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India's Hunt for Critical Minerals

Import dependencies make diversifying supply sources and addressing trade risks the need of the hour

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Disclaimer:

The authors assume full responsibility for any errors or omissions in this report.

Key Findings

Minerals at risk – with high import dependency and reliance on a few countries – include synthetic and natural graphite, lithium oxide, nickel oxide, nickel sulphate and copper cathodes. The procurement strategy of these minerals needs intervention to diversify the sources.

Critical mineral demand is soaring, threatening supply chain security, affordability, and energy stability in importing countries. The International Energy Agency forecasts a 2-3 fold increase in demand by 2030, exacerbating these concerns.

India needs to carefully craft its import strategy to circumvent risks while balancing international ties. It should develop a strategy to source each mineral efficiently while minimising disruptions.

India can deepen its strategic partnerships with geopolitically stable countries and increase its procurement of minerals from them as domestic demand for these minerals rises. The country can explore investment opportunities in resource-rich, friendly nations, such as Australia, Chile, Ghana and South Africa.

Executive Summary

With ambitious climate goals in place, India's demand for critical minerals is likely to grow exponentially in the coming years. Critical minerals like cobalt, copper, graphite, lithium and nickel play a central role in the energy transition and are found in few countries. India remains largely dependent on imports for these minerals and their compounds with 100% dependency for lithium, cobalt and nickel. There is a need for India to invest in resource-rich, friendly nations and minimise its reliance on imports, especially from countries with a potential trade risk in the future.

The transition to clean energy sources has intensified the need for critical minerals such as cobalt, copper, graphite, lithium and nickel. These minerals play a central role in manufacturing clean technology equipment, such as solar panels, wind turbines, electric vehicles and batteries. Besides, they are vital for manufacturing defence and electronic equipment.

Acknowledging the importance of these minerals in the energy transition, the government of India has initiated a multi-pronged approach to acquiring and sourcing critical minerals. The approach includes developing international partnerships and acquiring resources, as well as exploring domestic mines.

India remains largely dependent on imports for energy transition minerals and their compounds, with 100% import dependency for minerals like lithium, cobalt and nickel. This situation is likely to continue as the demand for critical minerals is expected to more than double by 2030, while domestic mines will take more than a decade to start producing.

India needs to carefully craft its import strategy to circumvent risks while balancing international ties. It should develop a strategy to source each mineral efficiently while minimising disruptions. Furthermore, geopolitical risks also play a part in shaping India's international critical minerals procurement policy.

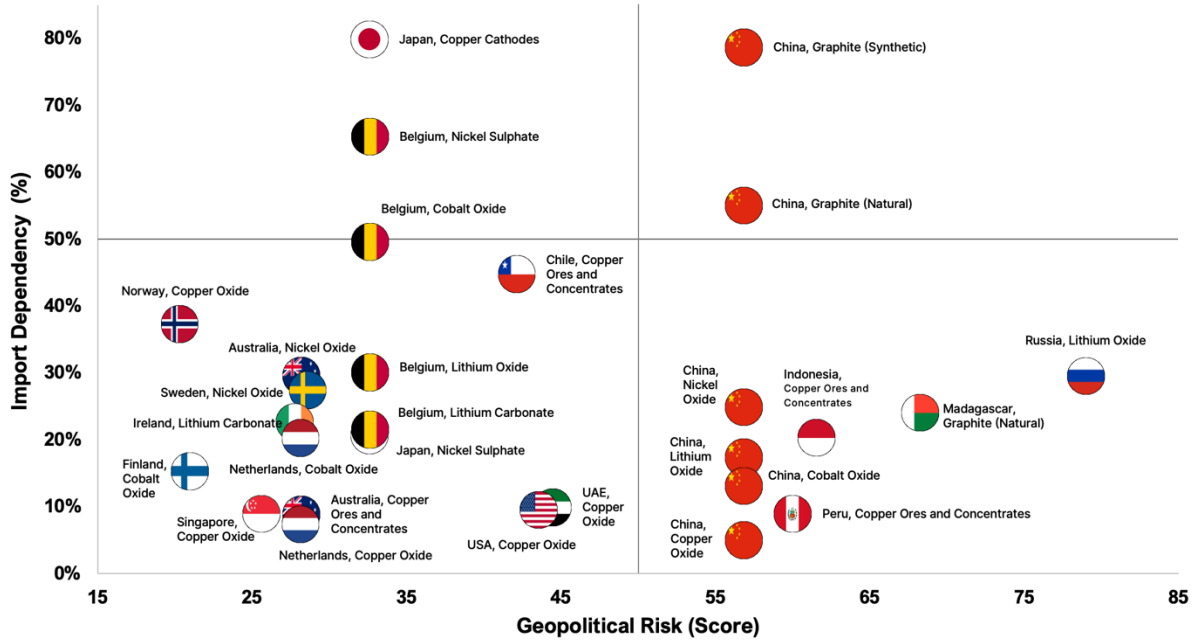
In this report, we analyse the key minerals crucial to the energy transition from the perspective of import dependency, trade dynamics, domestic availability and global price fluctuations. In the **ES figure** below, we map the minerals and their compounds based on import dependency and geopolitical risks.

Minerals at risk include graphite (natural and synthetic), lithium oxide, nickel oxide, copper cathodes, nickel sulphate, cobalt oxide, and copper ores and concentrates. Such minerals have high import dependency. India imports some of them from countries with a high geopolitical risk. The countries with high geopolitical risks are Russia, Madagascar, Indonesia, Peru and China. India should strive to

reduce its dependency on these countries by identifying new international resources and expediting the domestic production of minerals.

India can also explore investment opportunities in resource-rich, friendly nations, such as Australia and Chile, as well as African countries like Ghana and South Africa.

Figure ES: India Import Dependency of Key Minerals vs. Geopolitical Risk



Source: UN Comtrade, Control Risks, Fragile States Index, IEEFA

Background

At the 28th Conference of Parties (COP28), leaders of various countries committed to phase out fossil fuels, aiming to restrict the global temperature increase to 1.5°C. This decision reflects the urgent need to combat climate change and transition to a low-carbon economy. However, the rapid growth of clean technology has triggered a surge in the demand for minerals vital for driving sustainable innovations.

Integrating renewable energy sources, such as wind and solar, into its electricity mix primarily drives India's energy transition. In addition, either electricity or clean-burning fuels like hydrogen are decarbonising the transportation and heavy industry sectors.

Critical minerals like cobalt, copper, graphite, lithium and nickel play a central role in the energy transition. In June 2023, the government of India, through an inter-ministerial committee formed by the Ministry of Mines, identified 30 critical minerals for India based on their economic importance and supply risks.[1] This list overlaps with some of the critical minerals identified by the US, Canada, the UK, the EU, Japan and South Korea.

With the passing of the Mines and Mineral (Development and Regulation) Amendment Bill, 2023, India allowed the exploration and mining of lithium and other atomic minerals by private companies.[2]The new license facilitates and incentivises private sector participation in all spheres of exploration for critical and deep-seated minerals.

The Ministry of Mines launched the first auction in November 2023 with 20 mineral blocks, including nickel, lithium and graphite, across multiple states.[3] This was followed by three more auctions for various critical minerals across several states in the subsequent months. While some blocks received a good response and are progressing, the government has to cancel the auctioning of several other blocks due to lack of adequate bids **(Table 1).**

[1] Ministry of Mines, GoI. Critical Minerals for India. June 2023.
[2] Press Information Bureau. Parliament Passes Mines and Minerals (Development & Regulation) Amendment Bill, 2023. 2 August 2023.
[3] Press Information Bureau (PIB). Twenty Critical Mineral Blocks Spread Across Eight States to be Auctioned. 29 November 2023.

Table 1: Critical Mineral Auctions in India

Auction tranche	Launch date	Minerals	No. of blocks auctioned	Geography	Status
First Tranche	29 November 2023	Nickel, lithium, graphite, and potash	20	Across eight states	13 blocks cancelled
Second Tranche	29 February 2024	Tungsten, vanadium, graphite, nickel, and potash	18	Across eight states	14 blocks cancelled
Third Tranche	14 March 2024	Glauconite, graphite, nickel, potash, lithium and titanium	Seven (auctioned under second attempt)	Across five states	Three blocks cancelled
Fourth Tranche	24 June 2024	Graphite, potash, nickel, and rare earth elements	21 (including 11 new blocks)	Across six states	-

Sources: Government and news reports

Critical mineral auctions have struggled to attract investment due to unclear mineral reserve data, concerns over companies' mining capabilities and inadequate technology.[4] The International Energy Agency (IEA) notes that mining projects typically require 16+ years from discovery to production, compounding these uncertainties and leading to a lacklustre auction response.[5]

Industry experts suggest that government support – such as viability gap funding and technology development – is essential as the absence of major players raises doubts about the attractiveness of the auctioned blocks.

Rising Demand

According to the IEA, growing solar and wind power capacities, electric car sales, and stationary battery storage capacities have led to a demand growth of 30% for lithium and 8-10% for nickel, cobalt and graphite in 2023. The IEA expects the demand for key minerals to double by 2030 in the stated policies scenario. It predicts that demand will more than double by 2030 and triple by 2050 in

[4] Business Standard. Mining majors give a miss to country's maiden critical minerals auction. 24 June 2024.
[5] IEA. The Role of Critical Minerals in Clean Energy Transitions. March 2022.

the Announced Pledges Scenario (APS).[6] The agency forecasts even stronger growth in the net zero emissions scenario, with the demand for critical minerals nearly tripling by 2030 and growing over 3.5 times from the current levels by 2050.

With the rising demand for critical minerals worldwide, there is concern about the supply of these minerals and the prices at which these minerals and processed products will be available to consuming countries. The concentration of mineral reserves and mineral processing capacity in a few countries and regions exacerbates concerns. According to the World Economic Forum, the top three producers accounted for about 50-90% of the mining and processing of lithium, graphite, cobalt, nickel, copper and rare earth minerals in 2022.[7]

With ambitious climate goals, such as installing 500 gigawatts (GW) of renewable energy capacity by 2030[8], transitioning 30% of the vehicles to electric by 2030, and achieving net zero greenhouse gas emissions by 2070, India's demand for critical minerals will likely grow exponentially in the coming years. A recent study by the Centre for Social and Economic Progress (CSEP) estimates that the demand for copper and nickel from the power sector alone will grow approximately 5.4 times and 10.7 times by 2025 and 2047, respectively, in the base case Net Zero Emissions pathway.[9]

While India is struggling to kickstart the domestic production of critical minerals, its demand for critical minerals is growing, leading to excessive dependence on imports. The Indian government has set in motion several initiatives to accelerate domestic production to bridge the gap between the demand and supply of these minerals. In November 2023, the Ministry of Mines announced that it would grant funds to research and development (R&D) institutes and startups and introduced guidelines for promoting research and innovation in startups and micro, small and medium enterprises (MSMEs) in mining, mineral processing, metallurgy and the recycling sector.[10] The ministry has set aside approximately Rs120 million (US$1.4 million) for R&D projects and around Rs200 million (US$2.3 million) for the science and technology programme for the financial year (FY) 2025.[11] Additionally, in June 2024, the ministry unveiled a scheme to partially reimburse exploration expenses for holders of exploration licences.[12]

In June 2024, the government certified two newly Notified Private Exploration Agencies (NPEAs). So far, NPEAs have initiated 31 projects with approximately Rs352.3 million (US$4.1 million) in funding from the National Mineral Exploration Trust (NMET).

