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NAVIGATING THROUGH THE DEMAND AND SUPPLY GAP

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The Copper Report: Navigating Through the Demand and Supply Gap

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Executive Summary

Copper lies at the heart of the energy transition as a critical component for transforming the Indian economy, from the power grid and electric vehicles (EVs) to construction and advanced manufacturing. Moreover, as India focuses on simultaneously achieving accelerated economic growth and a green transition, the growth in demand for copper is bound to intensify.

Various international agencies have projected significant growth in global copper demand under different scenarios. Global refined copper demand is projected to reach around 33 million tonnes in 2035 and 37 million tonnes by 2050 under the stated policy scenario (International Energy Agency, 2025). S&P Global forecasts it to rise substantially, reaching 53 million tonnes by 2050. Similarly, the International Copper Association (ICAI) anticipates that copper demand will reach about 50 million tonnes by 2050. Given that current global refined copper production stands at approximately 26.5 million tonnes annually, the demand–supply gap is expected to become acute unless there is a considerable increase in production capacity or technological advancements.

As discussed in this report, in India, projections indicate copper demand will increase significantly, reaching 3.24 million tonnes by Fiscal Year (FY) 2030 within the conventional sectors, with construction, industrial, and electricity primarily dominating copper usage. Additionally, the energy transition sector, although currently smaller, is expected to experience rapid growth, with demand projected to reach 274 thousand tonnes by FY 2030.

This report provides a comprehensive examination of the copper sector in India, highlighting its current status, strategic importance, and emerging vulnerabilities throughout the supply chain. By mapping India's copper ecosystem against global trends, it identifies critical gaps and delivers actionable recommendations to secure a resilient, future-ready copper value chain.

This report aims to:

- Provide a global overview of the copper sector, mining, and processing.
- Estimate India's copper demand in the energy transition and conventional sectors until FY 2030.
- Evaluate India's domestic production constraints, global supply chain risks, and the impact of policies on copper mining, processing, and downstream industries.
- Assess India's import dependency at different segments of the value chain by analysing trade patterns of ore and concentrates, cathodes, and semi-finished and finished goods.
- Assess the potential of copper recycling for circularity and examine the concomitant opportunities and challenges in providing a supplementary source of secondary raw material in India.
- Propose strategic recommendations to key Indian stakeholders to ensure a resilient and sustainable copper supply chain.

Methodology

The report adopts a qualitative research methodology supplemented by extant quantitative analysis from the Centre for Social and Economic Progress (CSEP) of copper demand projections. We have adopted the following sequence of steps:

- An extensive review of literature, government reports, acts and legislation, industry reports, case studies, and other policy documents pertinent to Indian and global copper supply chains and industries.
- Research consultations with subject matter experts, stakeholder interactions, internal presentations, and meetings and discussions with scholars at CSEP.
- Focused group discussions, closed-door meetings, and interviews with government officials, industry and academic experts, and fellow researchers in other think tanks and research organisations.

Key Findings and Analysis

Global Copper Scenario: Supply Chain Risks

The global copper landscape is highly concentrated, with a few geographies dominating its extraction and China owning over 44% of global processing capacity. The copper supply chain is vulnerable to geopolitical turmoil, resource nationalism, regulatory and governance challenges, and sustainability concerns. By 2050, global refined copper demand is projected to reach 50 million tonnes, driven by energy transition and industrialisation needs.

- **Resource Depletion and Limited Exploration:** While reserves are depleting and ore grades are declining, increased exploration investment in recent years has not yielded significant discoveries. Of the total copper discoveries, very few have progressed towards actual mine development. Not much focus has been given to greenfield areas to unlock the intrinsic, uncharted potential.
- **Export Restrictions:** Export restrictions on critical raw materials, including copper, are increasing as countries leverage natural resources to benefit their national economies. For example, Indonesia's planned ban on copper concentrate exports poses a risk to global supply stability.
- **High Processing Costs and Plummeting TC/RCs**: Copper processing requires high upfront Capital Expenditure(CAPEX) and Operational Expenditure(OPEX), with declining ore grades further driving up costs. Globally, treatment and refining charges (TC/RCs) are plummeting drastically due to the huge expansion of smelting capacity on the demand side, combined with supply crunches of ore and concentrates. This situation erodes smelters' margins. Escalating costs with diminishing profit margins deter investor interest.
- **Geopolitical and Environmental Risks:** Geopolitical risks refer to uncertainty due to politically unstable sourcing regions and unprecedented export restrictions. Declining ore grades render mining more energy and water-intensive, increasing operational and logistics costs. Latin American mines face water scarcity issues and operational disruptions pertaining to social unrest over environmental concerns, while Africa's mining sector grapples with governance challenges.

India's Copper Scenario: Demand–Supply Gaps

India's net-zero commitment by 2070, clean energy transition, infrastructure expansion, and rising private consumption will drive up the demand for copper. Despite significant reserves, India remains a net importer of copper due to low exploration success, outdated technologies, exhausted mines, the inefficacy of auctions to attract new mining and exploration blocks, insufficient investment, and limited private sector participation. At the current production rate, known copper reserves can be sustained for only approximately 45 years, necessitating the need for alternative supply sources and leveraging recycling potential. The closure of a major copper smelter in Tuticorin has reduced cathode output by 40%, exacerbating import dependence. Sourcing of copper from secondary sources is also limited due to low recycling capacity and nascent infrastructure. The rising import of copper-embedded finished products indicates domestic midstream processing constraints and undermines the scope for domestic value addition.

Challenges in the Indian Copper Value Chain

- **Upstream**: Under the current mining policy regime, India's geological potential remains underexplored, coupled with a complicated auction regime and delayed statutory clearances, thus leading to a lack of new investments. The sole domestic copper miner, Hindustan Copper Limited (HCL), faces operational inefficiencies, leading to stagnant ore and concentrate production.
- **Midstream**: Raw material scarcity, technological inefficiencies, and plummeting TC/RCs reduce the competitiveness of the midstream sector. The closure of Sterlite's Tuticorin smelter due to environmental non-compliance left Hindalco as the only primary supplier of refined copper. However, this situation has started to improve with the commencement of operations at Adani's Kutch Copper Limited's 0.5 million-tonne processing plant. Another new plant with a similar capacity will also be commissioned by 2029.
- **Downstream**: Increased reliance on imported copper products undermines domestic processing. Domestically produced cathodes are insufficient for downstream processing. Trade agreements and liberal import policies facilitate duty-free imports. At the same time, the easy import of finished products, many of which are subsidised in their exporting nations, has undermined the price competitiveness of India's midstream and downstream copper sectors.
- **Recycling**: India's secondary copper infrastructure remains underdeveloped, informal, and unregulated, raising safety and purity concerns. The domestic scrap market needs to be formalised, given the immense copper recovery potential from scrap and e-waste.
- **Trade**: India became a net importer of copper cathodes in FY 2019, while imports of copper ore and concentrates declined due to reduced processing demand. To secure raw materials, India is diversifying its supply sources, though Indonesia's ban on copper concentrates poses a risk. Historically, a net importer of copper products such as wires, rods, pipes, and tubes, India has recently achieved a surplus in rod exports, indicating the growth of its domestic manufacturing sector and improving export competitiveness.

Policy Recommendations

Upstream: Enhancing Exploration and Mining

India is import-reliant for more than 50% of its copper needs. Given the rising copper demand across the world and India's growing copper needs, India must explore and extract more copper, as large resources and reserves lie unexplored and hence not mined. Policy reforms are urgently needed to attract investment in exploration and mining activities to ensure a favourable return on investment.

Given copper's strategic significance to India's economy, the mineral concession procedure—from auctioning to granting statutory clearances and commencing mining operations—needs to be streamlined to avoid any unnecessary delays and backlogs.

Midstream: Strengthening Processing Capabilities

To stabilise eroding margins, smelters should consider diversifying revenue streams by capitalising on high-value by-products such as sulphuric acid, gold, and silver, as well as using more intermediate products, including blister copper, anodes, and scrap (Fastmarkets, 2025). Strategic collaborations, including joint ventures, contract manufacturing, and long-term commercial agreements among miners, processors, and downstream industries, are important to drive technological innovation, risk-sharing, and economies of scale. The existing environmental regulatory frameworks need to be strengthened. Domestic companies should be encouraged to achieve globally recognised certifications like the "Copper Mark" to reinforce credibility and transparent third-party verification in responsible sourcing, processing, and recycling.

Downstream: Bolstering Domestic Manufacturing

The large-scale entry of Kutch Copper is expected to make domestic cathodes available and cost-competitive for downstream manufacturers, reversing India's status as a net importer. There is a need to undertake a comprehensive review of existing trade agreements and duty structures, particularly the agreements with the Association of Southeast Asian Nations (ASEAN), Japan, South Korea, and the United Arab Emirates (UAE). Strategic vertical integration is required to streamline operations across the copper value chain, consolidating fragmented market segments for improved efficiency. Quality Control Orders (QCOs) should be reassessed to avert any supply crunches of cathodes to the downstream industries without compromising on quality.

Recycling and Circular Economy Measures

Regulatory oversight is needed to structure and formalise the scattered and unorganised sector engaged with collection, sorting, and reprocessing through adherence to environmental and safety standards. It is important to develop a robust domestic secondary copper market by facilitating direct linkages between scrap vendors, recyclers, and copper processors. Industries should be encouraged to use more recycled materials, guided by the overarching principles of the circular economy. Extended Producer Responsibility (EPR) rules need to be strengthened and made effective to ensure proper end-of-life management and resource recovery.

Leveraging Foreign Policy Instruments: Across the Value Chain

India should proactively engage with key copper-reserve-rich and copper-producing countries such as Chile, Peru, the Democratic Republic of Congo (DRC), Australia, and Zambia through resource diplomacy, strategic acquisitions, and effective partnerships. Apart from KABIL-led G2G initiatives, more Business-to-Business (B2B) and Government-to-Business (G2B) collaborations are essential in the areas of exploration, technology and knowledge exchange, value-added processing, and recycling. Existing bilateral relationships should be leveraged more effectively, along with multilateral forums such as the Mineral Security Partnership, Indo-Pacific Economic Framework, Supply Chain Resilience Initiative, and Quad–ASEAN, to deepen economic cooperation. Trade, investment, and offtake agreements should be used strategically as alternative finance mechanisms to secure a sustainable copper supply chain.

Concluding Remarks

India's growing copper demand calls for a holistic and comprehensive strategy that integrates the domestic copper value chain with international partnerships, technological advancements, and sustainable practices. Strengthening upstream and midstream capacities while fostering a robust downstream manufacturing sector will be crucial in bridging the demand–supply gap and prioritising domestic value addition. By adopting strategic policy interventions and aligning with international best practices, India can enhance its copper self-sufficiency and secure a resilient supply chain for future industrial growth and energy transition.

Contents

Abbreviations

ACC	Advanced Chemistry Cell
AIFTA	ASEAN-India Free Trade Agreement
AITIGA	ASEAN-India Trade in Goods Agreement
ASEAN	Association of Southeast Asian Nations
BESS	Battery Energy Storage System
BHP	Broken Hill Proprietary Company Limited
BIS	Bureau of Indian Standards
B2B	Business-to-Business
CAG	Comptroller and Auditor General (of India)
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CCCR	Continuous Cast Copper Rods
CEA	Central Electricity Authority (of India)
CEPA	Comprehensive Economic Partnership Agreement
CL	Composite License
CPCB	Central Pollution Control Board
CSEP	Centre for Social and Economic Progress
CVD	Countervailing Duty
DRC	Democratic Republic of Congo
EoL RR	End-of-Life Recycling Rate
EPR	Extended Producer Responsibility
ESG	Environmental, Social, and Governance
ETP	Electrolytic Tough Pitch
EU	European Union
EV	Electric Vehicle
FCM	Forward Charge Mechanism
FDI	Foreign Direct Investment
FY	Fiscal year, April-March (FY 2024 refers to April 2023-March 2024)
G3	Preliminary Exploration
G4	Reconnaissance Survey
GCP	Gujarat Copper Project
GDP	Gross Domestic Product
GSI	Geological Survey of India
GST	Goods and Services Tax
G2B	Government-to-Business
G2G	Government-to-Government
GVA	Gross Value Added
GW	Gigawatt
HCL	Hindustan Copper Limited
HS Code	Harmonized System Code

HVAC	Heating, Ventilation, and Air Conditioning
ICAI	International Copper Association India
ICC	Indian Copper Complex
ICE	Internal Combustion Engines
ICSG	International Copper Study Group
IEA	International Energy Agency
IESS	India Energy Security Scenarios 2047 (Version 3.0)
IIT-ISM	Indian Institute of Technology-Indian School of Mines (Dhanbad)
IPEF	Indo-Pacific Economic Framework
ITC	Input Tax Credit
KABIL	Khanij Bidesh India Limited
KCC	Khetri Copper Complex
LED	Light Emitting Diode
MDO	Mine Developer and Operator
MECL	Mineral Exploration Corporation Limited
ML	Mining Lease
MMDR Act	Mines and Minerals (Development and Regulation) Act 1957
MoM	Ministry of Mines
MoU	Memorandum of Understanding
MSME	Micro, Small and Medium Enterprises
MSP	Mineral Security Partnership
MTPA	Million Tonnes per Annum
NMET	National Mineral Exploration Trust
NPEA	Notified Private Exploration Agencies
NZE	Net Zero Emissions
OGP	Obvious Geological Potential
OPEX	Operational Expenditure
ORER	Overall Recycling Efficiency Rate
PGE	Platinum Group Elements
PLI	Production-Linked Incentive (Scheme)
PPP	Public-Private Partnership
PTA	Preferential Trade Agreement
QCO	Quality Control Order
Quad	Quadrilateral Security Dialogue
R&D	Research and Development
RCM	Reverse Charge Mechanism
SCRI	Supply Chain Resilience Initiative
SI	Substitutability Index
USGS	United States Geological Survey

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The Ministry of Mines, Government of India, released a "Vision Document on Copper Sector" in July 2025. The CSEP Copper Report may be read alongside this government vision document.

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01

Backdrop

Copper is a cross-cutting critical mineral. It is the backbone of all energy transition initiatives to achieve net-zero greenhouse gas emissions. Switching to renewable energy technologies for power generation and electrifying the global vehicle fleet are key pillars of the energy transition, both of which are highly copper-intensive. Copper is essential not only for renewable technologies like wind, solar, storage batteries, and electric vehicles (EVs) but also plays a critical role in conventional applications, including power generation, transmission, distribution, construction, and the end-use sectors. The annual global demand for refined copper is expected to increase from 26.5 million tonnes in 2023 to 50 million tonnes by 2050, driven by the energy transition, growth in digital infrastructure, and rapid industrial growth (International Copper Association, 2023).

India's copper requirements and resilience should be studied in the face of the expected surge in global copper demand. India, as part of its climate action strategy, has committed to achieving net-zero emissions (NZE) by 2070 and aims for 50% of its cumulative electric power installed capacity to come from clean energy sources by 2030 (Government of India, 2022). Demand for copper will increase concomitantly.

India is projected to become the second-largest copper-consuming economy by 2050 (S&P Global, 2022). India is a net importer of copper, lacking self-sufficiency in its supply chain. India's upstream segment grapples with challenges such as limited exploration, low commercial viability of new mines, minimal private sector participation, poor grades, and outdated equipment and technologies, resulting in sub-optimal production of copper ore and concentrates. The midstream and downstream segments also struggle due to underutilised midstream processing capacity, inadequate investment, declining copper cathode production, and rising imports on account of the closure of one of the significant processing units in Tuticorin. While copper demand in India accelerates, a non-resilient supply chain generates an enduring demand–supply gap, likely to hinder the country's industrial growth and climate change commitments.

To meet the growing demand, India largely depends on the global copper supply chain, which is also complex and faces several risks and vulnerabilities, including resource exhaustion in existing mines, diminishing grades, geotechnical and operational issues, a low focus on greenfield exploration, limited discoveries, and delays in commissioning new mines. The mining and processing of copper are concentrated in a handful of countries that dominate a significant share of overall production. In this context, risks related to "resource nationalism" in the form of export restrictions also threaten the global supply chain. Additionally, geopolitical turmoil, inefficient mining policies, environmental, social, and governance (ESG) concerns, high taxation, import tariffs, price fluctuations, and market volatility jeopardise India's ability to secure its copper supply for the future.

This report assesses the current status and evolving role of the copper sector in India as the country aligns its rapid growth and ensuing copper demand with production and supply chain vulnerabilities. By positioning India's copper supply chain within the global landscape, the report identifies various gaps and offers recommendations to gain resilient access to copper. After setting the backdrop, Section 2 outlines the stages of the copper value chain from exploration to end-use through a simplified graphical representation. Section 3 examines the global copper landscape, including exploration, mining and processing, demand drivers, and challenges. Section 4 focuses on India's growing demand for copper. It projects India's future copper requirements in both the conventional and energy transition sectors. Building on this, Section 5 outlines India's copper supply-side factors, including upstream exploration and extraction, midstream production of refined copper, and downstream manufacturing of copper products, along with constraints and their growth potential. Section 6 evaluates India's trade scenarios in upstream copper ores and concentrates, midstream cathodes, and downstream wires, tubes, and pipes. It reveals India's significant import dependence on copper. The factors driving these trends, such as domestic mining policy, tariff structures, trade incentives, and other barriers, have also been explored. Section 7 outlines copper's circular economy issues and the initiatives taken by India. The challenges in scrap collection, processing inefficiencies, and policy gaps in copper recycling infrastructure have also been addressed.

