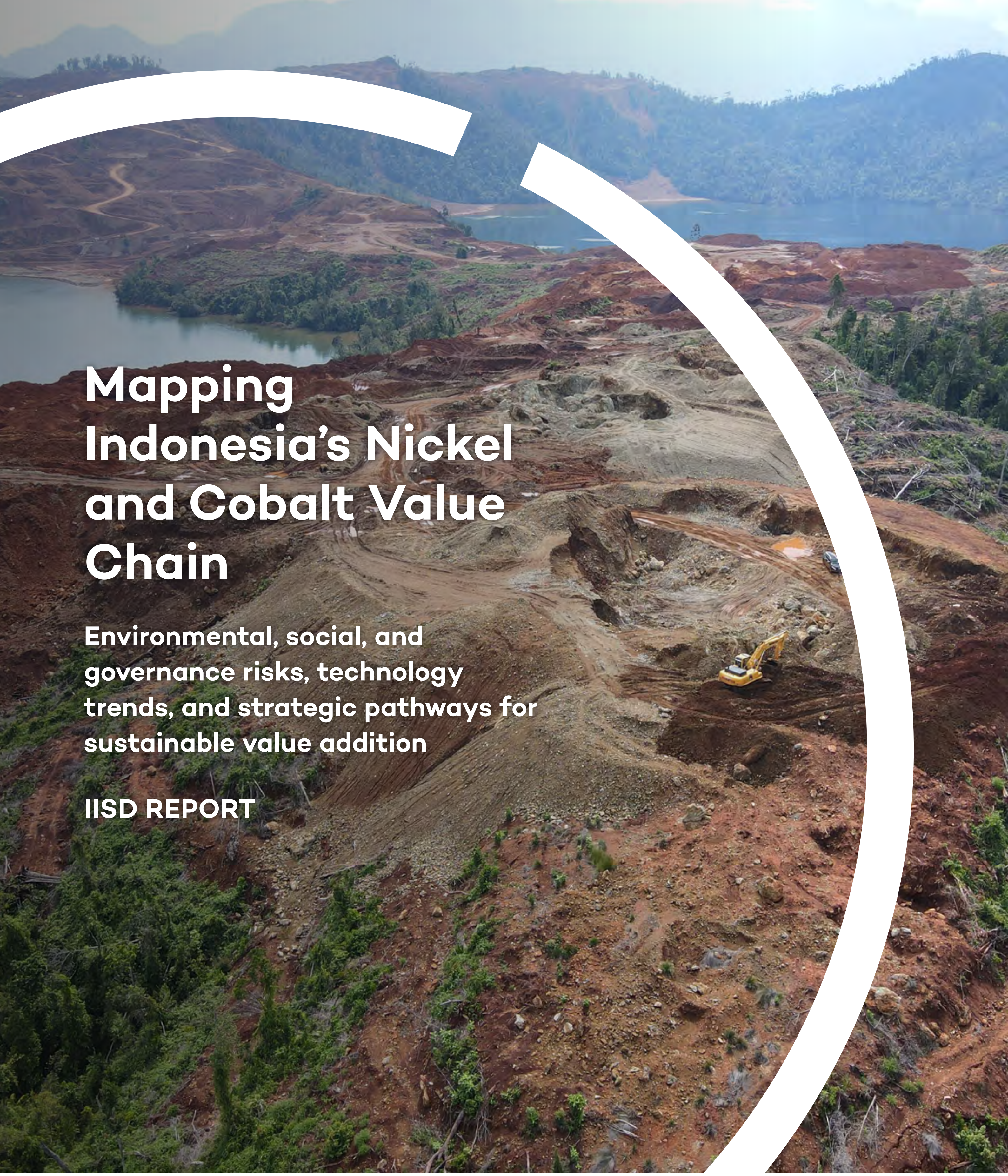

Mapping Indonesia's Nickel and Cobalt Value Chain

Environmental, social, and governance risks, technology trends, and strategic pathways for sustainable value addition

IISD REPORT

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September 2026

Published by the International Institute for Sustainable Development

International Institute for Sustainable Development

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Mapping Indonesia's Nickel and Cobalt Value Chain: Environmental, social, and governance risks, technology trends, and strategic pathways for sustainable value addition

September 2026

Written by Carlo Starace and Grégoire Bellois

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Acknowledgements

The authors of the study are indebted to Bertram Lang, Ege Tekinbas, Elena Cornaro, Lorelie Astrera, Martha Maulidia, Murtiani Hendriwardani, Ottavia Rezola, Richard Bridle, Sophia Esmail, and William Davis for their valuable contributions to the report. Grégoire Bellois provided editorial comments. Hans Baumgarten and Ronald Brouwer provided coordination support.

The authors would also like to thank Shanghai Metals Market for valuable comments and recommendations that they provided to the report.

Executive Summary

Global critical minerals demand has been rising in recent years, buoyed by the global transition to less carbon-intensive energy sources, including the increasing adoption of battery storage technologies and the digital revolution, as well as defence uses. This growth in critical minerals demand brings about several challenges. Mineral demand is expected to outpace supply growth due to delays in new mine developments and geopolitical tensions, among other issues. Together with extreme concentration of production and processing for some of these minerals, supply risks can arise. Countries facing these risks have undertaken a wave of government actions and announcements, while producer countries are seizing opportunities to add value to their domestic value chains.

Indonesia holds a strategic advantage. It has the world's largest reserves of nickel, a key mineral for some of the most widespread types of battery cathodes. In 2023, it mined 2 million tonnes (Mt) of nickel representing around 55% of global output. The country is also very well endowed in cobalt, another essential product that is co-located with nickel resources, and it supplied 13% of the world's primary cobalt production in 2023. However, its processing capacity is still heavily skewed toward the production of Class II nickel products; 95% of currently operating processing facilities are pyrometallurgical and are geared toward producing ferronickel and nickel pig iron. These methods have substantial energy requirements and release high levels of greenhouse gas emissions. However, Indonesia has introduced high-pressure acid leaching (HPAL) facilities to produce Class I nickel products suitable for battery cathodes. These facilities are being planned and are under construction. This development hints at further expansion of nickel and cobalt production for battery cathodes at lower energy consumption, although it presents distinct environmental challenges such as highly corrosive waste materials and a high risk of heavy metal and chemical contamination and acid mine drainage.

Indonesia has registered clear advances in environmental, social, and governance (ESG) regulations and has enacted new efforts to decarbonize its mining and processing industries. This positions the country as a hub for battery manufacturing, but potential competition could arise from other similarly endowed countries. Competitors include Brazil, which has Mt of nickel reserves and abundant hydropower, and Australia, which has 24 Mt of nickel reserves and superior ESG credentials. These two countries are also advancing expansion strategies that could erode Indonesia's cost and volume advantages. Moreover, Indonesia faces geopolitical vulnerabilities that threaten its positioning: 51% of current nickel capacity is managed by Chinese firms and 26% by joint ventures with Chinese companies. These foreign investments expose the country to potential technological lock-in and supply chain disruption amid commercial and political tensions between the United States and China.

The expansion of Indonesia's nickel and cobalt industry also poses serious ESG challenges, which cannot be ignored if the country wishes to position itself as a reliable source of sustainable batteries. Water depletion and pollution represent acute threats, while the carbon intensity of Indonesia's nickel processing remains well above global averages. The reliance on captive coal-fired power generation in remote areas exposes workers and surrounding communities to dust exposure, air pollution, and public health crises. Biodiversity loss has accelerated sharply, with forest clearance in 2023 being double the amount in 2020. The human toll of Indonesia's nickel boom is also noteworthy and should be tackled. Investigations document long working hours, inadequate protective equipment, and delayed or unpaid wages. Occupational health and safety failures are serious concerns, and communities have been severely affected. Nickel projects frequently lead to land conflicts and evictions, with consultations often excluding Indigenous communities and consent obtained only after operations have begun. Only 24.2% of Indonesian land is registered to women, constraining their ability to access compensation, while customary land claims are routinely ignored and people who resist transfers face retaliation or imprisonment.

Moreover, significant shifts in the battery manufacturing landscape will substantially affect the direction that Indonesia can take in the next decade. Lithium iron phosphate batteries contain no nickel and now make up approximately 50% of global electric vehicle (EV) batteries. Nickel-based chemistries, however, remain dominant in North America and Europe. Nickel demand for EV batteries is estimated to constitute approximately 16% to 17% of all minerals required by 2040. This estimate suggests that nickel has the potential to maintain a substantial share in EV battery markets despite competition from lithium iron phosphate. As the transport sector electrifies further, driving up demand, it could be very profitable for Indonesia to establish a footprint in this industry.

Consideration must also be given to a third component for battery cathodes that is currently lacking in Indonesia: lithium. Indonesian industry can access the necessary lithium-based chemicals (lithium hydroxide and lithium carbonate) required for battery manufacturing in the near term from nearby Australia or other parties. However, Indonesia's vulnerability to lithium scarcity is compounded by concentration risk in lithium refining, as China currently dominates global refining capacity and restricts access to lithium battery and extraction technologies. Indonesia's lithium refinery, PT Chengtok, depends on Chinese processing technology, which creates a potential vulnerability to Chinese export restrictions in a shortage scenario. Diversifying access to refining technologies is a non-negotiable element of Indonesia's battery manufacturing strategy, while establishing multiple partnerships with diverse lithium producers will be essential to secure supply. It will be important to consider numerous ESG issues related to lithium production and to establish sustainable supply chains, while domestic refining capabilities should be developed as a longer-term resilience measure.

Consideration must be given to broader demand analyses. An EV value chain could potentially use only fragments of Indonesia's enormous nickel potential, as vehicles are often the target of trade restrictions in international commercial disputes. At the same time, while the exceptional growth of EVs cannot be overstated, battery exports still only represent 0.6% of global total export value. This figure suggests maintaining a dose of caution when downstreaming policies target EV value chains excessively and indicates the value of maintaining a sustained focus on alternative, sustainable metallurgical applications.

Non-battery uses, primarily steel alloys and other metallurgical applications, will absorb approximately 50% of global nickel demand through 2050. Indonesia's battery manufacturing strategy should therefore consider the continued importance of traditional nickel markets, which offer predictable, long-term demand trends. Importantly, global stainless steel market value is projected to increase 50% within a decade, from USD 207 billion in 2023 to USD

320 billion. Indonesia exports more than 99% of its stainless steel production by weight in semi-finished or hot-rolled forms, indicating significant downstream manufacturing potential. The country is also in a trade deficit for numerous products containing stainless steel, which strengthens the argument for this downstreaming strategy. This dual strategy would allow Indonesia to capture the high-growth battery segment while exploiting immediate commercial opportunities in traditional stainless steel markets, where demand growth remains robust due to urbanization trends.

A special note should be raised on the potential depletion of Indonesia's nickel reserves at current production rates if no additional efforts are made to improve circularity in the industry. Current estimates indicate that the lifespan of reserves producing through HPAL facilities is 17 years, and reserves producing ferronickel and nickel pig iron have a lifespan of only 9 years, if production rates keep up with current global demand.

Globally, nickel enjoys strong recyclability rates, with a 68% end-of-life recycling rate. This rate is particularly high for stainless steel (95%), and a rising stock of end-of-life batteries reveals a rising recyclability rate for battery cathodes, too. Indonesia currently exports most of its processed nickel, therefore failing to generate significant opportunities for industrial scrap recycling. It also sits on 11.5 Mt of ferronickel slag and tailings annually, which it currently underutilizes. Direct nickel recovery from slag remains economically marginal due to low metal content, but use of the slag feedstock for construction is already being tested and should be encouraged. As ore grades decline and pressure builds to increase production to keep pace with internal and global demand, it will be essential to enhance the domestic recycling of industrial scrap and end-of-life products, especially if Indonesia chooses to move further downstream in the production of battery cathodes and stainless steel. These steps would offer Indonesia a strategic path toward higher value-added downstream production and greater resource efficiency and leadership in both primary and secondary nickel markets, allowing it to slow the depletion of its nickel reserves.

Indonesia finds itself at multiple crossroads and each choice comes with potential trade-offs. A structural surplus of Class II commodities, combined with the vastness of Indonesia's resources, has contributed to global oversupply. This risks trapping Indonesia in an economic model centred on rapid exploitation of its natural reserves for low-value production. A pivot toward Class I commodities through HPAL production would tap into reserves with a longer lifespan, but an overexposure on this front risks stranding Indonesia in a very competitive and risky market. It is clear, therefore, that a balance must be struck between the current extractive model and an overextension toward Class I products.

Indonesia may therefore wish to focus its nickel value chain development efforts in three areas: improving the profitability of nickel mining and refining; further developing the manufacture of downstream Class I nickel products, such as batteries and their components; and further expanding downstream from nickel pig iron and ferronickel to expand production of stainless steel.

Each of these choices will require Indonesia to align its industrial growth with strong ESG standards, enhancing domestic technology and skills, and managing market and geopolitical risks. The proposed preliminary recommendations in the study include strict environmental permitting and biodiversity protection, decarbonization through renewable energy and carbon pricing, and the enforcement of labour rights with community benefit programs. The recommendations also promote transparent governance via blockchain licensing and beneficial ownership disclosure, alongside independent audits. To boost innovation, they recommend a national technology hub, vocational training, and global university partnerships, especially with China. Finally, recommendations urge policy-makers to incentivize and establish national traceability systems, quality controls, and a high-level task force to monitor ESG compliance and public reporting.

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Abbreviations and Acronyms

AMDAL	Environmental Impact Analysis
CO_2e	carbon dioxide equivalent
CMSI	Consolidated Mining Standard Initiative
DRC	Democratic Republic of the Congo
ESDM	Ministry of Energy and Mineral Resources (Energi dan Sumber Daya Mineral)
ESG	environmental, social, and governance
EV	electric vehicle
FPIC	Free, Prior, and Informed Consent
GESI	gender equality and social inclusion
GHG	greenhouse gas
HPAL	high-pressure acid leaching
ICMM	International Council on Mining and Metals
IEA	International Energy Agency
IGF	Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development
IISD	International Institute for Sustainable Development
IMIP	Indonesia Morowali Industrial Park
IRENA	International Renewable Energy Agency
IRMA	Initiative for Responsible Mining Assurance
ITC	International Trade Centre
LFP	lithium iron phosphate
MAKMUR	Critical Mineral Management for Sustainability (Manajemen Mineral Kritis untuk Keberlanjutan)
MHP	mixed hydroxide precipitate
MSP	mixed sulphide precipitate
Mt	million tonnes
NCA	nickel-cobalt-aluminium
NMC	nickel-manganese-cobalt
OHS	occupational health and safety

UN United Nations

USD United States dollar

1.0 Introduction

1.1 Purpose and Scope of the Mapping Study

Minerals and metals are crucial components of our society: powering energy, running technology, and driving economic, social, and technological advancement (Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development [IGF], 2024). Their uses and applications include solar photovoltaics, electric vehicle (EV) batteries, smartphones, data transmission networks, data storage servers, consumer electronics, medical devices, and household appliances.

Global critical minerals demand has been rising in recent years, buoyed by the global transition to less carbon-intensive energy systems. This shift includes the increasing adoption of battery storage technologies and the digital revolution, as well as rapidly increasing defence uses in a new era of geopolitical instability.

In response to rising global demand for these metals and minerals, Indonesia's national mining policy over the past decade has placed strong emphasis on downstreaming as a core strategy to enhance the domestic value added of mineral commodities. The policy has been central to Indonesia's government—as evinced in a series of speeches delivered by the president—and can be described as the process of adding value along the supply chain by increasing the complexity of Indonesia's raw materials through processing, refining, and manufacturing (Cabinet Secretariat of the Republic of Indonesia, 2022; Ministry of Energy and Mineral Resources, Indonesia [Energi dan Sumber Daya Mineral, ESDM], 2019). This approach has been applied most prominently to nickel and has become the cornerstone of Indonesia's natural resource industrialisation strategy. It aims to transform the country from a raw material exporter to a producer of high-value industrial products (Tangkudung & Kaseger, 2024).

As part of the same downstreaming effort, Indonesia plans to establish a strong EV battery ecosystem, aiming to produce 600,000 vehicles by 2030 (Cabinet Secretariat of the Republic of Indonesia, 2024).

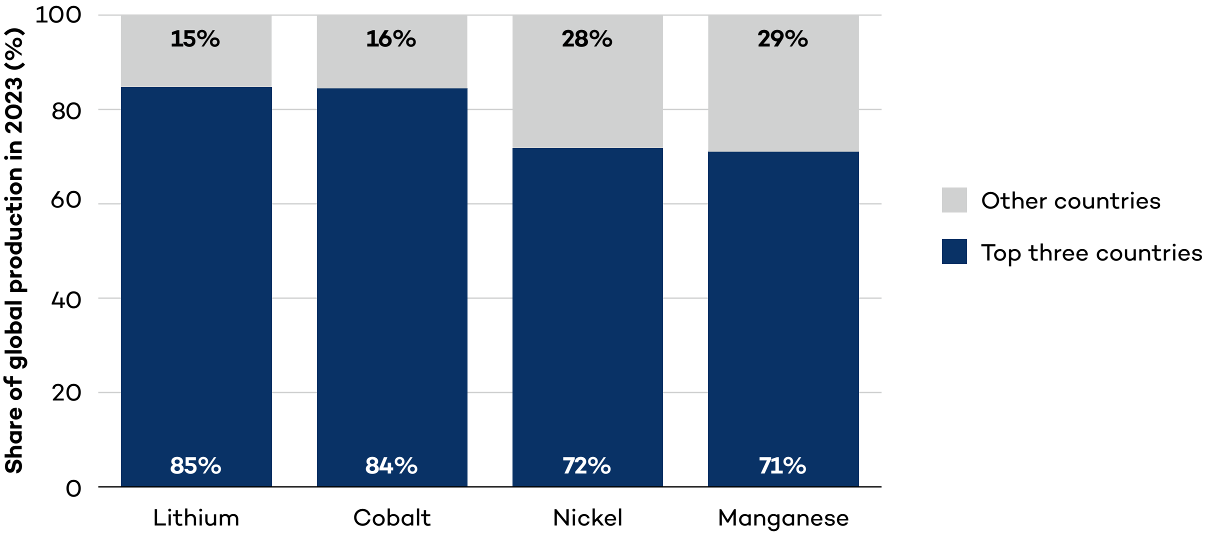
This mapping study is the first of a series of knowledge products to be developed under the Critical Mineral Management for Sustainability project (Manajemen Mineral Kritis untuk Keberlanjutan, MAKMUR) to help the country improve its mineral resource governance by building the capacity of government ministries responsible for the mining and energy sectors. Its main purpose is to examine Indonesia's production base for nickel and cobalt, which Indonesia possesses in abundance and which are key to the establishment of an EV battery value chain. The study will examine Indonesia's strategic positioning and produce a first set of recommendations that will be examined in greater depth with other products in the MAKMUR project. The recommendations will touch on

- energy policies for mining activities,
- industrial policies considering evolving demand trends,
- partnership strategies, and
- environmental, social, and governance (ESG) and traceability requirements.