[6] International Energy Agency. Global Critical Minerals Outlook 2024.
[7] World Economic Forum. Energy Transition and Geopolitics: Are Critical Minerals the New Oil?. April 2024
[8] Ministry of Power, GoI. 500GW Non-Fossil Fuel Target.
[9] Centre for Social and Economic Progress. Projecting Critical Mineral Needs for India's Clean Energy Transition. June 2024
[10] PIB. Mines Ministry to invite proposals from Start-ups, MSMEs & Individual Innovators to promote Research and Innovation in Mining and Mineral Processing, 15 November 2023.
[11] Business Standard. Mining majors give a miss to country's maiden critical minerals auction. 24 June 2024.
[12] PIB. Initiatives to Promote Exploration and Processing of critical minerals. 22 July 2024.

The 2024 Union Budget highlighted plans for a Critical Mineral Mission.[13] The initiative will focus on enhancing domestic production, recycling critical minerals and acquiring critical mineral assets abroad. Its objectives are developing technology, building a skilled workforce, establishing an extended producer responsibility framework, and creating an appropriate financing mechanism. The government has proposed a complete waiver of customs duties on 25 critical minerals and a reduction of the Basic Customs Duty on two others.[14] This move is intended to boost the processing and refining of these minerals, ensuring their availability for strategic sectors. The Ministry of Mines will also auction offshore mines to increase the availability of critical minerals.

At present, the lack of domestic production has led to 100% import dependence for key minerals like lithium, cobalt and nickel, which poses significant economic and strategic risks.[15] The successful implementation of these initiatives will be crucial for addressing this reliance on imports and safeguarding India's economic and strategic interests.

Five Critical Minerals

In this paper, we examine India's import dependency, its implications and global price movements in recent years for five critical minerals (and their compounds)[16] – cobalt, copper, graphite, lithium and nickel – integral to the clean energy transition.

Cobalt

Cobalt is crucial in manufacturing lithium-ion batteries, essential for electric vehicles (EVs) and grid-scale energy storage.[17] It is used in the cathode of rechargeable batteries and to enhance stability, energy density and overall performance. It is also used in nickel-cadmium and nickel-metal hydride batteries. Cobalt's versatility extends beyond batteries. Various industrial sectors use cobalt oxide in gas sensors, field emission materials, solar absorbers and catalysts in fuel hydrocracking. According to the IEA's analysis, its APS estimates that clean technologies will require 177 kiloton (kt) of cobalt by 2030. The total demand by 2030 will amount to about 344kt.

Cobalt Domestic Production and Imports

India has approximately 44.91 million tonnes of cobalt ore resources.[18] Despite this, there is no domestic cobalt production. It exists only in secondary form, either as nickel-bearing laterite deposits

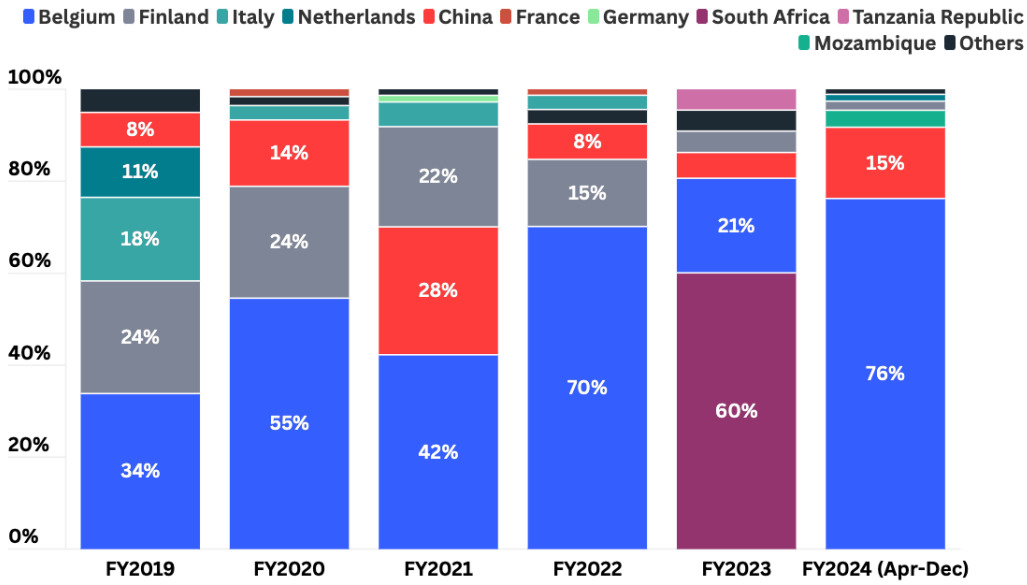
[13] PIB. Critical Minerals Mission proposed for domestic production, recycling, and overseas acquisition. 23 July 2024.
[14] PIB. 25 critical minerals, three more cancer drugs among items exempted from customs duty. 23 July 2024.
[15] The Hindu. India, U.S. exploring combined engagement with third countries to source minerals. 4 October 2024.
[16] HS Codes of all compounds are listed in Annexure 3
[17] Cobalt Institute. Cobalt life cycle
[18] Indian Minerals Yearbook, Cobalt, 2022. Page 2.

or as copper slag produced by hydrogen chloride. India also lacks cobalt refining capacity, leading to 100% import dependence for battery-grade cobalt.[19,20]

India imports cobalt oxides and hydroxides mainly from European countries, such as Belgium, Finland, Italy, France, Germany and the Netherlands **(Figure 1)**. Total imports of cobalt oxide and hydroxide between April 2017 and December 2023 were US$61.5 million. China is also an important exporter to India beyond the European nations. In FY2023, India imported approximately 445 tonnes of cobalt from South Africa, 152 tonnes from Belgium, 41 tonnes from China, 34 tonnes from Finland and 33 tonnes from Tanzania. Over the last six years, Belgium has consistently emerged as a key exporter of cobalt to India. Belgium was the largest exporter of cobalt oxide and hydroxide to India between April and December 2023.

India's cobalt imports reflect the standings of different countries in the global cobalt supply chain. In 2023, China and Finland were the two largest cobalt refiners in the world.[21] Finland plays a crucial role in the EU's cobalt supply – it boasts of the largest known cobalt reserves and the only cobalt-producing mines in Europe. Additionally, it is a key producer of refined cobalt. Within the EU, Belgium is the most significant refiner after Finland.[22,23]

Figure 1: Cobalt Oxide and Hydroxide Imports by Country, Top 5 (%)



Source: UN Comtrade

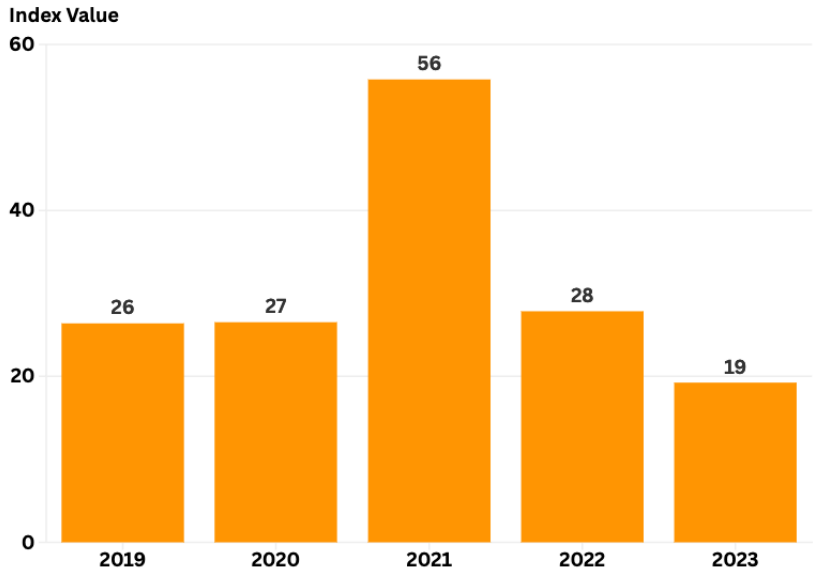
[19] Indian Minerals Yearbook, Cobalt, 2022. Page 3.
[20] Australian Trade and Investment Commission, Unlocking Australia-India critical minerals partnership potential, July 2021. Page 14.
[21] Statista. Distribution of refined cobalt production worldwide in 2023, by country. 9 July 2024.
[22] Geoenergy. A mining industry overview of cobalt in Finland: exploration, deposits, and utilization. 2023.
[23] IEA. The Role of Critical Minerals in Clean Energy Transitions. May 2021

Cobalt Prices

Geopolitical factors heavily influence the cobalt supply chain, and monopolistic dynamics characterise the market. Notably, around 70% of cobalt mining happens in the Democratic Republic of Congo, while over 70% of cobalt processing and refining happens in China. This concentration makes the cobalt market susceptible to disruptions. In 2023, China and Finland were the largest refiners of cobalt in the world.

In 2021, cobalt prices increased sharply as the demand for cobalt grew significantly, driven by the EV sector, which for the first time surpassed other battery applications as the primary end-use of the mineral **(Figure 2)**. However, cobalt prices fell sharply in the second half of 2022.[24,25] In 2023, there was a market surplus due to an increase in supply, and prices continued to decline, though slower.[26] Additionally, the shift to alternative battery chemistries, such as lithium iron phosphate (LFP) and NMC 811, which use significantly less or no cobalt, is also reducing demand, contributing to market uncertainty. Consumers and traders are postponing long-term contracts, anticipating further price declines. This cautious approach will likely continue until the market stabilises and a clearer picture of future demand-supply dynamics emerges.

Figure 2: Europe Cobalt Oxide 72% in Warehouse, Rotterdam, Avg. Annual Price Index



Source: BloombergNEF

[24] Fastmarkets. Cobalt ends year on volatile note. 6 January 2023.
[25] Bloomberg. The Cobalt Market Saw a Record-Breaking Supply Boom in 2022. 7 March 2023.
[26] Cobalt Institute. Cobalt Market Report 2023. 13 May 2024.

Copper

Owing to its versatility and exceptional conductivity, copper finds use in various applications, including power cables and cathodes for renewable energy technologies. Industries that use copper include electronics, construction, transportation, telecommunications and plumbing.