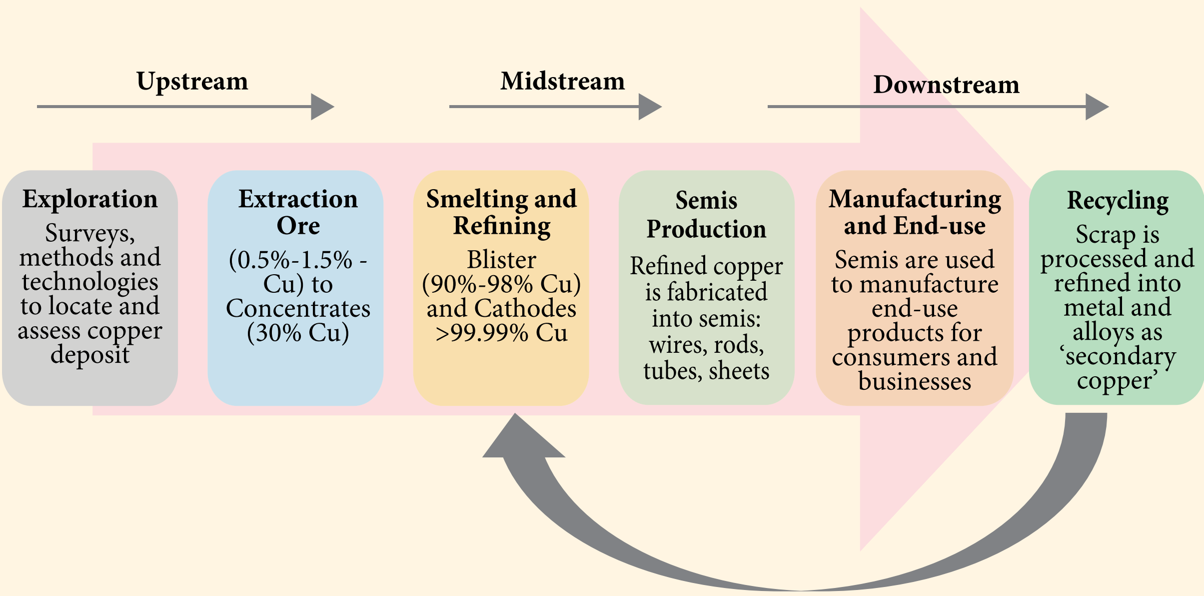
Finally, Section 8 synthesises the findings from the preceding sections and outlines a comprehensive policy framework for strengthening India's copper sector, offering recommendations to key stakeholders—including the government, industries, and policymakers—to develop a robust strategy to secure the future of copper in India in alignment with international best practices.

02

Stages of the Copper Value Chain: From Mines to Market

The copper value chain progresses through multiple stages, from exploration to end-use. After exploration and allocation of the mining site, copper ore undergoes crushing, grinding, and beneficiation to yield concentrates with 20%–30% copper content. Copper ores are classified into oxides and sulphides, with oxides being more abundant but lower in grade and processed via hydrometallurgy (aqueous solution). In contrast, sulphides, though richer in copper, require pyrometallurgical treatment (heating the ore). Concentrates (26%–32% copper) are smelted to produce molten matte (58%–60% copper), which is then converted to 98% pure blister copper. Further refining removes impurities, producing high-purity cathodes (>99.99% copper) through electrolysis or electrowinning. These cathodes are fabricated into semi-finished products like wires, rods, and sheets, which serve as essential inputs for various industries before reaching end-use applications. The flowchart in Figure 1 outlines a simplified representation of the copper value chain.

Figure 1: Simplified Representation of the Copper Value Chain



Source: Authors' design based on secondary sources.

03

Global Copper Scenario

3.1 Exploration

Currently, global copper reserves (economically mineable) amount to 1 billion tonnes, with Chile holding the largest share (19%), followed by Peru (12%) and Australia (10%) (USGS, 2024). Total copper resources, constituting both identified and undiscovered resources, stand at 5.6 billion tonnes, of which identified copper resources are 2.1 billion tonnes (ICSG, 2024).[1]

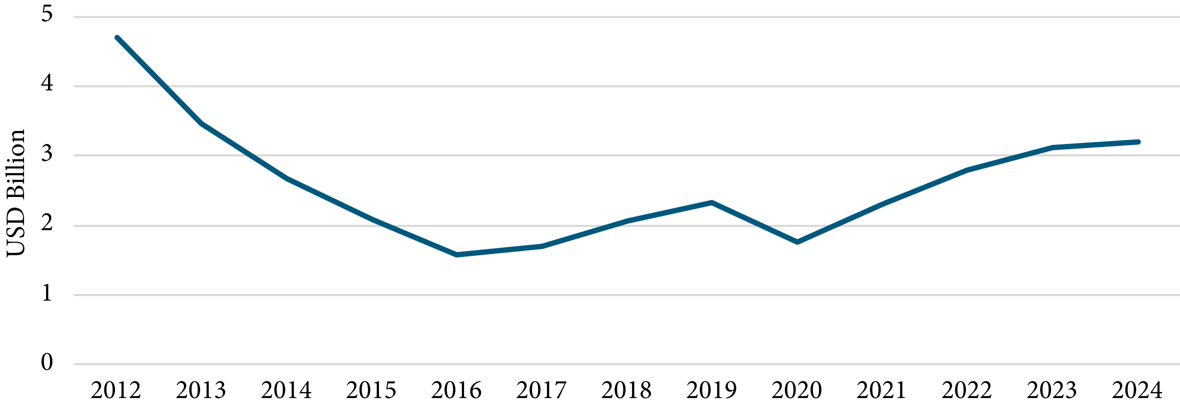
With an average yearly mined production rate of 22 million tonnes, the current reserve repository is estimated to last for just 45 years, necessitating more exploration ventures to discover new reserves and resources. Notably, from 2000 to 2023, the global copper reserves inventory increased by 76%. In 2012, the exploration budget for copper reached a decade-high of USD 4.7 billion, followed by a sharp decline until 2016 (S&P Global, 2024). Since 2016, there has been a general upward trend in the global copper exploration budget, despite a dip to USD 1.76 billion in 2020, perhaps on account of the COVID-19 pandemic (Figure 2).

In 2024, Latin American countries such as Chile and Peru, home to the world's significant copper reserves, incurred exploration budgets of approximately USD 637 million and USD 233 million, respectively (S&P Global, 2024). Canada, with 7.6 million tonnes of copper reserves, saw a significant 42% increase in its exploration budget, reaching approximately USD 336 billion. In contrast, despite Australia's substantial copper reserves of around 100 million tonnes, its exploration budget declined by 23% from the previous year, likely due to tighter market conditions.

Fluctuations in metal prices, market volatility, higher operating costs, and geopolitical turmoil have had a considerable impact on financing activities in the mining and processing industries, including exploration. While the global non-

[1] Mineral resources indicate the presence of natural concentration of a mineral under the earth's crust in such form that economic extraction of a commodity is regarded as feasible, either currently or at some future time. The resource becomes identified when its location, grade, quality, and quantity are known or can be estimated from specific geologic evidence. Mineral reserve refers to the portion of an identified resource from which a usable mineral or energy commodity can be economically and legally extracted at the time of determination (USGS, 2024)

Figure 2: Global Copper Exploration Budget



Source: S&P Global (2024).

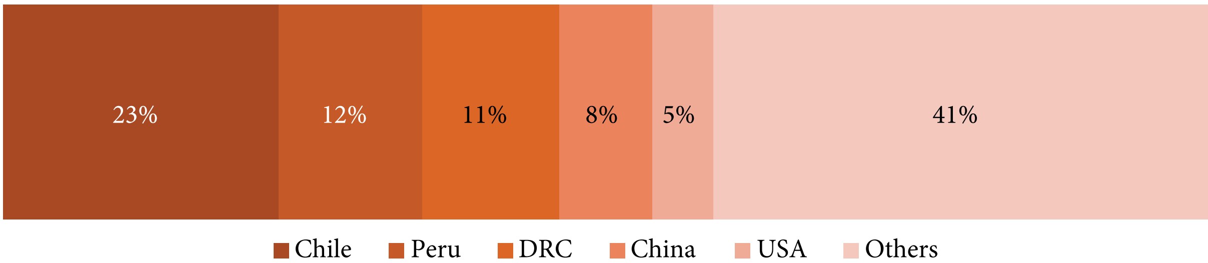
ferrous exploration budget in 2024 dwindled by 3% over its previous year's value, copper, nickel, and lithium budgets experienced bright spots, reflecting their crucial usage in energy transition technologies and accelerating global demand (S&P Global, 2024a).

Despite the increase in the copper exploration budget, investment has not resulted in significant discoveries. Only four discoveries were made in the last five years (2019–2023), amounting to 4.2 million tonnes of copper (DeCoff, 2024). Of the 239 copper deposits discovered between 1990 and 2023, only 15 have moved forward towards actual development. Moreover, most of the discoveries are expansions of existing assets, with limited effort being given to greenfield exploration in uncharted areas, which could tap into new potential. Although the copper exploration budget has been rising since 2020, it has not surpassed its 2012 level.

3.2 Mining and Processing

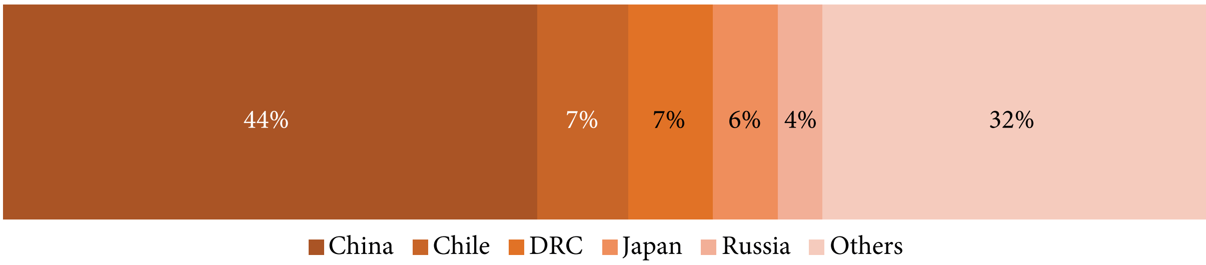
The mining and processing of copper are concentrated in a handful of countries that dominate a significant share of overall production. In 2023, mined copper was estimated to be 22 million tonnes, while refined copper output was estimated to be 27 million tonnes (USGS, 2024). Chile was the leading producer, with 5 million tonnes of mined copper metal, followed by Peru (2.6 million tonnes) and the Democratic Republic of Congo (DRC) (2.5 million tonnes), contributing to approximately 46% of global mined copper production (Figure 3). The processing landscape is more concentrated than mining, with China dominating over 44% of global refining (Figure 4).

Figure 3: Global Copper Extraction (2023)



Source: USGS (2024).

Figure 4: Global Copper Processing (2023)



Source: USGS (2024).

Despite holding 10% of global copper reserves, Australia often takes a back seat in the copper mining landscape, producing just 4% of global output in 2023. A combination of factors, including higher labour and regulatory costs, rigorous environmental safeguards, and geological complexity, has deterred copper mining operations in Australia. However, this scenario is beginning to shift. Mining conglomerates like Broken Hill Proprietary Company (BHP), Rio Tinto, and Harmony Gold have shown interest in expanding operations to South Australia, moving away from Queensland, which once served as the country's copper production hub. BHP's recent acquisition of South Australian miner Oz Minerals offers growth potential, including high-grade deposits at Prominent Hill, the Carrapateena Copper-Gold Project, and several promising copper and nickel projects on the West Coast (Evans, 2024).

Countries like Russia and Mexico also have sizeable copper reserves, but have not adequately mined these resources. Geopolitical tensions, high taxation, operational inefficiencies, and uncertain political scenarios have resulted in this stagnation. In Russia's case, its dominance in conventional energy sectors, such as oil and gas, has often overshadowed interest in copper mining.

3.3 Global Demand Drivers

Copper, often referred to as "Dr Copper," serves as an economic barometer, as its price is a reliable indicator to pulse the global economic health. Historically, it was among the first metals used by humans, dating back approximately 10,000 years, and was initially used in jewellery and amulets. Around 3000 BC, copper was alloyed with tin to produce bronze, which was widely used in weaponry, armour, tools, and household items. Brass, an alloy of copper and zinc, was primarily used in coinage and utensils. Copper's unique properties, such as electrical conductivity, ductility, efficiency, and corrosion resistance, were later discovered in the late 18th and early 19th centuries. Since then, copper has been an indispensable metal across power generation, electrical and electronics, transmission, wiring, transport, manufacturing, construction, electricity distribution, and consumer goods. From its early usage in ornaments and currency to its latest frontier in clean energy and semiconductors, this red metal's utility has evolved through a journey of innovation and advancements.

Global refined copper demand is projected to reach around 33 million tonnes in 2035 and 37 million tonnes by 2050 under the stated policy scenario, primarily driven by the rapid deployment of renewables, with copper being the cornerstone of electrification (International Energy Agency, 2025). Projections from an S&P Global report suggest that under a high-ambition scenario with increased mined capacity utilisation and recycling rates, the supply shortfall would peak at 1.6 million tonnes by 2035, after which supply is expected to exceed demand due to a decline in energy-transition-related demand and an increase in secondary production (S&P Global, 2022). In contrast, under the rocky road (business-as-usual) scenario, the supply deficit will peak at 9.9 million tonnes in 2035. Although the deficit is expected to narrow thereafter, demand would be more than supply, with projected demand reaching 53 million tonnes by 2050, while total global production is estimated to be 50.4 million tonnes.

The Asia-Pacific region represents the largest market for copper, driven by rapid urbanisation, industrialisation, and auto-manufacturing growth. Renewable technologies like wind, solar, and EVs are more copper-intensive than conventional energy sources (International Energy Agency, 2021). For example, four-wheeled passenger EVs require 40 to 80 kg of copper compared to about 23 kg in internal combustion engine (ICE) vehicles. Additionally, each EV charger requires 0.7 to 8 kg of copper, depending on the speed of charging (International Copper Association, 2017).

On copper's substitutability, while aluminium presents itself as an immediate alternative due to its lower cost and abundance, it is only 60% as conductive as copper, making it less energy-efficient and less durable. Silver, though a superior conductor with lower electrical resistivity, is significantly more expensive for widespread industrial applications, limiting its feasibility as a substitute.

3.4 Challenges in the Global Copper Scenario

Geographical Vulnerability and Declining Ore Grade

The average copper ore grade worldwide has declined by approximately 25% between 2003 and 2013, impacting mine production (Calvo et al., 2016). In Chile alone, the average copper ore grade declined by 30% from 2005 to 2019 (International Energy Agency, 2021). Lower ore grades generate more debris, which escalates both operational and logistics costs, and mining becomes more energy- and water-intensive. The geographical distribution of copper mines is predominantly in arid, water-stressed regions, leading to the sharing of water resources with local communities, which poses potential conflicts if not managed judiciously (Sebrell & Kragelund, 2022). To address the water-intensive nature of copper mining, installing desalination plants to use seawater could offer an alternative solution to this problem. However, it requires a significant capital expenditure (CAPEX). Furthermore, Chile and Peru, situated in a tectonic zone, are prone to earthquakes, with potential fears of disrupting copper mining operations.

Many major copper mines are nearing the end of their operational life, compounded by ageing infrastructure and equipment failures. Over 200 copper mines are anticipated to exhaust their reserves before 2035, with no significant new mines in the pipeline to substitute them (Mills, 2024). Many of the Zambian copper mines are adversely affected by persistent drought conditions, which have led to reduced dam levels, triggering a power crisis and threatening the country's planned copper expansion.

Export Restrictions

Export restrictions are sometimes implemented to leverage natural resources in ways that protect domestic industries, address the social and environmental costs of mining and processing, and encourage domestic value addition. However, when raw materials are heavily concentrated geographically and exporting nations control a large share of the global market, even modest export restrictions can create significant market sensitivities. Such restrictions may impact foreign users and investors, disrupt international trade dynamics, and increase costs for manufacturers dependent on these imported materials.

Since 2009, export restrictions on critical raw materials, including copper, have increased fivefold. Between 2020 and 2022, over 20% of global exports of key raw materials, such as copper ore, faced at least one export restriction (OECD, 2024). Export bans by China on rare earth extraction and refining technologies, Indonesia on nickel, and African nations such as Zimbabwe, Ghana, and Namibia on unprocessed raw materials, including lithium, have exacerbated the weaponisation of critical minerals, significantly disrupting global trade flows and supply chains. Indonesia is also planning to ban copper concentrate exports starting in 2025 to promote domestic processing industries, reduce import reliance on raw materials, and boost national economic value addition (Indonesia Miner, 2024). However, Freeport Indonesia has cautioned that this could lead to an export revenue loss of up to USD 2 billion, operational disruptions for mining companies, and potential trade disputes.

Plummeting TC/RCs

The treatment and refining charges (TC/RCs), which represent the processing fees that mining companies pay to smelters and refiners for converting semi-processed ore or concentrates into cathodes or finished metals, constitute a substantial portion of their revenue. Globally, TC/RCs have been plummeting, driven by raw material scarcity and an enhancement in smelting capacity. Typically, miners and smelters engage in long-term contracts informed by an annually agreed-upon benchmark framework. The initial settlement between a major miner and a smelter usually establishes the benchmark TC for the year ahead (Chadha & Pal, 2024).

