumitomo Metal Mining Co., Ltd. (Venturer) 84.38%; Nickel Asia Corporation (Venturer) 15.62%, Japan, Philippines	
Celestial		Global Ferronickel Holdings, Inc.	Philippines	Global Ferronickel Holdings, Inc. (Venturer) 90%; Unnamed Owner (Venturer) 10%, Philippines, USA	
Casiguran		Century Peak Holdings Corporation	Philippines	Century Peak Holdings Corporation (Owner) 100%, Philippines	
Carrascal-Cantilan		Marcventures Holdings, Inc.	Philippines	Marcventures Holdings, Inc. (Owner) 100%, Philippines	
Carrascal		Carrascal Nickel Corporation	Philippines	Carrascal Nickel Corporation (Owner) 100%, Philippines	
Cagdianao		Platinum Group Metals Corporation	Philippines	Platinum Group Metals Corporation (Owner) 100%, Philippines	
Cagdianao		Cagdianao Mining Corporation	Philippines	Nickel Asia Corporation (Owner) 100%, Philippines	
Adlay-Cagdianao-Tandawa		C.T.P. Construction and Mining Corporation	Philippines	C.T.P. Construction and Mining Corporation (Owner) 100%, Philippines	
Legnica Refinery	Poland	KGHM Polska Miedz S.A.	Poland	KGHM Polska Miedz S.A. (Owner) 100%, Poland	
KGHM Polska Miedz		KGHM Polska Miedz S.A.	Poland	KGHM Polska Miedz S.A. (Owner) 100%, Poland	
Yuzhuralnikel Refinery	Russia	Yuzhuralnikel Joint Stock Co.	Russia	Yuzhuralnikel Joint Stock Co. (Owner) 100%, Russia	
Verkhny Smelter		Public Joint Stock Company Ufaleynickel	Russia	Public Joint Stock Company Ufaleynickel (Owner) 100%, Russia	
Ufaleynickel Refinery				Public Joint Stock Company Ufaleynickel (Owner) 100%, Russia	

Talnakh Smelter		Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel	Russia	Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel (Owner) 100%, Russia	
Serovsky		Eurasian Natural Resources Corporation Limited	United Kingdom	Eurasian Resources Group S.à r.l. (Owner) 100%, Luxembourg	
Refining Shop and Nickel Electrolysis Shop Plant		Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel	Russia	Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel (Owner) 100%, Russia	
Kola Division		Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel	Russia	Public Joint Stock Company Mining and Metallurgical Company Norilsk Nickel (Owner) 100%, Russia	
Kolosori	Solomon Islands	Pacific Nickel Mines Limited	Australia	Pacific Nickel Mines Limited (Owner) 80%, Australia	
Impala Bafokeng	South Africa	Impala Platinum Holdings Limited	South Africa	Impala Platinum Holdings Limited (Owner) 100%, South Africa	3620
Crocodile River		Eastern Platinum Limited	Canada	Eastern Platinum Limited (Owner) 100%; Northam Platinum Holdings Limited (Fractional), Canada, South Africa	3340
Rustenburg		Sibanye Stillwater Limited	South Africa	Sibanye Stillwater Limited (Owner) 100%, South Africa	1700
Modikwa		African Rainbow Minerals Limited	South Africa	Anglo American Platinum Limited (Venturer) 50%; African Rainbow Minerals Limited (Venturer) 41.5%; Private Interest (Carried) 8.5%, South Africa, South Africa, China	856