As the world's biggest producer of nickel and the second-largest producer of cobalt (IGF, 2025a), Indonesia can naturally leverage its advantage by supplying medium- and high-nickel EV batteries of the nickel-manganese-cobalt (NMC) and nickel-cobalt-aluminum (NCA) types, which are sold and used widely in Europe and North America. The study will also focus on lithium and how lithium products can be integrated into Indonesia's nickel and cobalt industries.

A second mapping study, also part of the MAKMUR project, will focus specifically on sustainable supply chains for lithium. Lithium is the fourth-most important component of NMC and NCA batteries. However, its production is highly concentrated, and securing the supply of lithium products will thus be more challenging for a country seeking to establish an EV battery value chain.

Figure 1. Production of key battery cathode minerals, 2023



Source: Reichl & Schatz, 2025.

1.2 Methodology and Evidence Base

This study was conducted through a combination of desk research and a series of in-depth interviews with local stakeholders. The research drew data from the following sources:

- Indonesian government sources: five bilateral interviews with
    - ESDM (Director General of Mineral and Coal, and Director of Mineral and Coal Program Development)
    - Ministry of National Development (Bappenas)
    - Indonesia Battery Corporation (President)
    - Huayou Indonesia (Zhejiang Huayou Cobalt Co., Ltd.)
- A focus group discussion held on February 26, 2026, to discuss Indonesia's mining governance landscape; international ESG standards and their relevance for Indonesia;

gaps and opportunities on ESG implementation for strengthening compliance mechanisms and performance indicators; policy recommendations, coordination practices, and good practice of gender equality and social inclusion (GESI) for ESG compliance in mining for Indonesia's context. The following participants attended:

- Directorate General of Mineral and Coal, ESDM
- Directorate of Environmental Impact Prevention for Business and Activities, Ministry of Environment and Forestry
- Directorate of Occupational Safety and Health Institutional Development, Ministry of Manpower
- Mineral Industry Agency
- Asosiasi Penambang Nikel Indonesia
- Forum Industri Nikel Indonesia
- Mind ID
- PT. Vale Indonesia
- Satya Bumi
- Indonesia Business Coalition for Women Empowerment
- Lembaga Penyelidikan Ekonomi dan Masyarakat Fakultas Ekonomi dan Bisnis Universitas Indonesia (Institute for Economic and Social Research, Faculty of Economics and Business, University of Indonesia)
- Pusat Studi Energi Universitas Gadjah Mada (Energy Studies Center, Universitas Gadjah Mada)
- Research Centre for Politics and Government at Universitas Gadjah Mada
- Extractive Industries Transparency Initiative Indonesia

- Sector-specific research studies
- Open-source databases such as World Mining Data, United Nations, and World Trade Organization trade data
- Market analyses by industry associations ranging from mining to battery manufacturing
- Reports and mapping studies by international organizations in the mining and energy field
- Assessments by international standards organizations
- Reports by non-governmental organizations or other civil society groups

In-depth interviews have been carried out in both bilateral and focus group discussion formats, and they included government agencies and ministries as well as private sector actors in mining and battery manufacturing.

1.3 Structure of the Mapping

The study starts by outlining the global context, including the role of critical minerals in the energy transition, global demand and supply risks, and their initial implications for Indonesia.

The following chapters focus specifically on Indonesia, examining its strategic position, resource base, and industrial policy landscape, as well as comparing it with peer countries.

The report then addresses ESG dimensions for nickel and cobalt before turning to future market trends, including battery chemistry developments, metallurgical uses, and recycling opportunities, examining potential future production avenues for Indonesia given its current resource base.

It concludes with a set of recommendations, divided into strategic actions and ESG and traceability measures. These recommendations will be analyzed with greater care in a series of technical studies within the MAKMUR project.

Finally, the study includes special considerations for GESI elements throughout. GESI requirements help ensure that battery value chains contribute to inclusive national development. A GESI perspective assesses how operations in the supply chain, including extracting and processing minerals, may create or exacerbate human rights or other environmental or social risks for different groups (women and men, Indigenous Peoples, youth, people with disabilities, and local communities).

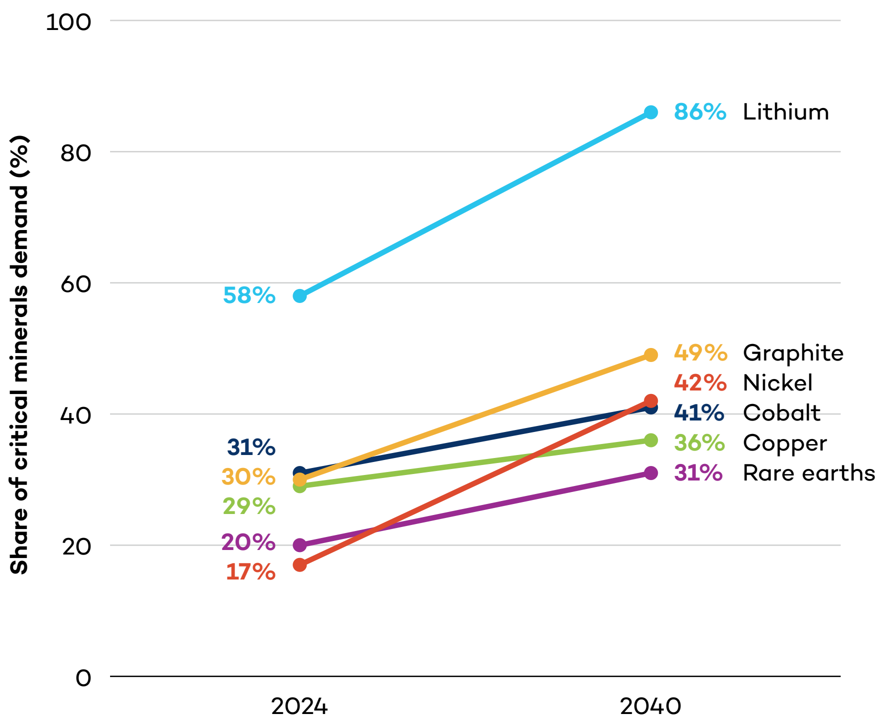
2.0 Global Context

2.1 Role of Critical Minerals in the Energy Transition

Critical minerals have emerged as strategic assets in the global transition toward a low-carbon economy. Worldwide demand for low-carbon energy technologies such as EVs, wind turbines, and solar panels continues to accelerate, and as a result the requirement for diverse mineral resources has surged dramatically (International Renewable Energy Agency [IRENA], 2023). Minerals that are essential for clean energy technologies are classified as critical due to their high economic value. They also carry significant supply risks that constrain the development and deployment of emerging energy technologies (IRENA, 2023).

The transition toward low-carbon energy systems, as well as digital technologies, will likely exert a significant impact on the nature of global critical mineral demand in the future. The International Energy Agency (IEA, 2022) estimates that average shares of demand for critical minerals directly attributable to the energy transition will rise substantially from 2024 to 2040. While 58% of global demand for lithium is driven by the energy transition as of 2024, this figure will rise to more than 80% in 2040, according to the more conservative Stated Policies Scenario (IEA, 2022). The shares of nickel and cobalt demand from clean energy sources will rise from 17% and 31% respectively in 2024 to more than 40% in 2040.

Figure 2. Share of critical minerals demand driven by energy transition technologies, 2024–2040

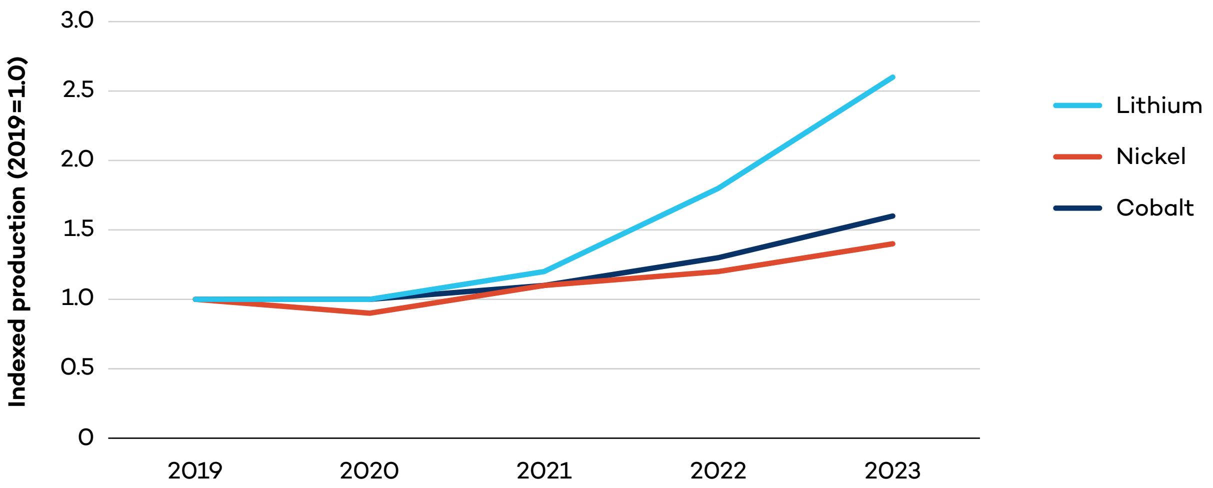


Source: IEA, 2025a.

2.2 Global Demand and Supply Risks

The accelerating transition toward renewable energy technologies, the electrification of energy systems worldwide, and the rapid rise of battery storage technologies have caused global demand for critical minerals to rise sharply in recent years. Lithium mined-output growth rates increased by more than 2.6 times between 2019 and 2023, while nickel and cobalt increased by about 1.5 times each during the same period (Reichl & Schatz, 2025).

Figure 3. Global indexed production of lithium, nickel, and cobalt, 2019–2023

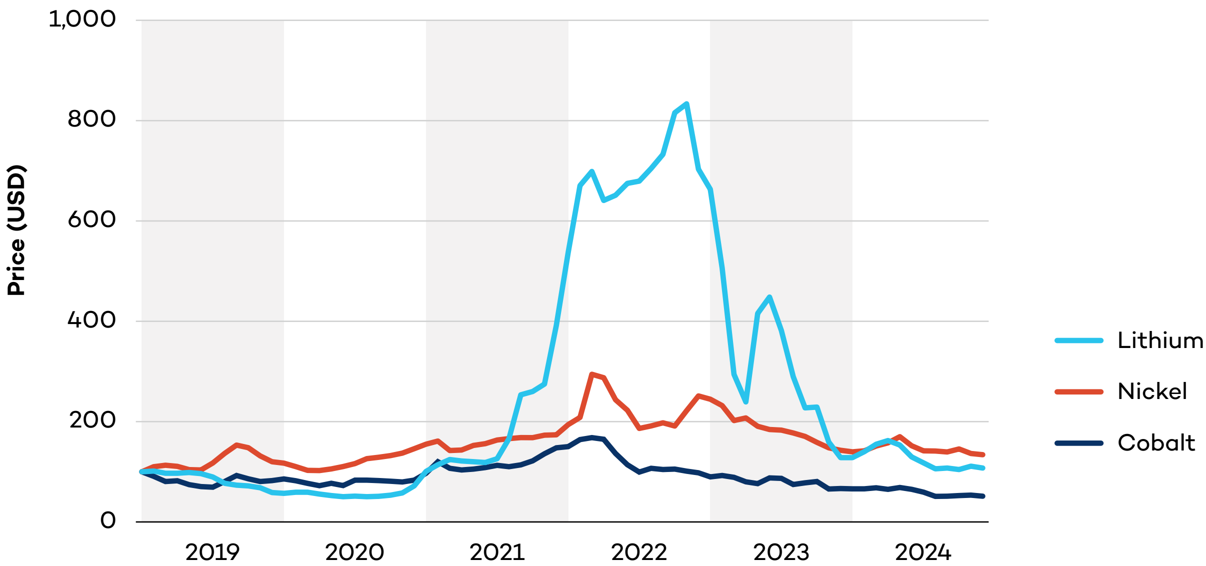


Note: Indexed production values normalize annual output relative to a base year (2019, set to 1.0), indicating the proportional increase or decrease in global production compared to the base year.
Source: Reichl & Schatz, 2025.

Global production must keep pace with rising demand while overcoming key challenges. Production of critical minerals, including nickel, cobalt and lithium, is highly concentrated (Reichl & Schatz, 2025), which can generate substantial supply vulnerabilities. These vulnerabilities are intensified by trade disruptions, creating a source of geopolitical risk and price volatility.

Between January 2019 and October 2024, for example, lithium prices peaked at more than eight times their previous levels before falling back. Nickel prices almost tripled in the same period, with cobalt experiencing similar trends before falling to below its starting point at the end of the observed period (World Bank Group, n.d.; see Figure 4). Such price volatility can exacerbate uncertainty, stymie investments, and threaten critical supplies.

Figure 4. Monthly USD prices for nickel, cobalt, and lithium, January 2019–October 2024



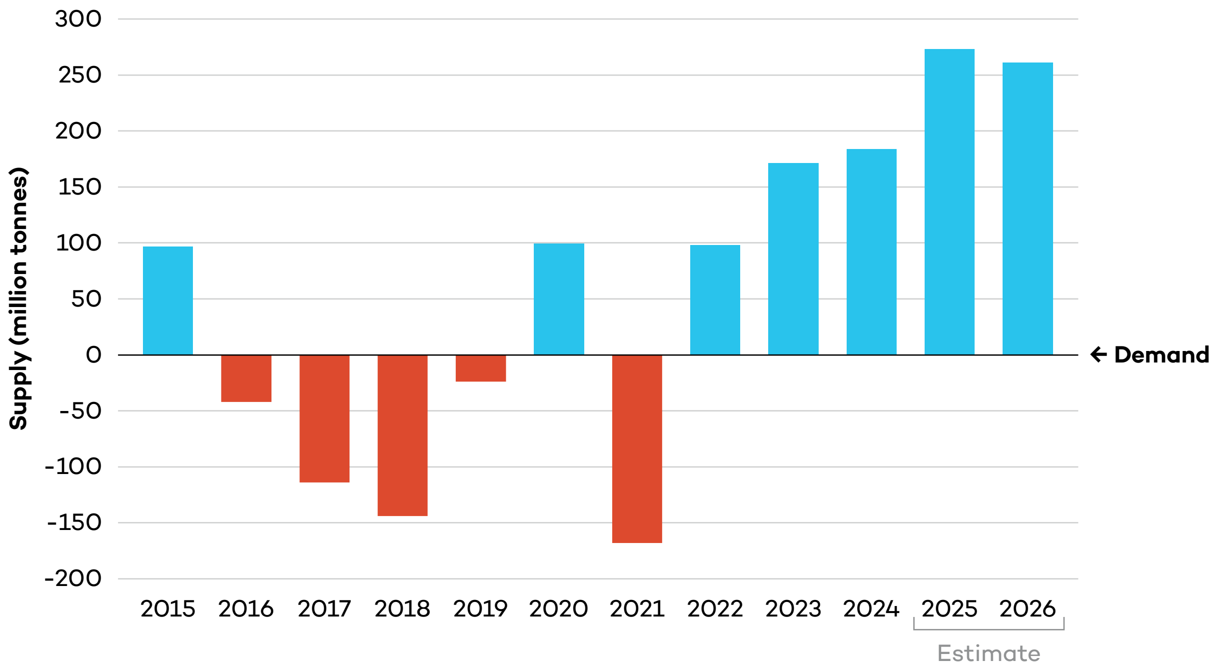
Note: January 2019 data are indexed to 100.
Source: World Bank Group, n.d.

Nickel

Historically, nickel has served as a fundamental raw material for producing stainless steel and various metal alloys. In 2021, the stainless steel sector accounted for approximately 69% of total global primary nickel consumption, while the battery sector represented only about 7% (IGF, 2025b). This demand structure is now undergoing a transformation, driven by the accelerating adoption of EVs and the expansion of battery-based energy systems. The IGF (2025b) foresees that batteries will make up approximately 41% of nickel demand by 2040.

In addition, over the past 3 years, the nickel market has experienced oversupply, largely due to increased production in Indonesia. This oversupply is projected to continue into 2026, further depressing prices.

Figure 5. Global nickel supply-demand gap, in million tonnes (Mt), 2015–2026



Source: IGF, 2025b; International Nickel Study Group, 2024.

According to the IGF, the global nickel market is expected to grow due to increasing demand for EV batteries, energy storage and electronics, rising nickel consumption in stainless steel production, and expanding applications in electroplating. From 2021 to 2040, battery applications are projected to increase by 34%, rising from 7% to 41% of primary nickel consumption by 2040 (IGF, 2025b). While still representing the largest share of nickel end use, stainless steel's share of the nickel market is estimated to decrease from 69% in 2021 to 45% by 2040, a decline of 24% (IGF, 2025b).

Cobalt

Cobalt is chiefly used in the manufacturing of rechargeable batteries. At present, EVs account for about 45% of cobalt demand, while portable electronics make up about 26% (IGF, 2025b). The metal is an essential component in several battery chemistries, including NMC and NCA.