Notably, the TC/RCs negotiated between Chilean miner Antofagasta and Chinese smelter Jiangxi Copper for 2025 are set at USD 21.25 per tonne, reflecting a drastic 73% drop from the previous year's TC/RC of USD 80 per tonne (Reuters, 2024a). This processing fee, at a 15-year low, erodes processors' margins, leading to potential capacity reductions, declines in production, and, in some cases, even closures when operating costs become unsustainable. While big players may explore flexible strategies to secure their feedstock, smaller entities, which rely solely on purchasing concentrates from the open market, face increased vulnerability to market fluctuations. While global copper smelting capacity has been rising, the availability of concentrates has been sluggish. In China, the total smelting capacity is projected to reach 16 million tonnes by 2025 and 17 million tonnes by 2027 (Commodity News, 2024). In addition to China's rampant dominance in capacity expansion, several new smelters are in the pipeline to be commissioned, including Freeport-McMoRan's Manyar smelter in Indonesia (1.7 MTPA), Adani's Kutch Copper in India (1 MTPA), and a 0.5-MTPA copper smelter by Ivanhoe Mines and Zijin Mining Group in the DRC. It is estimated that one tonne of new smelting capacity necessitates around four tonnes of concentrates, thereby exerting downward pressure on TC/RCs.

The plummeting TC/RCs create substantial operational challenges for smelters and refiners in a usual copper business model, jeopardising their profitability and sustainability in a highly competitive market. To stabilise eroding margins, smelters should consider diversifying revenue streams by capitalising on high-value by-products such as sulphuric acid, gold, and silver, as well as using more intermediate products, including blister copper, anodes, and scrap (Fastmarkets, 2025).

High Processing Costs

Copper processing necessitates high capital expenditure (CAPEX) and operational expenditure (OPEX). While larger processing plants are generally more expensive, they tend to be more cost-efficient per unit of cathode produced.

In addition to expenses related to utilities, infrastructure, equipment, and machinery, there are other costs associated with labour, contingency, and regulatory compliance. More advanced technology is required to process degraded ore and concentrates, further driving up costs. For instance, technologies such as flash smelting and converting improve efficiency but require substantial upfront investment in specialised equipment (Metso, 2024).

Energy is another critical cost driver, with electricity being a primary contributor to operating expenses. Electricity costs can vary widely depending on location, tariff structures, and the energy sources used. Endeavouring decarbonisation efforts and greening existing initiatives further escalate total costs. For example, achieving NZE by 2050 will require a global CAPEX outlay of approximately USD 460 billion in the copper industry alone (International Copper Association, 2023).

These high costs, coupled with diminishing profit margins, can deter investment in new facilities, hindering capacity expansion and R&D efforts. Higher processing costs are likely to increase the price of finished products, adversely impacting the economy. The adoption of cost-effective technologies, such as Rio Tinto's Nuton bio-heap leaching technology, which achieves up to an 85% recovery rate from sulphide ore, offers a sustainable and economically viable alternative to conventional processing methods (Rio Tinto, 2024).

Social Licence to Operate

Copper mining poses significant environmental externalities, including environmental degradation, water contamination, and land degradation, which often lead to unrest among local communities. This unrest can jeopardise the "social licence to operate" for mining companies. The situation is exacerbated in the absence of an efficient mining policy regime and an unstable political scenario. For instance, in 2023, First Quantum Minerals Ltd.'s Cobre Panama operations, which produced 0.35 million tonnes of copper in 2022, equivalent to 1.5% of the global copper supply, were directed to be shut down due to concerns over environmental impacts, biodiversity risks, and the absence of a competitive bidding process for mining rights (Radwin, 2023). Similarly, the Las Bambas copper mine in Peru has also faced significant operational disruptions due to ongoing protests and blockades related to grievances over environmental impacts, political instability, and inadequate local development. Since its inception in 2016, the mine has had to halt operations for more than 600 days due to multiple blockades of a key transport route (Reuters, 2024). Peru exemplifies broader challenges faced by mining industries globally, where labour strikes, protests, and disputes frequently disrupt production and hinder investment and expansion efforts. These issues highlight the importance of ESG concerns and of fostering stable regulatory frameworks and political environments to ensure the long-term viability of the copper sector.

Environmental and Social Implications

Copper extraction and processing result in environmental externalities and social adversities, primarily due to the nature of mining operations and associated industrial processes. Globally, copper mining predominantly happens through open-pit mining, which causes substantial land use, deforestation, and biodiversity and wildlife habitat loss. Copper mining has a relatively larger impact on biodiversity than other base metals (Kobayashi et al., 2014).

Mine tailings, effluents from water treatment plants, and the release of sulphuric acid and other toxic elements cause severe environmental pollution, posing serious risks to ecosystems and human health. Copper smelting and processing are particularly concerning due to their reliance on chemicals, including sulphuric acid, which can result in acid mine drainage, contaminating local water bodies, soil, and aquatic ecosystems. Furthermore, copper smelting generates large volumes of waste, with approximately 75% of copper concentrate ending up as slag, posing disposal challenges and environmental risks (US EPA, 2024).

This sector is also energy-intensive, with a substantial proportion of energy requirements being met through the combustion of fossil fuels. These processes emit greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Additionally, copper ores often contain sulphur compounds, the combustion of which during processing releases toxic sulphur dioxide (SO_2). Airborne dust containing heavy metals such as arsenic (As), cadmium (Cd), and lead (Pb) deteriorates air quality.

Prolonged exposure to these pollutants wreaks havoc on human health, often leading to widespread protests and social unrest, jeopardising the social licence for operating the industries. For instance, in 2015, a lawsuit was filed against a mining conglomerate in the Nchanga mine in Zambia for alleged pollution and health damage caused by the spillage of acids and toxic chemicals into local drinking water sources (Sebrell & Kragelund, 2022). Similarly, in the DRC, foreign mining companies operating in the copper and cobalt belt frequently fail to comply with environmental obligations, resulting in large-scale pollution due to weak regulatory oversight. In India, at the Khetri Copper Complex (KCC) in Rajasthan, inadequate tailings management elevated copper levels in the soil, adversely impacting agriculture (Punia, Siddaiah, & Singh, 2017).

Copper mining is also water-intensive, with an approximate requirement of 90 cubic metres to extract a tonne of copper (Mills, 2023). Lower-grade ores require relatively more water. Moreover, the geographical distribution of copper mines is predominantly in arid, water-stressed regions, leading to the sharing of water resources with local communities and posing potential conflicts if not managed judiciously. For example, in 2022, copper mines in Chile faced a production decline of up to 17% year-on-year, partially due to water scarcity and prevailing drought conditions in the region.

Over the years, countries have developed and mandated various policy instruments and laws for comprehensive environmental protection. In India, key tools such as the Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA), under the regulatory oversight of the Ministry of Environment, Forest and Climate Change (MoEF&CC), have played a vital role in evaluating the environmental and social impacts of projects. These instruments must be implemented more stringently, effectively, and inclusively to ensure the meaningful participation of affected communities. Additionally, the Sustainable Development Framework of the Ministry of Mines (MoM), aligned with the National Mineral Policy, provides a robust approach to responsible and sustainable mineral development. Beyond regulatory compliance, companies should proactively adopt responsible practices across the entire value chain.

The challenges in the global copper scenario are expected to impact the Indian copper sector as well, given its significant reliance on the wider dynamics of the global copper supply chain.

04

Demand for Copper in India

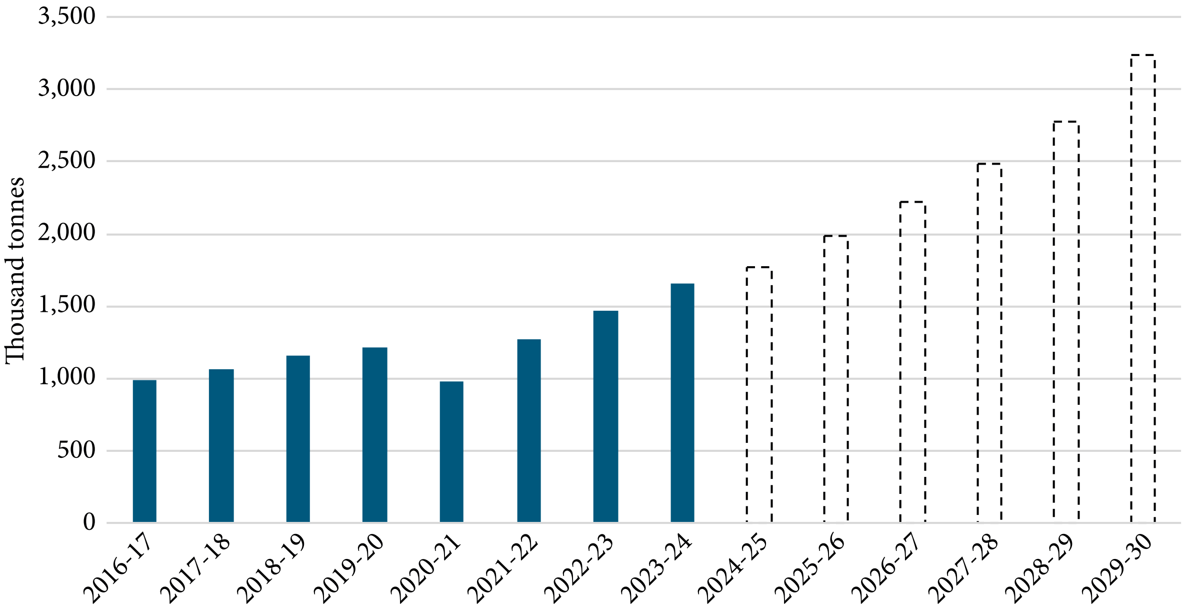
Copper is one of the identified critical minerals in India. There is a burgeoning demand for copper on account of its traditional uses as well as its applications in the green energy transition. India's net-zero commitment by 2070, clean energy transition, infrastructure expansion, and rising private consumption will drive up the demand for copper. Despite significant reserves, India remains a net importer of copper due to low exploration success, outdated technologies, exhausted mines, the inefficacy of auctions to attract new mining and exploration blocks, insufficient investment, and limited private sector participation. At the current production rate, known copper reserves can sustain for only approximately 4.5 decades, necessitating the need for alternative supply sources and leveraging recycling potential. The closure of a major smelter in Tuticorin has reduced cathode output by 40%, exacerbating import dependence. Sourcing of copper from secondary sources is also limited due to low recycling capacity and nascent infrastructure. The rising import of copper-embedded finished products indicates domestic midstream processing constraints and undermines the scope for domestic value addition.

4.1 Projections for India

The demand projections for copper in both conventional and energy transition sectors in India until Fiscal Year (FY) 2030 are illustrated in Figures 5, 6, and 7.

For the conventional sector, demand estimation is based on data from the International Copper Association India (ICAI), which tracks holistic copper consumption in embedded forms—either domestically produced or imported—between FY 2017 and FY 2024 (ICAI, 2024). Based on the ratio of copper consumption in conventional sectors to historic and projected Gross Domestic Product (GDP) per capita at current prices, the copper demand in the conventional sector has been computed (Figure 5). The conventional sector largely encompasses copper demand in industry, infrastructure, agriculture, transportation, and consumer goods.

Figure 5: Copper Demand Projections (Conventional)



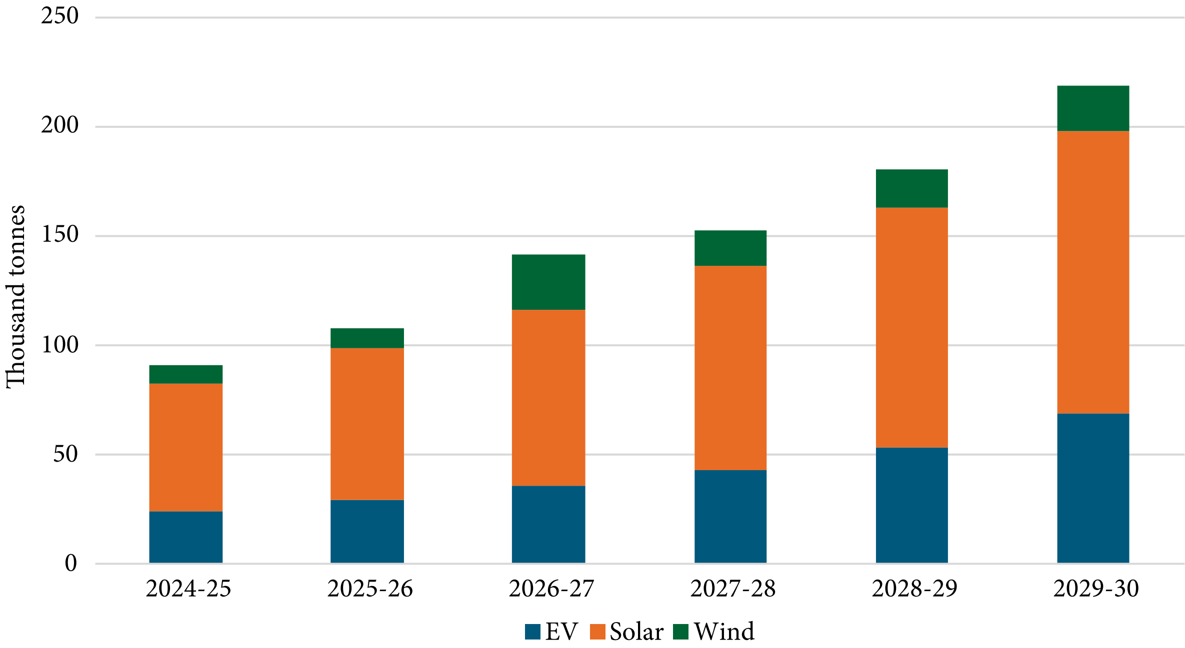
Source: ICAI annual reports; authors' computations.

In the energy transition sector, copper demand projections data for wind, solar, and Battery Energy Storage Systems (BESS) are obtained from the CSEP report *Projecting Critical Mineral Needs for India's Clean Energy Transition* (Chadha & Sivamani, 2024). These estimates align with NITI Aayog's *IESS 2047-Level 2* business-as-usual scenario, which reflects a practically achievable trajectory based on historical trends and recent progress (NITI Aayog, 2023). Figures 6 and 7 show the projected copper requirements corresponding to the additional installation of solar panels, wind turbines, and BESS throughout the projection period. Notably, copper demand in wind is expected to surge by 178% in FY 2027. Wind turbines installed during 2007 will need decommissioning or repowering by 2027, considering the 20-year average lifespan of a wind turbine.

EVs also represent a significant source of copper demand, given their use in batteries, motors, wiring, cables, and power electronics components. Here, demand projections for EVs, as shown in Figure 6, are based on anticipated sales of electric two-wheelers, three-wheelers, and cars by EV-Ready India (OMI, 2025). However, the dashboard projects an optimistic EV adoption rate in India. The total copper requirement in projected EVs has been computed based on data from ICAI's extensive market research. Furthermore, government initiatives such as *PM E-Sewa* and *E-Drive* are expected to facilitate the deployment of 24,028 e-buses by 2030, requiring approximately 6,800 tonnes of copper. As this rollout is not uniform across the years, the copper requirement in e-buses has not been considered in Figure 6.

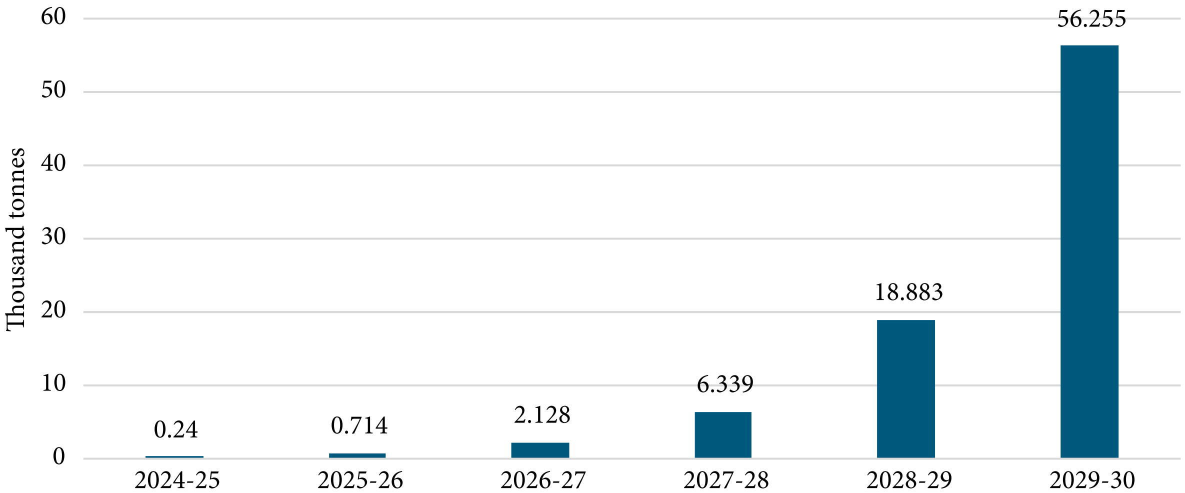
BESS, critical for grid stability and power storage, will also drive copper demand. While *NITI Aayog's IESS 2047* does not account for additional BESS installations until 2030, the *Central Electricity Authority (CEA)* projects a capacity increase of 41.65 GWh by FY 2030. Accordingly, Figure 7 presents year-wise copper demand estimates for BESS under the *CEA base case* scenario. Achieving India's interim climate targets of 500 GW of non-fossil fuel capacity and a 50% renewable energy share by 2030 is expected to push a sharp rise in BESS-related copper consumption in 2030 (Figure 7).

Figure 6: Copper Demand Projections (Energy Transition)



Source: OMI (2025); Chadha & Sivamani (2024); authors' computations.

Figure 7: Copper Demand Projections (BESS)



Source: Chadha & Sivamani (2024).

Overall, while conventional sectors will continue to account for a larger share of absolute copper demand, the rapid expansion of the renewable energy sector will result in a higher growth rate of copper consumption. Nonetheless, technological innovation, resource efficiency, and an improved recycling rate are likely to reduce the mineral intensity in the green energy sector.