Copper ores and concentrates are mined and processed into essential renewable energy technology components, including copper oxides/hydroxides for catalysts, high-purity copper cathodes for electrical applications (solar panels, wind turbines), and copper anodes for electrolysis, electroplating and electrolysers.

Total global copper demand grew at a CAGR of 3.1% for several decades before slowing to 1.9% over the last 15 years to 2021.[27] However, a combination of traditional and newer avenues arising from energy transition and digitisation will likely drive demand growth to 2.6-3.0% annually. According to the IEA analysis, the share of copper in clean energy technologies will rise to 12,000kt by 2030.[28]

The demand for copper grew by 16% in India in FY2023. This growth is expected to continue in the coming years, propelled by the increase in demand for consumer durables, infrastructure, clean tech and EVs.[29] However, India turned from a net exporter (until May 2018) to a net importer of copper in recent years as its copper smelting capacity halved due to plant-level environmental issues and protests.

Copper Domestic Production and Imports

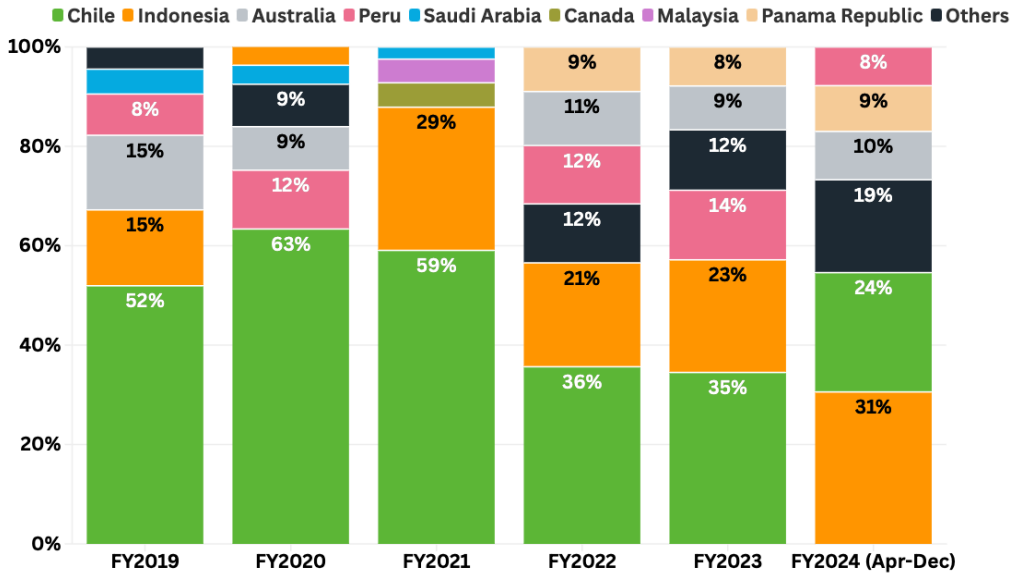
India's copper reserves add up to 163.89 million tonnes, but it still relies on imports to meet its growing demand. India combines imports, domestic production and scrap recycling, leveraging its installed refining capacity of 1 million tonnes to meet demand. Between April 2017 and December 2023, copper imports – including ores, concentrates, oxides, hydroxides, cathodes and anodes – were US$33.1 billion.

India imported copper ores and concentrates totalling 1.1 million tonnes in FY2023. This included 400,155 tonnes from Chile, 262,834 tonnes from Indonesia, 162,446 tonnes from Peru, 102,379 tonnes from Australia and 90,886 tonnes from Panama Republic. Chile and Peru are the top copper producers in the world **(Figure 3).** The strengthening of trade relations between Indonesia and India led to a strong growth of imports from Indonesia, which grew from 3.7% in FY2020 to 22.7% in FY2023. Since Australia's relations with India are friendly, its presence in the top ranks makes it a

[27] BHP Insights. How copper will shape our future. 30 September 2024.
[28] IEA. Copper: Outlook for Key Energy Transition Minerals. May 2024.
[29] The Hindu Business Line. India's copper demand likely to witness robust double-digit growth in 2024. 9 February 2024.

reliable and lucrative trade partner for copper. Between April and December 2023, Chile, Indonesia, Australia and Panama Republic exported the highest volumes of copper ore to India.

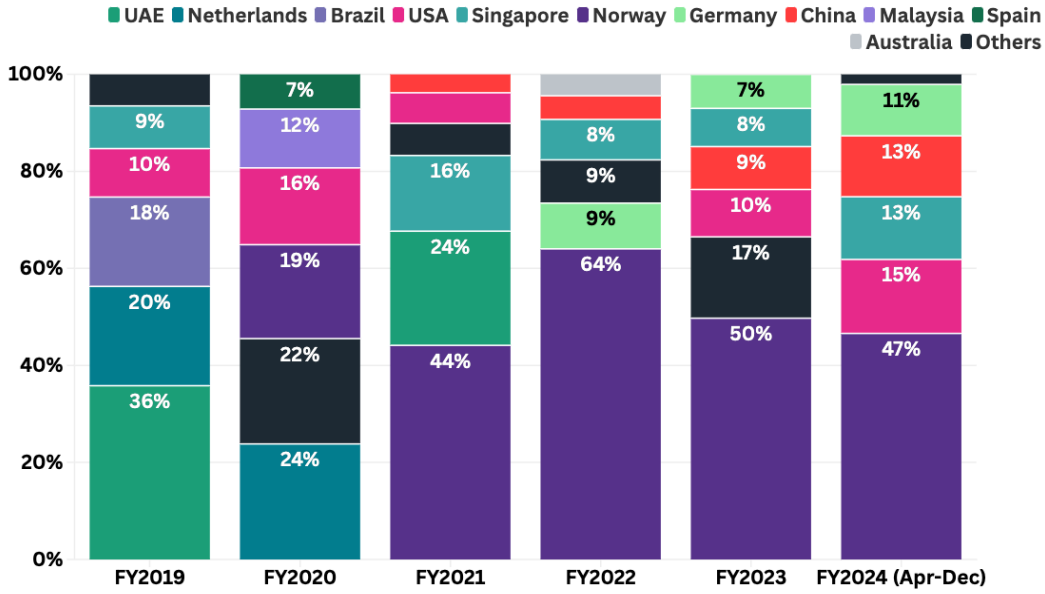
Figure 3: Copper Ores and Concentrates Imports by Country, Top 5 (%)



Source: UN Comtrade

India imported 359.8 tonnes of copper oxides in FY2023. Norway exported 179 tonnes to India, the US exported 35 tonnes, China exported 31.8 tonnes, Singapore exported 28 tonnes and Germany exported 25 tonnes. Though top trade partners for copper oxides and hydroxides are relatively low risk, India's imports need further diversification. Countries with copper mining and refining industries, such as Chile, Peru, the US, China and Australia, typically produce copper oxides and hydroxides. Norway is a key European copper producer, accounting for around 50% of Indian imports in recent years (**Figure 4**). The US, Singapore, Norway, Germany and China topped India's copper oxides and hydroxides imports between April and December 2023.

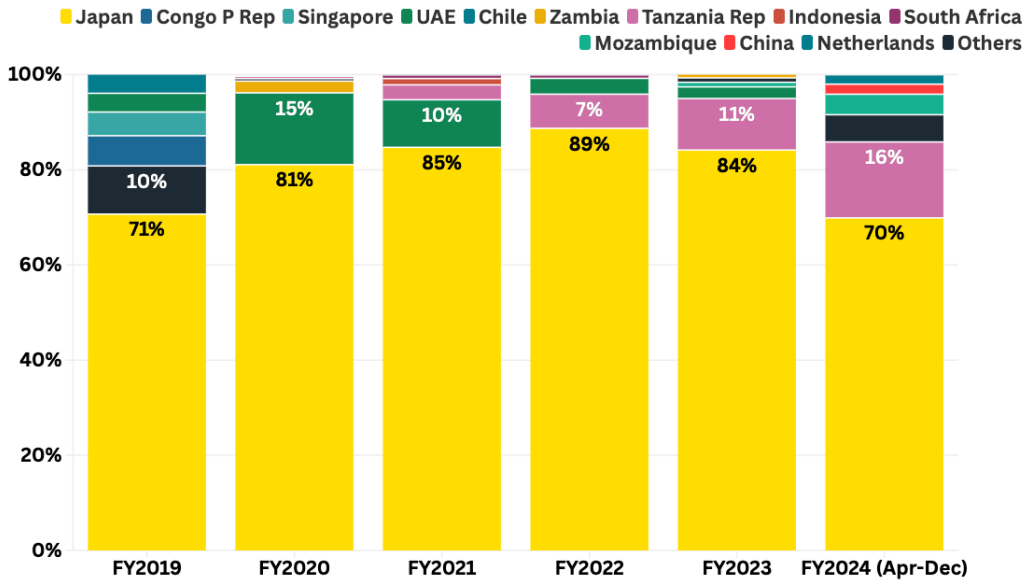
Figure 4: Copper Oxides and Hydroxides Imports by Country, Top 5 (%)



Source: UN Comtrade

India's imports of copper cathodes in FY2022 totalled 204,951 tonnes – 172,515 tonnes were imported from Japan, 22,201.8 tonnes from Tanzania, 5,023 tonnes from the UAE, 1,984.9 tonnes from Mozambique and 1,350.7 tonnes from Zambia. It is pertinent to note here that Japan is a key manufacturer of copper cathodes and a major exporter to India despite not having significant domestic reserves **(Figure 5)**. It does this by playing an important role in the processing and refining of copper by leveraging its advanced technology and strong industrial base. Countries like Congo and Zambia have established mining operations as both have significant copper reserves. Major operations like Mopani Copper Mines and Konkola Copper Mines refine copper ore into cathodes. Other countries like Tanzania and Mozambique leverage their ports and proximity to copper-rich countries to export cathodes. Between April and December 2023, Japan and Tanzania were the top countries exporting copper cathodes to India.