Cobalt-free lithium iron phosphate (LFP) batteries are gaining market share, but the overall demand for cobalt in the battery sector has continued to rise. Beyond batteries, cobalt is also used in superalloys, particularly for aerospace applications. In 2023, global cobalt demand reached nearly 200,000 tonnes, which is more than twice its level in 2016. This trend was driven largely by the growth of the battery market (IGF, 2025b).

Cobalt prices declined sharply from a high of about USD 82,000 per tonne in 2022 to USD 34,000 in 2023, and further to roughly USD 21,000 in early 2025. This drop was mainly due to an oversupply, driven by increased output from the Democratic Republic of the Congo (DRC) and Indonesia.

Total cobalt demand could experience a yearly 7% increase until 2030. This growth will be driven in part by EVs, which will see a rise in market share from 43% of demand in 2024 to 57% in 2030. Cobalt supply is also projected to increase, albeit at a slower pace than demand. This trend will potentially translate into a heightened need for the metal, leading to new exploratory activities and to the development of new sites, contingent on available investments (Cobalt Institute, 2025).

Lithium

Lithium is the most dynamic of all critical minerals, with demand growth far outpacing that of other comparable commodities. The low-carbon energy sector represents the highest proportion of growth from 2024 to 2040, with demand for batteries expected to increase fourteenfold by 2040 compared with the 2020s (IGF, 2025b). Although the stationary energy storage sector remains a minor consumer of lithium, its demand is also projected to increase.

Long-Term Demand Outlook and Market Balance Challenges

Although demand for critical minerals such as nickel, lithium, and cobalt is projected to grow substantially across all energy transition scenarios, a high degree of uncertainty persists regarding the future balance between supply and demand. Divergence among scenario projections indicates that the global mineral market will face significant challenges in maintaining structural equilibrium between long-term supply and demand (IEA, 2025c).

For lithium, while short-term supply remains relatively sufficient, existing production capacity is not adequate to sustain the projected growth in demand over the medium to long term. The IEA (2025a) estimates that without additional investment and accelerated project development, lithium supply will meet less than 40% of global primary demand by 2040. Meanwhile, nickel and cobalt markets are currently in a surplus position, largely driven by a surge in production capacity from Indonesia. However, this surplus is expected to be temporary. According to the IEA's Announced Pledges Scenario, both markets are projected to tighten considerably by 2035—particularly if major planned production projects fail to materialize on schedule (IEA, 2024a).

From a geographical perspective, China currently dominates global lithium consumption, accounting for approximately three-quarters of total usage, followed by Japan and South Korea; the latter is home to some of the world's largest cathode manufacturing facilities (IEA, 2025c). However, as the EV industry expands and decarbonization policies gain momentum across multiple regions, lithium consumption is expected to shift toward other markets, such as the United States, the European Union, Indonesia, and India, after 2030.

3.0 Indonesia's Strategic Position

Indonesia aims to position itself further downstream in the value chain and to potentially establish an EV battery manufacturing industry. This chapter evaluates Indonesia's capacity in three of the metals necessary for battery cathode production: nickel, cobalt, and lithium. In addition, it will analyze the current state of Indonesia's industrial policy landscape, as well as its relative positioning vis-à-vis other similarly sized countries in the region and in the G20 country group.

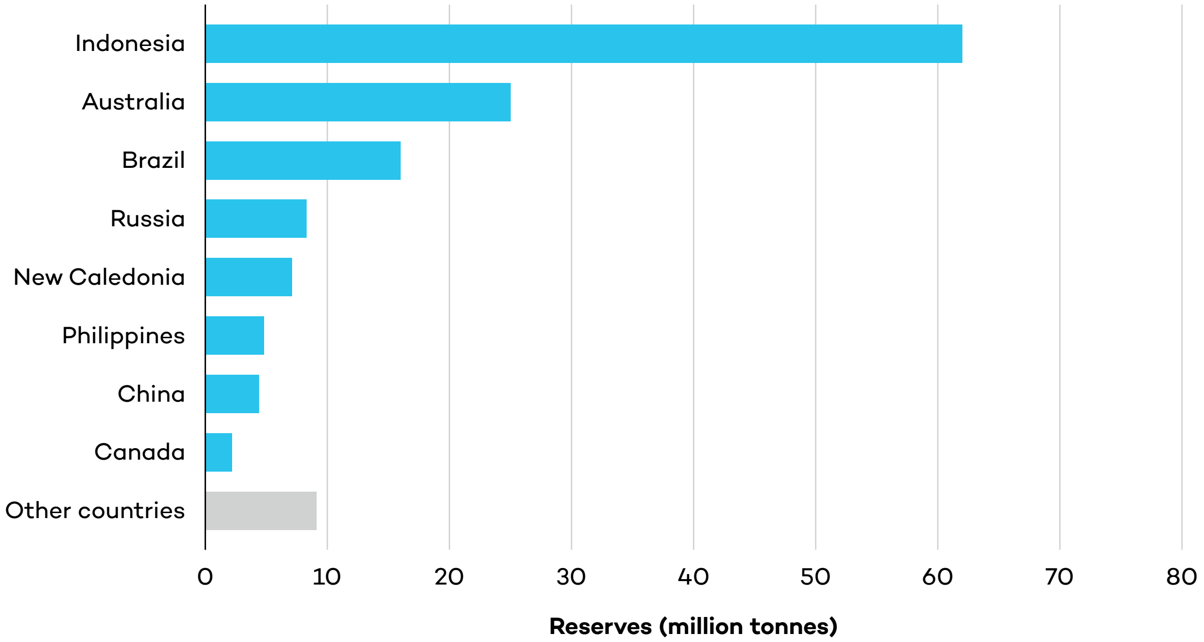
3.1 Resource Base Overview

Indonesia holds a pivotal position in the global critical minerals value chain as the primary supplier of nickel, accounting for 59% of the world's production in 2023 (Reichl & Schatz, 2025). It is also rapidly increasing its role as a cobalt producer, from 350 tonnes in 2019 (less than 0.5% of the world's total) to 18,200 tonnes in 2023 (more than 9% of the world's total) (Reichl & Schatz, 2025). Despite the absence of significant lithium production capabilities, Indonesia could integrate its strategic advantage on nickel and cobalt sources coupled with its home-grown refining capabilities to develop a strong EV battery production system. In short, the country's resource endowment represents a significant competitive advantage, enabling it to play a central role in the supply of raw materials for EV batteries and the broader clean energy transition (Anugrah et al., 2023).

Nickel Resources

Indonesia currently has the largest nickel resources globally. This strategic strength established the country as one of the key players in the global energy transition (see Figure 6). As of 2024, the country's nickel reserves are estimated at approximately 62 Mt (U.S. Geological Survey, 2025e), accounting for roughly 45% of the world's known deposits. This substantial upward adjustment from the 21 Mt reported in 2022 (ESDM, 2024) is driven by intensified exploration and updated geological mapping conducted across Sulawesi, Halmahera, and Papua. Indonesia's nickel endowment is primarily composed of laterite deposits, characterized by ore grades ranging between 0.9% and 1.5% nickel and average thicknesses of 8 m to 16 m, depending on geomorphological conditions (Anugrah et al., 2023).

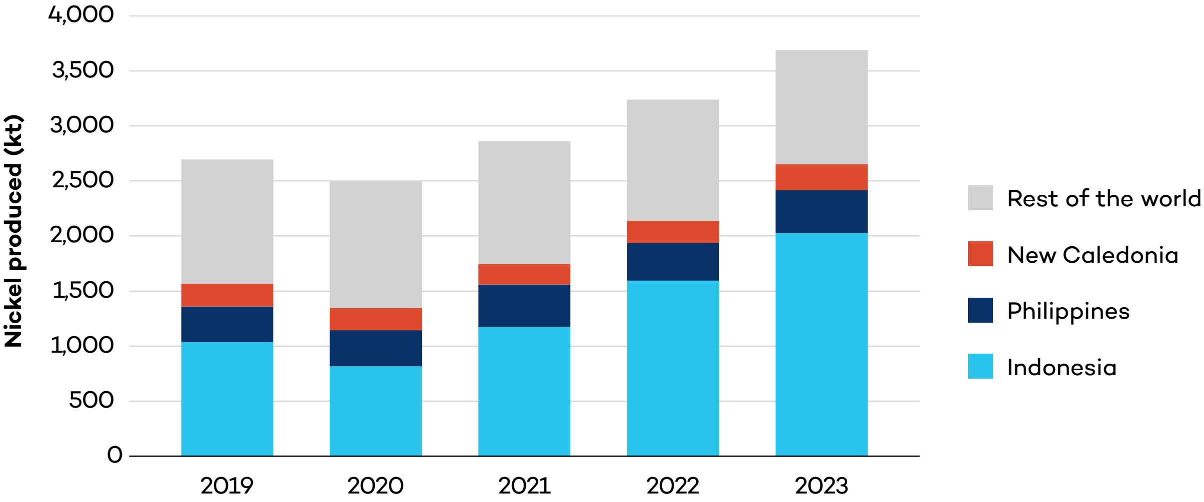
Figure 6. Global nickel reserves (2025 estimates)



Source: U.S. Geological Survey, 2025.

In 2023, Indonesia produced 2.03 Mt of nickel—about 55% of the world's total mined output (Reichl & Schatz, 2025). The Philippines produced the second-highest amount, reaching roughly 11% of global nickel production in the same year. Yet this high-output, simple model could lead to problems, including over-exploitation. Based on the current production and demand dynamics, the estimated lifespan for reserves supplying mixed hydroxide precipitate (MHP) through high-pressure acid leaching (HPAL) facilities is 17 years, while ferronickel and nickel pig iron reserves have a lifespan of only 9 years (ESDM, 2024). These estimates raise concerns about the long-term sustainability of Indonesia's resources, especially if the nickel production line isn't modified to optimize ore utilization and nickel recovery from slag and tailings discarded from mining activities.

Figure 7. Global nickel primary production, 2019–2023

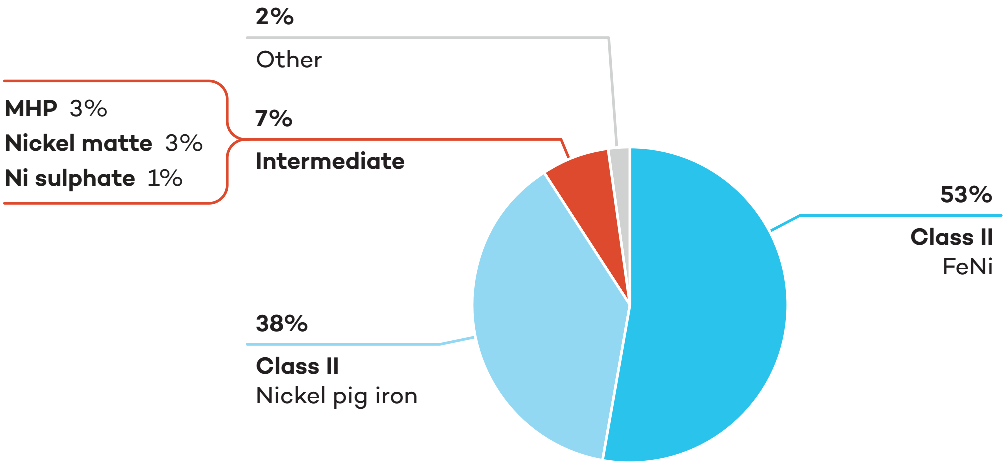


Source: Reichl & Schatz, 2025.

The processing structure of Indonesia's nickel industry is largely determined by the characteristics of its ore deposits. High-grade saprolite ore is processed through pyrometallurgical methods, particularly the rotary kiln electric furnace system, to produce ferronickel and nickel pig iron. These are key intermediates for stainless steel production and are Class II nickel products that are unsuitable for producing battery cathodes. In contrast, limonite ore undergoes hydrometallurgical processing, notably HPAL, and yields MHP, a critical precursor for EV battery materials (Anugrah et al., 2023). More than half (52%) of Indonesia's indicated resources are composed of limonite ores with a nickel grade of less than 1.5% (ESDM, 2024), which makes them suitable for battery cathode production and indicates substantial room for expansion. However, this potential is not supported by existing processing facilities; interviews with government agencies indicate that approximately 20% of Indonesia's nickel production is aimed toward the battery path. Currently, the ESDM reports 107 licences for mineral production and 147 processing facilities, of which 49 are currently active, 35 are under construction, and 36 are in various stages of planning (ESDM, 2024)). Of these, only seven active processing plants currently produce MHP, which is essential to produce nickel-based battery cathodes, indicating substantial room to grow nickel products in the battery supply chain.

The picture is confirmed by an overall review of Indonesia's current nickel production capacity by commodity type, which reveals that more than 90% of existing capacity is for Class II products such as ferronickel and nickel pig iron.

Figure 8. Nickel production capacity by commodity type, 2024



Source: Reichl & Schatz, 2025.

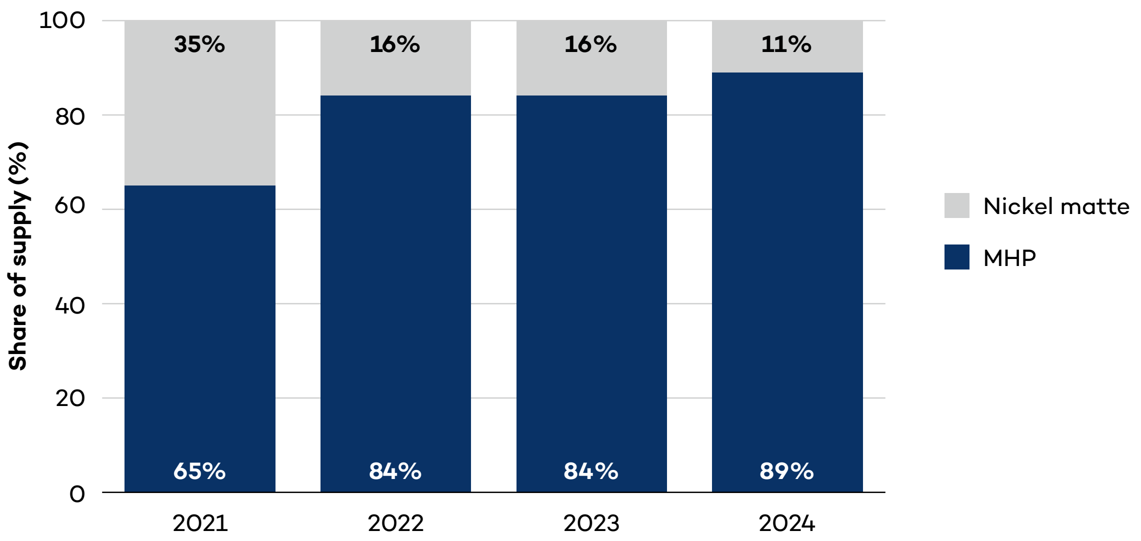
Complexes such as Halmahera Persada Lygend, in North Maluku, are worth noting for their capacity to produce ferronickel as well as battery-grade nickel products, including both nickel sulfate and MHP. This analysis suggests that there is enormous room for expansion of hydrometallurgical processing facilities, especially considering Indonesia's nickel ore composition. In fact, projects are already advancing to produce other nickel products, such as nickel sulfate produced by Zhejiang Huayou Cobalt (Guberman et al., 2024). At the same time, examples exist of facilities integrating both processing methods (pyrometallurgical and hydrometallurgical) during earlier production phases. This route could optimize expansion costs in early processing and support efforts for a future expansion strategy by providing large feedstocks for future refining operations.

Cobalt Resources

Cobalt, a key component in NMC battery chemistries, is intrinsically linked to Indonesia's nickel laterite deposits. The country's cobalt is a by-product of nickel mining, with the highest concentrations found in limonite zones (Anugrah et al., 2023). According to ESDM's latest Minerals Yearbook (2024), Indonesia holds substantial and growing cobalt resources. Indicated cobalt ore resources more than doubled between 2019 (4.2 Mt) and 2023 (9.3 Mt), with exploitable reserves climbing up to 650,000 tonnes.

At the same time, Indonesia's cobalt production has surged from 1,000 tonnes per year to 30,000 tonnes per year between 2020 and 2024, reaching 13% of the world's total production (Cobalt Institute, 2025). Much of this rise was due to the production of MHP as a co-product of low-grade laterite nickel ores through the HPAL process. This type of production has risen steadily, from 65% to 89% of Indonesian cobalt production in the years 2021 to 2024 (Cobalt Institute, 2025; see Figure 9), suggesting potential avenues for expansion and highlighting Indonesia's role in the global supply value chain. In the beginning of 2025, about 70 nickel-cobalt projects were identified (compared with 10 in 2021), of which close to 70% were from HPAL processing facilities (Cobalt Institute, 2024).

Figure 9. Cobalt supply by intermediate product in Indonesia, in kt, 2021–2024



Source: Cobalt Institute, 2025.

While no accurate census of all existing capacity currently exists in the public sphere, the major players in the production of battery-grade nickel and cobalt products are shown in Table 1.

Table 1. Major producers of nickel and cobalt battery-grade products, 2023

Commodity	Major operating companies	Locations of main facilities	Estimated annual capacity (kt)
Nickel			
Matte	PT Antam Tbk	Pomalaa, Southeast Sulawesi	24
	PT Huayue Nickel Industry	Weda Bay, North Maluku	50
	PT Vale Indonesia Tbk	Sorowako, South Sulawesi	80
	Tsingshan Holding Group	Morowali, Central Sulawesi	80
Sulfate	PT Halmahera Persada Lygend	Obi Island, South Halmahera	54
MHP	PT Halmahera Persada Lygend	Obi Island, South Halmahera	100
	PT Huayue Nickel Cobalt	Morowali, Central Sulawesi	60
	PT QMB New Energy Materials	Morowali, Central Sulawesi	50

Commodity	Major operating companies	Locations of main facilities	Estimated annual capacity (kt)
Cobalt			
Matte	Pt Vale Indonesia Tbk	Sorowako, South Sulawesi	1
MHP	PT Halmahera Persada Lygend	Obi Island, South Halmahera	12
	PT Huayue Nickel Cobalt	Morowali, Central Sulawesi	8
	PT QMB New Energy Materials	Morowali, Central Sulawesi	4

Source: US Geological Survey, 2023.