Amandelbult		Anglo American Platinum Limited	South Africa	Anglo American Platinum Limited (Owner) 100%, South Africa	749
Mototolo		Anglo American Platinum Limited	South Africa	Anglo American Platinum Limited (Owner) 100%, South Africa	532
Union Section		Siyanda Resources (Pty) Ltd	South Africa	Siyanda Resources (Pty) Ltd (Venturer) 85%; Bakgatla Ba Kgafela (Venturer) 15%, South Africa, South Africa	453
Kroondal		Sibanye Stillwater Limited	South Africa	Sibanye Stillwater Limited (Owner) 100%, South Africa	302
Palabora		Palabora Copper Proprietary Limited	South Africa	HBIS Group Company Limited (Venturer) 35%; General Nice Development Limited (Venturer) 20%; Tewoo Group Co., Ltd. (Venturer) 20%; The Industrial Development Corporation of South Africa Limited (Venturer) 20%; China-Africa Development Fund (Venturer) 5%, China, South Africa, China, Hong Kong, China	50
Eland		Northam Platinum Holdings Limited	South Africa	Northam Platinum Holdings Limited (Owner) 100%, South Africa	45
Western Platinum Smelter		Western Platinum Refinery Ltd	South Africa	Western Platinum Refinery Ltd (Owner) 100%, South Africa	
Tharisa		Tharisa plc	Cyprus	Tharisa plc (Owner) 100%, Cyprus	
Thabazimbi Smelter		Northam Platinum Holdings Limited	South Africa	Northam Platinum Holdings Limited (Owner) 100%, South Africa	
Styldrift 90JQ		Impala Platinum Holdings Limited	South Africa	Impala Platinum Holdings Limited (Owner) 100%, South Africa	
Rustenburg Smelter		Impala Platinum Holdings Limited	South Africa	Impala Platinum Holdings Limited (Owner) 100%, South Africa	

Rustenburg Smelter		Anglo American Platinum Limited	South Africa	Anglo American Platinum Limited (Owner) 100%, South Africa	
Rustenburg Refinery		Anglo American Platinum Limited	South Africa	Anglo American Platinum Limited (Owner) 100%, South Africa	
Polokwane Smelter		Anglo American Platinum Limited	South Africa	Anglo American Platinum Limited (Owner) 100%, South Africa	
Platinum Mile		Sibanye Stillwater Limited	South Africa	Sibanye Stillwater Limited (Venturer) 91.7%; Mvelaphanda Holdings (Proprietary) Limited (Venturer) 8.3%, South Africa, South Africa	
Pilanesberg		Sedibelo Resources Limited	United Kingdom	Sedibelo Resources Limited (Owner) 100%, United Kingdom	
Pandora		Sibanye Stillwater Limited	South Africa	Sibanye Stillwater Limited (Owner) 100%, South Africa	
Palabora Smelter		Palabora Copper Proprietary Limited	South Africa	HBIS Group Company Limited (Owner) 35%; General Nice Development Limited (Owner) 20%; Tewoo Group Co., Ltd. (Owner) 20%; The Industrial Development Corporation of South Africa Limited (Owner) 20%; China-Africa Development Fund (Owner) 5%, China, South Africa, China, Hong Kong, China	
Marikana Smelter		Sibanye Stillwater Limited	South Africa	Sibanye Stillwater Limited (Venturer) 82%; Incwala Resource (Pty) Limited (Venturer) 18%, South Africa, South Africa	
Marikana		Sibanye Stillwater Limited	South Africa	Sibanye Stillwater Limited (Venturer) 95.25%; Incwala Resource (Pty) Limited (Venturer) 4.75%, South Africa, South Africa	
Impala Refinery		Impala Platinum Holdings Limited	South Africa	Impala Platinum Holdings Limited (Owner) 100%, South Africa	
Brakpan Refinery		Sibanye Stillwater Limited	South Africa	Sibanye Stillwater Limited (Owner) 82%; Incwala Resource (Pty) Limited (Owner) 18%, South Africa, South Africa	