Figure 5: Copper Cathodes Imports by Country, Top 5 (%)



Source: UN Comtrade

Copper Prices

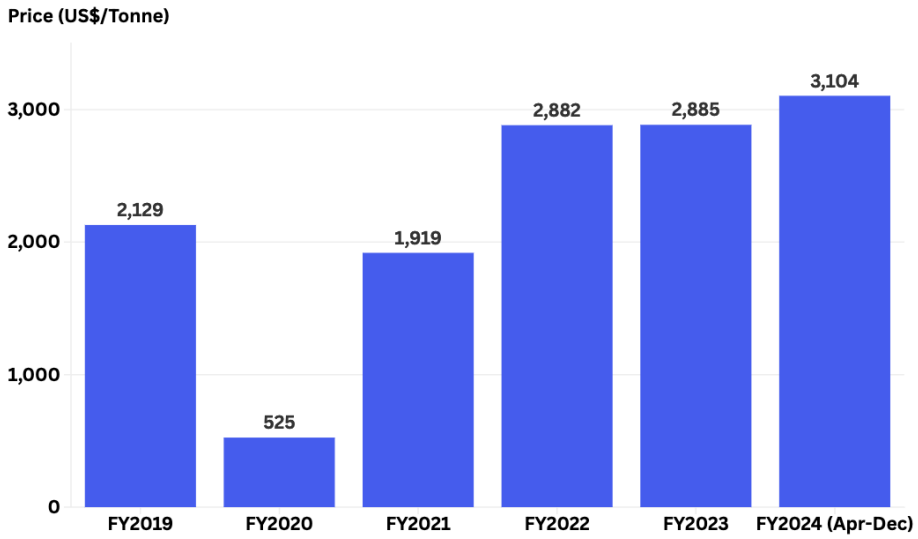
Copper and copper compound prices have been increasing in recent years, both globally and in India, driven by the increasing demand for copper in the renewable energy, EV, electronics and consumer durables sectors. The volatility and relatively lower prices during 2018-2021 were due to disruptions in the global supply chain.

In 2018, trade conflicts between the US and China hurt demand and reduced prices. The strong US dollar that year also contributed to low demand and prices. In India, between April 2018 and April 2019, exports of copper and copper products (including cathodes) reduced by almost US$3.5 billion. This was due to a government-ordered shutdown of Vedanta's copper smelter in Tamil Nadu following pollution-related protests at the plant site. This led to India becoming a net importer of copper.

To counter the impact of the plant closure and reduce dependency on imports, Indian companies and the government have been focusing on increasing domestic production. Hindustan Copper, India's only vertically integrated copper producer, has been investing in expanding mining capacity to boost output.

Following the COVID-19 pandemic, pent-up demand and supply chain concerns emerging from Russia's invasion of Ukraine increased copper ores and concentrates prices in FY2022 **(Figure 6)**. Prices have remained elevated as demand has risen and the war continues.

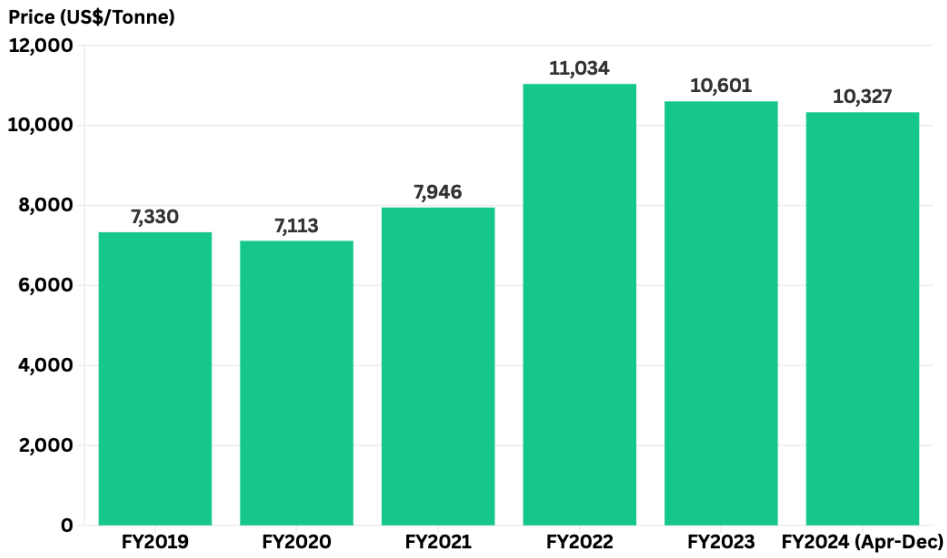
Figure 6: India Copper Ores and Concentrates Average Annual Import Prices (US$/tonne)



Source: UN Comtrade

Copper oxide and hydroxide prices mirrored broader copper market trends from FY2019 to FY2023, with a sharp recovery post-pandemic and a subsequent softening as global economies adjusted **(Figure 7)**. The long-term outlook remains bullish due to their essential role in growing industries like renewable energy and electronics, but short-term fluctuations depend on economic conditions and supply constraints.

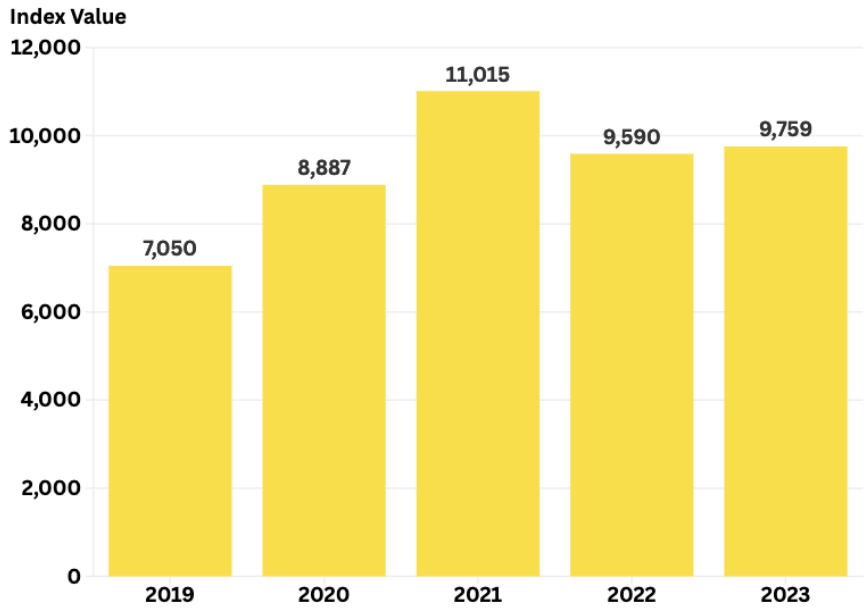
Figure 7: India Copper Oxides and Hydroxides Average Annual Import Prices (US$/tonne)



Source: UN Comtrade

Between FY2018 and FY2023, the price of copper cathodes fluctuated due to global economic conditions, supply chain disruptions and varying demand, driven by growth in the infrastructure, renewable energy and EV sectors (**Figure 8**). Prices were stable at around US$6,000–US$6,500 per tonne in 2018 and 2019 but dropped in early 2020 due to the pandemic, only to rebound sharply, peaking over US$10,000 in 2021 as global economies recovered. Prices stabilised between US$8,000 and US$9,500 per tonne in 2022 and 2023 amid inflation, rising interest rates and China's economic slowdown. In India, refined copper (cathode) production increased by approximately 16.08% from FY2022 to FY2023, while net imports increased by 180% to bridge the supply gap.[30] Major producers like Chile, Peru, Zambia and Congo (DRC) played crucial roles, while African exporters, especially Zambia and Congo, faced logistical and infrastructure challenges. Despite these hurdles, long-term demand remained strong, driven by the green energy transition.

Figure 8: Copper Cathode Shanghai Changjiang Average Annual Spot Price Index



Source: BloombergNEF

The sector is recovering, driven by the increasing demand for copper in the renewable energy and EV sectors, alongside government initiatives to boost domestic mining. The industry is poised for a rebound but still faces significant challenges in environmental compliance, mining inefficiencies and global competition.

[30] Times of India. ICA India reports notable 16% growth in copper demand in 2023. October 2023.

Graphite

Graphite, known for its high thermal and electrical conductivity, durability, low weight and chemical stability, is essential for a sustainable future. It is primarily used in battery manufacturing. Amorphous (natural) graphite is used in lithium-ion batteries as a conductive additive or binder in electrodes, enhancing battery performance and life cycle. It is also used in supercapacitors, making it suitable for EVs. Graphite is also used in components for solar and wind industries, as well as hydrogen fuel cells. According to IEA's analysis, graphite demand for clean technologies will amount to 6013kt by 2030.[31]

Synthetic graphite – made by high-temperature treatment of petroleum coke and coal tar – offers superior performance and consistency compared with natural graphite but is more expensive and emissions-intensive. It is used as an anode material in lithium-ion batteries for EVs, preferred for its higher energy densities, faster charging rates and longer life cycle. Synthetic graphite also serves as a catalyst support in fuel cell electrodes. However, its fossil fuel origins make it controversial, especially in the EU.[32]

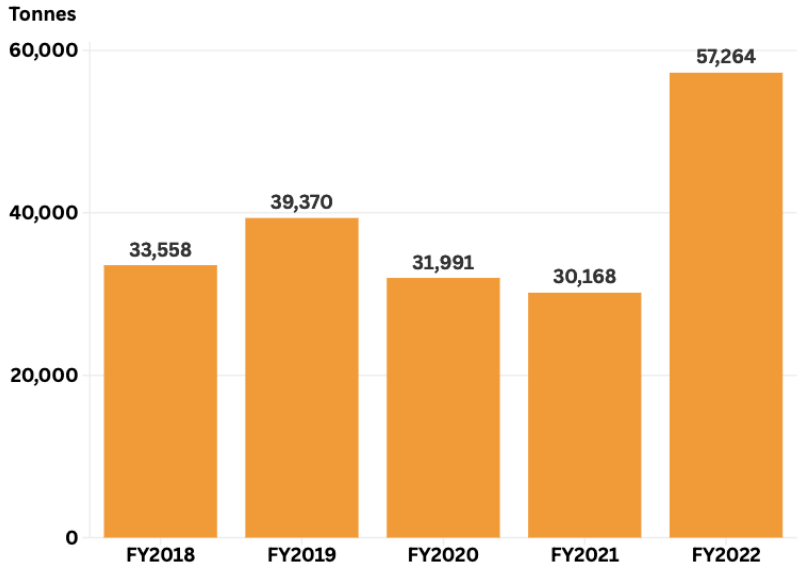
Graphite Domestic Production and Imports

India has an estimated 211.62 million tonnes of graphite, with 8.56 million tonnes in reserves and 203.6 million tonnes in remaining resources.[33] The Indian government auctioned 13 graphite-rich blocks in the first four tranches of critical mineral auctions between November 2023 and June 2024. They lie in Tamil Nadu, Odisha, Arunachal Pradesh, Madhya Pradesh and Jharkhand. Four of these blocks in Odisha and Tamil Nadu have secured bids.

India relies on imports for 60% of its graphite demand for use in batteries despite having one of the largest synthetic graphite-producing companies in the world – Graphite India.[34,35] From April 2017 to December 2023, total imports of natural and synthetic graphite to India were valued at US$1.8 billion. Graphite production has seen a significant increase in the last reported year **(Figure 9)**, with Tamil Nadu, Odisha and Jharkhand leading since 2017. Graphite is used in India primarily in the pencil-making, foundry and refractory industries. Other industries that use graphite include dry cell batteries, cement, iron and steel production, and paint.

