From Ore to Opportunity

Value addition dilemmas and pathways for resource-rich countries

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About WDI

The William Davidson Institute at the University of Michigan (WDI) is a global non-profit affiliated with the University of Michigan that operates at the intersection of education, entrepreneurship, and impact across emerging markets. We are dedicated to unlocking the power of business and markets to tackle critical global challenges and drive inclusive economic growth. We mobilize entrepreneurs, investors, governments, and academia to drive pioneering solutions across sectors, with a focus on energy and e-mobility, climate-health, and health.

Methodology

This research was conducted and funded by WDI during the second half of 2025. The authors designed and scoped the research based on our experience with topics related to EV value chains in low- and middle-income countries, and in consultation with experts involved with critical minerals research and strategy within specific countries and at regional and global levels. We conducted an extensive literature review, interviewed several experts, and involved a number of practitioners in the review process to ensure the publication could be as accurate and relevant as possible. We also presented initial insights from our research at Africa E-Mobility Week in Addis Ababa, Ethiopia, in November 2025, and incorporated informal feedback we received during and surrounding the session.

We aim to build on this research with partners by digging deeper into related topics within the same and new countries. We welcome any feedback and suggestions for areas of future research and collaboration.

Executive summary

The global transition from a fossil-fuel-based energy system to one that relies on clean energy has heightened the importance of lithium, nickel, and other minerals critical to the development of electric vehicles (EVs) and clean-energy technologies. **Rapidly-expanding EV supply chains, in particular, present an immediate opportunity for resource-rich countries, many of which are low- and middle-income, to leverage their resources into higher-value roles.** These countries see this moment as a chance to break with old extractive models by "adding value" at home — processing, refining, and manufacturing instead of exporting raw ore. Many are now explicitly tying their critical minerals to ambitions in EV supply chains. Importing countries seek to secure supply and capture key segments of these value chains, opening the door to new opportunities and partnerships on one hand and increased competition on the other.

Yet, for resource-rich countries, turning geological endowments into broad-based development is far from straightforward. This report argues that value addition has been treated as an almost mythical objective — omnipresent in policy discourse but elusive in practice. Existing work tends to focus on enabling factors, such as infrastructure, a stable policy framework, and an investment climate, without fully unpacking the dilemmas and trade-offs inherent in different value-addition strategies. To fill this gap, the report examines two minerals (lithium and nickel) and four resource-rich countries (Chile, Ghana, Indonesia, and the Philippines) that highlight contrasting pathways in value-addition strategies related to the EV supply chain, considering different geologies, governance models, and contexts **(Figure 1 on page 5).**

Across these cases, our research shows that every pathway to value addition involves difficult choices. The report distills these tensions into **five core dilemmas,** cutting across minerals and geographies, that decision-makers must grapple with, and that will shape the outcomes of value addition strategies. **These dilemmas relate to pursuing a realistic position in the EV value chain, balancing control and governance with investment attractiveness, reconciling speed with appropriate standards and social license, reducing market dependence and expanding diversification, and managing technology and innovation risks.** By pointing to these dilemmas, we seek to underscore that policymakers' choices bring a host of effects, and involve key trade-offs that need to be carefully considered.

The report concludes that there is no single model to emulate. Instead, decision-makers need realistic, evidence-based strategies rooted in national goals, capabilities, and constraints — and a clearer view of who bears which risks and who captures which benefits, along with the relevant time horizon. By making these trade-offs explicit and drawing out lessons from four diverse country experiences, the report aims to support more realistic expectations and better-informed choices about how, and how far, to pursue value addition from minerals in the EV value chain.

For countries and decision-makers willing to confront these dilemmas, critical minerals can unlock new opportunities, anchor industrial ecosystems, and foster new development pathways — whether by carving out niches in refining, battery manufacturing, and EV assembly, or by specializing as suppliers of responsible materials and associated services. Exploring all possible pathways to value addition, with a clear view of the dilemmas and trade-offs involved, can help countries capitalize on opportunities and overcome constraints.