4.2 Copper's Contribution to Economic Value Addition

The role of copper in the Indian economy can be expressed not only through the direct demand for the metal in various industries but also through its indirect contributions. These indirect contributions can be measured through an input-output framework, which is a quantitative economic model that represents the interdependencies between various sectors in the economy. This framework can be used to compute the economic significance of copper, specifically through the Gross Value Added (GVA) multipliers of all the sectors that consume the metal.

GVA is the value added during the production of goods and the delivery of services. It is a measure of the payments made to the factors of production. In the input-output context, the GVA multiplier measures the total increase in the economy's GVA given an increase in the final demand of a sector; this accounts for the direct increases in GVA as well as the indirect gains from other production sectors expanding to satisfy the final demand increase. A higher GVA multiplier indicates a larger impact on economic activity.

The paper Assessing the Criticality of Minerals for India (Chadha, Sivamani, & Bansal, 2023) computes a "GVA multiplier score" for various minerals.[2] The score is computed by taking a measure of the GVA multipliers of all sectors consuming a particular mineral. Some of the key sectors consuming copper include electronics manufacturing and materials for construction and infrastructure. Given the high GVA multipliers of these sectors, with their relatively large indirect effects, copper was found to have a relatively high GVA multiplier score (0.259 multiplier coefficient, a 1.1 multiplier score, ranked 19 out of the 43 minerals studied), highlighting its importance in creating value addition in the economy.

[2] These scores are computed using the GVA multipliers from the CSEP Input-Output Table for India 2019–2020. The GVA multiplier is defined as the ratio of the sum of the direct and indirect GVA changes to the direct GVA change due to a unit increase in final demand. Sectors with high GVA multipliers are considered economically more important, as they have a higher potential to increase returns to the factors of production. For each mineral's GVA multiplier, a GVA multiplier score is assigned, which may increase the economic importance of the mineral.

05

India's Copper Supply-Side Factors

This section will examine the supply-side dynamics, challenges, and opportunities in India's copper sector throughout the copper value chain. The state-owned Hindustan Copper Limited (HCL) is the sole producer of copper ore and concentrates in the country. In the midstream sector, the private companies Hindalco and Vedanta dominate domestic cathode production. The closure of Vedanta's Sterlite Copper plant, with its substantial 400,000-tonne-per-annum capacity, turned India into a net importer of copper cathodes. However, this scenario is poised to improve with the entry of Kutch Copper, which is planning a 1-MTPA processing facility aimed at both meeting domestic demand and expanding the export basket.

Given copper's strategic significance to India's economy, the mineral concession procedure—from auctioning to granting statutory clearances and commencing mining operations—needs to be more streamlined to avoid any unnecessary delays and backlogs. The National Mineral Policy 2019 emphasised that the states shall endeavour to auction mineral blocks with pre-embedded statutory clearances. The mining clearances should be combined into a one-stop shop for post-lease clearances in India. The PARIVESH portal can be very effective in implementing this solution. The PARIVESH portal is a single-window hub providing data for post-lease clearances after the submission of applications. The web-based portal monitors applications for environment, forest, wildlife, and coastal regulation zone clearances (Bansal & Kapoor, 2022).

5.1 Indian Upstream Scenario

Exploration

Despite India's enormous geological potential, sharing a similar geological history with mineral-rich regions like Western Australia and Eastern Africa, only 29% of the country's Obvious Geological Potential (OGP) has been identified as a high-potential area by the Geological Survey of India (GSI). Nonetheless, unlike other critical minerals such as nickel, cobalt, and lithium, India holds significant copper reserves of 163.89 million tonnes, with a metal content of 2.16 million tonnes (Table 1) (Indian Bureau of Mines, 2024).

Table 1: Domestic Copper Reserves vs Resources

Copper Inventory as of 2020	Ore (million tonnes)	Metal (million tonnes)
Reserves	163.89	2.16
Resources	1660.87	12.20
Remaining Resources	1496.98	10.04

Source: Indian Bureau of Mines (2024).

India's total copper resources stand at 1.66 billion tonnes, containing 12.20 million tonnes of metal. However, the copper grade is generally considered average to poor. Of the total remaining resources of approximately 1,497 million tonnes, 153 million tonnes are classified as pre-feasibility resources, which could become economically viable depending on technological, environmental, and economic changes. Notably, of the total resources, 8.28 million tonnes of ore are estimated to contain a high-grade copper content of 1.85% or more, which remains largely untapped and requires cutting-edge exploration techniques. With an average extraction rate of 3.7 million tonnes per year, the current copper reserve base can sustain production for approximately 44 years. While the expansion of reserves and resources may extend this timeframe, an accelerated extraction rate to meet growing demand could lead to resource scarcity sooner.

Despite India's geological potential, efforts to convert resources into reserves have been limited. The National Mineral Exploration Trust (NMET) was established in 2015 to accelerate mineral exploration, where 2% of the royalty paid by mining leaseholders is accrued to the NMET fund. The NMET has allocated approximately Rs 116 crore (1 crore is equal to 10 million) for copper and associated minerals exploration, representing just 4% of the total exploration budget for non-fuel minerals from 2017 to 2024 (Table 2) (NMET, 2024). Although most of the NMET-funded projects were completed by 2022, there were no major discoveries in domestic copper reserves and resources.

The National Mineral Policy (2019) encourages private sector participation in reconnaissance and exploration. However, in the existing policy regime, private investment has been minimal, with major copper exploration conducted by government agencies like the Mineral Exploration Corporation Limited (MECL) and GSI. Only three projects, with an estimated cost of Rs 5 crore, as approved by the NMET, have been undertaken by Notified Private Exploration Agencies (NPEAs) (Table 2). Whereas, the MoM currently enlists 33 NPEAs (Ministry of Mines, 2025). Moreover, most explored copper blocks remain at preliminary stages (G3 and G4), showing a low level of success in the commercial viability of mines.

Table 2: Spending on Copper Exploration from NMET

Commodity	Agency	No. of Projects	Level	Total Estimated Cost (in Rs Crore)
Copper	MECL & Tata Steel Ltd.	13	G2, G3, G4	56.67
Copper and Gold	MECL	4	G4	10.86
Copper, Gold, and REE	MECL	1	G4	3.39
Copper, Gold, and Molybdenum	MECL	1	G4	4.02
Copper, Lead, and Zinc	MECL	5	G4	13.29
Barium, Gold, Lead, Copper, and Tungsten	MECL	1	G4	2.63

Commodity	Agency	No. of Projects	Level	Total Estimated Cost (in Rs Crore)
Gold, Copper, Lead, Zinc, Nickel, and Cobalt	MECL	1	G4	4.80
Nickel, Copper, and Associated Minerals	MECL	1	G4	0.39
Copper, Lead, Zinc, and Graphite	MECL	1	G4	1.81
Copper, Lead, Zinc, and Gold	MECL	1	G4	0.49
Polymetals (Cu, Au, Ag)	MECL	1	G4	1.09
Ni-Cr-Cu, PGE-Au	NPEA GeoExpOre Pvt. Ltd	1	G3	0.86
Gold, Copper, Graphite, and Associated Minerals	MECL	1	G4	2.16
Copper and Associated Minerals	MECL& M/s Kartikay Exploration and Mining Services Pvt Ltd	3	G3	8.33
Copper, Lead, and Zinc	MECL	1	G3	1.39
Copper and Associated Minerals	MECL, CMPDI	2	G3, G4	5.25

Source: NMET (2024).

India clearly lags in exploration spending, as only 1% of the global exploration budget has been spent in India (Government of India, 2023). Compared to global exploration spending, as discussed in Section 3.1, Indian exploration spending on non-fuel minerals is very low and concerning.

The MoM has taken some steps to encourage exploration. These include the granting of Exploration Licences (ELs) and directly sanctioning exploration projects to NPEAs for critical and deep-seated minerals (Ministry of Mines, 2023). However, the exploration of deep-seated minerals like copper is inherently risky, associated with the deposit's complexity and other geographical barriers, resulting in the commercial viability of less than 1% of explored projects (Chadha et al., 2023a). Without guaranteed mineral concessions over discovered blocks, private exploration companies, particularly junior miners,[3] are unlikely to invest their technical expertise and financial resources, as the blocks would be put up for auction with no certainty of winning the bids. States that announced auctions for ELs have not been very successful in attracting junior miners and specialised exploration agencies (Narayan, 2024). Consequently, of late, the MoM has taken over the responsibility for EL auctions by auctioning 13 blocks, including two for copper (Government of India, 2025). Previously, three copper blocks in Maharashtra, Madhya Pradesh, and Karnataka were offered for EL auctions, all of which were annulled; of these, the Devadurga EL block in Karnataka has again been put up for re-auctioning. The success rate of these centrally conducted bids for ELs is yet to be seen.

HCL, a key player in India's copper mining landscape, undertakes exploration to assess ore body depth extensions within its mining leases (MLs), aiming to expand its copper

[3] A junior miner represents a small mining company which specialises in exploration of one or a few minerals. They make profits from selling their explored mining sites to the major mining and extracting companies.

inventory. In FY 2023–2024, HCL increased its exploration CAPEX to Rs 55 crore, which was the highest in the past decade (HCL, 2024). As of 2023, HCL's MLs contained a total copper ore reserve and resource of 698.44 million tonnes, with an average grade of 0.96% copper. In 2023, HCL signed a three-year Memorandum of Understanding (MoU) with MECL to leverage its expertise for exploration and allied activities in its MLs in Jharkhand, Madhya Pradesh, and Rajasthan.

However, production has not kept pace with this growth. Moreover, a Comptroller and Auditor General (CAG) report highlighted that HCL had not conducted any greenfield exploration in the past three decades, and its brownfield exploration efforts were deemed unsatisfactory in both quality and extent (CAG, 2023).

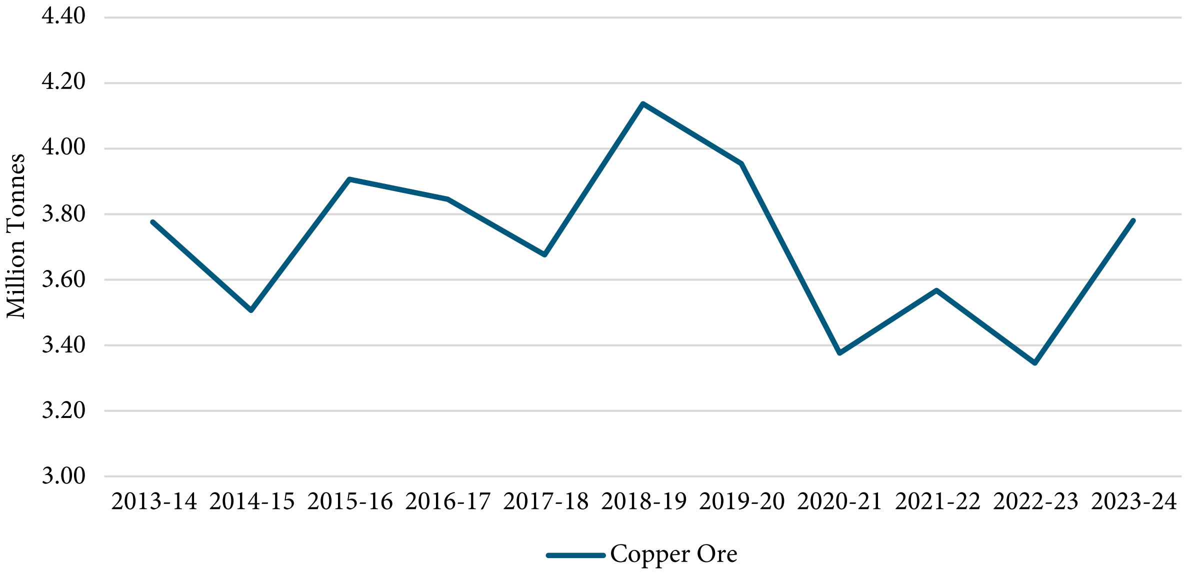
Despite these initiatives and other ongoing deliberations, collaboration with private sector expertise remains limited, and India's exploration landscape continues to be dominated by the public sector.

Extraction

Despite India's substantial domestic copper reserves, the country's ore and concentrate production has remained stagnant over the years (Figure 8). In 2023, global mine production reached approximately 22 million tonnes, whereas India's ore production during FY 2024 was a mere 3.8 million tonnes, with metal-in-concentrate production amounting to only 24,760 tonnes (HCL, 2024). The metal-in-concentrates extracted from the total ore is low and has been decreasing over the years, reflecting a decline in ore grade in India (Figure 9).

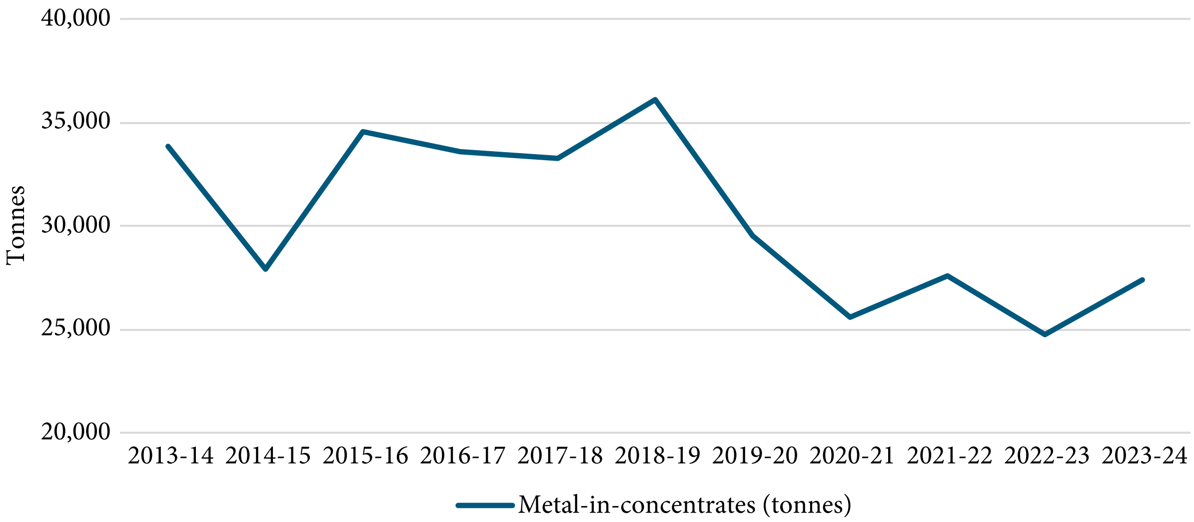
HCL, a public sector undertaking, remains the sole integrated producer of primary copper in the country. It owns and operates five copper mines and is actively involved in mining, beneficiation, and, to a lesser extent, smelting, refining, and casting of refined copper. HCL is targeting an increase in ore production capacity to 12.20 million tonnes per annum (MTPA) by FY 2028–2029 (HCL, 2024). However, in 2010, the company committed to scaling up the then level of 3.6 MTPA to a projected mining capacity of at least 12.41 MTPA by FY 2017 (HCL, 2011). Several strategies were pursued to achieve this target, including the expansion of existing operations, the reopening of closed mines, undertaking brownfield and greenfield exploration, adopting advanced technologies for cost-effective operations, and strategically acquiring mines both domestically and abroad. Despite these ambitious plans, as of 2023, HCL's ore production remains at just 3.8 million tonnes, with the revised target of 12.2 MTPA now being postponed to FY 2031. While HCL controls around 45% of India's copper ore reserves and resources, with an average grade of 0.95%, the company's inconsistent production and overall underperformance are disappointing.

Figure 8: Domestic Production of Copper Ore



Source: Indian Minerals Yearbook, various years (IBM).

Figure 9: Production Trend of Metal-in-Concentrates



Source: Indian Minerals Yearbook, various years (IBM).

A closer examination of HCL's mining operations reveals that many of its current mines are either exhausted or approaching exhaustion. In its bid to triple its production by FY 2028–2029, the company endeavoured to implement the following key expansion strategies (HCL, 2024):

- The Malanjkhand mine in Madhya Pradesh, currently producing 2.5 MTPA, has initiated underground mining operations as the open-cast reserves have been exhausted. Further expansion of the underground mining capacity is under negotiation at the contract level.
- In Rajasthan's Western Sector (Khetri and Kolihan mines), proposed expansions aim to raise ore production capacity from the current 1 MTPA to 3 MTPA. However, efforts to increase the Khetri mine's capacity from 0.5 MTPA to 1.5 MTPA were hindered by geological complexities.
- In Jharkhand's Surda mines, the plan to enhance production from 0.4 MTPA to 0.9 MTPA is pending statutory approvals.

- Reopening closed mines, such as Kendadih and Rakha at the Indian Copper Complex (ICC) in Jharkhand, is also under consideration. The Kendadih mine was reopened in 2021, but its performance fell short of expectations, leading to its closure in 2023. For the Rakha mine, discussions on extending the ML, which expired in 2021, and obtaining other necessary approvals are ongoing with the State government.

In 2023, HCL signed an MoU with the Indian Institute of Technology–Indian School of Mines (IIT–ISM), Dhanbad, to conduct R&D activities aimed at improving productivity through state-of-the-art technologies, knowledge upgradation in the arenas of exploration, ore beneficiation, and workforce training and skill development (HCL, 2023). HCL is also planning to invest a CAPEX of Rs 2,000 crore to increase ore production to 12.2 MTPA by FY 2031, focusing on its Malanjkhand Copper Project. It is also harbouring collaborations with the copper conglomerate Codelco for technology and knowledge-sharing in mining and beneficiation (Press Trust of India, 2025).

While these strategies appear ambitious to achieve domestic self-sufficiency in mining, a parliamentary committee reported that HCL had utilised only 6% of the budget allocated for mine expansion during 2011–2012 (Ministry of Mines, 2012). HCL's decision to allocate a Rs 1,176.12 crore contract for developing underground mines at Malanjkhand to an allegedly black-listed contractor was financially imprudent, with only 50% of the work completed after incurring a hefty Rs 606.83 crore. The project faced a cost escalation of Rs 538.44 crore. Delays in submitting requisite documents for statutory clearances impacted ore production by 1.191 million tonnes, causing a temporary suspension of operations at the Surda mines (CAG, 2023).