[31] IEA. Graphite: Outlook for Key Energy Transition Minerals. May 2024.
[32] Fastmarkets. Lack of investment, diversification biggest challenges for European graphite market. 2 October 2023.
[33] Indian Minerals Yearbook. Graphite. December 2023.
[34] Australian Trade and Investment Commission. Unlocking Australia-India critical minerals partnership potential. July 2021. Page 14.
[35] Fastmarkets. Natural and synthetic graphite market guide.

Figure 9: Natural Graphite Production in India



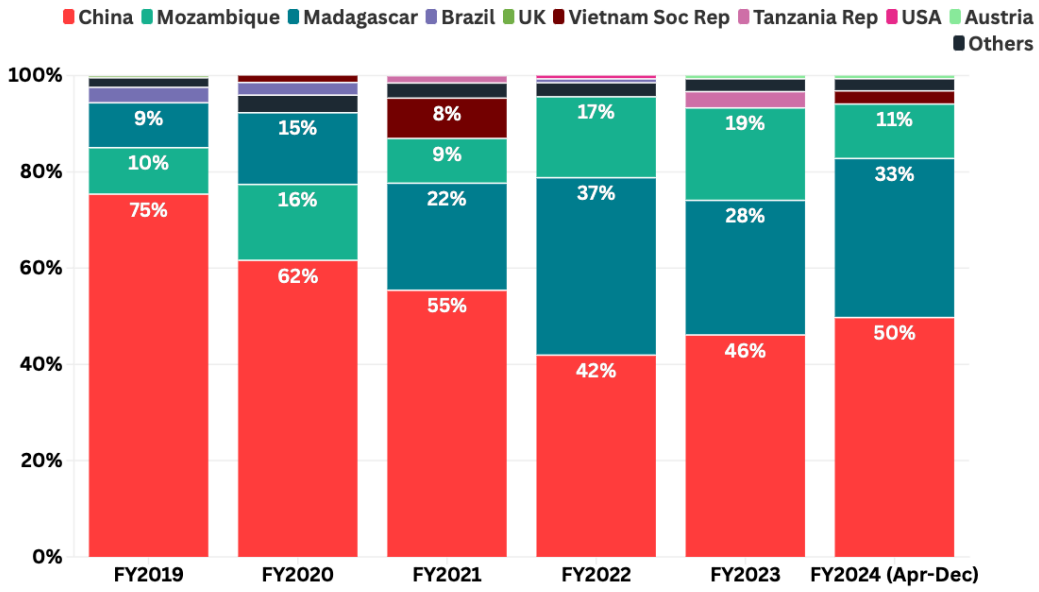
Source: Indian Minerals Yearbook (2018, 2019, 2020, 2021, 2022), Indian Bureau of Mines

China, which refines 90% of the world's graphite for EV battery anodes, is a key import hub for India, accounting for over 50% of its total imports annually, on average. The top graphite producers in the world in 2023 were Madagascar, Mozambique and Brazil. Tanzania has some of the world's largest graphite reserves. This is reflected in India's imports of natural graphite **(Figure 10)**. The imports for 2023 (April-December) also reflect this trend, with maximum imports being from China, Mozambique and Madagascar.

In FY2023, India imported 20,471 tonnes of natural graphite from China, 12,418 tonnes from Madagascar, 8,525 tonnes from Mozambique, 1,500 tonnes from Tanzania and 288 tonnes from Austria. Austria is a major import hub owing to the presence of a refractory factory, RHI-Magnesita. The company merged its other two Indian subsidiaries, RHI Clasil and RHI India, into the publicly listed Orient Refractories in May 2021.[36] RHI Magnesita India has since invested US$325 million in building its capacity, with plans to expand further.[37] This is reflected in Austria's imports to India from FY2023 onwards.

[36] Th Economic Times. RHI Magnesita's two Indian businesses merge with Orient Refractories Limited. 19 May 2021.
[37] The Hindu BusinessLine. RHI Magnesita India plans ₹3,600 cr capex. 6 September 2024.

Figure 10: Natural Graphite Imports by Country, Top 5 (%)



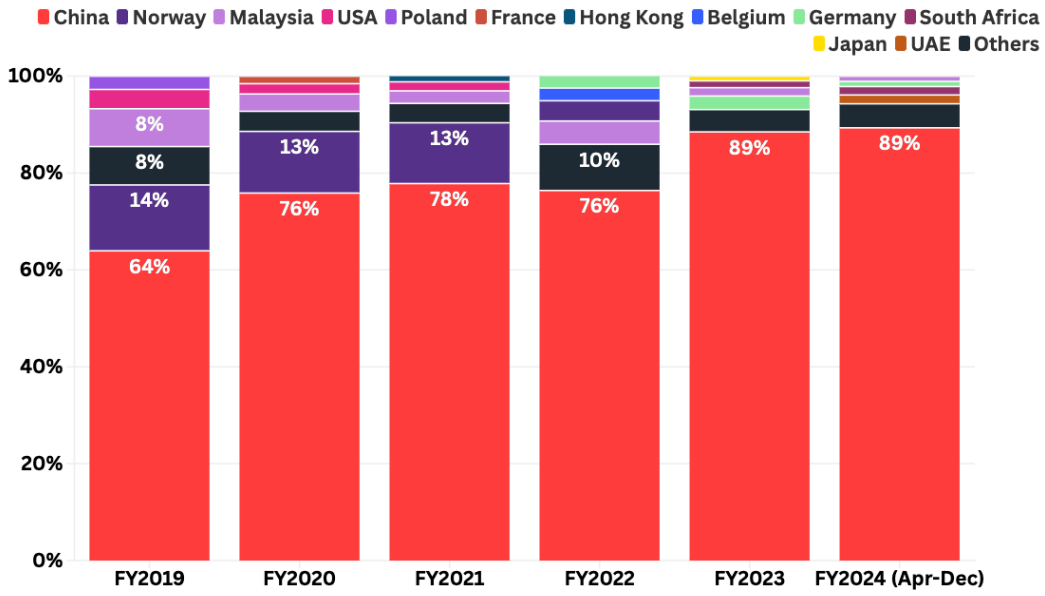
Source: UN Comtrade

Since 2021, China has been favouring synthetic graphite output. Though the material performs better in battery anodes, it is more expensive than its natural counterpart. Under the new export curbs, countries will have to apply for permits to ship high-quality synthetic graphite.[38] Though India's dependence on China for natural graphite is decreasing, the opposite is true for synthetic graphite **(Figure 11)**.

Some of the world's largest synthetic graphite-producing companies are in China, the US, Japan and Germany.[39] Key European exporters include Norway, Poland and France.[40,41] In FY2023, India imported 41,661 tonnes of synthetic graphite from China, 1,316 tonnes from Germany, 812 tonnes from Malaysia, 660 tonnes from South Africa and 451 tonnes from Japan. Between April and December 2023, China continued dominating India's synthetic graphite imports.

[38] Reuters. China, world's top graphite producer, tightens exports of key battery material. 21 October 2023.
[39] Fastmarkets. Natural and synthetic graphite market guide.
[40] UC Davis. Releasing the Pressure: Understanding Upstream Graphite Value Chains and Implications for Supply Diversification. 4 January 2024.
[41] ECGA. Graphite in Batteries. 2023.

Figure 11: Synthetic Graphite Imports by Country, Top 5 (%)



Source: UN Comtrade

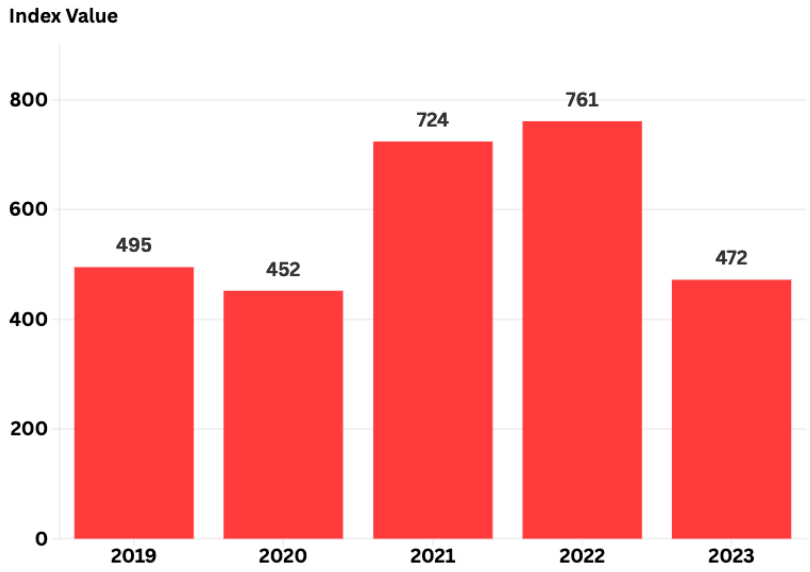
Graphite Prices

China influences global natural graphite prices due to its dominance in the supply chain. Natural graphite prices increased marginally in 2018 and 2019 due to the Chinese government's regulations on industrial pollution and the environmental impact of the steelmaking sector. After some downward adjustments in 2020, supply chain disruptions due to COVID-19, a surge in EV sales and rising production costs led to a spike in prices in 2021 and 2022 (**Figure 12**). There was some price correction in 2023, but prices are expected to increase again due to supply tightness arising from stringent environmental regulations in China.[42]

In late 2023, China announced that the country would be curbing graphite exports, tightening supply globally. According to industry representatives, China made the move in the interest of its national security to leverage its dominance over the global mineral supply chain. This was in response to the US and the Netherlands imposing curbs on exporting semiconductors and related manufacturing equipment to China. These restrictions apply to natural graphite and its products, as well as synthetic graphite.

[42] Fastmarkets. China's graphite industry struggles to adapt: ICCSINO. 19 April 2023.

Figure 12: China Natural Graphite, Avg. Annual Price Index



Source: BloombergNEF

Synthetic graphite prices have followed a trajectory similar to natural graphite but to a varying degree. COVID-19 led to an increase in synthetic graphite prices in 2020 and 2021. Following this, there was a sharp decline in prices as production resumed in 2022. Post-COVID-19, synthetic graphite anodes cornered most of the market share; however, there are concerns that its feedstock – petroleum coke and coal tar pitch – will eventually raise its prices. In 2023, needle coke prices fell, reducing synthetic anode prices. Synthetic graphite competes with natural graphite in producing anodes as it is more affordable, purer and predictable.

Synthetic graphite prices are expected to moderate in the short term.[43] Natural graphite will see greater demand from markets other than China. India has an opportunity to meet global demand as an ex-China natural graphite supplier, as its exports are cost-effective. Large markets, such as North America and some European countries, which do not produce natural graphite, are looking to diversify their supply chains. These countries/regions may find it lucrative to trade with India as graphite demand increases.