Figure 1: Summary table of countries examined

LITHIUM

Chile

MINING INDUSTRY

Chile is the world's top copper and second-largest lithium producer; mining comprises approximately 13.6% of its GDP. Almost all lithium is refined domestically into battery-grade carbonate (and some hydroxide) and exported to Asia, but Chile has no battery or cathode manufacturing, leaving major downstream value uncaptured.

GOVERNANCE FRAMEWORK

Lithium is legally "strategic" and "non-concessionable," so private firms operate only via state-controlled mechanisms (joint ventures and special contracts, for example).

VALUE-ADDITION STRATEGY

Chile leverages more sustainable production backed by high renewable electricity. Innovation is key, with a focus on direct lithium extraction (DLE) to optimize production and reduce negative impacts. It seeks to create opportunities for small and medium enterprises (SMEs) involved in the mining industry and battery recycling.

NOVEL VALUE-ADDITION POLICIES

There are preferential pricing and secure supply agreements for investors willing to build downstream plants and earmarked R&D/public-goods payments from mining companies.

KEY CONSTRAINTS

Chile must grapple with a lack of an automotive end market, social and environmental concerns, dependence on still-unproven DLE, repeated failures of downstream projects, and a new, more pro-deregulation government likely to speed permitting at the risk of weakening environmental and social safeguards.

LITHIUM

Ghana

MINING INDUSTRY

Ghana is the leading producer of gold in Africa and sixth in the world, but the country has seen limited dividends from its mineral wealth so far. Ghana's first commercial lithium project at Ewoyaa has faced repeated delays and is yet to be ratified by the parliament to enable lithium production.

GOVERNANCE FRAMEWORK

This is a predominantly private-led model with the state holding a non-contributory 10% "free carried" equity interest in all large-scale mining leases, alongside fiscal take-through royalties and taxes.

VALUE-ADDITION STRATEGY

The current lithium project agreement includes a requirement for local refining, pending a feasibility study.

NOVEL VALUE-ADDITION POLICIES

Ghana is exploring byproduct related opportunities and taxation reforms to enable further investment in exploration.

KEY CONSTRAINTS

Lithium price volatility and governance concerns have stalled the Ewoyaa project, leading to economic hardship for local communities and social and political risk to Ghana's lithium ambitions.

NICKEL

Indonesia

MINING INDUSTRY

Indonesia is the world's top nickel producer and has the most reserves in the world. Most of the deposits are laterite (lower-grade), which are best suited for the stainless steel industry. The country is making a concerted effort to transition to processing its nickel domestically for use in EV batteries.

GOVERNANCE FRAMEWORK

The central government has constitutional authority over mining activities, including permitting and licensing , and does so to a mix of private and public entities.

VALUE-ADDITION STRATEGY

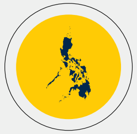
Aligning its minerals with integrated EV-battery ambitions , Indonesia has invested in and incentivized EV battery and vehicle manufacturing locally, set targets to grow the domestic EV market, and is promoting recycling and end-of-life innovation.

NOVEL VALUE-ADDITION POLICIES

An export ban of raw nickel ore, targets, and a variety of fiscal and non-fiscal incentives spanning several years have been key to Indonesia's value-addition strategy.

KEY CONSTRAINTS

Despite indications of success, significant challenges persist related to environmental damage and deepening social inequality, dependency on China for investments and offtake, and demand risk if the EV battery market continues to shift away from nickel-based chemistries.



NICKEL

Philippines

MINING INDUSTRY

The Philippines is the second-largest producer of nickel (laterite deposits) and has a long history of exporting raw ore. It has started transitioning processing in a limited way to align with EV-related opportunities. Nickel ore is largely exported to China and Indonesia for further processing and manufacturing.

GOVERNANCE FRAMEWORK

All mineral resources are owned by the state, and the state exerts control over all aspects of mining and processing, working with private sector entities through agreements.

VALUE-ADDITION STRATEGY

The government seeks to foster a mining "renaissance" with a focus on local value addition.

NOVEL VALUE-ADDITION POLICIES

In 2025, the government passed a new mining law that included fiscal reforms but notably did not include a previously-proposed nickel ore export ban that would have been similar to Indonesia's.