Challenges such as outdated equipment, logistical and technological shortcomings, an ageing workforce, low processing efficiency, and optimal utilisation of existing copper mines have hampered HCL's business operations. For instance, the Kolihan mine experiences frequent crusher breakdowns, and the KCC faces water shortages and equipment failures.

As a result of prolonged underperformance by HCL, JSW Group has secured the Mine Developer and Operator (MDO) contract for two of HCL's mines in Jharkhand. With a planned capital investment of Rs 2,600 crore, the project targets an ore production capacity of 3 MTPA and is expected to begin partial operations in the second half of FY 2027. While JSW Steel is a steel conglomerate, this marks the company's first foray into the copper and broader non-ferrous metal markets (JSW Group, 2025).

Apart from HCL's current mines, the Ingaldal copper mine, owned by Hutti Gold Mines Limited (HGML) and encompassing an ML area of 259 hectares in Karnataka, operated only from 1965 to 1994 despite its lease validity being extended until 2013 (MoEFCC, 2017). It was shut down primarily due to declining copper prices and other economic factors. According to the latest IBM Bulletin, this ML remains under State government ownership but is currently non-operational (IBM, 2023). Given its substantial known reserves of 9.164 million tonnes and its historical production rate of 250 tonnes per day, strategically restarting operations at the Ingaldal mine could significantly contribute to bridging the raw material supply gap and meeting the rising copper demand in India.

Regarding the auctioning of new copper blocks, only five have been successfully auctioned since the auction regime was introduced—four copper blocks and one for copper and gold (Ministry of Mines, 2025). As the blocks were awarded under Composite Licences (CL), further exploration is required before commencing mining operations. However, the average lead time from initial discovery to production is around 17 years (International Energy Agency, 2021). Moreover, industries report that although the quality of reserves is not a concern, the average area size of these blocks is insufficient for commercial viability. The government has expanded the area limit for MLs from 10 square km to 50 square km and for CLs from 25 square km to 100 square km for 24 critical minerals enlisted under the Mines and Minerals (Development and Regulation) Act 1957 (MMDR Act) (Government of India, 2024). In the new tranches of the critical mineral auctions, two copper blocks in Odisha and Arunachal Pradesh were also annulled due to limited participation and a lack of interest from potential bidders (Joshi, 2024).

Sole reliance on domestic reserves is not a prudent and sustainable strategy for copper mining and processing. Companies have moved out and acquired mines or stakes in copper-rich nations. Long-term offtake agreements also offer alternative funding mechanisms between producer and buyer, sometimes hedging against price fluctuations through pre-arranged buyer commitments. India should pursue strategic bilateral collaborations with mineral- and technology-rich countries and multilateral collaborations and regional partnerships such as the Mineral Security Partnership (MSP), Quad–ASEAN, the Supply Chain Resilience Initiative (SCRI), and the Indo-Pacific Economic Framework (IPEF) to explore copper-rich nations beyond its borders.

India's key bilateral relations on natural resources and energy security with countries such as Brazil, Chile, Venezuela, Australia, and those in Africa are important and can be leveraged further. Africa, particularly Zambia and the DRC, presents a promising opportunity given its enriched copper reserves. The Indian government has secured exploration rights for a 9,000 square kilometre block of potentially high-grade copper and cobalt deposits in Zambia (Walia, 2025). However, 45% of Zambian resource potential is still unmapped, and the Zambian government welcomes public-private partnerships (PPPs) to discover new resources (Baskaran & Yu, 2024).

Khanij Bidesh India Limited (KABIL) has been doing exploration and sampling of lithium blocks in Argentina and should proactively facilitate similar partnerships for copper exploration and mining in resource-rich countries. The recently launched National Critical Mineral Mission also emphasises mapping and acquiring critical mineral assets abroad through targeted financial and infrastructure support, encouraging both public and private companies to participate (Ministry of Mines, 2025). Although Vedanta holds an approximately 80% stake in the Konkola copper mines in Zambia, more Indian mining companies should capitalise on these emerging opportunities. India can enhance its share of economic benefits by strategically leveraging and negotiating trade and investment agreements such as FTAs, MoUs, and International Investment Agreements (IIAs) to support national development goals and foster more sustainable, resilient supply chains.

5.2 Indian Midstream Scenario

In India, cathode production grew from 644,200 tonnes in FY 2013–2014 to a peak of 830,500 tonnes in FY 2017–2018. However, production witnessed a sharp decline thereafter, primarily due to the closure of Sterlite Copper of Vedanta Ltd. in May 2018. With the hit of COVID-19, production fell to a low of 363,900 tonnes in 2020–2021. Cathode production has revived thereafter and has settled at about 509,000 tonnes in 2023–2024 (Figure 10).

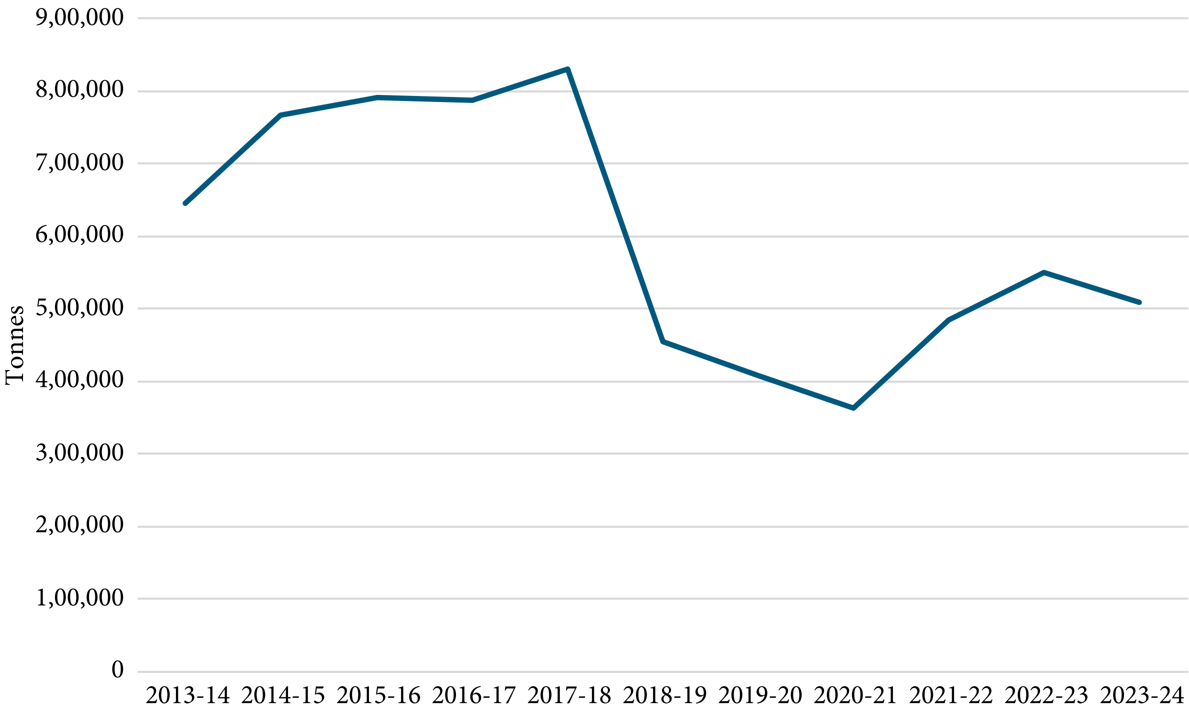
Currently, two major private players dominate the Indian midstream copper sector: Hindalco (Birla Copper) and Sterlite Copper (Vedanta). HCL has historically been the sole vertically integrated producer of refined copper, engaged in mining, beneficiation, smelting, refining, and casting of copper. It operated primary smelting and refining plants at the KCC in Rajasthan, the ICC in Jharkhand, and the Gujarat Copper Project (GCP), with installed capacities of 31,000 tonnes per annum, 18,500 tonnes per annum, and 50,000 tonnes per annum, respectively (HCL, 2024). Additionally, HCL operates a secondary copper smelter in Gujarat with an annual installed capacity of 50,000 tonnes.

However, due to economic challenges, HCL suspended smelting and refining operations at its KCC plant in December 2008. Subsequently, operations at the ICC and GCP plants were also discontinued due to financial non-viability (Ray, 2022). As a result, HCL shifted its business focus primarily to mining and processing copper ore into metal-in-concentrate for direct sale in the open market. Since 2020, the company has entered a PPP with Hindalco, wherein 60% of its concentrates are supplied to Hindalco for the production of refined copper (Hindalco, 2020). HCL's gradual phasing out from the copper processing spectrum has created opportunities for private players to expand their presence in the midstream sector.

Currently, Hindalco, a subsidiary of Birla Copper, is India's largest copper producer, playing a crucial role in significantly meeting the country's domestic refined copper needs. Its copper facility in Dahej, Gujarat, includes a port-based custom copper smelter, downstream units, and a captive jetty, with a combined annual production capacity of 500,000 tonnes. The facility has a cathode production capacity of 420,000 tonnes and a Continuous Cast Copper Rods (CCCR) capacity of 540,000 tonnes. In FY 2023–2024, cathode production was 368,000 tonnes, reflecting a 10% decrease from the previous year's production of 407,000 tonnes. In contrast, CCCR production exhibited a growth rate of 19% over the previous year, with a production of 488,000 tonnes in FY 2023–2024 (Hindalco Industries Limited, 2024).

Vedanta Ltd.'s Sterlite Copper operates two facilities: one in Tuticorin, Tamil Nadu, and another in Silvassa, Dadra and Nagar Haveli. The Tuticorin complex includes a copper smelter, refinery, sulphuric acid plant, phosphoric acid plant, and copper rod plant, with a smelting capacity of 400,000 tonnes per annum (Vedanta, 2025). The Silvassa facility consists of a refinery and two copper rod plants,

Figure 10: Domestic Production of Cathodes



Source: Indian Minerals Yearbook, various years (IBM).

with a combined capacity of 216,000 tonnes per annum. Sterlite was a key contributor to India's midstream copper market until 2018. In FY 2017–2018, the company contributed approximately 49% of India's total refined copper output. However, the Tuticorin plant was closed in May 2018, primarily due to widespread protests and public agitation stemming from concerns over severe pollution caused by persistent environmental non-compliance. Following the closure, India became a net importer of copper cathodes in the same year, with a production cut of approximately 45% in FY 2019 from its previous year. As of 2024, the Supreme Court has dismissed Vedanta's review petition to reopen the Tuticorin plant, citing environmental concerns about public health (Mukherjee, 2024). In FY 2023–2024, Vedanta's only operational Silvassa plant produced 141,000 tonnes of copper cathodes, registering a 5% decline from the previous year (Vedanta, 2024).

Both Hindalco and Vedanta depend on imported copper concentrates sourced either from their overseas mines or through international procurement. On the global stakes, Hindalco, through its wholly owned subsidiary Aditya Birla Minerals, previously owned the Mount Gordon copper mine in Australia but sold it in 2015 to focus on its smelting businesses in India (Aditya Birla Minerals, 2015). The company is now exploring equity stakes in the US and Canada. It has shown interest in sourcing raw materials from Mongolia but is facing logistical challenges (Walia, 2024). In 2023, Vedanta divested its stake in the Mount Lyell Copper Mine in Tasmania, Australia, due to strategic reasons. However, it regained control of the Konkola Copper Mines in Zambia in 2024, which had been under provisional liquidation since 2019 (Vedanta, 2024a). Vedanta also plans to invest USD 2 billion in Saudi Arabia in major copper processing projects, including greenfield smelter, refinery, and copper rod projects, by the end of FY 2026 (Businesswire, 2024).

Besides Hindalco and Vedanta, Adani's Kutch Copper Ltd. is marking a significant frontier into the metals sector with a USD 1.2 billion investment to establish a 1-MTPA plant in two phases in Gujarat. The first phase of the 500,000-tonne copper smelter was commissioned in March 2024 (Adani, 2024). An additional similar level capacity will be installed in the second phase, to be completed by March 2029. The company is negotiating a supply agreement with the Australian mining company BHP for purchasing up to 1.6 MTPA of copper concentrates valued at Rs 30,000 crore per year (Singh, 2024). Table 3 provides a brief overview of the present status of the Indian copper industry.

Table 3: At a Glance: Domestic Copper Industries

Companies	Installed Capacity (thousand tonnes)	Type	Present Status
HCL	68.5	PSU (integrated producer)	Since 2020, HCL has phased out cathode production. Currently, it sells concentrates in the open market and bulk to Hindalco through a PPP agreement.
Hindalco (Birla Copper)	500	Private (Port-based Custom Smelter)	Meets more than 50% of domestic refined copper requirements.
Sterlite Copper (Vedanta)	460	Private (Port-based Custom Smelter)	The Tuticorin smelter (400 kt) has not been operational since 2018.
Kutch Copper Ltd. (in-progress)	1000	Private (Port-based Custom Smelter)	The first unit of Phase 1 was commissioned in March 2024.

Source: Authors' compilation from secondary sources.

To mitigate import dependency and China's growing dominance in global processing, India must prioritise the areas and scopes to strengthen its midstream copper sector and integrate with the global supply chain. The sector must adopt advanced yet cost-competitive processing technologies and environmentally responsible practices, ensuring long-term community benefits, social impact, and sustainable stakeholder relationships. Fostering long-term partnerships and benefit-sharing with local communities is essential to maintain a sound social licence to operate. Companies can draw from global examples such as JX Nippon's green hybrid smelting technology, carbon footprint reduction strategies by introducing carbon-neutral electricity, and responsible procurement practices (International Copper Association, 2023a).

Given the capital-intensive nature of this sector, investments in technological advancements, innovation, knowledge-sharing, and R&D are imperative to develop a state-of-the-art smelting and refining sector for both primary and secondary copper production.

While tax benefits, subsidies, and incentives may offer short-term benefits, long-term collaboration among miners, processors, industry associations, and downstream industries through commercial agreements, contract manufacturing, and joint ventures can drive innovation, facilitate risk-sharing, and enhance economies of scale. Additionally, strategic measures such as mergers and acquisitions, blended financing, and long-term supply contracts can help optimise resource utilisation. Regulatory frameworks and policies should incentivise Indian companies to embrace more sustainable practices throughout their operations, beyond just sustainability reporting. Third-party certifications such as the "Copper Mark" can reinforce additional credibility on responsible sourcing, processing, and recycling, aligning with international sustainability standards.

5.3 Indian Downstream Scenario

As the final stage of the copper value chain, the downstream sector is integral to *value addition* before products reach the market. A well-developed downstream sector significantly contributes to a country's GDP by fostering economic diversification, supporting ancillary industries, and creating jobs. Fetching substantial investment, advanced technological capabilities, R&D, and well-channelled market access are imperative factors for maximising value addition and enhancing the downstream sector's resilience. Challenges in the upstream and midstream segments inevitably affect the downstream sector, as it relies on these stages for its primary inputs.

Across India, many companies manufacture a wide range of value-added copper products, including wires, cables, tubes, and pipes, serving diverse industrial applications. The closure of the Tuticorin copper plant has been a major setback for the sector. However, the trade figures, as discussed in Figures 11 to 20, indicate that while India used to produce cathodes substantially, it used to be a net importer of downstream copper products even before the shutdown of the Tuticorin copper plant. A stakeholder consultation for our research revealed that the domestic procurement of refined copper is not as price-competitive as procurement through duty-free or low-duty imports. To curb the influx of substandard refined copper imports and ensure the highest quality standards, a Quality Control Order (QCO) was implemented in 2023, mandating that certain copper products such as wire rods, bars, strips, and tubes be imported with Bureau of Indian Standards (BIS) certification (Ministry of Commerce & Industry, 2023). However, downstream manufacturers have raised concerns over supply crunches due to delays in obtaining BIS-approved certifications for many Japanese refiners, due to some complications. Here, the QCO on cathodes should be carefully reassessed to ensure it does not act as another non-tariff barrier amid ongoing supply constraints.

Currently, India's domestic downstream sector remains underdeveloped and scattered. While efforts must be made to stimulate domestic production, it is equally essential to streamline compliance mechanisms to ensure an uninterrupted supply through trade. Vertical integration can enable economies of scale, greater control over the supply chain, improved market insights, and faster market delivery. Lessons can be drawn from Indonesia's strategy of leveraging its raw material base to strengthen its processing and downstream industries in nickel and copper, attracting global investment. India's downstream industries can unlock significant growth by adopting advanced digital and analytics solutions, machine learning, AI-driven technologies, and digitalisation.

Resilient Prices

Copper unfurls attractive investment opportunities compared to other critical minerals, primarily due to its diversified demand and supply sources (International Energy Agency, 2025). Unlike battery metals such as lithium, nickel, and cobalt, which have exhibited high price volatility, copper prices have remained relatively stable.

For instance, due to oversupply in anticipation of accelerating demand, the price of lithium carbonate witnessed a sharp decline from an average of USD 68,100 per tonne in 2022 to USD 10,511 per tonne as of February 2025. Nickel, which reached a historic peak of USD 37,229 per tonne in 2007, has fallen to around USD 17,000 per tonne in 2024 (Statista, 2025). Similarly, cobalt prices have experienced a downward trend since 2022 due to oversupply.

On the other hand, the average copper price soared to USD 9,317 per tonne in 2021 from USD 6,174 in 2020 (Statista, 2025a). Later, the price remained generally elevated. The price peaked at around USD 10,174 per tonne in May 2024 and was USD 9,173 in May 2025. Such price resilience ensures impetus to different stages of copper production.