Lithium

Lithium is a key mineral that is used in batteries. It is pivotal in ensuring efficient, stable and consistent power delivery and storage. Its characteristic use is in batteries, lubricants, glass and ceramics. Further, 39% of India's current lithium demand is for pharmaceuticals, medicinal chemicals

[43] Fastmarkets. Spherical natural graphite prices plunge to 11-year lows on more competition from synthetic graphite. 20 June 2023.

and botanical products.[44] According to the IEA's analysis, lithium demand for clean technologies alone will amount to 442kt by 2030 and 1203kt by 2040.[45]

Lithium Domestic Production and Imports

India does not produce lithium and depends on imports for lithium battery material.[46] For the EV sector, this means relying on China, Chile, Bolivia, Argentina and Australia. Total imports of lithium, lithium-ion, lithium carbonates, and lithium oxides and hydroxides from April 2017 to December 2023 were about US$11.9 billion.

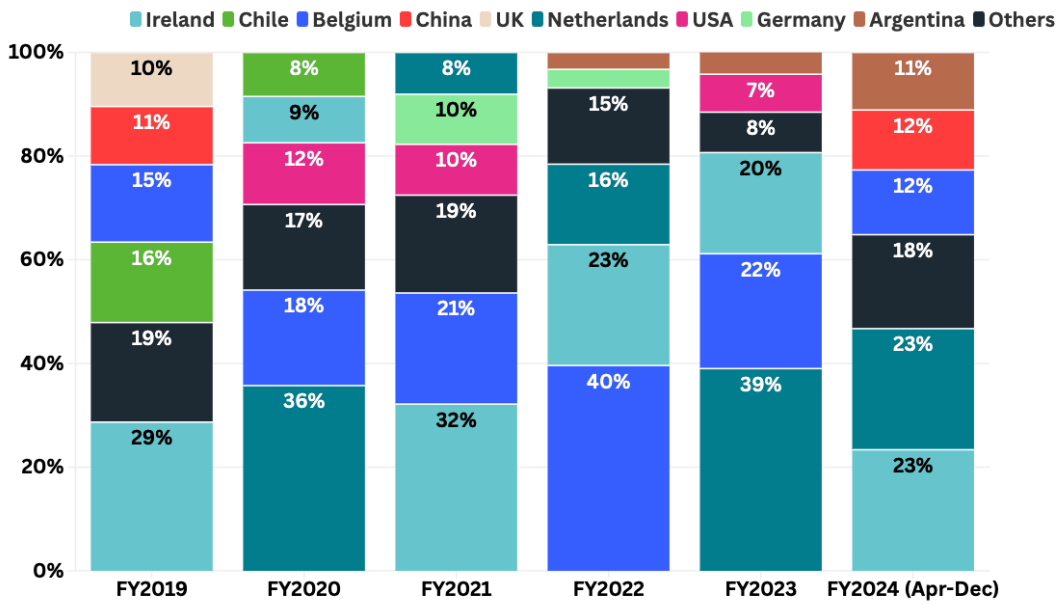
While lithium reserves in the country are unknown, a large lithium block was discovered in February 2023 in Jammu and Kashmir's Reasi district, Salal-Haimana area.[47] Experts infer that the area is likely to have resources to the extent of 5.9 million tonnes.[48] Other regions in India that have reserves are Jharkhand, Rajasthan and Chhattisgarh.

India imports lithium carbonates from Chile, China, Argentina and the US, which are the biggest lithium producers in the world **(Figure 13)**. The Netherlands, Belgium and Ireland are likely trading hubs used to reroute lithium carbonate to India. These European countries have maintained their position as top exporters to India over the years. Argentina has maintained its position in the ranks, likely by leveraging its rich lithium reserves in the "Lithium Triangle" (which it shares with Chile and Bolivia), multinational refineries, and access to ports. Going forward, increased trade can be expected between Australia, Canada, Finland, France, Germany, Italy, Japan, South Korea, Sweden, the US, the UK and India, which are all part of the Minerals Security Partnership (MSP).[49]

In FY2023, India imported 400 tonnes of lithium carbonate from the Netherlands, 227 tonnes from Belgium, 200 tonnes from Ireland, 75 tonnes from the US and 43 tonnes from Argentina. Between April and December 2023, India imported lithium carbonate mainly from Ireland, Belgium, the Netherlands, Argentina and China.

[44] CSEP. Assessing the Criticality of Minerals for India, Addendum: Mineral Factsheets. April 2023. Page 25.
[45] IEA. Lithium: Outlook for Key Energy Transition Minerals. May 2024.
[46] Australian Trade and Investment Commission. Unlocking Australia-India critical minerals partnership potential. July 2021. Page 14.
[47] NDTV. In A First In Country, Lithium Reserves Found In Jammu And Kashmir. 10 February 2023
[48] India Today. In a first, India finds huge lithium deposits, can rev up its EV plans. 10 February 2023.
[49] The Mineral Security Partnership (MSP) is a collaboration of several countries and the European Union (EU) to develop sustainable and diverse supply chains for critical minerals. The member countries include the United States, Australia, Canada, Finland, France, Germany, Italy, Japan, Norway, the Republic of Korea, Sweden, the United Kingdom, India and the EU countries.

Figure 13: Lithium Carbonate Imports by Country, Top 5 (%)



Source: UN Comtrade

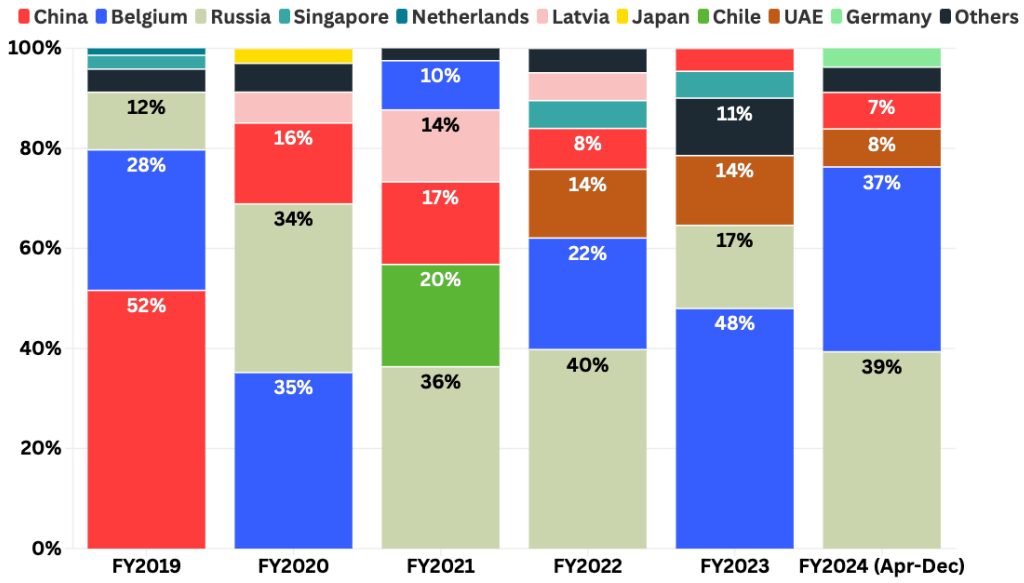
In FY2023, India imported 537 tonnes of lithium oxide and hydroxide from Belgium, 186 tonnes from Russia, 156 tonnes from the UAE, 60 tonnes from Singapore and 51 tonnes from China **(Figure 14)**. Over the years, China slipped in the rankings. This is likely to continue as India diversifies its supply chain.

As the demand for lithium and its compounds grows, there will be higher dependency on imports in the coming years. To safeguard against global supply chain disruptions and the subsequent energy and economic security risks, India will have to focus on bridging the gap with domestic mining of lithium and manufacturing of lithium batteries.

A concerted effort to partner with and foster bilateral relations with other lithium-rich nations should also be a priority for India. South America, for example, has become a leading supplier of lithium, with Chile's exports being valued at around US$8 billion in 2022.[50] From April 2023 to December 2023, Belgium and Russia made up most of the lithium oxide and hydroxide imports to India. Enhancing trade with other countries of the global South could prove to be a mutually beneficial relationship.

[50] Benchmark Source. South America to reclaim place as the leading lithium-producing region by 2027. 8 February 2024.

Figure 14: Lithium Oxide and Hydroxide Imports by Country, Top 5 (%)



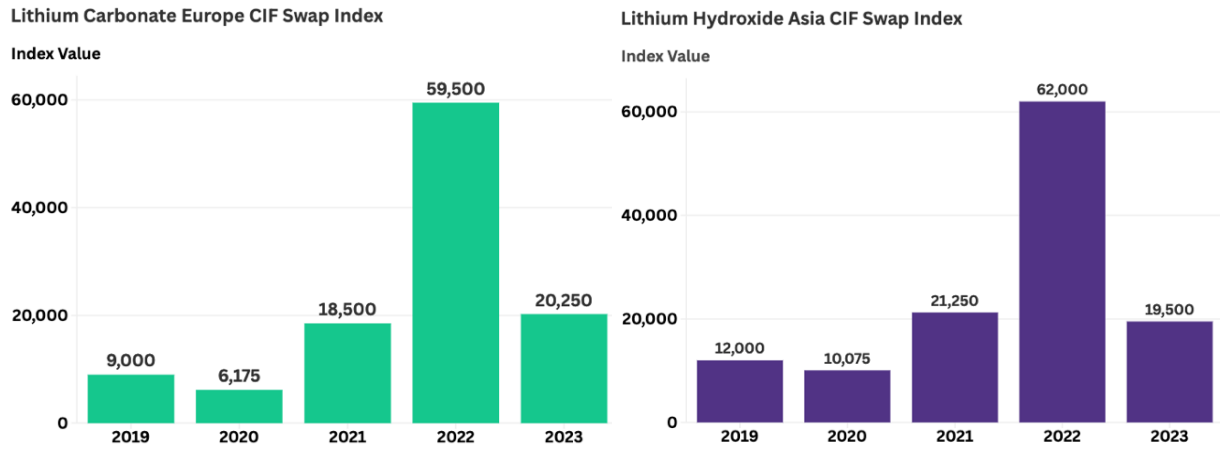
Source: UN Comtrade

Lithium Prices

Like other critical minerals, lithium prices are volatile because the production and refining of the mineral are highly concentrated in certain countries, which makes it vulnerable to geopolitical risks. Aside from the key countries that control most of the global lithium production, 60% of the lithium processing takes place in China. There is also a lack of transparency in the pricing mechanisms for lithium and its compounds.

Lithium carbonate and hydroxide prices dropped in 2020 **(Figure 15)**. This decline was due to a supply glut in the market, particularly as the pandemic disrupted demand across various industries, including EVs and consumer electronics. However, this drop was short-lived. By 2021 and 2022, as the global economy began to recover and the demand for EVs surged, lithium prices started to rise, driven by tighter supply and increasing demand for lithium-ion batteries.