Lithium Resources

Despite lithium's crucial role in the clean energy transition, Indonesia currently lacks confirmed lithium reserves, although initial exploratory activities suggest potential resources that need to be explored further. Most notably, the activities have revealed the presence of lithium in brine water systems located in central Java. Two of these sites, Bledug Kuwu and Bledug Cangkring, reveal notable concentrations of lithium particles, at 1,000 and 600 parts per million respectively, after the lithium carbonate crystallization has taken place (ESDM, 2024). Together with recent developments in geothermal technologies and salt production, these observations reveal untapped production potential that can be unlocked with additional partnerships and collaborations. In the Bledug Kuwu field, for example, a partnership with the French company Eramet has intensified the exploration (Indonesia Miner, 2024).

Further downstream, Indonesia is proceeding with Chinese lithium producer Jiangsu Lopal Tech. Co. Ltd. on an LFP production facility in Kendal Special Economic Zone in Central Java (Simamora, 2025). At the same time, the ChengTok lithium project in Indonesia Morowali Industrial Park (IMIP; Sulawesi) is scheduled to become fully operational in 2026 and will produce lithium salts from spodumene concentrate imported from China, Zimbabwe, and Australia. This specific project is intended to reach an annual production capacity of 60,000 tonnes of lithium compound per annum (Chengxin Lithium, n.d.). In both cases, lithium is being secured or would need to be secured from third parties at different stages of the value chain, if lithium extraction in Central Java is not achieved in a reasonable timeframe. A strategic roadmap on how to secure lithium products in the absence of direct extraction in Indonesia will be provided in a subsequent MAKMUR product.

3.2 Industrial Policy Landscape

Indonesia's downstreaming efforts are supported by a wide array of laws, incentives, and regulations.

Constitutional and Legal Foundation

Constitutionally, this policy is rooted in Article 33(3) of the 1945 Constitution of the Republic of Indonesia. The constitution stipulates that the land, water, and natural resources are to be controlled by the state and used for the greatest prosperity of the people (Desdiani et al., 2023). This principle provides the normative foundation for the government's downstream mineral policy—one that prioritizes not only resource exploitation, but also sustainable management and equitable distribution of economic benefits.

The implementation of this constitutional mandate has been codified through a series of legislative and regulatory instruments. Law No. 4 of 2009 on Mineral and Coal Mining, as amended by Law No. 3 of 2020, requires holders of mining business permits and special mining business permits to process and/or refine their extracted minerals domestically.

The regulatory framework has evolved since 2014 (Table 2), beginning with Law No. 3 of 2014 concerning Industry and Government Regulation No. 14 of 2015 outlining the National Industrial Development Master Plan 2015–2035. The most significant regulatory milestone came in 2019 with Minister of Energy and Mineral Resources Regulation No. 11/2019, which implemented an export ban on nickel ore with less than 1.7% content, strategically forcing domestic processing (Tangkudung & Kaseger, 2024).

Table 2. Indonesian laws and policies concerning nickel downstreaming

Law/policy	Description
Nickel export ban and downstream processing mandate (2014, 2020)	Law No. 4 of 2009 on Mineral and Coal Mining initially introduced the requirement for mining companies to refine minerals domestically before export. Government Regulation No. 1 of 2014 reinforced this requirement by banning the export of raw nickel ore to promote domestic smelting and refining. The ban was briefly relaxed in 2017 due to economic concerns but was reinstated in 2020 (Regulation No. 11/2019), prohibiting the export of nickel ore with less than 1.7% purity grade.
Tax incentives for nickel smelters and Special Economic Zones	The government provides tax holidays, import duty exemptions, and other fiscal incentives to encourage investment in nickel processing. Special Economic Zones like Morowali and Weda Bay industrial parks have been established to attract foreign investors, particularly from China.

Law/policy	Description
Government moratorium on Class II nickel smelters (2024)	Due to concerns over supply and environmental damage, the government has paused approvals for new Class II nickel smelters (used for stainless steel production). The goal is to shift focus toward Class I nickel processing, which is crucial for EV battery production.
Omnibus Law (Job Creation Law) — 2020 and 2023 revisions	The Omnibus Law (Law No. 11 of 2020, updated in 2023) streamlines mining regulations, making it easier for businesses to invest in mineral processing. It reduces bureaucratic hurdles, provides longer mining permit durations, and facilitates foreign direct investment in smelter projects.
Presidential Regulation No. 55/2019 — EV battery industry acceleration	This regulation prioritizes the use of domestic nickel to produce EV batteries rather than stainless steel. It also established the Indonesia Battery Corporation to integrate the nickel value chain into EV production. This government initiative has the support of the four large stakeholders and state-owned companies in the country, each with a 25% stake: Inalum (aluminum smelting), Antam (mining), Pertamina (oil and gas), and PNL (national utility for electricity generation and distribution). Finally, the regulation also introduced potential export taxes on low-grade nickel products to encourage value-added processing.
Law 4/2009 concerning mineral and coal mining	Law 4/2009 sets out the general legal framework that manages mineral and coal production. It sets conditions that affirm existing contracts of work remain valid until expiry but must be adjusted to comply with the new law, including environmental and value-added requirements. It mandates that mining companies process and refine minerals domestically within 5 years of enactment, aligning with Indonesia's mineral downstreaming strategy and imposing export restrictions on unprocessed ores.

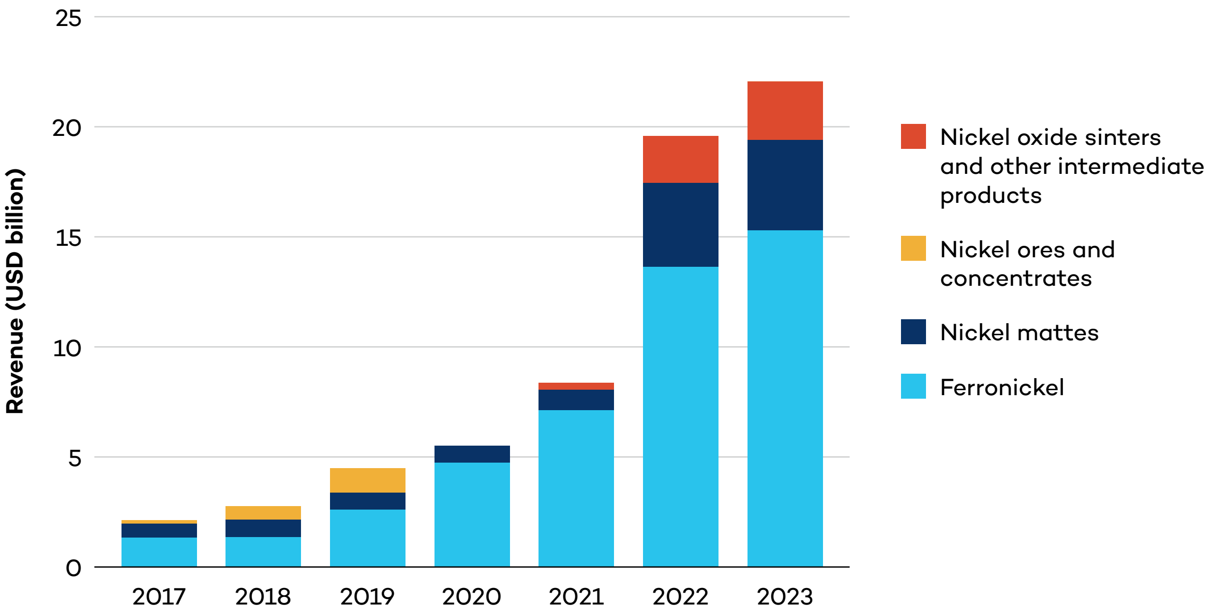
Source: International Institute for Sustainable Development (IISD), 2025.

Strategic Objectives

A few internal priorities have influenced Indonesia's decision to pursue a downstreaming policy in the last few decades. Goals include stimulating employment, driving national development, and moving the economy up the value chain from being a pure exporter of raw materials (Edarsasi, 2025).

As a result of these policies, Indonesia's nickel processing capacity has increased substantially, through both pyrometallurgy (rotary kiln electric furnace) and hydrometallurgy (HPAL) methods. In 2023, nickel-related exports surged to USD 34.44 billion, up from USD 4.31 billion in 2017, highlighting the impact of these policies (Purwanto, 2024). Similarly, the export of crucial intermediate products and battery precursors, such as MHP and mixed sulphide precipitate (MSP), as well as nickel sulphates, has grown from non-existent in 2017 to around 12% of all export revenues in 2023 (Coordinating Ministry of Maritime Affairs and Investment Republic of Indonesia, 2024).

Figure 10. Nickel export revenues by product, in USD billions, 2017–2023



Source: United Nations, n.d. (HS codes: 26, 72, 75).

These production trends are predicted to continue, driven by an expansion of MHP/MSP production capacity in the coming years. Moreover, existing nickel sulphate production capacity in Indonesia could easily translate into an expansion of cobalt sulphate production, which uses largely the same leaching technologies. Cobalt sulphate production could potentially necessitate the addition of dedicated cobalt separation circuits in existing facilities and other adaptations, but these steps should be easy to execute, and it should be easy to expand production of cobalt sulphate alongside nickel sulphate.

Moving forward, the objectives include using this momentum, achieving a higher value-added industrial base to support the digitalization of the economy, using increasingly green energy resources to support such industries, and growing a local talent pool from engineering and science undergraduates, directing them to work in international companies in the field of technology (Coordinating Ministry of Maritime Affairs and Investment Republic of Indonesia, 2024).

Indonesia will have to consider international ESG requirements when further developing its industrial strategy. Considering international policy moves such as the European Union Batteries Regulation and the U.S. Inflation Reduction Act—both mandating requirements for battery value chains and stressing compliance with responsible sourcing, labour rights, occupational health and safety (OHS), and environmental rules—any future move in downstreaming processes is recommended to closely align to international standards. This is especially important if Indonesia seeks to compete in the global battery market.

Some practices are currently in place and will be detailed in the mapping study (ESG and Sustainability).

3.3 Comparison With Peer Countries

Indonesia occupies a uniquely influential position in the global critical minerals landscape due to its extensive reserves and assertive industrial policies. This influence is manifested particularly in its downstreaming policies for nickel, which have helped the country transition to the forefront of the global supply chain for EV battery materials, beyond being merely a supplier of ore. This section will analyze Indonesia's comparative advantages and disadvantages across the value chain for all three minerals, relative to similarly sized economies and key regional players.

Nickel

Among emerging economy countries and major G20 producers, Indonesia dominates the nickel mining and processing industries and is undertaking a shift further downstream to intermediate nickel products from laterite resources, such as MHP and MSP. Countries like Brazil, however, could eventually develop into serious competitors. Brazil's nickel reserves are third in size globally (16 Mt) and its abundance of cheap hydropower could help it compete with Indonesia's mining and processing costs. Moreover, because most of its nickel deposits are in laterite form, Brazil can specialize in processing technologies similar to those used in Indonesia by foreign companies (HPAL). Vale, already operating in Indonesia, is planning to expand an HPAL facility in the state of Piauí, Brazil. Australia is another competitor—its nickel reserves are second in size globally, but costs are currently too high compared to Indonesia. However, the country could position itself as a trusted partner for markets where sustainability considerations in mining operations are more salient. Australia is already positioning itself as a major producer of sustainable nickel, and if planned expansions further downstream are successfully implemented, it could begin to occupy export markets to Europe or the United States (Blue Cobalt Project). New Caledonia's operations have been hampered by unrest linked to its contentious status within the French Republic. However, operations could resume at full scale—its MHP enjoys higher ESG credentials due to the territory's integration in the French legal framework. Finally, the Russian Federation keeps a strong presence in Class I nickel from its nickel sulfide deposits, but its role in international markets could be hampered by geopolitical tensions. To retain its predominant position in nickel markets for battery products, Indonesia should maintain its current expansion projects for midstream processing facilities to fend off competition from countries like Brazil, while at the same time consolidating efforts to improve ESG enforcement in view of Australia's attempt to occupy that market niche. Table 3 presents a detailed comparison of nickel reserves and production in these and other countries.

Overall, approximately 70 early-stage greenfield and brownfield nickel projects are under development worldwide (IEA, 2025c), as are 30 refinery projects, mostly located in Australia, Brazil, and Cuba. Many of these projects, however, are still in their initial stages and have a long way to go before coming online.

Table 3. Comparison of nickel downstreaming potential in various countries

Country	Reserve size (Mt)	Downstreaming integration
Indonesia	62	Heavy downstreaming operations in processed nickel, battery chemicals, stainless steel, room for growth in HPAL production for battery-grade nickel (Guberman et al., 2024), with a few projects further downstream for the production of nickel sulfate (Zhejiang Huayou Cobalt and others).
Philippines	4.8	Most of the exports consist of ore sent to China, with a few existing HPAL facilities (Argus Media, 2025).
Vietnam	3.6	Limited but expanding through partnerships.
Australia	24	Currently not active downstream from processing. The Australian critical minerals strategy aims for further downstreaming, but production costs and a shrinking mining base are causing the industry to decline (Mandala Partners, 2024).
Russia	8.3	Strong presence in refined nickel value chain: the state-owned mining company Nornickel accounted for 17% of global output of refined nickel in the form of Class I products from nickel matte (Guberman, 2024).
France (New Caledonia)	7.1	Currently only one HPAL facility (Goro) exists and produces nickel hydroxide precipitate, the same step in the value chain as MHP produced in Indonesia. Further downstreaming is hampered by unrest and by higher electricity prices (Burton, 2022).
Canada	2.2	The Canadian critical minerals strategy allocates resources for downstreaming. Declining production and a lack of existing in-house battery-grade nickel production create challenges, but the strategy includes downstream expansion plans. Canada is primarily an exporter of ore and concentrates.
Brazil	16	Brazilian nickel production has expanded substantially in the last 10 years. Costs are sometimes below average due to abundant hydropower (Vieira Lima et al., 2025). Existing production for battery-grade nickel extends downstream to concentrate, and Vale plans to establish an HPAL facility in Piauí laterite deposits (International Nickel Study Group, 2021).

Sources: IISD research from Mining Technology, 2024; Gonzales, 2024; Zadeh, 2025; and sources cited within the table.

Cobalt

Due to its dominance in global nickel production, Indonesia is well positioned to advance downstream in the cobalt value chain, too. Global competition in this case would come directly from the DRC, which has expanded downstream into the same step of the value chain currently occupied by Indonesia—that is, intermediate cobalt products. A drastic improvement in ESG compliance would, however, allow Indonesia to position itself as a more sustainable source of cobalt products, clearly differentiating itself from Congolese production, which is troubled by environmental and societal issues. Other actors to observe are the Russian Federation and Australia. Russia has specialized in the production of cobalt hydroxide through hydrometallurgy on nickel matte and can become competitive in the production of cobalt cathodes, but its export routes and international ESG certification might be hampered by continuing geopolitical tensions. Australia has the potential to move further downstream, but higher operational costs have, for now, prevented a serious downstreaming effort. High perception of ESG compliance, however, together with an extensive deployment of solar-powered, battery-backed electricity, could enable Australia to ramp up production in the future. Finally, Türkiye presents itself as a potential new actor in the cobalt scene. While no extensive downstream expansion has yet occurred, the expansion of cobalt sulphate production through closer integration with the European Union could transform the country into a strategic export hub. Table 4 presents a detailed comparison of cobalt production in these and other countries.

Table 4. Comparison of cobalt downstreaming potential in various countries

Country	Reserve size (Mt)	Downstreaming integration
Indonesia	0.65	Downstreaming operations in nickel are encouraging downstreaming for cobalt, too. Similar to nickel, cobalt is still absent in the refining stage but an expansion in HPAL plants will lead to greater production of MHP and MSP. A few projects for cobalt sulfades suggest the country is moving further downstream.
Philippines	0.26	Exports MSP, but there is no evidence of further refining activity in its nickel-cobalt value chain (U.S. Geological Survey, 2022).
DRC	6	A dominant player in the upstream sector, with a comparably cemented position in the same stage of cobalt manufacturing as Indonesia (cobalt hydroxide from copper, rather than MHP from nickel), as well as an ongoing project in Lualaba to expand further downstream (Organisation for Economic Co-operation and Development, 2019).
Russia	0.25	The exploitation of new nickel and copper deposits could add 8 kt per year of cobalt production. Cobalt hydroxide is currently produced through hydrometallurgy processes on nickel matte (Boyarko & Bolsunovskaya, 2025).
Australia	1.7	The country's production from lateritic resources is not currently positioned downstream, with most patents from Australian actors focused on upstream processes (Nadig, 2024). Australia's critical minerals strategy aims to expand midstream and to increase MHP/MSP production. Some projects, such as Cobalt Blue, plan to produce cobalt and nickel hydroxide further downstream, initially from third-party MHP/MSP and then from locally produced precipitates (WA Investments, 2025).