Investment Scenario

While falling price patterns in critical minerals may support energy transition initiatives by lowering production costs, they could also cause the downsizing of mining operations, production cuts, and other cost-cutting measures that could deter investor interest. Here, copper's favourable market outlook, driven by demand outpacing supply, offers significant investment potential. However, on the recent domestic investment portfolio, JSW Group's investment of Rs 2,600 crore in mining and Adani's USD 1.2 billion investment in processing imply growing private players' interest. However, the prolonged absence of renowned foreign players and global mining conglomerates in the Indian copper market is not a promising development. Despite a foreign direct investment (FDI) inflow of USD 17.59 billion in the metallurgical industries between April 2000 and June 2024, the entire mining and metallurgical sector has seen very limited international participation, particularly after Rio Tinto's exit in 2017 (IBEF, 2025).

Global investment in clean energy now nearly doubles that in fossil fuels, reaching USD 2 trillion in 2024. India's clean energy investment grew to USD 68 billion in 2023, a 40% increase from the 2016–2020 average, but requires a further 20% rise to meet the country's climate ambition (International Energy Agency, 2024). Emerging markets and developing economies, except China, contributed only 15% of global clean energy spending. Hence, there is enough room to boost clean energy spending. Consequently, investment in the copper sector is also expected to increase.

Role of Incentives

Incentives usually aim to stimulate investment, enhance competitiveness, and drive innovation, thus contributing to overall economic development. The Production-Linked Incentive (PLI) scheme was introduced to promote domestic manufacturing, enhance the global competitiveness of India's manufacturing sector, and attract FDI to achieve the overarching objectives of the Make in India initiative. Key beneficiaries of the PLI scheme include sectors such as automobiles, Advanced Chemistry Cell (ACC) batteries, and electronics, which are also major consumers of copper. The PLI Scheme on "White Goods" aims to establish a complete component ecosystem for air conditioner and LED light manufacturing in India and position the country as a significant player in global supply chains. In 2024, from July to October, 38 companies, including micro, small, and medium enterprises (MSMEs), expressed interest in enrolling under the PLI, with a net committed investment of Rs 4,121 crore (Ministry of Commerce & Industry, 2024).

The growth of these industries is a key demand driver for copper, highlighting the need for a resilient copper strategy for India. For instance, the growth of the air-conditioning and refrigeration sectors will boost the production of copper tubes. Additionally, there is a pressing need to expand the scope of the PLI-ACC scheme to incentivise the production of copper foil, which is a very crucial component in lithium-ion batteries and is currently largely imported from China and Korea.

The PLI scheme, while offering incentives on incremental sales, does not address critical factors such as material efficiency, sourcing criteria for raw materials (domestic or imported), or added incentives for adopting specific technologies, innovation, or R&D. For instance, benefits under the PLI scheme can be availed even when many components are imported (Livemint, 2022). The final product may merely involve assembly in India. Consequently, the manufacturing sector may still rely heavily on imported raw materials without fostering domestic upstream and midstream development, undermining efforts to establish a robust and resilient copper value chain.

It needs to be noted that schemes like the PLI should be considered short-term measures rather than long-term provisions. Prolonged reliance on incentives and subsidies may hinder the beneficiary industries from becoming self-reliant and globally competitive.

06

India's Copper Trade Scenario

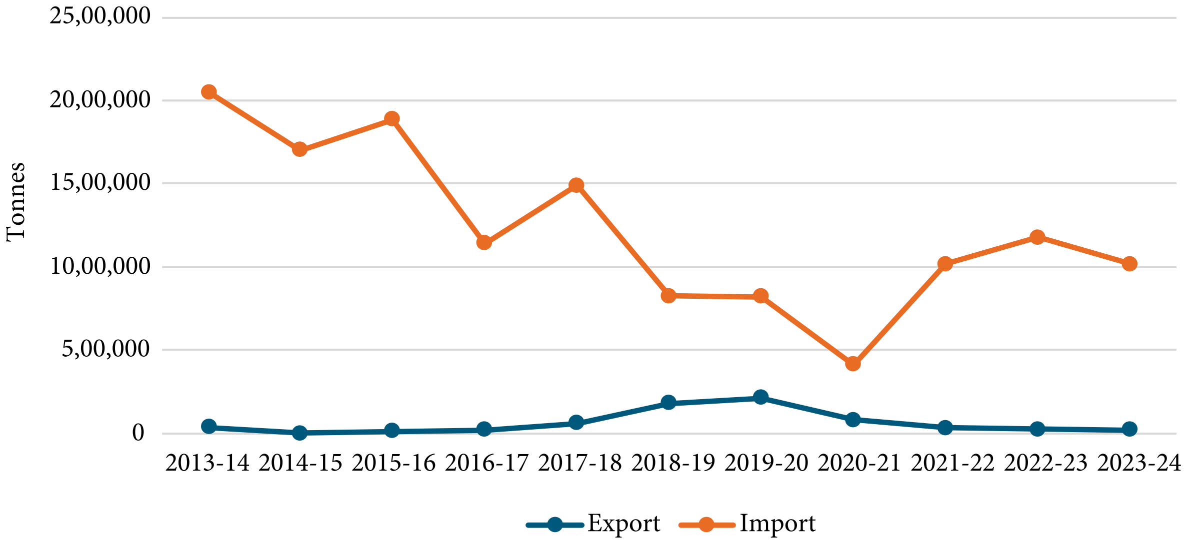
India's copper sector remains highly dependent on imports due to limited exploration and mining activities, insufficient domestic processing, and a fragmented downstream industry. This section examines India's import dependency at various stages of the copper value chain by analysing the trends of key copper products over the years, with a focus on major sourcing countries. Additionally, it explores the impact of trade agreements and policies on India's import patterns. The analysis considers copper ores and concentrates (HS Code: 26030000) and cathodes (HS Code: 74031100) to assess upstream and midstream trade trends, respectively. Furthermore, three key downstream products—copper wire (diameter >6 mm) (HS Code: 74081190), commonly referred to as copper wire rods in industry parlance; copper wire (diameter ≤6 mm) (HS Code: 74081990); and copper tubes and pipes (HS Code: 74111000)—are taken into consideration to understand trade dynamics in the downstream sector.

6.1 Upstream

India's copper sector has relied on imports of raw materials (ores and concentrates) over the years. However, imports declined over the years 2013–2014 to 2020–2021 and increased thereafter (Figure 11). The declining imports can be attributed to the domestic production of ores and concentrates meeting the needs of the midstream sector to a large extent during these years.

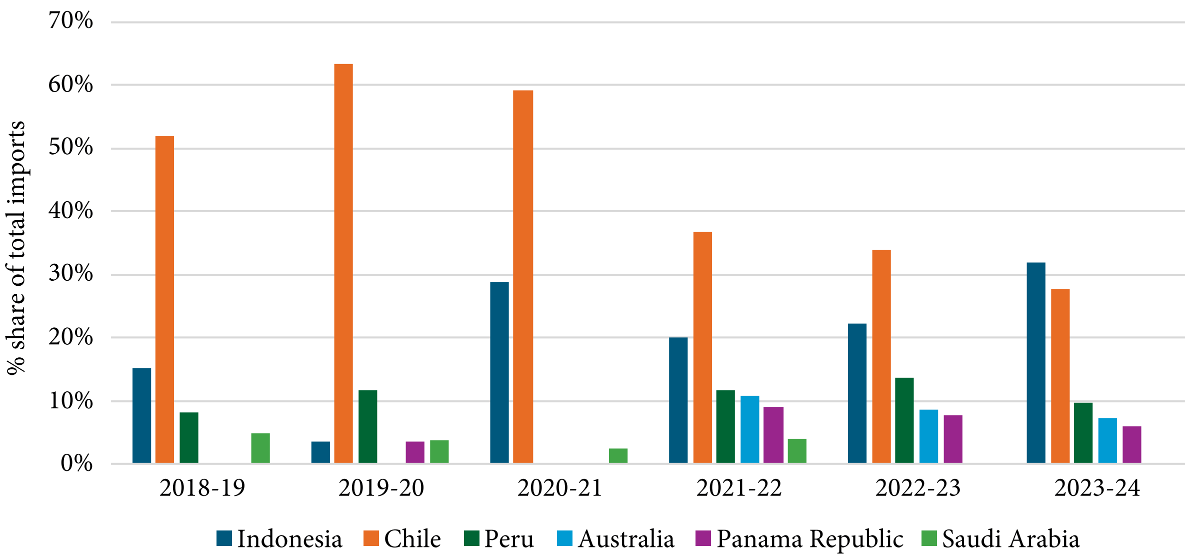
The Union Budget 2024–2025 eliminated customs duty on copper ore and concentrates to boost their imports. Chile, the world's largest copper producer, is a major supplier to India, facilitated by the India–Chile Preferential Trade Agreement (PTA), which allows zero import duty on copper ore and concentrates (Figure 12). The next most important sourcing country for India is Indonesia, with 32% of imports in FY 2024. One positive development during the period between FY 2020 and FY 2024 is that India has diversified its import-sourcing countries, moving away from Chile. However, the Indonesian export ban on copper concentrates from 2025 could pose challenges for India's copper sector.

Figure 11: Import-Export: Copper Ore and Concentrates



Source: Department of Commerce (2025).

Figure 12: Significant Import Sourcing Countries: Ore and Concentrates



Source: Department of Commerce (2025).

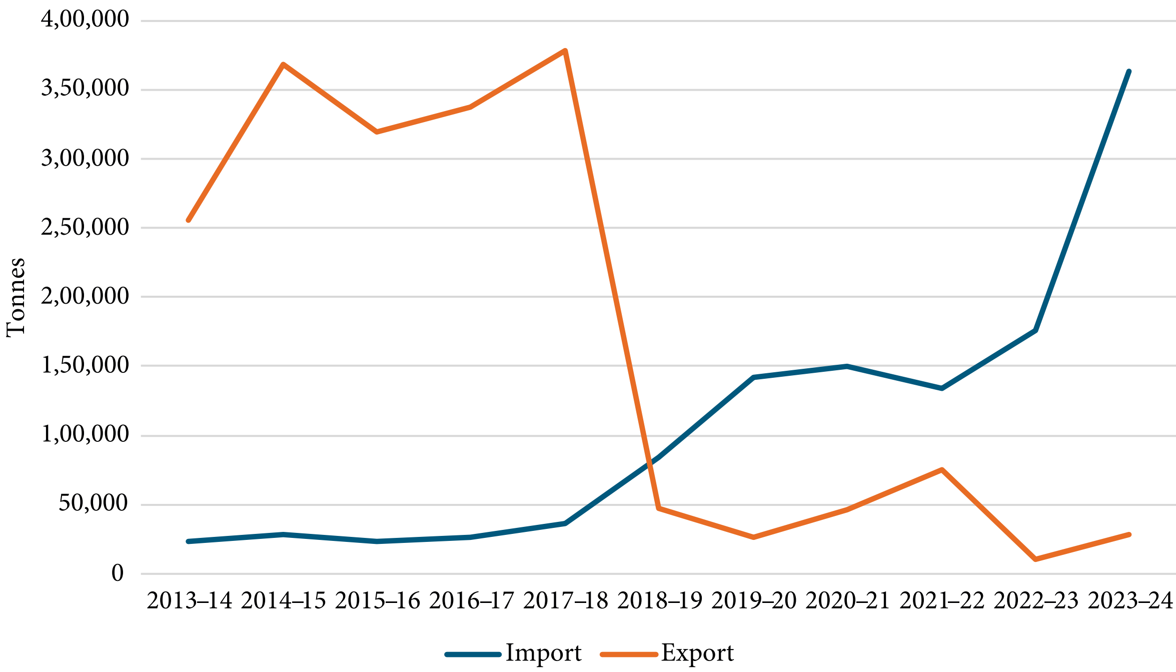
6.2 Midstream

India's accelerating domestic demand for refined copper, coupled with insufficient domestic production and the closure of the Sterlite copper processing facility in 2018, has led to an import reliance on cathodes. Since 2018–2019, India has transitioned from being a net exporter to a net importer of copper cathodes following the shutdown of Sterlite's copper plant in Tuticorin. As production fell by 45%, imports of cathodes surged, from 36,257 tonnes in FY 2018 to 363,052 tonnes in FY 2024, with a Compound Annual Growth Rate (CAGR) of approximately 47% (Figure 13). It is to be noted that in 2016–2017, when India was a surplus producer of cathodes, its key export destinations included China, Malaysia, Singapore, Korea, and Taiwan.

India has been sourcing a sizeable portion of its copper cathodes from Japan (Figure 14). Favourable trade agreements have also facilitated this, particularly the Comprehensive Economic Partnership Agreement (CEPA) between India and Japan, which has been in effect since 2011. While the Most Favoured Nation duty rate on cathodes is set at 5% ad valorem, cathodes became duty-free in 2021 under the India–Japan CEPA (JICEPA), providing a strong incentive for Indian manufacturers to procure from Japan over other countries (Ministry of Commerce and Industry, 2021).

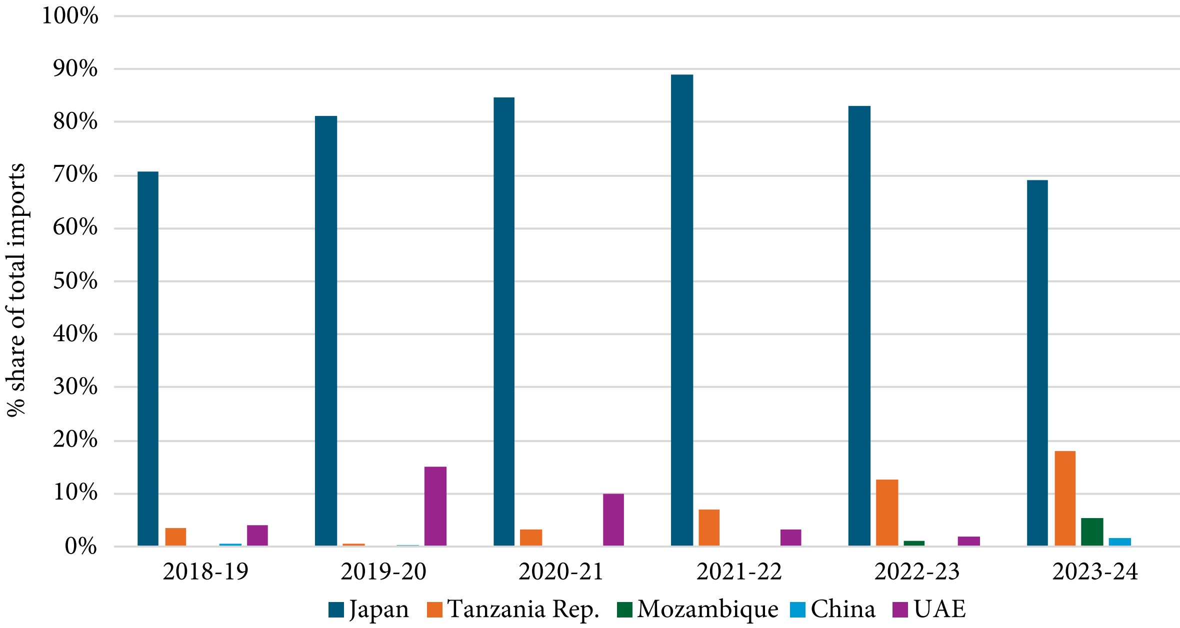
Despite relying entirely on imports for copper ores and concentrates, Japan has established itself as a leading global exporter of copper cathodes, leveraging its advanced processing technologies that ensure high purity levels meet international standards, a customer-centric approach, strategic bilateral relations, and a robust industrial base. As of 2023, Japan was the world's third-largest exporter of copper cathodes, with total exports valued at approximately **USD 5.51 billion** (World Integrated Trade Solutions, 2023). Although globally Chile was the largest exporter of cathodes in 2023, with exports valued at approximately **USD 16.95 billion**, the preferential tariff concessions under the India–Chile PTA, offering a 50% reduction in duty for up to **5,000 tonnes per annum**, are not conducive for India, given India's voluminous cathode imports.

Figure 13: Import-Export: Cathodes



Source: Department of Commerce (2025).

Figure 14: Significant Import Sourcing Countries: Cathodes



Source: Department of Commerce (2025).

6.3 Downstream

Downstream copper products include copper wires, pipes, and tubes. These are then used as inputs into copper appliances. The wires are generally classified by a diameter of less than or equal to 6 millimetres and greater than 6 millimetres (also referred to as rods). While copper wires are essential for manufacturing electrical conductors, telecommunications wiring, and various electronic products, copper tubes and pipes play a crucial role in the heating, ventilation, and air conditioning (HVAC), plumbing, and refrigeration industries. These products are vital for electric grids and decarbonisation.

While India was a net exporter of copper cathodes until FY 2018, it has been a net importer of copper wires, tubes, and pipes, with the trade gap continuously increasing in the case of tubes and pipes (Figures 15, 17, and 19). However, copper wires of greater than 6 millimetres recorded an export surplus in FY 2024.

This trend can be explained by the widespread demand for copper rods across multiple sectors, encouraging the gradual establishment of the domestic rod manufacturing sector and increasing its export competitiveness of late. In contrast, copper tubes are primarily used in niche industries such as HVAC and refrigeration, where India currently has limited market penetration and inadequate manufacturing capacity.

India primarily imports these products from ASEAN countries, the UAE, and, to a lesser extent, Japan (Figures 16, 18, and 20). These economies have well-established, export-oriented manufacturing bases that focus on value-added processing. The UAE has significant manufacturing prowess for copper rods, with companies such as Union Copper Rod LLC and Ducab Metals Group leveraging advanced technologies like Southwire Continuous Rod Casting to ensure high-quality production. In 2023, the UAE ranked as the world's second-largest exporter of copper wire, with an export value of USD 3.3 billion.