Booysendal North		Northam Platinum Holdings Limited	South Africa	Northam Platinum Holdings Limited (Owner) 100%, South Africa	
POSCO Nickel Refinery	South Korea	POSCO Holdings Inc.	South Korea	POSCO Holdings Inc. (Owner) 100%, South Korea	
Onsan Smelter		Korea Zinc Company, Ltd.	South Korea	Korea Zinc Company, Ltd. (Owner) 100%, South Korea	
Onsan Plant		Korea Nickel Corp.	South Korea	Korea Zinc Company, Ltd. (Owner) 33.93%; Young Poong Corporation (Owner) 27.14%; POSCO Holdings Inc. (Owner) 25%; Young Poong Culture Foundation Co., Ltd (Owner) 5%, South Korea, South Korea, South Korea, South Korea	
Korean Metals Plant		Australian Strategic Materials Ltd	Australia	Australian Strategic Materials Ltd (Owner) 100%, Australia	
Gwangyang Smelter		Societe Miniere du Sud Pacifique SA	New Caledonia	Societe Miniere du Sud Pacifique SA (Venturer) 51%; POSCO Holdings Inc. (Venturer) 49%, New Caledonia, South Korea	
Pobuzhskiy Plant	Ukraine	Solway Investment Group Limited	Switzerland	Solway Investment Group Limited (Owner) 100%, Switzerland	
Clydach Refinery	United Kingdom	Vale S.A.	Brazil	Vale S.A. (Owner) 100%, Brazil	
Eagle	USA	Lundin Mining Corporation	Canada	Lundin Mining Corporation (Owner) 100%, Canada	16429
East Boulder		Sibanye Stillwater Limited	South Africa	Sibanye Stillwater Limited (Owner) 100%, South Africa	
Loma de Niquel	Venezuela			Venezuela (Venturer) 91.4%; Corporacion Caracas (Venturer) 8.6%, Venezuela, Venezuela	
Ta Khoa	Vietnam	Blackstone Minerals Limited	Australia	Blackstone Minerals Limited (Venturer) 90%; Mechanical Engineering and Metallurgy Joint Stock Company (Venturer) 10%, Australia, Vietnam	
Trident - Enterprise	Zambia	First Quantum Minerals Ltd.	Canada	First Quantum Minerals Ltd. (Owner) 100%, Canada	4527
Munali		Consolidated Mining and	United Kingdom	Consolidated Mining and Investments Ltd (Optionee) 68%; Jinchuan Group International Resources Co. Ltd (Optionor) 32%, United Kingdom, Hong Kong	4000

		Investments Ltd			
Trident - Sentinel		First Quantum Minerals Ltd.	Canada	First Quantum Minerals Ltd. (Owner) 100%, Canada	
Mwinilunga		Mining Properties Corporation	BVI	Mining Properties Corporation (Owner) 100%, BVI	
Unki	Zimbabwe	Anglo American Platinum Limited	South Africa	Anglo American Platinum Limited (Owner) 100%, South Africa	3603
Trojan		Bindura Nickel Corporation Limited	Zimbabwe	Bindura Nickel Corporation Limited (Owner) 100%, Zimbabwe	3180
Selous Plant		Zimplats Holdings Limited	Guernsey	Zimplats Holdings Limited (Owner) 100%, Guernsey	
Mimosa		Sibanye Stillwater Limited	South Africa	Impala Platinum Holdings Limited (Venturer) 50%; Sibanye Stillwater Limited (Venturer) 50%, South Africa, South Africa	

12.2 Appendix B – Tungsten Ownership Table

Table 8: Overview of active and operating tungsten mining and processing projects, including company, country, supply chain stage, production (where available) and shareholder structure.