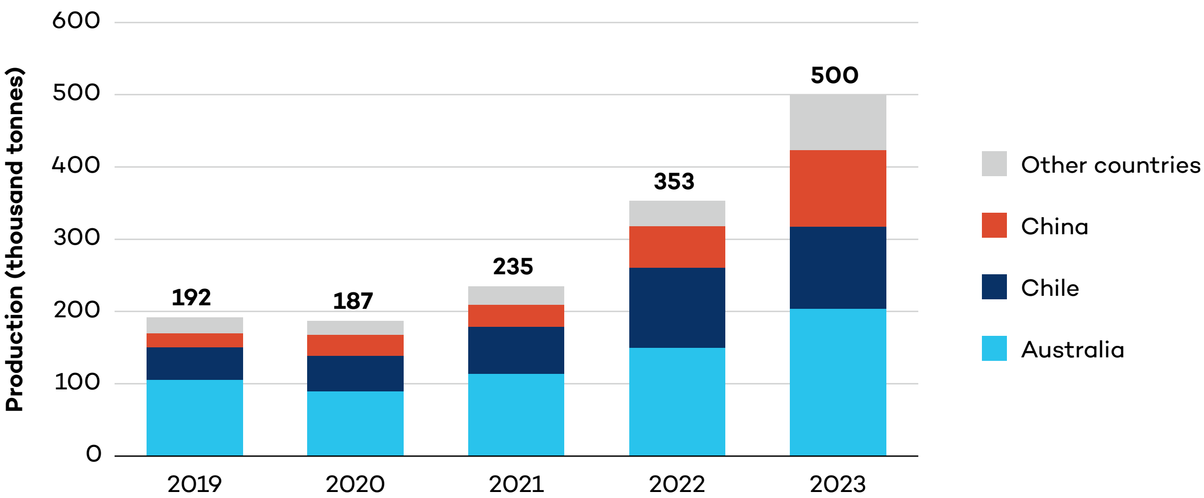
Country	Reserve size (Mt)	Downstreaming integration
Türkiye	0.091	Türkiye is a rising player in the nickel and cobalt industries. The British Geological Survey has indicated the country is the only significant source of such minerals in Europe. It currently exploits three nickel-cobalt laterite deposits and has already specialized in MHP. One of its sites in Eti Bakır is testing to expand further downstream to cobalt sulfide from pyrite, participating in the European STREAMS project (Sustainable Technologies for Reducing Europe's Battery Raw Materials Dependence) funded with Horizon Europe (Eti Gübre, n.d.). Other downstreaming initiatives have currently been stopped.

Sources: IISD research from U.S. Geological Survey, 2023; Carbon Credits, 2025; and others cited in the table.

Lithium

Indonesia possesses an advantage in terms of an already established double route for nickel and cobalt processing (both pyrometallurgical and hydrometallurgical), which can be adapted and expanded to process lithium across multiple nodes of the value chain. Moreover, Indonesia's proximity to Australia, and the potential geopolitical tensions between Australia and China, could position Indonesia as a privileged export outlet for countries considered universally reliable on ESG compliance. Australia, as can be seen in Figure 11, is the largest producer of lithium worldwide. It is also projected to maintain a high level of raw lithium production in the future (Evans, 2024). This scenario would allow Indonesia to source much of its lithium from a country considered an ally of the United States, which would in turn allow Indonesia to counter the negative impact from the tightening of Foreign Entity of Concern rules, potentially including origin of supply in the manufacturing process.

Figure 11. Top global lithium producers by production volume, in kt, 2019–2023



Source: Reichl & Schatz, 2025.

Overall, Indonesia is well endowed in key strategic mineral deposits and is well situated to serve as a key processing hub for other countries' lithium inputs. Its key vulnerability, however, lies in the dominance of Chinese players throughout its processing chain. IISD estimates indicate that more than 50% of Indonesia's current nickel processing capacity is managed by Chinese firms, and 26% by domestic firms in joint ventures with Chinese firms These estimates are corroborated by data gathered by the government in deep-focus interviews, which reveal that only about 10% of smelters in Indonesia are owned domestically. This level of foreign ownership potentially exposes Indonesia to geopolitical shocks, particularly considering exacerbated trade and military tensions between the United States and China. It could leave Indonesia stranded on one side of the geopolitical rift in terms of access to technology, export markets, and lithium inputs.

4.0 ESG and Sustainability for Nickel and Cobalt

On February 26, 2026, the IGF held a focus group discussion in Jakarta about mining governance and ESG frameworks. The discussion included representatives from government agencies, industry associations, non-governmental organizations, and private companies.

As mentioned, Indonesia sits at the centre of the global EV and battery supply chain as the main producer of nickel. Global nickel demand is projected to grow more than fourfold by 2030, and Indonesia will remain its primary driver. However, the discussions held in Jakarta highlighted that this strategic position does not come with guarantees: Indonesia is strong in resource endowment, but significantly weaker in ESG metrics, and concrete cases already exist where environmental concerns have influenced nickel investment plans in Indonesia (Eramet, 2024).

Together with the financial risks linked to investing in projects lacking sufficient ESG standards (Fu et al., 2024), those cases suggest that investors, buyers, and financial institutions are increasingly using ESG performance to inform their strategy. It also suggests that countries and companies assessed as having high ESG risk face higher costs of capital and reduced investment, if not outright project cancellation. It is therefore important for Indonesia to map out existing ESG challenges in its mining operations, which are discussed in this section.

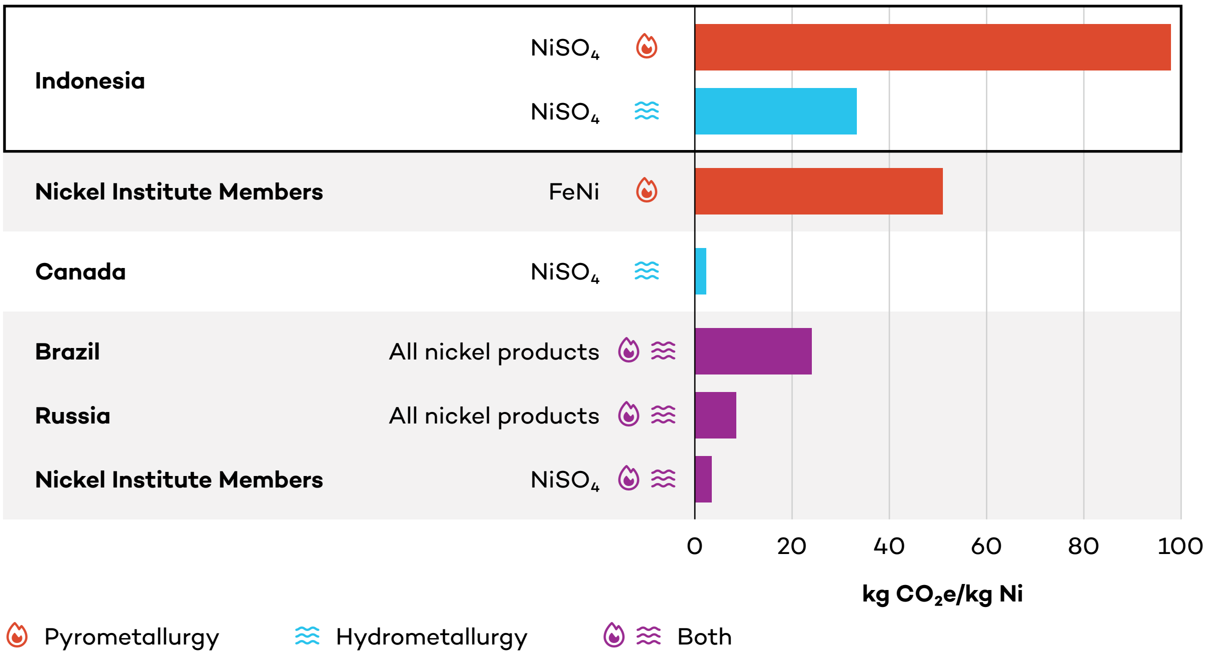
4.1 Water Resource Depletion and Pollution

Compared to processing with a rotary kiln electric furnace, high pressure acid leaching (HPAL) consumes more water due to the large amounts needed to produce sulphuric acid, which is necessary to dissolve nickel and cobalt from ore. Water bodies near mining activities in Indonesia have been polluted. For example, water samples have revealed unsafe levels of metals near Kabaena Island, which have led to a decline in fish populations and the contamination of shellfish consumed by the Bajau community and linked to deaths and health issues (Satya Bumi, 2024). Additionally, water from six rivers close to Indonesia Weda Bay Industrial Park is unsafe to drink due to high hexavalent chromium, pH, and dissolved solids (Climate Rights International, 2024). Water quality monitoring data is not made publicly available (Climate Rights International, 2024).

4.2 Carbon Emissions and Energy Intensity

Producing battery-grade nickel from Indonesia's laterite ore is emissions-intensive and emits a considerable amount of carbon dioxide due to high energy needs and the use of coal (IEA, 2021). Converting Class II nickel pig iron into nickel matte, an intermediate battery material, results in nearly three times the greenhouse gas (GHG) emissions of HPAL processing (Castillo et al., 2022). While data are available for different types of nickel products, no global study has accurately compared GHG emissions by product type. Mining companies operating in Indonesia have higher emissions than global averages. However, there is significant potential for improvement—for example, interviews with major nickel and cobalt players indicated the existence of HPAL systems that are able to reduce GHG emissions to as low as 5.5 kg CO_2e/kg nickel (MHP), placing Indonesian stakeholders on par with competitors in Canada or Brazil. Air pollution, including coal dust, from laterite mining also poses public health risks including respiratory illness (Nasution et al., 2024).

Figure 12. Comparison of nickel GHG intensity per country and type of production, in kg CO_2e/kg nickel



Source: IISD analysis based on data from Carbon Credits, 2025; Minviro, 2023; Mistry et al., 2016; Nickel Institute, 2025; PT Vale, 2022.

4.3 Biodiversity Loss

In Indonesia, nickel mining and processing has contributed to deforestation. Rates of deforestation rose following Indonesia's 2014 raw mineral export ban and the construction of the IMIP (Ginting & Moore, 2021), and forest clearance in 2023 was double that in 2020 (Mighty Earth, 2024). An analysis revealed that between 2011 and 2018, areas of nickel operations in Indonesia had nearly twice as much deforestation compared to non-mining areas (Lo et al., 2025). Nickel concessions require a forest area approval form to clear forests, and companies are mandated to replant natural forests twice the size of the area cleared (Mighty Earth, 2024). Indonesia does not currently have an effective system for cumulative impact assessment or landscape-level conservation planning in mining regions.

Nickel mining in Indonesia often occurs near protected and high-biodiversity areas, which puts flora and fauna at risk from soil and air contamination. This proximity can cause population declines in already threatened species and reduce ecosystem services. Nickel mining can also alter the structure, composition, and abundance of plant and animal life, potentially resulting in permanent loss if no remediation is undertaken (Climate Rights International, 2024). Operations such as the Weda Bay Nickel project encroach upon protected forests and potential buffer zones for national parks, destroying critical forest corridors and habitats for endangered species and threatening aquatic biodiversity in surrounding water bodies (Earthworks, 2025).

4.4 Waste Management

In March 2025, multiple tailings dam failures at IMIP killed three workers and exposed hundreds to heavy metals, risking their health (Moore, 2025). Tailings management methods used in Indonesia include backfilling and tailings dams, which face constraints due to areas with high rainfall and seismic activity. For example, IMIP sits on the Matano Fault, an active fault within the Central Sulawesi Fault System, and in a region that has experienced many strong earthquakes in recent years. Heavy rainfall can add to the risk of water accumulation, which places pressure on tailings dams (Moore, 2025). IMIP is projected to generate millions of tonnes of tailings annually; concerns surround disposal methods, as clearing forests to build tailings dams may cause potential leaks, soil, and water pollution. While deep-sea tailings disposal is prohibited, it has generated significant international opposition on environmental grounds as it poses risks of severe water pollution and heavy metal contamination (Morse, 2020).

4.5 Labour Rights

Labour rights concerns are widespread in Indonesia's rapidly expanding nickel industry. At the dedicated focus group discussion in Jakarta, participants remarked that regulation is considered sufficient, but implementation is lacking. Indonesia's Ministry of Manpower identified three key areas to which companies must pay greater attention: (a) industrial relations (wage systems and trade union relations), (b) worker protection (safety standards), and (c) social security.

Investigations by civil society groups have documented long working hours, inadequate protective equipment, delayed or unpaid wages, and limited access to effective grievance mechanisms at several industrial parks—mostly experienced by foreign workers, though not exclusively. Worker testimonials also describe fear of retaliation for raising safety or labour concerns, underscoring structural barriers to accessing remedies (Climate Rights International, 2024). These cases raise serious concerns about potential downward pressure on labour standards and the viability of decent work in Indonesia's mining boom. However, due to a lack of rigorous, publicly available data or academic studies comparing local and foreign workers and documenting working conditions over time, it cannot be concluded systematically that the influx of foreign workers has caused a sector-wide deterioration of working conditions.

4.6 OHS

Occupational safety in nickel processing in Indonesia is a concern. Discussions in Jakarta have highlighted some recurring problems, including a high rate of unreported workplace accidents; the absence of specialist medical facilities, particularly for burns, which are a significant risk in smelter operations; and environmental hazard factors that have not been systematically assessed, meaning that the personal protective equipment in use does not correspond to the actual risks present. Reliable accident data are scarce, though Indonesian nickel facilities reported 114 incidents that led to 101 deaths and 240 injuries between 2015 and the first half of 2024 (Lakshmi & Mariska, 2024b). Workers indicate that safety risks are covered up, leading to repeated accidents such as explosions (Liljas, 2024; Reuters, 2023). Reports also highlight inadequate personal protective equipment, language barriers between foreign and Indonesian workers, and fear of retaliation for raising safety concerns, undermining reporting and prevention (Lakshmi & Mariska, 2024a). The Omnibus and Mineral and Coal Mining laws weakened labor protections, including OHS standards, and eased licensing with less environmental and social scrutiny, including worker and community protections (Solidar, 2024).

The inspection system is also constrained. Discussions in Jakarta revealed approximately 200 labour inspectors at the central level, with a total of about 1,500, including regional inspectors. This figure is acknowledged as being severely insufficient to oversee all companies operating across Indonesia.

In response to inspectorate capacity limitations, the Ministry of Manpower has developed a self-assessment system: companies complete approximately 100 questions on labour norms through an online application, filled in jointly by both management and workers' union representatives, as a check-and-balance mechanism. Results are expressed as a colour-coded score: green (compliant), yellow (requires improvement), and red (non-compliant). Inspectors then prioritize site visits to companies categorized as red.

4.7 Indigenous Peoples and Community Rights

Indonesia has not ratified International Labour Organization Convention No. 169 and does not consistently embed Free, Prior, and Informed Consent (FPIC) as a legally enforceable consent requirement across its mining and permitting framework. As a result, FPIC expectations are introduced, where relevant, through international standards, lender covenants, or voluntary ESG frameworks rather than statutory requirements. In addition to FPIC-related gaps that limit the applicability of safeguards at key stages (e.g., land access and major project changes), another weakness is limited access to remedy as an ongoing requirement throughout the project life cycle.

Indigenous and customary communities near nickel projects report inadequate or no consultation, opaque land-acquisition processes, and insufficient compensation (Lakshmi & Mariska, 2024a), and consent is often secured after operations have already begun. Human rights organizations have also raised concerns that reforms under the Job Creation Law and ease of National Strategic Projects' measures may accelerate permitting and land procurement while weakening participation safeguards, increasing the risk of land acquisition and displacement without meaningful consultation, including for Indigenous Peoples and local communities (Amnesty International, 2024a).

Under Indonesia's National Strategic Projects framework, several nickel developments have been permitted to bypass local consent requirements, further eroding procedural safeguards (Amnesty International, 2024b). In some nickel-affected areas, communities report that they expected land access arrangements to be temporary or limited given the customary status of the land, yet customary tenure claims are often not adequately recognized in practice. Reports also describe retaliation against and criminalization of individuals opposing land transfers, including restricted access, legal threats, and imprisonment. These shortcomings disproportionately harm women: only 24.2% of land in Indonesia is registered to women, and despite equal rights under the Agrarian law, customary norms, language barriers, and low legal literacy impede women's access to compensation, remedies for land loss, and livelihood restoration (IGF, 2026).

Beyond land tenure and consultation, nickel industrial development can also create material risks related to community health and safety, particularly where communities live near industrial parks and processing facilities. These risks extend beyond workplace OHS compliance because exposures can occur outside the workplace, can affect non-workers (including women, children, and other vulnerable groups), may manifest over longer time horizons, and can raise questions of accountability, monitoring, and remedy. At the IGF Focus Group Discussion in Jakarta, the Ministry of Manpower highlighted that exposure to industrial chemicals can have carcinogenic effects (triggering cancer), mutagenic effects (causing genetic mutations in subsequent generations), and teratogenic effects (causing birth defects or foetal death when pregnant women are exposed).

Interviews with government agencies suggested that some tensions stem from the principle of state control over natural resources, which is common in many jurisdictions. However, this understanding should also take into account how "state control" and "public interest" powers are interpreted and implemented in practice, particularly where customary tenure is difficult to formalize and participation, compensation, and remedy mechanisms are weak. In this context, international standards (including FPIC-aligned approaches where relevant) do not necessarily conflict with the Constitution; rather, they typically require stronger due process, inclusive consultation, and rights-compatible remedy alongside state-led resource governance. Interviewees emphasized that Indigenous and customary communities are diverse, which means a one-size-fits-all consultation model is rarely effective, given the different languages, governance systems, tenure arrangements, and varying degrees of legal recognition among such groups.

These tensions have translated into practical issues on the ground, blocking production. At the focus group discussion in Jakarta, representatives from a major mining group reported that for the past 2 years, they have been unable to carry out any activities at several operational sites due to community rejection and the presence of illegal farmers within their operational area. Participants further noted a perceived coordination and mandate gap in addressing such land-use and community engagement disputes, with responsibilities viewed as fragmented across institutions and no single agency clearly positioned to lead dispute resolution. This gap contributes to prolonged uncertainty and escalation of conflicts. A parallel case was raised in Jember, where gold reserves of enormous potential have not been mined solely due to community rejection. This result reinforces that ESG compatibility is not only about technical compliance; unresolved social challenges can undermine project continuity and require stronger engagement, dispute-resolution pathways, and rights-compatible remedy.

4.8 Structural Corruption and Transparency

Permit centralization can improve consistency and reduce operational fragmentation, but it can also create integrity risks if oversight and transparency mechanisms are weak. In its nickel sector analysis, Transparency International Indonesia raises concerns that elements of the permitting reform framework may in practice reduce accountability and increase corruption vulnerabilities (Transparency International Indonesia, 2024). The China Global South Project found that 98 out of 332 projects involved corruption or illegal mining, with 90 of those cases specifically involving corruption in mining projects (China Global South Project, 2024).