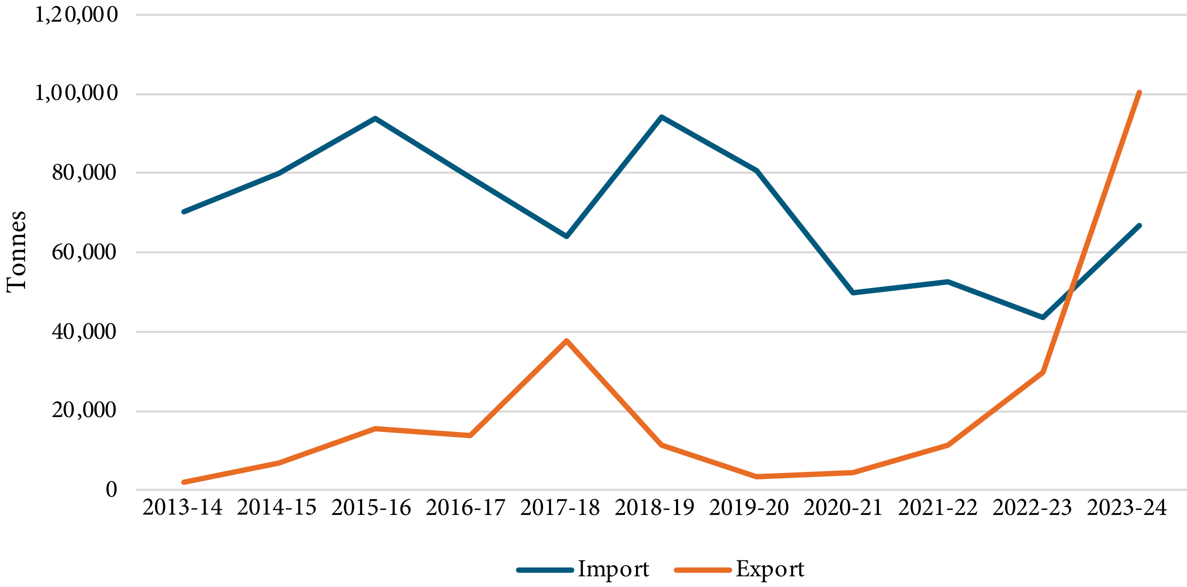
Additionally, trade agreements have played a crucial role in shaping the trade landscape. The India–UAE CEPA, which came into effect in 2022, further provided tariff rate concessions on imports of copper wires into India. The ASEAN–India Free Trade Agreement (AIFTA) enables countries such as Malaysia, Thailand, and Vietnam to export copper wires and tubes to India at zero duty, making their products more competitive than domestic alternatives. ASEAN nations also benefit from rules of partial cumulation, where a value addition of 40% to 45% across the ASEAN region qualifies goods for preferential tariffs. For instance, Malaysia and Thailand import copper concentrates from Indonesia, process them domestically, and export them to India at zero duty (Banik, 2022).

However, Indian industries have reported adverse impacts due to the influx of cheaper imports, leading to a decline in their market share to approximately 20% (Rathore, 2020). Many domestic producers struggle to compete with the subsidised prices of products imported from ASEAN countries. To address these challenges and ensure fair competition, the Directorate General of Trade Remedies imposed countervailing duties (CVD) in 2019 on subsidised imports of copper wire rods from Indonesia, Vietnam, Thailand, and Malaysia (DGTR, 2019). A similar duty was also levied on copper tubes and pipes to counter heavily subsidised imports from Vietnam, Thailand, and Malaysia, which had caused material injury to Indian manufacturers (DGTR, 2022). However, copper wire and rod imports have remained significant from those countries even after the imposition of CVD, ranging from 2.47% to 10.27%. This persistence in imports suggests that the imposed duties may not be enough to fully offset the subsidies provided by exporting countries, allowing them to continue offering competitively priced products in the Indian market. Alternatively, domestic manufacturers may lack the competitiveness required to withstand high import volumes, even with CVD in place. Concerns have also been raised regarding the re-routing of exports from non-ASEAN countries through ASEAN countries to circumvent taxation and benefit from preferential tariff rates (Rao, 2024).

Copper wire imports (HS Code: 7408) surged by 215% from 2010–2011 to 2023–2024, while exports increased by only 81% over the same period (Department of Commerce, 2025). In FY 2024, total copper wire imports were valued at USD 1,183 million, with ASEAN countries accounting for approximately 40%. Given these concerns, a comprehensive review of the ASEAN–India Trade in Goods Agreement (AITIGA) has been prioritised in the recent 21st ASEAN–India Summit.

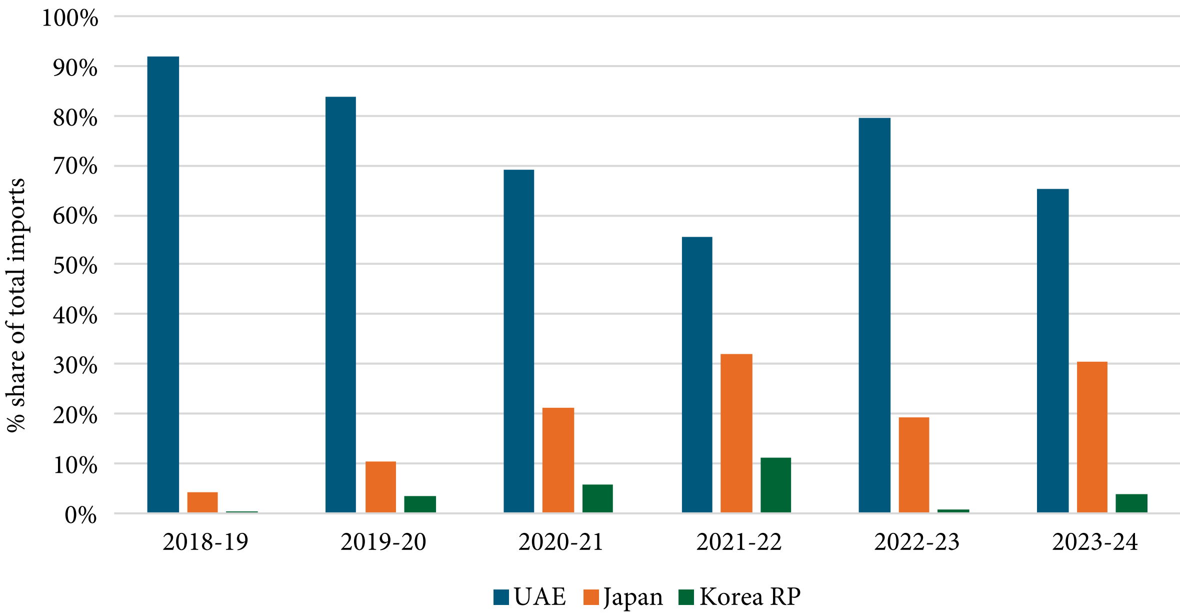
India's declining trend in raw material imports, alongside a gradual increase in imports of value-added products such as cathodes, wires, and tubes, lays out two possibilities. The midstream processing sector lacks adequate capacity to process ore and concentrate to meet domestic demands. Imports of finished products seem to be more cost-competitive than domestic procurement, which also undermines domestic *value addition*.

Figure 15: Import-Export: Copper Wire >6 mm (Copper Rods)



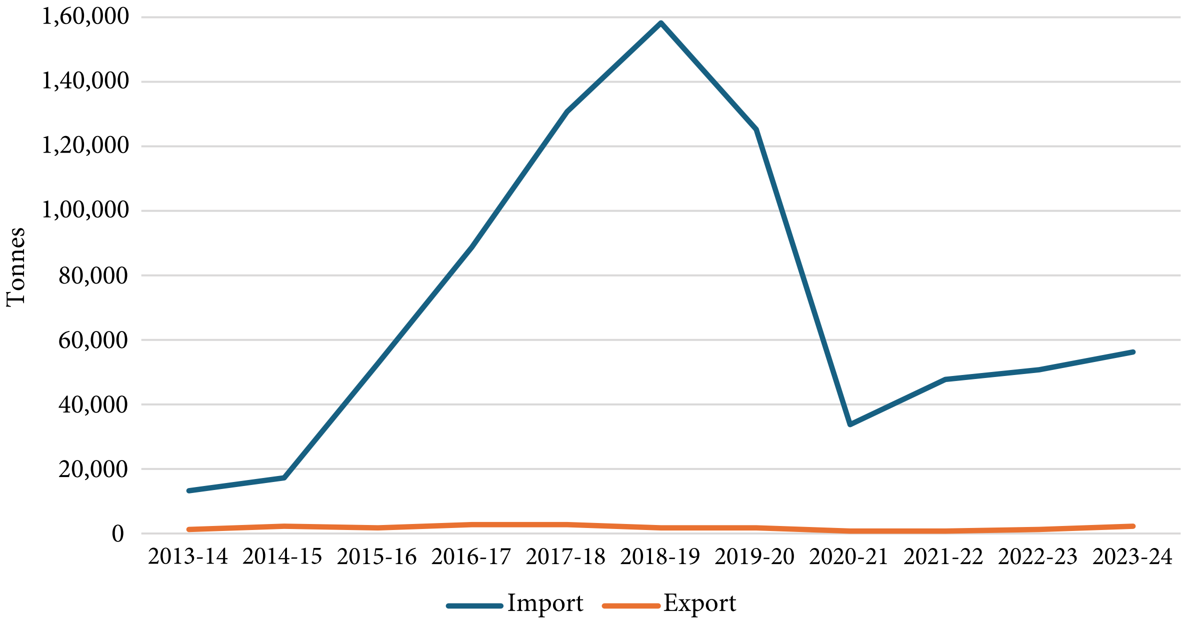
Source: Department of Commerce (2025).

Figure 16: Significant Import Sourcing Countries: Copper Wire (>6 mm) (Copper Rods)



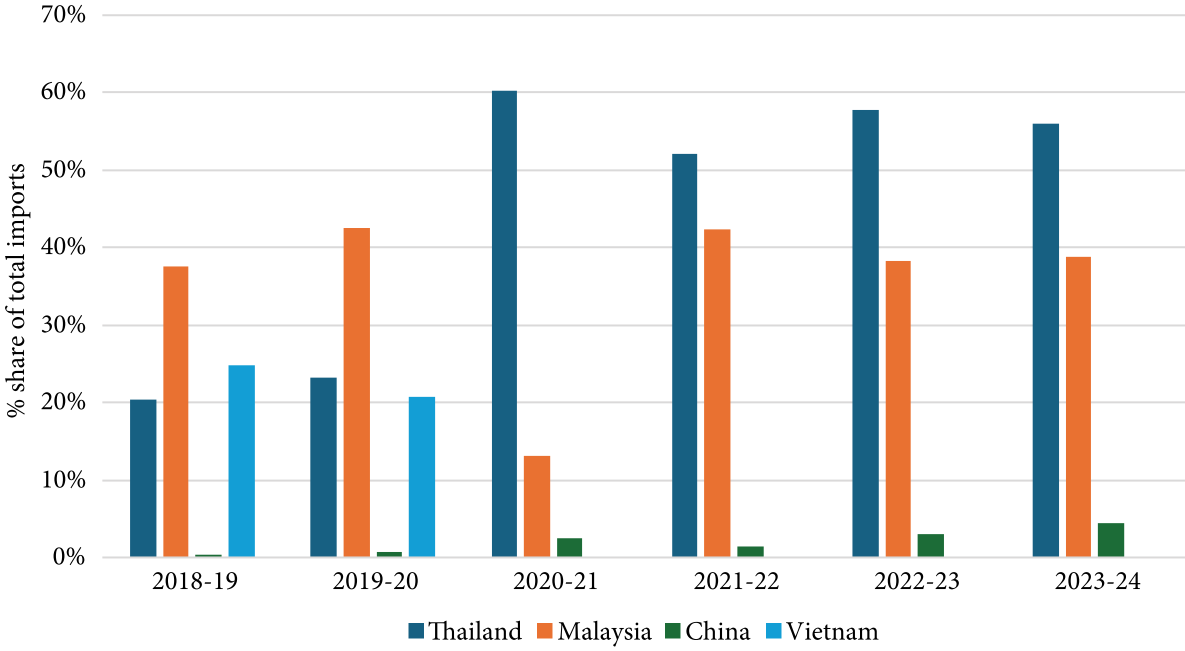
Source: Department of Commerce (2025).

Figure 17: Import-Export: Copper Wire (≤6 mm)



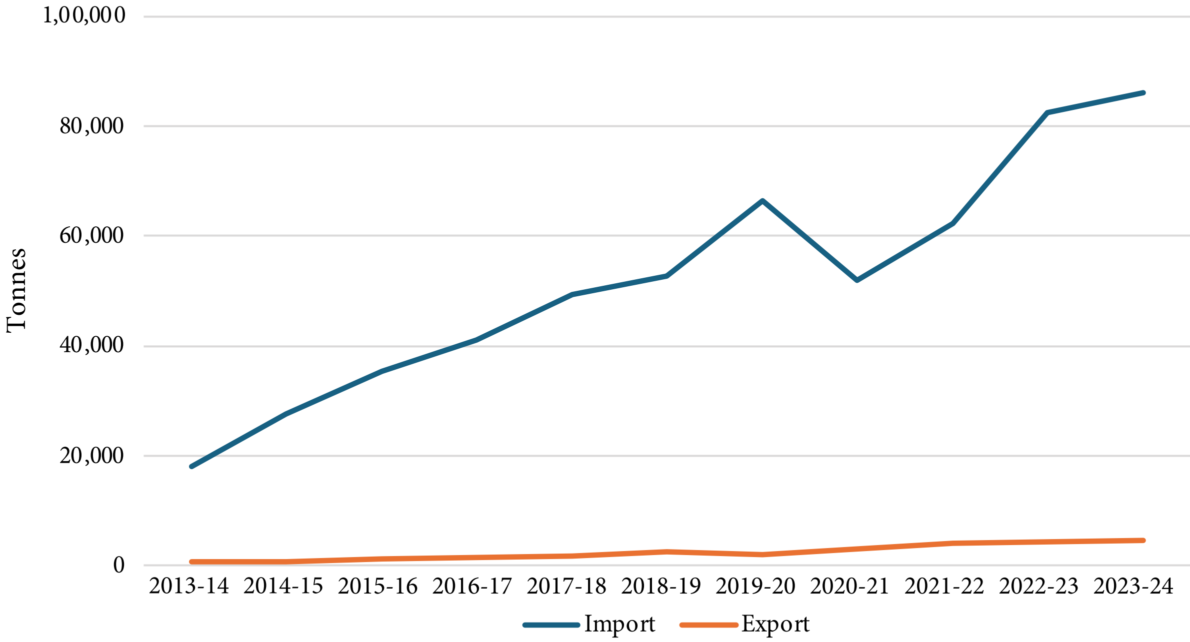
Source: Department of Commerce (2025).

Figure 18: Significant Import Sourcing Countries: Copper Wire (≤6 mm)



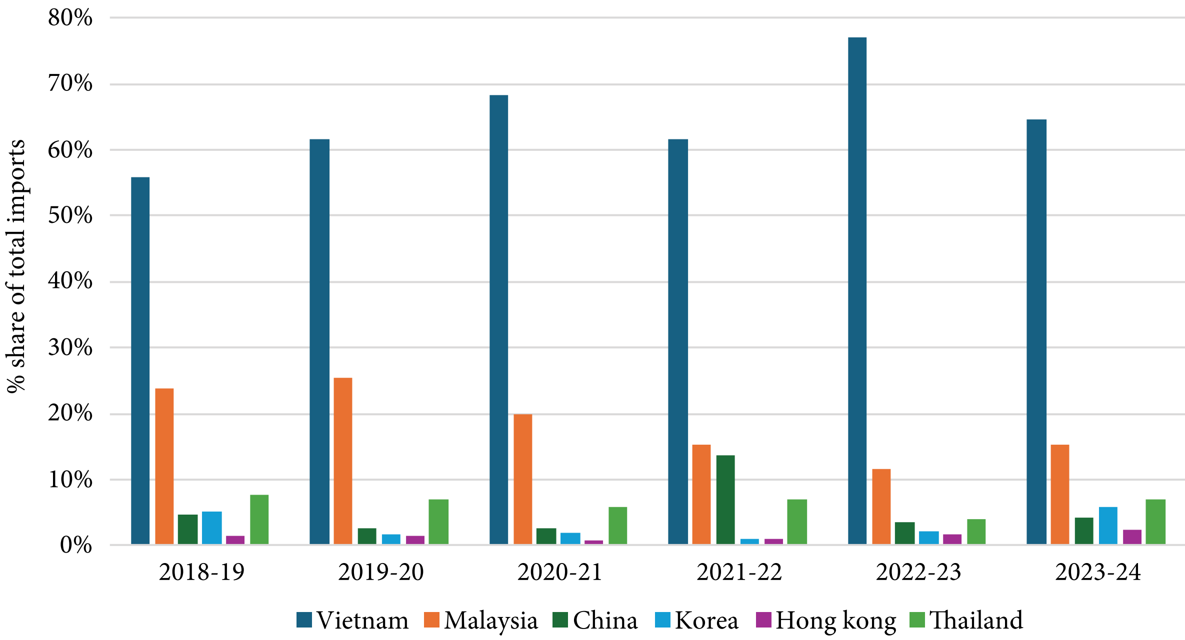
Source: Department of Commerce (2025).

Figure 19: Import-Export: Copper Tubes and Pipes



Source: Department of Commerce (2025).

Figure 20: Significant Import Sourcing Countries: Copper Tubes and Pipes



Source: Department of Commerce (2025).