Company	Country	Stage	Projects	Products	Mine production (t)	Global mine production share	Tungsten production (t)	Key shareholders
EQ Resources Limited	Australia	Mining & Processing	Mt Carbine (Australia) Saloro (Spain)	Tungsten ores and concentrates	2,430	3.12%	2,430	EQ Resources 93% (Australia) Cronimet 7% (Germany)
Group 6 Metals Limited	Australia	Mining & Processing	Dolphin Tungsten Mine (Tasmania)	Tungsten ores and concentrates	333	0.43%	333	Gwenda Chadwick 15.08% (UK) Others: Diversified
Tungsten Metals Group Limited	Australia	Refining	ATC Ferrotungsten Factory (Vietnam)	Ferrotungsten			4,000	SG Hiscock & Co 12.06% (Australia) Others: Diversified
Wolfram Bergbau und Hütten AG	Austria	Mining, Processing, Refining & Recycling	Mittersill (Mining & Processing, Austria) St. Martin im Sulmtal (Refining, Austria) Chiplun (Recycling, India)	Tungsten ores and concentrates, APT, tungsten carbide and metal powder, tungsten oxides.	910	1.17%		Sandvik 100% (Sweden)
Almonty Industries	Canada	Mining & Processing	Panasqueira Mine (Portugal, operating) Sangdong Mine (South Korea, under construction) Los Santos Mine (Spain, development) Valtreixal (Spain, development)	Tungsten ores and concentrates	500	0.64%	500	Plansee Group 15.2% (Austria) Deutsche Rohstoff AG 12.3% (Germany) Others: Diversified
Chongyi Zhangyuan Tungsten Co., Ltd.	China	Mining, Processing, Refining & Recycling	Taoxikeng Tungsten Mine (China) Xin'an Tungsten Mine (China) Dayu Shilei Tungsten Mine (China)	Tungsten concentrates, APT, tungsten powder, tungsten oxides, tungsten carbide powder and cemented carbide	4,154	5.33%	32,000	Zelan Huang 60.65% (China) Others: Diversified
CMOC Group	China	Mining, Processing & Refining	Sandaozhuang (China)	Tungsten concentrates and ATP	7,975	10.22%		Cathay Fortune Corporation 24.69% (China) CATL 24.68% (China) HKSCC Nominees Ltd. 16.66% (Hong Kong) Others: Diversified
Hunan Nonferrous Metals Corporation Limited	China	Mining, Processing & Refining		Tungsten concentrates, APT, tungsten oxide, tungsten powder, tungsten carbide and ferrotungsten				State-owned (China)
Jiangxi Tungsten Industry Group Co. Ltd	China	Mining, Processing & Refining	9 mines 8 processing plants	Tungsten concentrates, APT, tungsten oxide, tungsten powder and tungsten carbide	10,000	12.82%	30,000	State-owned (Jiangxi, China)
Jiangxi Yaosheng Tungsten Co	China	Mining, Processing & Refining	2 affiliated mines 4 processing plants	Tungsten concentrates, APT, tungsten carbide, tungsten oxide, tungsten powder and cemented carbide	3,000	3.85%	25,000	Chongyi Jinlong Industry and Trade Co. 100% (China)
MinMetals	China	Mining, Processing & Refining	Shizhuyuan Mine (China) Xianglushan Mine (China)	Tungsten concentrates, APT, tungsten carbide, high-tech products	7,500	9.62%		State-owned SASAC 100% (China)
Xiamen Tungsten Co., Ltd.	China	Mining, Processing, Refining & Recycling	Xingluokeng Mine (China) Youmapo Mine (China, development) Saemangeum Recycling Facility (South Korea)	Tungsten concentrates, APT, tungsten powder, tungsten oxides, tungsten carbide powder and cemented carbide			10,000	Fujian SASAC 32% (China) Others: Diversified
Zijin Mining Group Company Limited	China	Mining & Processing	Dayutang / Malipo Tungsten Mine (China) Xiangyuan (China)		3,571	4.58%		Minxi Xinghang State-owned AIC Ltd 22.89% (China) HKSCC Nominees Limited 22.48% (Hong Kong) Others: Diversified
Mitsubishi Materials	Japan	Processing, Refining & Recycling	H.C Starck: Goslar (Germany) Sarnia (Canada) Ganzhou (China)	Tungsten oxides, tungsten carbides and high-tech tungsten products			13,300	The Master Trust Bank of Japan 17.6% (Japan) Others: Diversified
Midural Group	Russia	Refining	Kluchevsky Ferroalloy Plant (Russia)	Ferrotungsten				Yildirim Group 49% (Türkiye) Others: Diversified
Moliren LLC	Russia	Refining	Roshal (Russia)	Ferrotungsten				Not publicly available
Wolfram Mining and Processing Ltd	Rwanda	Mining & Processing	Gifurwe Mine (Rwanda)	Tungsten ores and concentrates				Not publicly available
Tungsten West PLC	UK	Mining	Hemerdon Mine (UK, feasibility)	Tungsten ores and concentrates				HSBC Global Custody Nominee Ltd 15% (UK) Others: Diversified
Kennametal	USA	Processing, Refining & Recycling	20+ processing plants	Tungsten concentrates, tungsten powder, tungsten carbide and high tech products				BlackRock Inc 27.92% (USA) Others: Diversified
Masan High-Tech Materials	Vietnam	Mining, Processing, Refining & Recycling	Nui Phao mine (Vietnam) MTC plant (Vietnam)	Tungsten ores and concentrates, APT, tungsten oxides and sodium tungstate	3,493	4.48%		Masan Group Corporation 86.4% (Vietnam) Mitsubishi Materials Corporation 10% (Japan)
Premier African Minerals Ltd	Zimbabwe	Mining & Processing	RHA Tungsten Mine (Zimbabwe, maintenance)	Tungsten ores and concentrates				Canmax 14.11% (China) Others: Diversified