Stakeholders have raised concerns that regulatory and institutional capacity gaps can contribute to inconsistent enforcement and create opportunities for rent-seeking. For example, Publish What You Pay Indonesia highlights transparency and oversight weaknesses in aspects of mining permitting and governance, which may elevate integrity risks and undermine predictability for both communities and investors (Publish What You Pay Indonesia, 2025). Reported cases include allegations of illegal nickel ore export and manipulation of surveyor reports on commodity contents. Stakeholders have warned of greenwashing risks, where "green" branding is not matched by transparent disclosure of social and environmental impacts, including pollution and emissions linked to captive coal-fired power in some nickel and battery industrial settings. Moreover, the regional agencies' lack of legal authority and weak and inconsistent enforcement of regulations to accompany legal reforms that centralize permitting (for example, through the Job Creation Act) may reduce accountability and increase vulnerability to corruption. This risk was also highlighted at the focus group discussions in Jakarta. The government has proposed a One Map Policy platform to integrate geospatial data from various ministries to resolve overlapping licences and area claims. However, this initiative had yet to show any concrete progress at the time of the discussions. Without such a platform, civil society organizations cannot effectively monitor cross-ministerial licensing overlap.

Indonesia has taken some steps forward in confirming that no legal obstacles exist to contract transparency, as demonstrated by its 2021 study on contract disclosure, which reviewed current disclosure practices and included follow-up initiatives to promote progress in this area (Extractive Industries Transparency Initiative, 2024). Nonetheless, major difficulties persist, such as the continued absence of published contracts, despite the study's conclusion that no legal restrictions prevent their disclosure. Companies are required to publish sustainability disclosures, and some information can be accessed through platforms such as the Global Reporting Initiative's Sustainability Disclosure Database and Indonesia's Extractive Data Portal, which is linked to the Extractive Industries Transparency Initiative. However, there is no single, comprehensive, publicly accessible platform that consolidates standardized, comparable ESG performance data across Indonesia's mining and battery sector (including contractors and industrial parks), particularly for site-level social indicators and outcomes.

A pervasive lack of transparency shields both corporations and government officials from accountability for the social and environmental consequences of nickel extraction and processing. Limited project information, including on environmental impacts, and ineffective engagement prevent affected communities from understanding and responding to the impacts of nickel operations on their lives (Climate Rights International, 2025b). Major operators like the Indonesia Weda Bay Industrial Park fail to provide publicly available air and water quality data despite clear legal requirements (Climate Rights International, 2024).

4.9 Supply Chain Concentration

The cobalt supply chain is highly vulnerable to concentration risk due to the dominant position of Chinese actors undertaking mining and refining activities. China processes approximately 68% of the world's cobalt (in addition to 35% of nickel, 59% of lithium, and 85% of rare earth elements), creating potential bottlenecks and strategic considerations in supply chains (Deravian & Mulligan, 2025). Chinese companies control a substantial number of cobalt refineries and mines essential for battery production. Cobalt mining is concentrated in the DRC, which accounts for an estimated 76% of global mine output of the metal (U.S. Geological Survey, 2025). This geographical concentration means that ESG issues in processing regions can have global implications for critical mineral availability. According to a 2023 study, joint ventures between major EV battery manufacturers, such as CATL and LG Chem, and Chinese mining corporations including China Molybdenum and China Huayou Cobalt Industry, have used forced labour in the DRC (Brehm et al., 2023).

4.10 Mine Closure and Post-Mining Plans

Closure challenges related to nickel mining in Indonesia include the effects of deforestation, such as carbon emissions from biomass loss, as well as soil contamination from pollutants produced post-mining (Nasution et al., 2024).

In Indonesia, mining inspectors under ESDM oversee the compliance of mining operations with technical and safety standards, including post-mining reclamation plans, although environmental oversight is primarily the responsibility of the Ministry of Environment (Kementerian Lingkungan Hidup) and its regional offices. Under Government Regulation No.78 of 2010 on reclamation and post-mining, mining permit holders are required to submit reclamation plans and post-mining activities to ESDM for approval, annual reclamation reports, quarterly post-mining activity reports, and post-mining financial guarantees (World Services Group, 2011). Should guarantees not be provided, the ministry can temporarily suspend operations and permanently revoke permits. For example, in September 2025, the ministry suspended 190 mining companies for not providing reclamation and post mining guarantees after providing three warnings between December 2024 and August 2025 (Indonesia Coal Mining Association, 2025). Reclamation strategies include, but are not limited to, curbing the total area of open-pit mining, controlling sediment and effluent, reshaping land surface, reforestation, and plant maintenance (PT Vale Indonesia, n.d.).

Overall, Indonesia has enacted strong regulations to meet some of the ESG issues listed above. However, gaps remain in scope and enforcement. IISD has carried out an analysis of Indonesia's existing regulations against the principal ESG mining indicators covered in international standards, the results of which are presented in Table 5. Measures to fill existing gaps will be explored in other knowledge products within the MAKMUR project.

Table 5. Existing ESG regulations in Indonesia

Aspect	Summary of international standards	Indonesian regulations	Gaps
Environmental indicators			
Biodiversity and ecosystem services	The International Council on Mining and Metals (ICMM) and the Initiative for Responsible Mining Assurance (IRMA) require biodiversity protection, ecosystem services assessment, and avoiding protected areas	Environmental Impact Analysis (AMDAL) regulations mandate impact assessments or "no net loss" targets. Biodiversity monitoring is not systematic	Add mandatory ecosystem services assessment and biodiversity monitoring protocols. Introduce "no net loss" or restoration targets
Waste and tailings management	ICMM and IRMA include tailings and waste management; IRMA also covers cyanide and mercury controls	Waste management is assessed via AMDAL. Deep sea tailings are not permitted. Guidelines on handling mine waste and managing tailings, waste dams, and acid mine drainage. No single, technical tailings regulation. Safety protocols for waste and tailings facilities across several regulations	Add specific controls for hazardous substances like mercury and cyanide
Mine closure and rehabilitation	ICMM and IRMA require closure planning and financial guarantees	Reclamation and post-mining activities required, and financial guarantees must be provided. Revegetation is required	Strengthen enforcement and monitoring of closure plans
Water	ICMM and IRMA require water management and public disclosure	Sets out protocols for monitoring domestic and industrial zone wastewater treatment and standards at national and local levels. Require businesses to report on water quality and wastewater management. Water quality monitoring data not public	Mandate disclosing water quality data publicly

Aspect	Summary of international standards	Indonesian regulations	Gaps
GHG emissions, climate change	ICMM and IRMA require GHG reporting and climate resilience planning	No mandate for climate governance or risk assessments. Encourages decarbonization aspects. Technical approvals required for high-emission entities	Introduce mandatory climate governance systems, risk assessments, and decarbonization plans
Social indicators			
Stakeholder engagement	All standards emphasize stakeholder engagement	Companies must share project info and develop public involvement plans. AMDAL requires proponents consult with affected communities	Encourage meaningful engagement and benefit sharing
Grievance mechanisms	IRMA and the Consolidated Mining Standard Initiative (CMSI) require formal grievance systems and access to remedies	Project-affected people can submit recommendations; grievance channels must be established	Standardize grievance, accessibility, and transparency mechanisms
Indigenous Peoples and FPIC	Global Reporting Initiative, ICMM, IRMA, and CMSI require respect for Indigenous rights and FPIC	Indigenous rights are recognized in law. FPIC is not mandated	Improve benefit-sharing frameworks and enforcement of Indigenous rights
Human rights	ICMM, IRMA, and CMSI require human rights due diligence and security protocols	No mandatory human rights due diligence	Mandate human rights due diligence and reporting
Labour rights and occupational safety	Global Reporting Initiative, ICMM, IRMA, and CMSI cover fair labour, gender equity, and safety	Labour rights and safety systems are mandated. Legislation on gender equality and equity to safeguard rights of female employees. Companies in hazardous industries and with at least 100 employees required to establish OHS management systems.	Improve enforcement and monitoring. Expand protections for vulnerable groups.

Aspect	Summary of international standards	Indonesian regulations	Gaps
Community health and safety	IRMA includes community health and safety	Environmental documents must consider public health; the safety of infrastructure is regulated. Existing community beneficiation programs under Indonesia's Community Empowerment Program are treated as a variable cost, ensuring continued support regardless of profitability	Strengthen health impact assessments and community safety protocols
Economic and governance indicators			
Transparency and accountability	All standards require financial transparency and contract disclosure	Companies required to publish sustainability reports. SIMBARA and Minerba One Data Systems exist where active mining licenses are published	Make sustainability reporting mandatory. Improve data accessibility
Anti-corruption	All standards require anti-bribery policies and beneficial ownership disclosure	Policies are recommended but not mandatory. Companies must disclose beneficial owners. Beneficial ownership registry is publicly accessible	Make effective anti-corruption policies and whistleblower systems mandatory
Supply chain and traceability	IRMA and CMSI require chain of custody and due diligence	Domestic supply prioritization is mandated. SIMBARA is designed to improve oversight of the value chain	Develop traceability systems and due diligence requirements for supply chains

Source: IISD, 2025.

The ESG risks related to lithium affect Indonesia differently. As stated before, lithium is not currently produced in Indonesia. The country will, therefore, need to focus on importing ESG-compliant lithium products and focus on building traceability systems to monitor this process. These aspects will be explored in greater detail in a subsequent MAKMUR product.

5.0 Future Market Demand and Strategic Implications

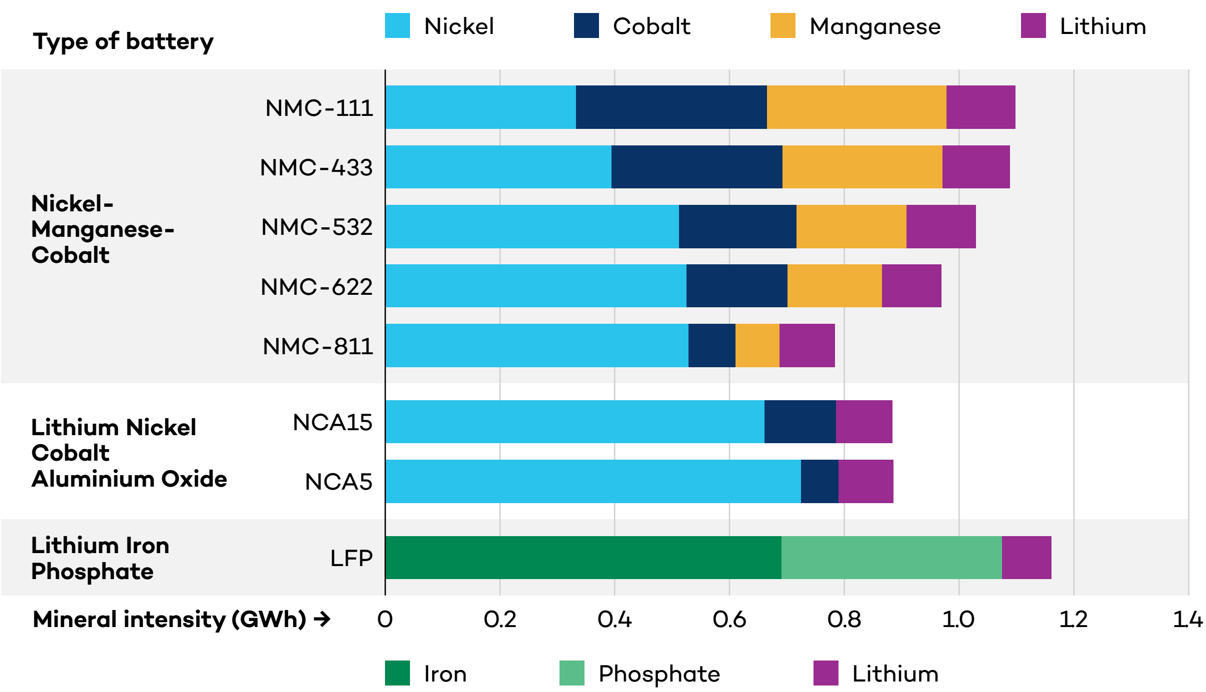
5.1 Battery Chemistry Trends and Implications

Over the past 10 years, battery growth has been driven by the accelerating electrification of the transport sector. According to the IEA, the volume of total battery use in 2023 was up to 2,400 GWh in 2023, four times the amount in 2020, and more than 90% of it was in the electric transport sector. This rapid growth has been driven by a remarkable decline in battery prices, which fell by 14% between 2022 and 2023 and have dropped by close to 80% since 2013 (IEA, 2024a). The growth in EV batteries has in turn been driven predominantly by light-duty vehicles, which use close to 90% of all batteries in the sector.

It is therefore key to remember that, despite the promising future of utility-scale battery applications due to the progressive electrification of energy systems, most of the growth in the battery industry and most price dynamics will continue to be driven from the EV battery market.

Lithium-ion batteries have been the key technology behind the impressive rise of batteries in the last decade. They come in multiple varieties and are commonly categorized by the element composition of their active cathode, which is one of the two electrodes storing ions during battery charging and discharging.

Figure 13. Mineral composition across battery chemistries, in grams per watt-hour, 2023



Source: Maisel et al., 2023.

Nickel-Manganese-Cobalt

This is the most common battery chemistry today. Nickel is a privileged material for the cathodes in this battery variety because of its energy density, which can better accommodate longer EV ranges. Moreover, pressures to reduce cobalt contents in these battery cathodes due to unethical mining practices have led to the development of several varieties of this cathode chemistry type, ranging from lower nickel contents in NMC-111 types to higher nickel contents in NMC-811.

Lithium Nickel Cobalt Aluminium Oxide

This battery type contains a higher nickel content due to the preference for nickel over cobalt and to take advantage of nickel's energy density. These batteries swap aluminium for manganese, trading some stability for a higher energy density and power. They are more thermally sensitive and their lifespan is on average shorter, but they can power EVs needing maximum range.

Lithium Iron Phosphate

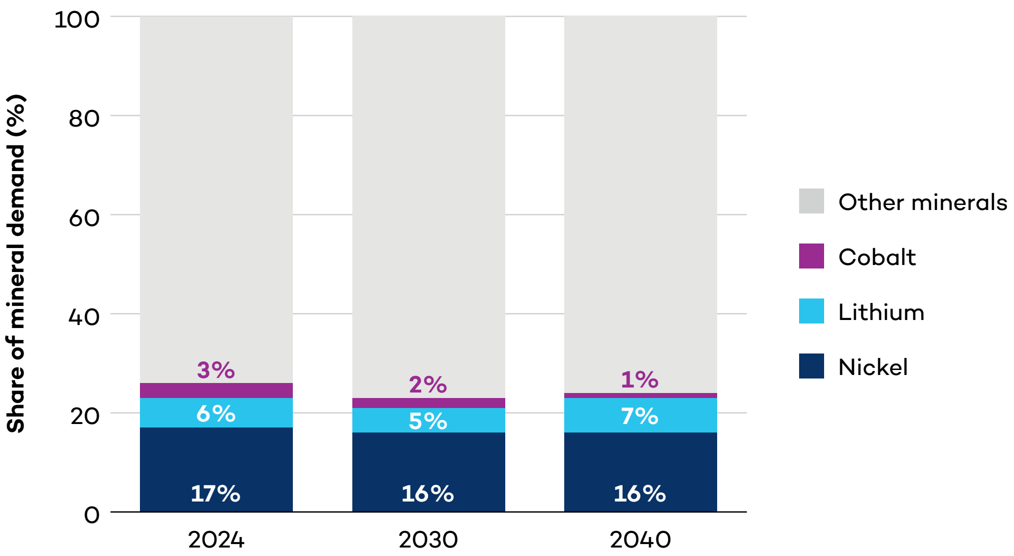
LFP batteries are about one-third cheaper today than NMC battery varieties (BloombergNEF, 2025). They contain no nickel but have substantially lower energy densities and can therefore guarantee lower autonomy ranges, which are the ranges vehicles can reach with a full battery. This technology has advanced substantially in the last few years and has been the cornerstone of China's EV battery strategy to undercut global competition. Recent advancements in battery lifespans, together with lower costs, have allowed this battery type to increase in market share at the expense of other varieties.

5.2 Predicting Future Demand

Demand for nickel-based EV batteries varies by region. LFP batteries supply most of the market in China, while EV battery cathodes sold in North America and Europe are mainly based on nickel-rich battery chemistries. Due to China's status as a leading destination for EV sales, LFP supplies almost half of the global electric car market in terms of cathode chemistry sales share (IEA, 2025c).

Industry analysis anticipates that high nickel cathode batteries will continue to account for a large share of global battery demand through 2040, as they remain favoured for high range EVs and other performance sensitive applications (Rho Motion, 2024). This increase reflects nickel's continued importance, especially in segments where higher energy density is required, such as long-range EVs, heavy-duty transport, and stationary storage with premium performance needs (Man, 2023). Moreover, nickel-based battery types perform better in colder climates such as in the United States and Europe (Mughees, 2025). As shown in Figure 14, nickel demand in EV batteries will remain at approximately 16% to 17% of total mineral demand in a scenario where policies remain unchanged.