KEY CONSTRAINTS

There are major social and environmental concerns associated with mining in the country that could be exacerbated by increased activity, and a lack of strong enablers such as reliable power, infrastructure, regulations, and incentives hinder private investment.

Introduction

The energy transition hinges on minerals. The "race" to secure these minerals is reshaping geopolitics and development pathways worldwide and creating two major country groups: those that have them and those that want them. For countries that have them ("resource-rich countries"), the current imperative — driven by growing demand for these minerals as crucial inputs for energy transition technologies — is to turn their geological endowments into domestic economic transformation via value addition. The aim is to **move beyond shipping out raw minerals toward processing, refining, and producing goods within a country or region, creating economic linkages that translate into greater value and benefits locally**.

This is particularly important given that many resource-rich countries are also low- and middle-income countries that have seen limited development gains to date despite their endowments. Framed this way, value addition is seen as an opportunity to break old patterns of extractivism, where producers gain little from their resources as higher-value industries are built abroad.

For countries that want these minerals, the goal is to secure and control their supply through a variety of mechanisms, while also striving to capture a greater share of the value embedded in energy transition technologies that these minerals make possible. This dynamic offers promising opportunities for both sets of countries, but capitalizing on these opportunities comes with challenges.

Minerals may be considered **"critical"** by a country when they serve as significant direct inputs to important actual or planned industrial activities but are not available domestically in sufficient quantities. The International Energy Agency (IEA) defines critical minerals as those that are essential inputs for clean energy technologies and whose supply is at risk due to geographic concentration, long lead times, declining resource quality, and environmental or social challenges of production.[1] The criticality of the minerals also hinges on the difficulty, cost, and performance penalties of substituting away from a given mineral,[2] and it is highly context- and country-specific.

The use of "critical" is not universal, however. Many stakeholders in Africa, for example, call these "green minerals," as they are used to build clean energy and green industrial value chains3 and because this term centers their development and energy transition priorities. Some key producing countries use the term "strategic mineral" or "strategic asset,"4 while other players may refer to them as "energy transition minerals"5 or "critical resource materials." In this report, we use the overarching term "critical minerals," but we examine them primarily through a developmental lens — asking how resource-rich countries can define and use their minerals to support value addition and their own industrialization and energy transition goals.

> The aim is to move beyond shipping out raw minerals toward processing, refining, and producing goods within a country or region, creating economic linkages that translate into greater value and benefits locally.

While minerals may be considered critical for one country, they may not be so for others, and this criticality is also dynamic. What's critical today may not be so tomorrow, since the importance of a mineral and the nature of its supply chain can change due to a variety of factors. Furthermore, given the growing risks associated with access, production, and availability of supply, "criticality" is a risk-assessment measure.[6] Minerals deemed critical by different countries and regions are listed in **Figure 2 on page 7**.

1 International Energy Agency (IEA). 2022. The Role of Critical Minerals in Clean Energy Transitions.
2 Nassar, N., et al. ScienceAdvances. 2020. Evaluating the mineral commodity supply risk of the U.S. manufacturing sector.
3 African Minerals Development Centre, African Union. December 2024. Africa's Green Minerals Strategy.
4 The International Institute for Sustainable Development. May 2023. ASEAN-IGF Minerals Cooperation: Scoping study on critical minerals supply chains in ASEAN.
5 Canpolat, Ezgi; Lokanc, Martin; Bakx, Jara; Baker, Steven; and Kaplan, Karen. World Bank. 2025. Fostering a Just Transition in the Energy Transition Minerals Sector in the Eastern and Southern Africa Region.
6 IGF. 2024. What Makes Minerals and Metals "Critical"?