Figure 15: Lithium Carbonate and Hydroxide Prices, CIF Swap Index



Source: BloombergNEF

Lithium prices witnessed a correction in 2023. The industry expects prices to fall further in 2024 due to an oversupply of lithium in the global market, resulting from low EV sales. EV sales, US efforts to bolster the supply chain, Chile's new lithium policy and increasing supply from Africa are some factors that can influence this market in 2024. Lithium demand will increase long-term as it is a cornerstone of clean energy technology.

Nickel

Nickel is integral to the renewable energy supply chain, particularly in lithium-ion battery production and as a catalyst in various energy conversion processes. The demand for nickel is expected to rise exponentially to meet this increasing demand. The IEA's APS expects the global EV fleet to reach almost 250 million by 2030.[51] Globally, the demand for nickel from the EV sector is projected to be 665,000 tons by 2025.[52] Nickel – albeit of a lower quality than what is required for batteries – is also used to produce stainless steel.

Nickel is used in various forms, including oxides, hydroxides, hydrides, sulphates and catalysts, each with specific applications. Nickel oxides and hydroxides are vital for lithium-ion battery cathodes, while nickel hydroxide is used in nickel-metal hydride batteries, particularly in hybrid vehicles and energy storage. Nickel sulphates are essential for high-nickel cathode materials in lithium-ion batteries.

[51] IEA. Prospects for Electric Vehicle Deployment. Global EV Outlook, 2023.
[52] Statista. Global demand for nickel in electric vehicle batteries from 2018 to 2025. 24 October 2023.

Nickel Domestic Production and Imports

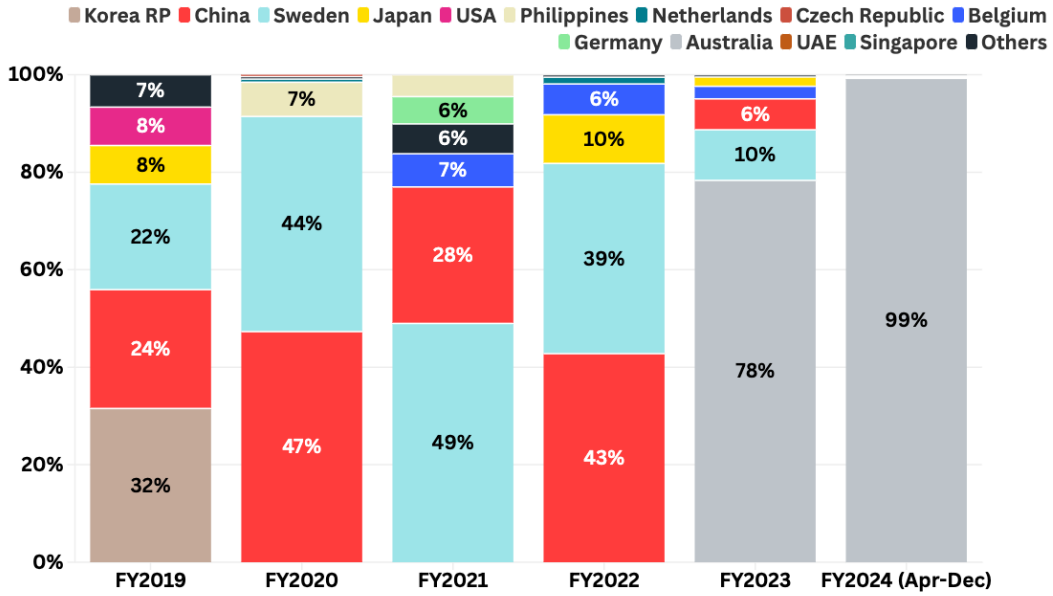
India's nickel reserves are estimated to be about 189 million tonnes, primarily found in the form of oxides, sulphides and silicates, often as a by-product of copper mining.[53] Despite this, India relies entirely on imports to meet its nickel demand for renewable energy applications.[54] This includes EVs, for which demand is increasing rapidly across the country. From April 2017 to December 2023, India imported nickel compounds and products worth approximately US$590 million.[55] Major import partners included China, Sweden, the US, France, Japan, Singapore, Malaysia, the Philippines and Belgium.

India aims to reduce import dependency by developing domestic extraction capabilities and forming alliances with nickel-rich countries. Investments are being made in advanced technologies to lower the costs of nickel mining, refining and utilisation. Hindustan Copper Limited's facility in Ghatshila, Jharkhand, established in 2016, was the first to produce London Metal Exchange (LME)-grade nickel metal and recover nickel sulphates.[56] Nicomet Industries, acquired by Vedanta in 2021,[57] claimed to be the only nickel producer in India, although neither company has reported significant nickel production.

India imports nickel and its compounds from China, Australia, the US, Finland, Sweden, the Philippines and South Africa **(Figure 16)**. Australia has emerged as the dominant exporter of nickel oxides and hydroxides as a result of the Australia-India Economic Cooperation and Trade Agreement (AI ECTA) signed in 2022.[58] In FY2023, India imported 1,760 tonnes of nickel oxides and hydroxides from Australia, 233 tonnes from Sweden, 142 tonnes from China, 58 tonnes from Belgium, and 42 tonnes from Japan. Between April and December 2023, India imported 99% of its nickel oxides and hydroxides from Australia.

[53] Indian Bureau of Mines. Indian Yearbook of Minerals. August 2021.
[54] Australian Trade and Investment Commission. Unlocking Australia-India critical minerals partnership potential. July 2021.
[55] Includes nickel oxides and hydroxides, nickel catalysts, nickel sulphate, nickel metal hydride.
[56] Indian Bureau of Mines. Indian Yearbook of Minerals. August 2021.
[57] Livemint. "Vedanta now India's lone nickel producer with Nicomet buy". 21 December 2021.
[58] Australian Government. Australia-India Economic Cooperation and Trade Agreement. December 2022.

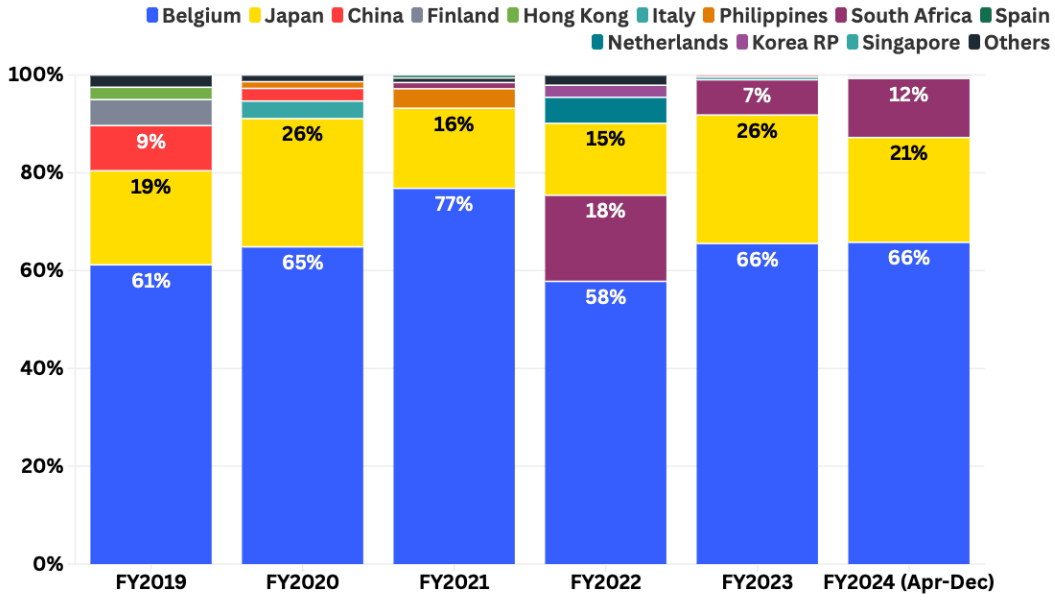
Figure 16: Nickel Oxides and Hydroxides Imports by Country, Top 5 (%)



Source: UN Comtrade

As mentioned earlier, nickel sulphates are primarily used to manufacture high-nickel cathode materials for lithium-ion batteries. More than 85% of India's nickel sulphate imports come from two countries – Belgium and Japan **(Figure 17)**. Both countries have well-developed metallurgical and refining industries, allowing them to produce high-quality nickel sulphate that meets international standards. They have developed robust supply chains and trade networks, making it easier, more reliable and cost-effective to export nickel sulphate to India. In FY2023, India imported 1,108 tonnes of nickel sulphates from Belgium, 444 tonnes from Japan, 121 tonnes from South Africa, 9.6 tonnes from Singapore and 6.6 tonnes from China. India has reduced import dependency on China for nickel sulphate in recent years. Belgium-headquartered company Umicore has made great advancements in producing and supplying nickel sulphate. Between April and December 2023, Belgium, South Africa and Japan continued to dominate the supply of nickel sulphate to India.

Figure 17: Nickel Sulphate Imports by Country, Top 5 (%)



Source: UN Comtrade

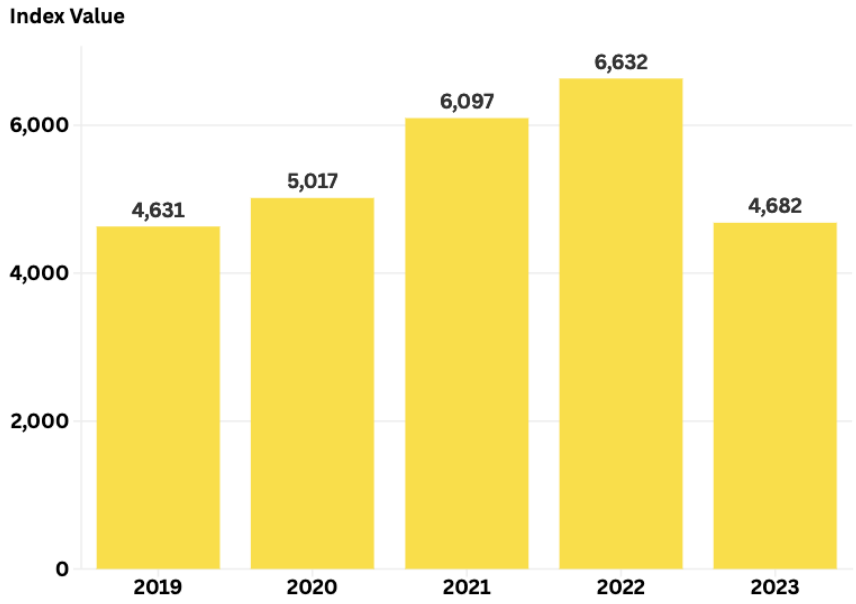
Nickel Prices

Global nickel prices started rising with COVID-19-related supply disruptions in 2020 and 2021 and were later affected by Russia's invasion of Ukraine in 2022 and the subsequent sanctions on Russian exports **(Figure 18)**. Prices started easing in 2023 with the moderation of supply concerns and the rise of nickel production and exports from Indonesia. South Korea, Japan, Indonesia and the Philippines will be key players influencing the market due to their partnerships and production of batteries. A rise in EV manufacturing and cathode production in China will likely influence the price of nickel sulphate.