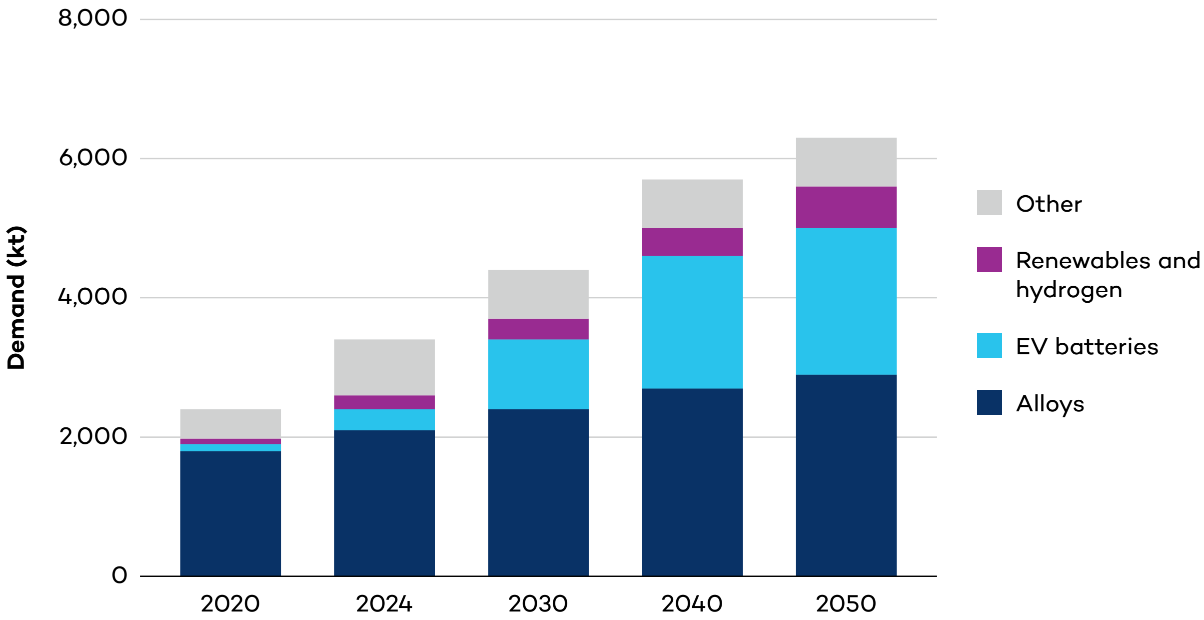
Figure 14. Nickel, cobalt, and lithium demand as a share of total mineral demand for EV batteries, 2024–2040



Source: IISD elaboration on data from IEA, 2025b.

It is worth mentioning that stakeholders involved in the creation of a battery value chain in Indonesia have argued in favour of stimulating an internal market for clear uptake of Indonesian batteries. Discussions in Jakarta have highlighted that almost all cathodes produced at the AMMAN smelter at the Batu Hijau mine are exported abroad, with only a tiny fraction absorbed locally. The electrification of Indonesia's motorways could therefore function as a buffer to accommodate new capacity and minimize the risks associated with an overreliance on exports. A new study by the Energy Shift Institute assesses that even at full capacity, an EV value chain would use only 1% of Indonesia's nickel production, based on the fact that the export of vehicles such as cars, motorcycles, or buses is often subject to trade restrictions in commercial disputes (Zuhdi et al., 2025). The study therefore downsizes the impact of this industry on government revenues and warns Indonesia against dismissing investments in alternative uses for nickel. According to the same study, metallurgical applications such as steel alloys, household appliances, and consumer goods could absorb much of Indonesia's production capacity, about 40% to 60%. The IEA estimates that steel alloys and other goods will occupy up to half of the world's global nickel demand up to 2050, suggesting that these uses for nickel will maintain an important market value for decades to come (IEA, 2025c).

Figure 15. Global nickel demand by sector



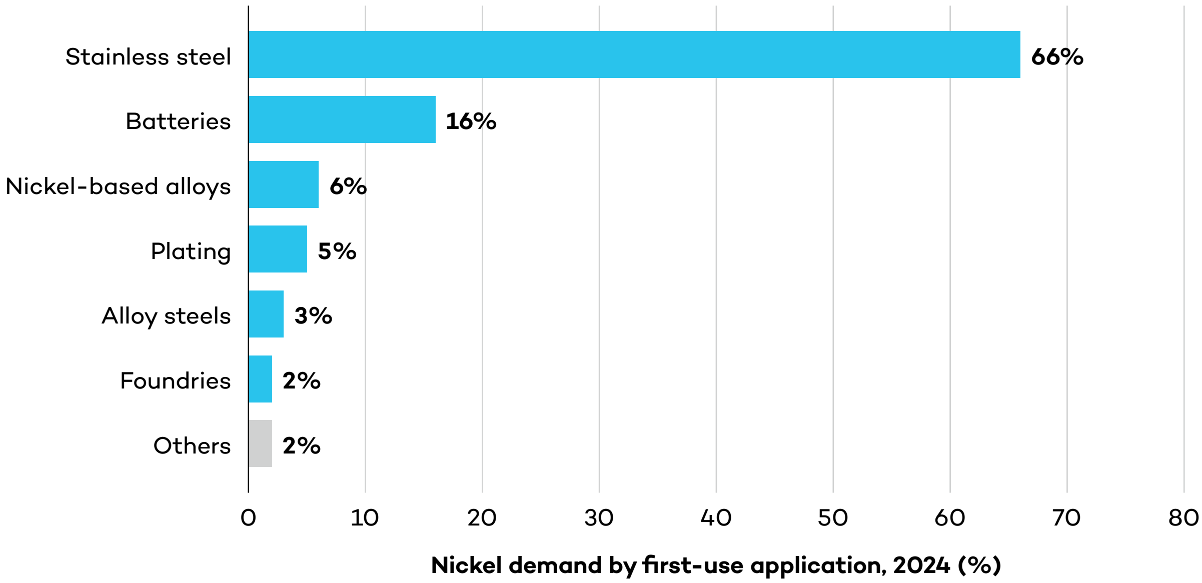
Source: IEA, 2025c.

Indonesia, as the world's largest nickel producer holding substantial reserves of nickel laterite ore, maintains a significant competitive advantage in the global energy transition. The national resource-nationalist agenda mandates increasing value-added activity within the country, supported by policies like the ban on raw ore exports (Edarsasi, 2025). Indonesia's downstream strategy is positioned to exploit the global demand for high-nickel, high-energy-density batteries. To capture the massive projected growth in the high-energy-density battery market (NMC/NCA), Indonesia would need to aggressively pivot toward producing high-purity Class I nickel chemicals, with the long-term downstream strategy tightly coupled with forecast demand for battery-grade inputs.

5.3 Stainless Steel and Other Metallurgical End Products of Nickel

In 2024, 66% of nickel's global demand was to produce stainless steel (Nickel Institute, 2025). Dedicated market reports predict the global market value of this specific type of production to continue increasing, from USD 207 billion in 2023 to USD 320 billion within a decade, an increase of more than 50% (Fortune Business Insights, 2024). While the IEA's most conservative scenarios predict that 60% of global nickel demand will be for non-battery production, most of this growth will be driven by stainless steel.

Figure 16. Demand for nickel by first application, 2024



Source: Nickel Institute, 2025.

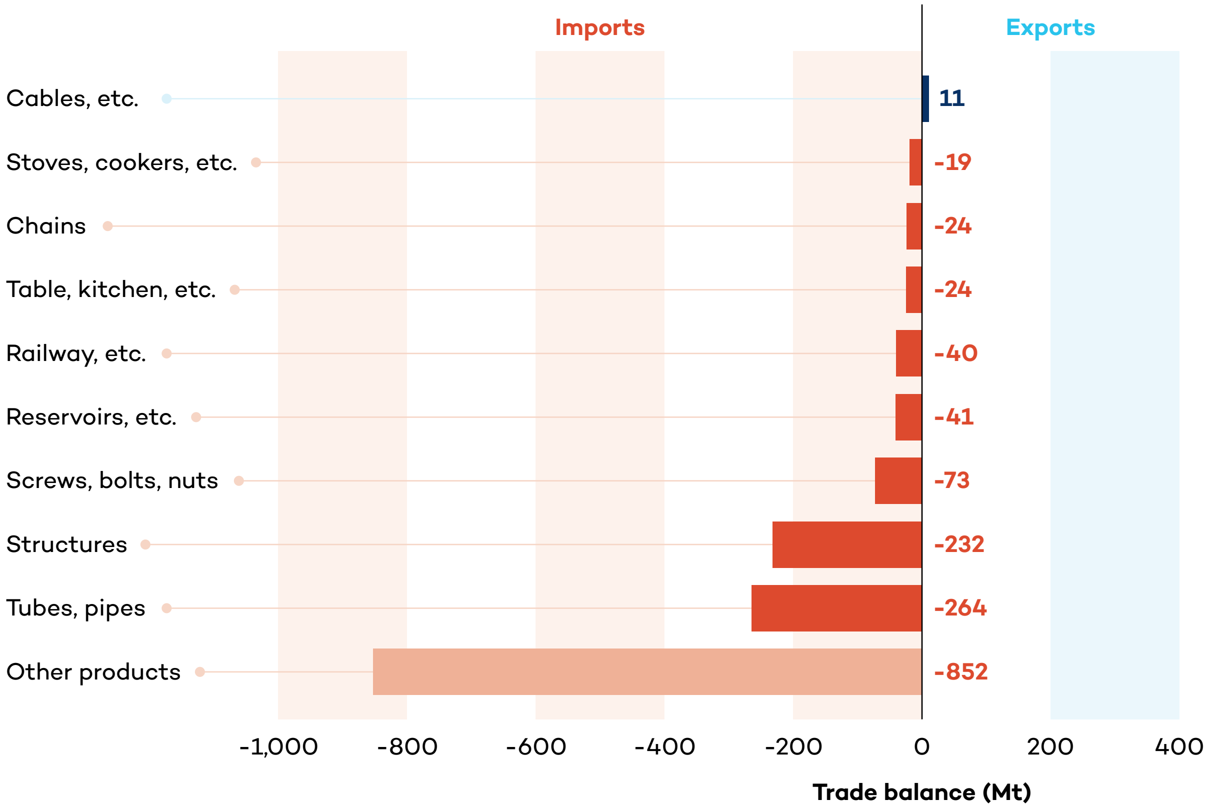
Stainless steel derives much of its ductility and weldability from nickel properties, as well as its ability to withstand higher temperatures without becoming deformed. For these reasons, and others, stainless steel products are suitable for a range of important sectors, including:

- industrial applications, such as power generation from low-carbon energy sources in the form of corollary equipment, chemical and petrochemical applications, electrical engineering, and food and beverages;
- architecture, building, and construction applications;
- transport applications unrelated to battery production, including chassis and body structures for road vehicles, railway applications, shipbuilding, and aerospace; and
- kitchen appliances and utensils, as well as other tools for the home and the office.

The extraordinarily wide range of applications for stainless steel and other metallurgical nickel end products should encourage the Indonesian government to maintain and expand pyrometallurgical establishments to produce ferronickel and nickel pig iron. Furthermore, Indonesia is encouraged to expand the production of other crucial metals in stainless steel alloys. In addition to nickel, the country already possesses sizeable lateritic iron ore resources, although a mapping document by ESDM reveals that additional efforts must be made for exploration initiatives and improved classification methodologies. Current yearly iron demand sits at 18 Mt, versus a production of about 2–3 Mt per year (ESDM, 2024).

Alongside developing and consolidating national iron ore production, Indonesia is encouraged to further downstream stainless steel production. Currently, more than 99% of Indonesia's stainless steel exports, by weight, are in the form of semi-finished products such as ingots and flat rolls, suggesting significant opportunities for the industry to satisfy the country's building, transportation, and home appliances industries (International Trade Centre [ITC], n.d.). At the same time, an analysis of exports and imports of iron and steel products, such as tubes, pipes, structures, screws, bolts, chains, tanks, stoves, tables, and other parts reveals an existing trade deficit of about USD 1.5 billion (ITC, n.d.). This deficit highlights the potential to not only downstream stainless steel production, but also to expand into industries aimed at the building, tools and appliances, and transportation sectors. Some organizations, such as Energy Shift Institute, have pointed to this gap to highlight a higher concentration of small and medium enterprises in such sectors, which could guarantee a greater distribution of economic benefits (Zuhdi et al., 2025).

Figure 17. Trade balance by category of iron and steel products, in Mt, 2024



Source: IISD analysis based on data from ITC, n.d.

5.4 Reserve Sustainability, Waste Recovery, and Recycling

As explained earlier in the report, estimates by ESDM based on current production and demand dynamics indicate an estimated lifespan of 17 years for reserves producing MHP through HPAL facilities. Meanwhile, ferronickel and nickel pig iron reserves have a lifespan of only 9 years. Discussions in Jakarta have confirmed this concern, providing estimates of 7- to 10-year lifespans for high-grade nickel reserves and 20-year lifespans for lower-grade ones. These predictions raise questions about the sustainability of Indonesia's current mining operations, especially the treatment of reserves and tailings, as well as recycling potential.

The global critical minerals recycling industry is growing in complexity and in volume, especially as more feedstocks for recyclable content are accumulated. Metals can be recycled in two separate stages: at the production stage or the manufacturing stage. Scrap that does not meet various quality standards is separated. This type of scrap, known as "new scrap," can occur at various stages of production, can yield additional volumes of metals, and can be traded internationally. "Old scrap" refers to metals that can be extracted from consumer and end products reaching the end of their life cycle. These products are collected, disassembled, treated pyrometallurgically or hydrometallurgically, and can yield metals that can be circulated back into production in the form of secondary products.

Nickel has high rates of recyclability. Its end-of-life recycling rate of 68% makes it one of the most efficiently recyclable critical minerals (Material Insights, n.d.). Historically, the mineral has enjoyed recycled input rates—defined as the ratio of secondary production to total mineral production—of nearly 30%, placing it among the top performers (IEA, 2024b).

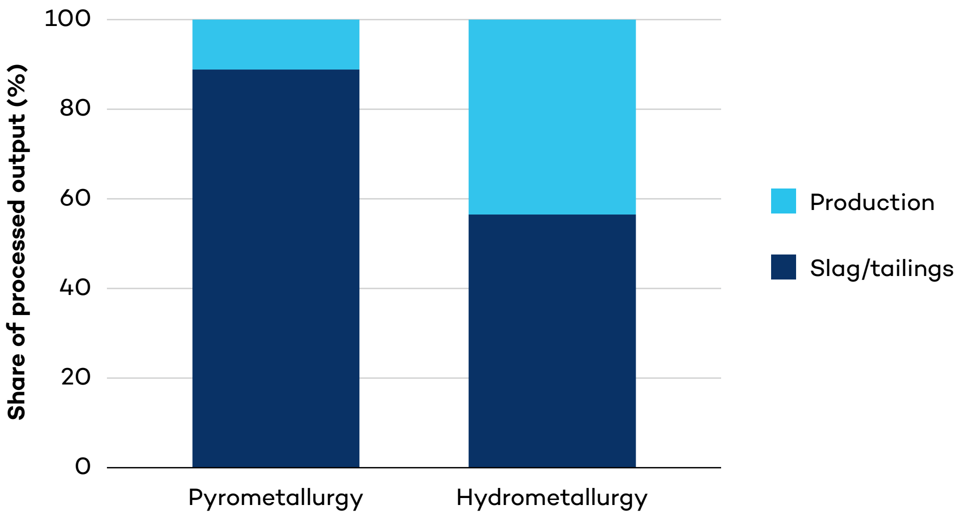
While these figures have been attributed to the recovery of nickel from stainless steel, which hovers at around 95%, the increasing volume of end-of-life nickel batteries reveals increasing recycling rates from this sector, too. The IEA has tracked the recycling rate of nickel from available battery recycling feedstock over the years and has observed a notable growth in this ratio in the last 5 years, reaching up to 55% (IEA, 2024b).

Indonesia is currently in a stage of nickel production that could encourage the extraction of metals from slag and tailings deriving from extensive mining and processing activities. Metal recovery from mining waste is projected to grow in importance as ore grades decline and prices continue to rise due to the energy transition and the adoption of artificial intelligence (AI). These factors will make waste treatment and recovery of metals more appealing, from both an economic and a technical perspective. Nickel is already displaying long-term declines in ore quality (Van der Voet et al., 2018).

A vast proportion of the waste products from nickel mining occurs in the form of ferronickel slag, a by-product of pyrometallurgical processes. Overall, about 8 tonnes of ferronickel slag are produced for every tonne of ferronickel production (Ulum et al., 2023). For HPAL facilities, the estimate is around 1.5 tonnes of tailings per tonne of limonite processed (Peh, 2024). Extrapolating from production estimates in 2023 (2.2 Mt of nickel), we can estimate that close to 16 Mt of nickel slag and tailings were produced, which are largely stocked underground in dry-stack tailings facilities, in underground caves, or used as a base for the construction of other facilities.

Indonesia is currently underutilizing this immense stock of nickel waste, although efforts to optimize its use exist. In 2020, Indonesia's Ministry of Industry launched a strategy to explore solutions for its nickel waste stockpiles by funding research and development into methods for the direct use of nickel slag (Shanghai Metals Market, 2020). In 2024, the release of a new standard (SNI 9290:2024) established criteria for the recategorization of parts of the nickel slag stockpile as material for industrial use. Existing pilot cases also suggest a way forward. For example, Trimegah Bangun Persada's incorporation of nickel slag into bricks and other building construction could be scaled nationwide (SWITCH-Asia, 2024). At the same time, the Mineral Industry Agency is advancing a concept of "Total Mining," where in addition to primary minerals, by-products and tailings must also be optimized for national development. The agency is currently carrying out a pilot project in PT Timah's Belitung tin ore operations that aims to establish some first guidelines on when and how to carry out re-mining operations or exploit existing tailings deposits. For now, however, further extraction of nickel from existing nickel slag stockpiles seems uneconomical. Estimating the concentration of nickel in ferronickel slag across the industry is not easy, but a study conducted in 2020 has revealed percentages ranging from 0.02% to 2.56%, across seven separate observation points, with a median of 0.37% (Majalis et al., 2020). These figures seem to suggest that additional nickel extraction would not make economic sense (yielding an estimate of 48,000 tonnes of nickel per 13 Mt of slag) and that prioritizing these stockpiles for construction purposes would perhaps be more prudent. This reflects the current view of the Indonesian government, which has indicated in interviews that tailings that are currently uneconomical to process will be stockpiled as a strategic asset.

Figure 18. Production of nickel slag and tailings in Indonesia per production method, 2023



Source: IISD calculations based on production figures from Lee et al., 2025.

The recovery of nickel from industrial scrap and end-of-life products, both of which have much higher nickel grades, could present an opportunity for Indonesia if it further downstreams its nickel production in battery manufacturing and in stainless steel. As Indonesia's economy expands and the existing stock of stainless steel- and nickel-containing consumer goods increases, it will become more important to establish a functioning recycling industry for "old scrap." Improving its recycling industry could drastically decelerate the depletion of existing nickel reserves and establish Indonesia as a leading player in both primary and secondary nickel production. This strategy would move Indonesia away from an intensely extractive and processing role toward more sustainable use of its resources.