07

Circular Economy: Recycling

Secondary copper derived through the recycling of old scrap (copper contained in end-of-life, post-consumer products) and new scrap (copper contained in discarded products during semi-fabrication or downstream manufacturing) exhibits physical and performance properties equivalent to those of primary mined copper, enabling circularity in the entire copper value chain. In the present context of dwindling copper reserves, declining ore grades, and delays in commissioning new mines, scrap containing embedded copper can provide an authentic source of raw materials, leveraging the inherent recyclability of copper. Moreover, copper recycling is 85% less energy-intensive than primary production (International Copper Association, 2025).

In 2023, 32% of total global copper usage was derived from recycled copper (ICSG, 2024). Here, "urban mines," in the form of electrical and electronic equipment waste (e-waste), present significant untapped potential for secondary copper. In 2022, approximately 62 million tonnes of e-waste were generated globally, containing embedded copper valued at an estimated USD 19 billion (Unitar, 2024).

7.1 Global Initiatives

Many countries are increasingly investing in recycling infrastructure to capitalise on the immense potential of secondary copper. This initiative will strengthen sustainability efforts and promote a circular economy. The global recycled copper market is anticipated to grow from USD 270 billion in 2024 to USD 468 billion by 2032, presenting a compelling incentive for companies (Market Data Forecast, 2024).

In 2024, Aurubis, a Germany-based company, established the first multi-metal recycling plant in the USA, with an annual capacity to process over 180,000 tonnes of complex recycling materials, including circuit boards and copper cables (Aurubis, 2024). Three major Chinese producers of copper, lead, and zinc formed the China Resources Recycling Group Co. Ltd., a state-owned enterprise aimed at creating a national platform for recycling and reusing resources from end-of-life consumer goods, e-waste, batteries, vehicles, and decommissioned wind and photovoltaic equipment (Taylor, 2024). Additionally, the European Union (EU)'s forthcoming Circular Economy Act seeks to stimulate market demand for secondary raw materials, waste reduction, and recycling, focusing on critical raw materials (Riebeling, 2024).

7.2 India's Initiatives

Although India has policy initiatives such as Extended Producer Responsibility (EPR) and the E-Waste (Management) Rules, 2022, to promote recycling, there remains enough scope for improvement and expansion under a robust recycling policy framework. The draft EPR rules issued by the Ministry of Environment, Forest and Climate Change (MoEF&CC) mandate that from FY 2028, new products made from non-ferrous metals must contain a minimum of 5% recycled content; the requirement for copper will progressively increase to 20% by FY 2031 (MoEFCC, 2024). However, while India has a well-established primary smelting and refining capacity, its recycling infrastructure is still underdeveloped.

As of 2023, there were 569 Central Pollution Control Board (CPCB)-approved e-waste recyclers, with a combined installed capacity of approximately 1.8 million tonnes annually (CPCB, 2023). However, in the specific context of copper recycling, government data from 2010 indicate the presence of only 35 CPCB-approved copper reprocessing units, with a total capacity of 242,000 tonnes per annum (Indian Bureau of Mines, 2011). Additionally, there are 132 facilities with a combined capacity of 517,000 tonnes per annum that recover copper along with other metals (Indian Bureau of Mines, 2024). There is also a dearth of updated data on the operational status and utilisation rates of copper reprocessing facilities in India.

In this context, Hindalco, in collaboration with the European technology vendor Metso, has expressed its intent to invest in a copper and e-waste recycling plant in India. This venture aims to produce 200,000 tonnes of recycled copper annually and process up to 350,000 tonnes of scrap and e-waste (AngelOne, 2024).

7.3 Recycling Challenges in India

While it is rightly said that today's scrap is tomorrow's raw material, the recycling value chain faces several inherent challenges. Therefore, meeting demands solely through recycled copper is not feasible due to several challenges, as discussed below.

Informal Sector

Copper recycling poses inherent complexities, requiring advanced technologies to deal with. In India, the copper recycling infrastructure, from scrap collection to processing, is dominated by a highly fragmented and unregulated informal sector. Many of these scrapped articles, including e-waste, contain significant quantities of hazardous toxins such as mercury, brominated flame retardants, and hydrochlorofluorocarbons. When not managed in an environmentally sound manner, these toxins pose severe risks to human health. Moreover, informal workers, including women and children, are often exposed to health hazards from inhaling harmful substances during recycling processes.

Downstream industries interested in recycling have reported significant challenges in sourcing copper scrap domestically due to the lack of a formalised and streamlined scrap market. The removal of customs duty on copper scrap in the Union Budget 2025–2026 is a strategic measure to facilitate a seamless inflow of scrap through trade channels, enhancing the competitiveness of domestic firms in recycling-based innovations for the export market. At the same time, India generates a substantial volume of copper scrap domestically. For instance, approximately 350,000 tonnes of end-of-life and process scrap copper were generated in FY 2021 (Business Standard, 2024). In addition, 80,000 tonnes' worth of copper scrap was imported in the same year. This domestically produced scrap must be efficiently used and reprocessed within the country by establishing a robust recycling infrastructure.

Besides, a sizeable portion of e-waste enters India illegally from developed nations due to lax regulations, inadequate monitoring, and the use of complex transhipment networks (Gill, 2019). Furthermore, there is a pressing need for an effective regulatory framework to restrict the import of low-quality copper scrap sold at cheaper prices. Low-quality scrap not only affects the quality of end products but also incurs higher processing costs and requires advanced technology, for which India's current recycling infrastructure is not adequately equipped.

Purity Concerns in Reprocessing

As the secondary processing infrastructure for copper recycling in India is not well-established, it leads to the direct re-melting of scrap instead of proper refining. In the absence of refining high-grade scrap or smelting and purifying low-grade scrap, the safety and quality of electrical and electronic components are compromised. Given the diverse categories of copper scrap, it is essential to ensure responsible recycling practices from collection, segregation, and reprocessing. Otherwise, it leads to the production of materials that fail to meet the highly conductive Electrolytic Tough Pitch (ETP) copper grade, which requires a purity of 99.9% or higher, as mandated by IS12444 standards (Business Standard, 2024). This level of purity is critical for the performance and safety of all electrical installations. While India has performed well in collecting discarded copper, the policy needs to focus on strengthening domestic recycling infrastructure to support high-quality and responsible copper recycling.

Longer Lifespan

Copper-embedded products typically exhibit higher longevity, resulting in a longer lifespan to attain their end-of-life, affecting their availability for recycling and reintroduction into the system. Over the past century, two-thirds of the 690 million tonnes of copper produced are still in productive use (International Copper Association, 2022). The time interval between consumption and the scrap generation phase varies significantly across sectors. A study shows that in the United States, from 1900 to 2016, the building and construction sector accounted for 37% of total copper consumption but contributed only 16% of total scrap generation. In contrast, electrical and electronic products consumed 25% of the total copper yet generated 32% of the total scrap due to the shorter lifespan of their products compared to those in construction (Wang, Liang, Yuan, & Cui, 2018). Despite copper's inherent recyclability, its End-of-Life Recycling Rate (EoL RR)[4] is 40%, whereas its Overall Recycling Efficiency Rate (ORER) is 56% (International Copper Association, 2022). Technological innovations aimed at maximising metal recovery and optimising copper usage can enhance recycling efficiency while reducing copper demand. For instance, an International Energy Forum report highlights that prioritising hybrid vehicles over battery EVs can reduce the additional copper demand associated with grid expansion and charging infrastructure, thereby promoting a more resource-efficient transition (Cathles & Simon, 2024).

GST Rationalisation

To streamline and formalise the metal scrap industry while ensuring tax compliance and revenue collection, the 54th Goods and Services Tax (GST) Council meeting introduced a Reverse Charge Mechanism (RCM) on scrap metal transactions (Dahiya, 2024). Under RCM, the tax liability shifts from the suppliers to the registered buyers, allowing them to claim Input Tax Credit (ITC) on GST paid, thus incentivising compliance. Suppliers must register under GST if their turnover exceeds the threshold limit of Rs 40 lakh (GN Law Associates, 2024). The RCM mandates registration by buyers from the organised sector and suppliers from the unorganised sector with a turnover below Rs 40 lakh. Scrap

[4] EoL RR: It measures the efficiency at which metal contained in EoL scraps is recycled. ORER: It measures the efficiency of collecting, pre-treating and finally recycling old and new scraps.

dealing with registered suppliers above the threshold limit will fall under the Forward Charge Mechanism (FCM).

An industry consultation for our research reveals that in the FCM, the default rate of GST payment is higher, affecting their ITC refunds. Hence, buyers may avoid scrap transactions under the FCM. Given that copper scrap is a high-value commodity, a significant number of suppliers have an annual turnover exceeding Rs 40 lakh. This low threshold poses a challenge for recyclers seeking to procure scrap from such players.

The RCM aims to eliminate the cost advantage of informal players, encouraging their formal registration and adherence to environmental standards (Dahiya, 2024). However, smaller scrap dealers may lack awareness of their implications, necessitating proper training and outreach for effective implementation.

While the introduction of the RCM on metal scrap transactions aims to enhance compliance and transparency, it also presents challenges related to administrative burdens, potential price adjustments, and adaptability.

08

Policy Recommendations

Policy recommendations (Table 4) are enumerated to adopt a holistic approach to the entire copper value chain, ensuring a seamless transition from mines to markets. While the challenges in raw material procurement directly affect midstream processors, the availability or scarcity of cathodes and other semi-finished goods influences the downstream sector, impacting businesses and consumers alike.

Table 4: Policy Recommendations catering to the Indian Copper Supply Chain

Challenges	Policy Recommendations
Upstream	
Global Challenge The average copper ore grade worldwide has been declining. Of the 239 copper deposits discovered between 1990 and 2023, only 15 have moved forward towards actual development. The current reserves are likely to meet global requirements for the next 45 years.	India is import-reliant for more than 50% of its copper needs. Considering the rising copper demand across the world and India's growing copper needs, India must explore and extract more copper, given that large resources and reserves lie unexplored and hence not mined.
Domestic Challenge The current policy regime in domestic exploration and mining has not been conducive to mining copper. Lack of exploration, complicated auction regime, combined with royalty and other statutory payments, and backlogs in obtaining clearances, discourage mining investments. HCL, the public sector copper mining company, has not kept up its promised copper mining activity.	Policy reforms are urgently needed to attract investments in exploration and mining activities to ensure a favourable return on investment. The greenfield exploration needs to be encouraged. NMET has provided less than 5% of its allocation to private explorers and should provide more. The risks taken by private players investing huge capital in exploration may be rewarded by considering giving them the right of first refusal or granting them mining rights over their explored blocks. HCL's performance warrants a comprehensive evaluation and revival for increasing future production to meet its past promises.

<table>
<tr><th>Challenges</th><th>Policy Recommendations</th></tr>
<tr><td>Procedural Delays

There are significant delays in obtaining relevant statutory clearances and other procedural requirements before commencing the extraction of minerals. Presently, none of the auctioned copper blocks since 2015 has progressed enough towards extraction. Besides, the abrupt closure of the Ingaldal copper mine with good reserves in Karnataka affects the domestic mining output.</td><td>Given copper's strategic significance to India's economy, the mineral concession procedure, from auctioning to granting statutory clearances and commencing the mining operation, needs to be streamlined to avoid any unnecessary delays and backlogs.

The National Mineral Policy 2019 emphasised that the states shall endeavour to auction mineral blocks with pre-embedded statutory clearances. The mining clearances should be combined into a one-stop shop for post-lease clearances in India.

The PARIVESH portal of the Ministry of Environment, Forests and Climate Change can be effective in the implementation of this solution.

Key Stakeholders: MoM, HCL, Ministry of Environment, Forest and Climate Change, and KABIL.</td></tr>
<tr><td colspan="2">Midstream</td></tr>
<tr><td>Financial Challenge

Copper processing requires high upfront CAPEX and OPEX, with energy being a critical cost driver. Declining ore grades and increasing requirements for environment-friendly operations add to the processing costs. Globally, treatment and refining charges are plummeting due to the huge expansion of smelting capacity combined with acute supply crunches of copper ore. This situation erodes smelters' margins. While the big players can still mitigate these challenges through diversified business portfolios, small-scale processors often bear the brunt.</td><td>To stabilise eroding margins, smelters should consider diversifying revenue streams by capitalising on high-value by-products such as sulphuric acid, gold, and silver, as well as using more intermediate products, including blister copper, anodes, and scrap.

Strategic collaborations, including joint ventures, contract manufacturing, and long-term commercial agreements among miners, processors, and downstream industries, are important to drive technological innovation, risk-sharing, and economies of scale.</td></tr>
<tr><td>Sustainability Challenge

Copper mining and processing result in environmental externalities, including air and water pollution, deforestation, biodiversity, and wildlife loss, which, if not adequately taken care of, jeopardise the "social license to operate", leading to social adversities and community unrest. For example, Vedanta's Sterlite Copper plant in Tuticorin, once a significant producer of copper cathodes, was shut down due to environmental non-compliance.</td><td>Strengthening existing environmental regulatory frameworks such as Environmental Impact Assessment (EIA), Social Impact Assessment (SIA), and Sustainable Development Framework (SDF) to ensure environmentally and socially responsible and sustainable operations along the copper value chain. Domestic companies should be encouraged to achieve globally recognised certifications like the "Copper Mark" to reinforce credibility and a transparent third-party verification in responsible sourcing, processing, and recycling.

Key Stakeholders: MoM, Ministry of Environment, Forest and Climate Change, Copper Mark, Indian and global copper industries and alliances.</td></tr>
</table>

Challenges	Policy Recommendations
Downstream	
Import Dependence India's downstream copper sector faces competition from imports of finished copper products, including wires, cables, pipes, and tubes. Imports from countries and regions with which India has PTAs further intensify this challenge. The closure of the Sterlite Copper plant has been a major setback for the downstream sector.	Leveraging Kutch Copper's large-scale entry to make domestic cathodes cost-competitive for downstream manufacturers and enhance India's export competitiveness as well, to reverse the status of being a "net importer." There is a need to undertake a comprehensive review of existing trade agreements and duty structures, particularly the agreements with ASEAN, Japan, South Korea, and the UAE.
Domestic Production One of the challenges is to accelerate the production of India's downstream copper sector. While there are PLI schemes for copper-embedded finished goods, there is no such scheme for copper fabricators. The existing PLI schemes, however, do not address critical factors such as material efficiency, sourcing criteria for raw materials (domestic or imported), or added incentives for adopting specific technologies, innovation, or R&D. Fabricators also feel slack on the availability of imported copper cathodes due to certain QCOs.	While the PLI schemes may be considered temporary measures to boost production in certain copper-consuming sectors, their scope should be expanded beyond mere production targets to the parameters of resource efficiency, material circularity, innovation, and environmental stewardship. Strategic vertical integration is required to streamline operations across the copper value chain, consolidating fragmented market segments for improved efficiency. QCOs should be reassessed to avert any supply crunches of cathodes to the downstream industries without compromising on quality. **Key Stakeholders:** Ministry of Commerce and Industry, Ministry of MSMEs, Ministry of Heavy Industries
Recycling	
Informal Sector The copper recycling infrastructure, from scrap collection to processing, is underdeveloped and dominated by a highly fragmented and unregulated informal sector. It often leads to direct re-melting of scraps instead of proper refining, compromising quality and safety.	Regulatory oversight is needed to structure and formalise the scattered and unorganised sector engaged with collection, sorting, and re-processing through adherence to environmental and safety standards. Targeted focus and investment should be directed towards the development of secondary copper processing infrastructure to ensure proper re-smelting and refining instead of direct re-melting to uphold safety standards, specifically in electrical equipment.
Fragmented Scrap Market Downstream industries interested in recycling face significant challenges in sourcing copper scrap domestically due to the lack of a formalised and streamlined scrap market. There is a lack of documentation of scraps having embedded copper generated domestically.	It is important to develop a robust domestic secondary copper market by facilitating direct linkages between scrap vendors, recyclers, and copper processors. Industries should be encouraged to use recycled materials guided by the overarching principles of the "circular economy." EPR rules need to be strengthened and effective to ensure proper end-of-life management and resource recovery. **Key Stakeholders:** Ministry of Environment, Forest and Climate Change, CPCB, and Ministry of Electronics and Information Technology (MeitY).

Challenges	Policy Recommendations
Across the Value Chain	
Foreign Policy Instruments Global Value Chains (GVCs) and supply chain diversification are critically important in today's scenario when copper mines are concentrated in very few countries, and the processing landscape is even more concentrated. Indian companies have strategically acquired stakes in overseas copper reserves. KABIL was established for resource diplomacy to enhance national mineral security. However, there remains enough room and opportunities to leverage India's foreign policy instruments effectively to secure the copper supply throughout the entire value chain.	India should proactively engage with key copper reserve-rich and copper-producing countries such as Chile, Peru, DR Congo, Australia, and Zambia through resource diplomacy, strategic acquisitions and effective partnerships. The Indian government has recently secured a 9,000-square-kilometre block in Zambia for copper and cobalt exploration by GSI. Apart from KABIL-led G2G initiatives, more B2B and G2B collaborations are essential in the areas of exploration, technology and knowledge exchange, value-added processing, and recycling. Existing bilateral relationships should be leveraged more effectively, along with multilateral forums such as MSP, IPEF, SCRI, and QUAD-ASEAN, to deepen economic cooperation. Trade, investment and off-take agreements should be utilised strategically as alternative finance mechanisms to secure a sustainable copper supply chain. **Key Stakeholders:** Ministry of External Affairs, KABIL.

Source: Based on the analysis discussed in the Report.

A comprehensive policy framework integrating these recommendations will enable India to develop a robust copper sector that integrates with global supply chains, fostering industrial competitiveness, sustainability, and long-term economic growth.

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