As mentioned earlier, the steel industry primarily drives demand for nickel. Nickel has historically been a small and volatile market and is set to be influenced by changes in its primary use. This will undoubtedly influence the price of nickel since most pricing mechanisms better reflect the stainless-steel market than the renewable energy supply chain.

These price variations have affected nickel trade in India. Over time, as seen with cobalt, nickel batteries could become the primary demand driver, influenced by the countries controlling nickel mining and production. It remains to be seen how the Indian mineral block auctions will reduce India's import dependency. Here also lies an opportunity for India to focus on building refining and processing capabilities to emerge as a value-adding hub globally.

Figure 18: Nickel Sulphate, China Ni 22% Price Index



Source: BloombergNEF

Way Forward

India’s ambitious renewable energy and technological advancement goals heavily depend on a stable supply of critical minerals. The country’s reliance on imports poses significant geopolitical challenges – India must develop strategies to mitigate risks associated with mineral dependencies and foster domestic production.

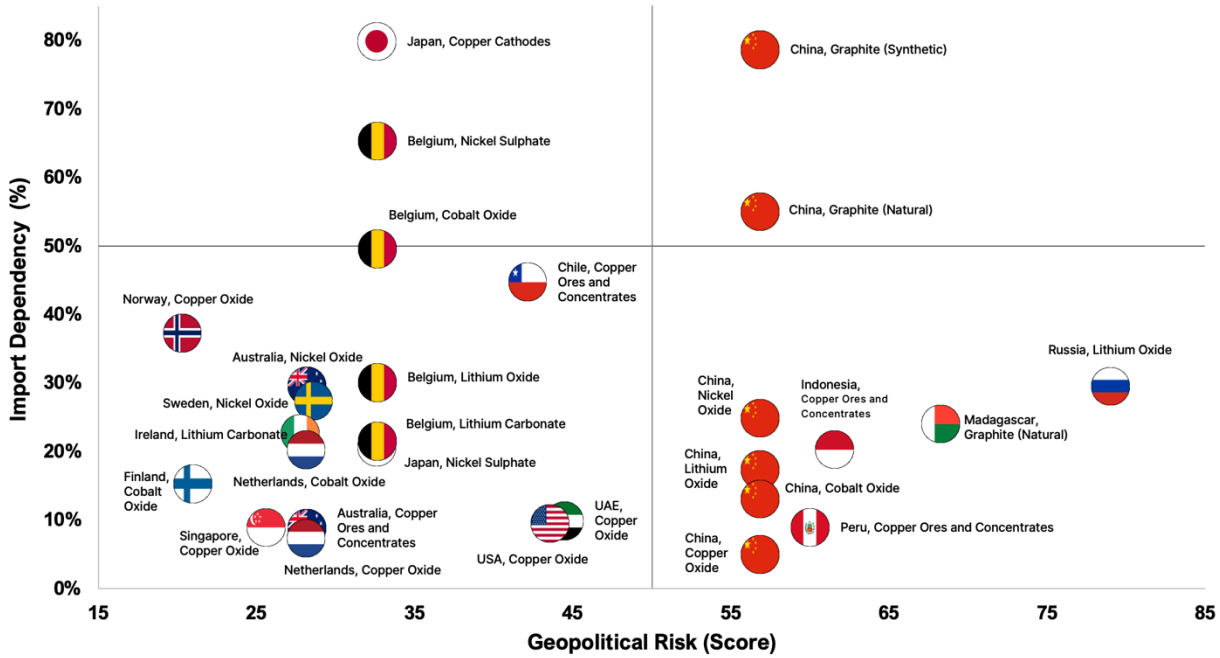
In this section, we map India’s import dependency and risk for key energy transition minerals and suggest steps for securing the supply chain.

In **Figure 19**, we plot India’s import dependence for key critical minerals (on the Y-axis) against the corresponding geopolitical risk associated with those imports by country (on the X-axis). The minerals analysed include compounds of nickel, lithium, cobalt, graphite and copper, all of which are essential for renewable energy technologies and battery production. We have sourced these minerals from India’s critical minerals list, highlighting their strategic importance.

We have derived the data from Harmonized System (HS) Code-based trade flow analysis, averaging 75% of total imports over FY2019 to FY2023 to stabilise trends. To assess country risk levels, we

used the Fragile States Index[59] and Control Risks' RiskMap[60], incorporating business risks (political, security, operational, regulatory, cyber and ESG) and state vulnerability factors (economic, social and demographic).

Figure 19: India Import Dependency of Key Minerals vs. Geopolitical Risk



Source: UN Comtrade, Control Risks, Fragile States Index, IEEFA

The following are the key takeaways from this analysis:

- **Minerals in the fourth quadrant** – Synthetic graphite and natural graphite – both have high import dependency on China. Policy interventions are needed to drive diversification in the procurement of these minerals. Mozambique, Madagascar, Brazil, and Tanzania are some countries with the highest graphite production. As part of the Global South cooperation initiatives, these countries could be favourable partners for India for graphite trading. Further, they are also being considered by the MSP as investment destinations. Other favourable countries to partner with are Mexico, Australia, Vietnam, and Namibia, given their potential for increased graphite production, as well as Germany, Norway, and Canada, which are members of the MSP.

- **Minerals in the third quadrant** – Copper cathodes and nickel sulphate – although imported from relatively less-risky countries such as Japan and Belgium, are still heavily import-

[59] Fragile States Index 2024
[60] Control Risks RiskMap 2024

dependent at 80% and 65%, respectively, on one country. Japanese companies like JX Nippon Mining & Metals and Mitsubishi Materials Corporation operate highly efficient copper refineries. As a QUAD member, Japan makes a strong case for favourable trade relations with India.[61] Regardless, the supply chains for these minerals need to be diversified to enhance supply security. The US is the fifth largest producer of copper in the world and could be another source of supply for India.

- **Minerals in the second quadrant** – Despite having a relatively low dependency on any one country, still have some minerals such as lithium oxide (30% dependency on Russia) and nickel oxide (25% dependency on China). Diversifying sources for these minerals is as important as for mineral compounds in the fourth and third quadrants. Developing domestic lithium refining capacity will help India integrate with the global lithium supply chain.

Overall, countries with high geopolitical risks are Russia, Madagascar, Indonesia, Peru and China. India should strive to reduce its dependency on these countries by identifying new critical mineral resources among more secure countries and expediting domestic exploration and production of minerals.

India is in a good position with minerals in the first quadrant, which have less import dependency on a single country and are sourced from geopolitically stable countries. India can deepen its strategic partnerships with these (less-risky) countries and increase its procurement of minerals from these sources as domestic demand for these minerals rises. India can also explore investment opportunities in resource-rich, friendly nations, such as Australia, Chile and some promising African countries.

[61] The Quadrilateral Security Dialogue (QUAD) is an informal strategic forum comprising the US, India, Australia and Japan. It aims to promote a free, open, prosperous and inclusive Indo-Pacific region.

Annexures

Annexure 1: Limitations of the study

The realm of critical minerals is a rapidly developing space, attracting interest from governments, businesses, researchers and communities. Despite the increasing demand for these minerals, there is a significant lack of accessible information regarding their supply chains. Basic data on mining companies and their operations, mining practices and their impact, pricing mechanisms, and trade flows from countries of origin to global markets remain largely unavailable. Discrepancies between data from various reporting organisations, a lack of standardisation in trade data units, changes in Harmonized System (HS) codes, and inconsistent reporting across geological surveys pose major challenges. Additionally, the presence of small, volatile markets without standardised pricing or contracts further hinders transparency in these supply chains.

In this study, the unavailability of pricing indexes with historical data impacted the analysis. Several indexes in different geographies and a lack of standardisation necessitated that each country exporting to India would base its prices on its local index. Furthermore, opacity with regard to the contracts deciding pricing complicates the timeline of any fluctuations observed.

Minerals such as lithium, nickel and cobalt are not produced in India. However, trade data captured at Indian ports indicates that the country imports and exports these minerals. Whether these minerals, compounds and materials are simply being rerouted or processed through ports is unclear, as the data does not capture which companies are involved in importing and exporting these minerals.

Transparency is the first step towards accountability. Moving forward, mining must be done sustainably, honouring the environment and affected communities. To ensure that the extraction and utilisation of critical minerals is ethical, we must begin by standardising data on their supply chains, making them accessible and comprehensive, and evaluating them fairly.

Annexure 2: Mineral End-use Applications

Mineral	End-use applications
Cobalt Oxide and Hydroxide	Cathodes in lithium-ion batteries (for EVs and energy storage)
	Pigments in ceramics and glass, catalysts in chemical reactions
Natural Graphite	Anodes in lithium-ion batteries (EVs, energy storage)
	Lubricants, refractories, pencils, brake linings
Synthetic Graphite	Anodes in lithium-ion batteries (EVs, energy storage)
	Electrodes for steel production, friction materials, and carbon brushes for electric motors

Copper Ores and Concentrates	Essential for wiring and electrical applications in renewable energy systems (solar panels, wind turbines)
	Construction, electronics, plumbing, and industrial machinery
Copper Oxides and Hydroxides	Used in solar cells, semiconductor applications, and battery technologies (research phase)
	Wood preservatives, fungicides, pigments
Copper Cathodes	Wiring for renewable energy systems (solar, wind) and power generation equipment
	Electrical cables, electronics, construction, and telecommunications
Lithium Carbonate	Cathode material for lithium-ion batteries (used in EVs, energy storage systems)
	Glass and ceramics production, air treatment
Lithium Oxides and Hydroxides	Key material for lithium-ion battery cathodes (EVs, energy storage)
	Lubricants, ceramics and glass production
Nickel Oxides and Hydroxides	Cathode material for batteries (used in EVs and grid storage)
	Electroplating, ceramics, catalysts
Nickel Sulphate	Cathode material in lithium-ion batteries (EVs and renewable energy storage)
	Electroplating, chemical industry

Annexure 3: HS Codes for UN Comtrade

Mineral	Subcomponent	HS codes
Nickel	Nickel Oxides & Hydroxides	28254000
	Nickel Sulphates	28332400
Lithium	Lithium Oxides	28252000
	Lithium Carbonates	28369100
Copper	Copper Ores & Conc	26030000
	Copper Hydroxide	28255000
	Copper Cathodes	74031100
Graphite	Graphite Amorphous	25041000
	Graphite Artificial	38011000
Cobalt	Cobalt Oxides	28220010
	Cobalt Hydroxides	28220020

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The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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