5.5 Wider Ecosystem of Inputs

To produce EV batteries, Indonesia must secure a host of other products that are crucial to the processing of critical minerals and the production of battery components. These include reagents for extraction and refining, such as sulfuric acid, ammonia, and solvent-extraction reagents; materials for anode production, such as graphite; and conductive salts and additives to produce electrolytes.

The production of some of these necessary inputs is very concentrated and exposed to disruptions caused by geopolitical events. Sulphuric acid, for example, is critical to leaching operations in Indonesia's HPAL facilities but supply has been severely impacted by the recently developing crisis in the Strait of Hormuz (Kavanagh & Rhodes, 2026). With Indonesia importing more than 75% of this resource from that area (Karyza, 2026), this disruption could develop into a sensitive flashpoint if a diplomatic resolution regarding the strait cannot be reached. Similarly, the production of carbonate solvents for lithium-ion battery electrolysers is heavily concentrated in China and in South Korea, creating other potential supply chain risks for a country like Indonesia that wishes to downstream its production.

6.0 Recommendations

6.1 Strategic Recommendations

The material in this report indicates that Indonesia finds itself at a crossroads and that each choice comes with potential trade-offs. A structural surplus of Class II commodities, coupled with the vastness of Indonesia's resources, has contributed to global oversupply and depressed prices. Combined with a relative lack of processing capacity further downstream and the short remaining lifespan of available reserves, these factors risk trapping Indonesia in an economic model that is centred on rapid exploitation of its natural reserves for low-value production. HPAL production would tap into reserves with a longer lifespan, but an overexposure on Class I production risks stranding Indonesia in a very competitive and risky market. It is clear that a balance must be struck between the current extractive model and an overextension toward Class I nickel production.

Indonesia may therefore wish to focus its nickel value chain development efforts in three areas: improving the profitability of nickel mining and refining; further developing the manufacture of downstream Class I nickel products, such as batteries and their components; and further expanding downstream from nickel pig iron and ferronickel to expand its production of stainless steel.

Switch to Lower-Cost Renewable Energy Sources and to More Sustainable Production Methods

Renewable energy generation costs have declined substantially and now situate the technology among the most competitive options in terms of cost per unit generated (IRENA, 2024). The government may therefore wish to revisit the regulatory framework to integrate renewable energy generation into mining operations, which could cut energy costs. Solar power is suitable for Indonesia, and government efforts to coordinate investment in solar parks can cut the costs of developing this form of energy (Hauber, 2025). Although it may be more costly for industries along the mineral value chain to run entirely on solar energy due to the need to combine such power with battery storage, hybrid solutions based on a mix of fossil fuels and solar energy can reduce energy costs, and for some facilities in Indonesia, hydropower can provide lower-cost energy than coal (Fauzianto et al., 2025). In addition, the government could improve the viability of renewable energy by increasing grid connections for industrial facilities and adding renewable energy generation to supply additional power through the grid (Fauzianto et al., 2025).

Another reason to increase the use of renewable energy is that doing so would substantially reduce emissions in these value chains, and high levels of emissions can negatively affect demand for metals and consumer products (Davis & Shafaie, 2023; Fauzianto et al., 2025; Peh, 2024). The government may therefore wish to take other measures to facilitate the use of renewable energy, which might include expanding electricity grid access, incentivizing the use of power wheeling (potentially through dedicated transmission infrastructure), expanding the grid in areas where relevant mines and industrial parks are located, and expanding interconnections with neighbouring countries to allow facilities to benefit from the low-carbon electricity generated in these countries. At the same time, the government will need to plan for the effects on coal-producing regions of the country—for example, by supporting the development of alternative livelihoods for coal miners who are likely to lose their jobs (Setiawan et al., 2025).

The strategic imperative for Indonesia is the aggressive deployment of HPAL technology, which represents the proven and essential process route for converting limonite ore into battery precursors. The economic rationale for this technological shift is compelling, as converting nickel ore into lithium, nickel, manganese, and cobalt materials for battery production is calculated to increase added value by up to 642 times (Anugrah et al., 2023). However, Indonesia's HPAL strategy must proactively address substantial environmental challenges inherent to laterite processing, particularly integrating low-carbon energy sources such as hydropower to mitigate high GHG emissions.

There is also a lack of skilled labour in the mining and mineral processing industries. This means that firms must rely on foreign labour, which raises costs. The government may wish to consider supporting universities to expand places for engineers, metallurgists, and geologists, and to strengthen the quality of teaching for such programs.

Expand Participation in Battery Value Chains

There appears to be much investor interest in battery manufacturing plants in Indonesia. By 2023, battery manufacturing plants with a total capacity of 90 GWh had been announced or were under development (Canto, 2023). In 2024, the country's first EV battery plant opened with investment by Hyundai Motor Group, LG Energy Solution, and the Indonesia Battery Corporation, producing battery cells using NMC chemistry with a total capacity of 10 GWh. And in 2025, construction began on an integrated battery complex that will cover all stages of the value chain from nickel mining to battery manufacturing (CATL, 2025). These projects suggests that it is commercially viable for the country to attract investment in this area.

However, there appears to be intense competition between countries around the world to develop EV battery industries within their territories, which may make it challenging for Indonesia to continue to gain market share in this area over time (Scurfield et al., 2025). To safeguard the future of its emerging battery industry, Indonesia may wish to leverage its position as one of the world's leading nickel and cobalt suppliers to encourage the signing of offtake agreements with firms such as car manufacturers to locate battery plants within the country, in return for reliable access to batteries. Due to the dominance of LFP batteries in China, Indonesia may wish to use commercial diplomacy (for example, export promotion agencies and overseas diplomatic missions) to promote exports of Indonesian-made batteries to other markets. These interventions are proven to promote export development (Afesorgbor, 2019; Cruz et al., 2018; Hayakawa et al., 2014; Marcelin & Nanivazo, 2019).

Moreover, ESG concerns about sourcing nickel-based products from Indonesia may discourage some car manufacturers to locate battery plants within the country. ESG concerns are important for consumer demand and broader company reputations. The government of Indonesia may therefore wish to address these concerns to strengthen its attractiveness as a location for manufacturing EV batteries. For example, allowing nickel and cobalt processing facilities to use captive renewable energy and/or expanding grid access could reduce concerns about GHG emissions from Indonesian production of the nickel and cobalt used in batteries. In addition, ongoing challenges include labour safety, land rights violations, and a lack of community consultation over mining projects in line with international norms.

Some commentators have raised concerns about the country's lack of lithium reserves for its emerging participation in EV battery value chains. Lithium is a key component in EV batteries, and Indonesia faces challenges in securing it. Even nickel-rich EV batteries require lithium-based chemicals (lithium hydroxide and/or carbonate; aheadoftheherd.com, n.d.).

Securing access to lithium products for use in Indonesian industry may not present a challenge in the short term. While there has been competition to secure offtakes, supply has exceeded demand for several years and this trend is expected to continue, in spite of rising demand (Williams, 2025). Indonesian companies can obtain lithium minerals on a commercial basis from nearby Australia, which was the source of more than 40% of the world's production of lithium content in 2023; the Indonesian government has indicated that it will import lithium minerals from Australia (GlobalData, 2025; Idoine et al., 2025). Though the market for lithium will be well supplied in the short term, by the 2030s, the IEA expects lithium supply shortages (IEA, 2025c). Indonesian industry may face lithium shortages if it does not secure long-term access to the mineral.

In addition to challenges in the long term regarding lithium sourcing, Indonesia may face difficulties with lithium refining. Currently, lithium is mainly refined in China (IRENA, 2023). Although China does not currently have export controls on lithium carbonate or hydroxide, the country does place controls on technologies related to lithium batteries and lithium-extraction technologies. Existing Indonesian lithium refinery PT Chengtok relies on Chinese processing technology, and access to this technology is a key competitive advantage in refining lithium for use in EV batteries (Anderson, 2025; Simamora, 2025). Restrictions on access to this specific technology could complicate Indonesia's efforts to develop its own refineries. Indonesia may therefore wish to pursue diversified access to processing technologies that allow it to secure its lithium supply. In addition, lithium refining carries significant environmental risks around high energy and water use, GHG emissions, and chemical waste handling. Indonesia may therefore wish to ensure that lithium refineries are subject to adequate environmental safeguards, and that these safeguards are respected and implemented. As mentioned in this report, the country's nickel industry has faced challenges related to non-compliance with environmental regulations, suggesting that non-compliance could also be a risk for lithium.

A lack of adequately trained workers for local battery manufacturing and a reliance on foreign technology due to weak research and innovation ecosystems also undermine Indonesia's competitiveness in battery production. Firms could reduce costs if they could hire more local battery experts and could also have a greater profitability if they were able to use locally developed intellectual property.

Accurately Estimate Potential Growth for EV Markets

As a potential latecomer to battery manufacturing, Indonesia may want to privilege internal consumption first, and then export to nearby countries. The IEA estimates that the share of EV car sales across Southeast Asia may reach 30% of total car sales by 2030. EVs are also estimated to reach the same share of the market in Indonesia alone. Overall, with the removal of EV import duties in countries such as Malaysia and Thailand, as well as the introduction of stimulus policies to encourage the adoption of electrified transportation, the IEA assesses the regional market to be positive and reveals a potential pathway for Indonesian industrial development (IEA, 2025d). Further studies on regional EV and battery market trends are encouraged.

Make LFP Contingency Plans

Indonesia benefits immensely from the nickel-rich battery chemistry trend and forecasts suggest that demand for nickel-rich battery chemistries will continue to grow in absolute terms until 2040. Nickel will also maintain its share of use in EV batteries through the same year, with producers on the ground predicting a stable role for nickel due to its improving cost competitiveness compared with LFP batteries. Nevertheless, there is a risk for Indonesia that these forecasts prove incorrect and that increasing LFP batteries and others could reduce demand for nickel-rich chemistries. The government may therefore wish to encourage technological agility and diversification or a focus on market segments where the disadvantages of LFPs (such as lower energy density) restrict their widespread application. Investment in both technologies is recommended by operators on the ground who see potential in both markets.

Maintain Investments in Alternative Uses for Nickel

Indonesia can reap substantial benefits from expanding downstream into the EV battery industry. However, it will be equally important to maintain investments in alternative uses of nickel that can help absorb the country's enormous production capacity. As stated above, single manufactured and semi-finished goods such as household appliances, consumer goods, components, and parts, as well as nickel for steel alloys, are estimated to be able to absorb 40% to 60% of Indonesia's nickel production by 2035 (Zuhdi et al., 2025). Similarly, while the extraordinary growth of demand for EVs cannot be overstated, the current global battery trade amounts to about half of the value of trade-in articles of iron and steel (ITC, n.d.), which might warrant caution against exaggerating efforts in the direction of EV battery manufacturing. Indonesia is therefore encouraged to maintain investment rhythms in nickel production that favour nickel pig iron and ferronickel to feed these end uses, and especially to stimulate the circularity of the industry by encouraging recycling practices and better use of mining waste. In addition, the country may wish to support localizing the manufacturing of products using stainless steel. In 2024, over 99% by weight of Indonesia's stainless steel exports were in semi-finished or hot-rolled forms (ITC, n.d.), meaning that the manufacture of stainless steel into products for use in construction, industry, or domestic settings occurred elsewhere.

In general, manufactured stainless steel products command a much higher price per kilogram than semi-finished or hot-rolled stainless steel. The price per kilogram of the stainless steel wire exported from Indonesia is about twice the price of semi-finished or hot-rolled products, while tube or pipe fittings and flanges of stainless steel earn about three times the price per kilogram. Prices for woven cloth of stainless steel can be even higher (United Nations, n.d.).

Expand the Use of Practices to Extract Nickel From Mining Waste and Expand Recycling Practices

Indonesia should stimulate research and development in processing technologies or streamlining and updating existing laws for mine waste recovery could be avenues to explore.

Similarly, Indonesia should seek opportunities to strengthen the collection and treatment of small electronics, consumer appliances, and other consumer goods that contain substantial amounts of nickel and that are the emblem of "urban mining."

Expand and Diversify Partnerships

Indonesia should pursue deeper and varied partnerships for the import of crucial technologies for processing and refining operations in its nickel and cobalt industry. At the same time, a diversified portfolio of source countries for lithium products and the establishment of multiple trade agreements across geopolitical fault lines can provide security against sudden supply constraints and price volatility, while facilitating investments (the Indonesia-European Union Comprehensive Economic Partnership Agreement could work as an example).

Make Contingency Plans for All Intermediary Inputs

The government of Indonesia should accurately map out all the inputs required for its downstreaming ambitions, aside from the critical minerals necessary for cathode and anode production. This preparation could help minimize unexpected supply chain restrictions.

6.2 ESG and Traceability Recommendations

Indonesia's nickel and cobalt strategy should evolve to balance industrial ambition with global ESG standards, strengthen domestic capabilities, and mitigate market and geopolitical risks. The following policy package integrates environmental safeguards, social protections, and technological upgrading to secure long-term competitiveness and premium market access.

Reserve Sustainability

- Consider optimizing not only primary minerals, but also by-products and tailings for national economic value, based on sampling guidelines for PT Timah's tailings in Belitung as a pilot project.

Decarbonization and Renewable Energy Transition

- Consider developing targets for renewable energy use for facilities along nickel, cobalt, and lithium value chains and associated industrial parks.
- Support the use of renewable energy by expanding grid infrastructure in areas where facilities operate. Introduce policies that allow power wheeling through the grid. Consider expanding grid interconnections that will allow facilities in Indonesia to benefit from low-carbon electricity produced in neighbouring countries.
- Coal-powered rotary kiln electric furnace operations should transition to renewable-based electric arc furnaces, targeting 40% to 60% emissions reductions by 2030 and linking permit renewals to credible decarbonization plans.

Labour Rights, Community Benefits, and Indigenous Rights

- Area-specific mitigation and understanding of local context should precede the design of any community development and empowerment program, and uniform mandatory standards should not simply be imposed across the board.
- Benefit-sharing should not be viewed as corporate philanthropy but as a right of the community. Research from the Research Centre for Politics and Government at Universitas Gadjah Mada shows that compensation received by communities is often reduced to cash payments and physical infrastructure, and even in that form, its distribution is inequitable due to the lack of a clear definition of which "community" is entitled to receive it.
- Participation forums should be government-facilitated rather than bilateral company-community forums, as assessments show that company-led forums tend to create new social hierarchies and rent-seeking relationships that are ultimately detrimental to community cohesion.
- Legislate to ensure that sociology, anthropology, and GESI expertise is present in the field, not only in Jakarta offices. ESDM itself has only recently recruited its first anthropologist, followed by additional sociologists and anthropologists within the Working Group.
- Legislate to ensure that all operators should comply with International Labour Organization core standards, conduct third-party labour audits every 6 months, eliminate forced-labour indicators, and ensure removal from the U.S. forced-labour list by 2027.
- Legislate to ensure that companies allocate revenues to apply FPIC-aligned processes where Indigenous and customary rights are at stake and align with the UN Declaration on the Rights of Indigenous Peoples.
- Strengthen and operationalize Indonesia's existing community development and empowerment framework by requiring transparent, participatory planning and monitoring, clear grievance pathways, and community oversight mechanisms for benefit-sharing. Where projects affect customary or Indigenous communities or lands, apply FPIC-aligned engagement and ensure agreements and benefit programs are

designed through meaningful consultation, with explicit provisions for women and other marginalized groups.

- All facilities should achieve International Organization for Standardization 45001 certification, integrate health impact assessments, and prioritize mitigation of respiratory and water-borne disease risks in host communities.
- Independent regional ombudsman offices should be established to mediate disputes, mandate remediation, and recommend permit suspensions when issues remain unresolved.
- Local community-benefitting projects that imply support for manufacturing activities should be tied to the government mandating the use of these products on a national scale.

Skills Development and Technology Innovation

- A national Nickel Technology Innovation Hub with a pre-defined annual budget should advance impurity reduction, recycling technologies, and solid-state precursor development in partnership with global and domestic research institutions.
- Producers should invest in workforce training, raise local technical employment, expand technical and vocational education and training programs in Sulawesi and Halmahera, and encourage in-company mentor-mentee programs to facilitate skills transfer.
- Foreign investors should establish joint research and development facilities and formal knowledge-transfer arrangements, particularly in cathode technology and advanced battery chemistry.
- The government can consider facilitating partnerships between Indonesian and foreign universities or allowing or encouraging the entry of foreign universities in Indonesia in the areas of mining, mineral engineering, metallurgy, geology, and battery technology. These initiatives would undertake research and provide courses in these areas to train workers in line with industry requirements. The focus should be on attracting leading foreign universities that can carry out cutting-edge research to support industry in Indonesia and equip workers with the skills needed to be hired in mineral value chains. Given China's leading role in battery technology, expanding existing partnerships with Chinese universities may be advisable.
- As Indonesia expands downstream industries for batteries, EVs, and renewable-energy components, national and subnational policies should ensure women's equitable access to emerging green and technical jobs. This includes integrating gender-responsive skills training; science, technology, engineering, and math education pathways; structured internships, mentorship programs, and workplace facilities such as child care to remove barriers to participation. Embedding these measures into industrial development strategies and sectoral regulations will support both a just transition and the creation of inclusive, sustainable employment opportunities. Preventive measures, inclusive planning, and good governance are essential to minimize risks and maximize community benefits.

Certification, Traceability, and Market Access

- A national digital chain-of-custody platform should be made operational to comply with the European Union Battery Regulation and the Organisation for Economic Co-operation and Development's due diligence requirements.
- A national quality-grading and testing system should prevent export of sub-standard nickel and strengthen Indonesia's premium reputation.

Strategic Implementation and Monitoring Framework

- A high-level Nickel Sustainability Task Force should monitor implementation of these actions, report to the presidency, and publish regular progress updates (at least annually).
- Annual public reporting and independent verification of ESG metrics should be mandatory, with penalties for misreporting.

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Published by the International Institute for Sustainable Development

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