Figure 2: Minerals defined as critical by countries and regions

Critical Minerals	Africa[1]	ASEAN[2]	LATAM[3]	US[4]	EU[4]
ALUMINUM	●	●		●	
BAUXITE		●	●	●	
BISMUTH				●	●
CHROMIUM	●			●	
COBALT	●	●	●	●	●
COPPER	●	●	●		
GOLD		●	●		
GRAPHITE	●		●	●	●
IRON	●	●	●		
LEAD			●		
LITHIUM	●		●	●	●
MANGANESE	●	●		●	●
MOLYBDENUM			●		
NICKEL	●	●	●	●	
PHOSPHATE	●				●
PLATINUM GROUP METALS	●			●	●
RARE EARTH MINERALS	●	●	●	●	●
SILVER			●		
TIN		●	●	●	
TITANIUM	●			●	
TUNGSTEN		●		●	
VANADIUM	●			●	●
ZINC	●		●	●	●

Note: For Africa, the minerals included correspond to those identified as core minerals under the African Green Minerals Strategy; for ASEAN and Latin America, those that contribute to the regions' production of globally recognized critical minerals; for the United States, minerals designated as critical by the country; and for the European Union, those deemed critical by the region.

Sources: [1]African Green Mineral Strategy; [2]ASEAN Centre for Energy; [3]ECLAC; [4]Jara, J. J.; Real, I. d., Guerrero Rojas, R.; and Hennings, B. BID. 2025. Minerales estratégicos de Chile.

Several additional factors further complicate the picture regarding critical minerals. While they are generally abundant globally, their mining and processing are geographically concentrated, with China currently dominating the processing of all major minerals. Many of the mineral resources have not been fully mapped, and data are unavailable in some cases. Additionally, levels of reserves (the mineral resources that can be accessed and profitably extracted) are dynamic and evolve as the minerals are mined. In many cases, easier-to-reach and higher-quality reserves have already been mined, making it more difficult and resource-intensive to extract and process additional reserves. In addition, sizable capital investments are needed to mine them — a challenge compounded by the lengthy timelines of mining development. The fact that environmental degradation and social exclusion in decision-making have historically accompanied mining activity worldwide further exacerbates these challenges for resource-rich countries.

Critical minerals are important because they are crucial inputs for clean energy technologies that are changing the way we power our energy system — across generation, storage, and use. **Chief among the technologies that require critical minerals are EV batteries, which account for the vast majority of global lithium-ion battery demand today.**[7] Beyond EVs, minerals are also crucial in the development of wind turbines, solar panels, grid infrastructure, and other clean energy technologies, and are therefore key enablers of the energy transition.

According to the IEA, demand for these minerals is expected to triple by 2030 and may quadruple by 2040, driven primarily by EVs and energy storage.[8] This surge in demand creates new opportunities for

7 Jaber, Samir. MetalsHub. August 2025. What's Driving Lithium Demand in 2025 and Beyond?

8 IEA. Critical Minerals.

> Rapidly-expanding EV supply chains, in particular, present an immediate opportunity for these countries to leverage their resources into higher-value roles.

resource rich countries to strengthen their longstanding role in mineral value chains and further enhance their position, while striving to generate the local economic benefits, jobs, and other opportunities that their communities demand and deserve. Rapidly-expanding EV supply chains, in particular, present an immediate opportunity for these countries to leverage their resources into higher-value roles. Many resource-rich countries are explicitly tying their critical minerals to the EV transition, positioning themselves not just as raw material suppliers but as emerging battery and manufacturing hubs. However, the window of opportunity to turn ambition into reality is quickly closing. Capturing market share will only become more difficult for new entrants as we move into the 2030s, raising the stakes for developing and implementing strategies that drive value addition.

As the discourse goes, value addition has become an almost mythical objective that seems both omnipresent in policy discussions and unachievable. Plus, while recent research examines the enabling factors for value addition, the dilemmas and trade-offs posed by different value-addition strategies for resource-rich countries receive less attention. This report fills that gap, dissecting trade-offs by analyzing the experience of four resource-rich countries with diverse strategies, policy frameworks, and goals. Rather than simplifying "value addition" as a panacea, we embrace nuance, delving into four different pathways and the interconnected factors that play a role in moving from ambition to reality, highlighting dilemmas that, while seen as predicaments, can also clarify the way forward.

Getting value addition "right" matters because the stakes are high. For resource-rich countries like Chile, Ghana, Indonesia, and the Philippines, moving even one or two steps down the value chain can multiply export earnings by shifting from raw ores to refined products and battery materials, rather than leaving most of that value to be captured abroad. Well-designed strategies can also anchor new industrial and services ecosystems around mining — engineering, infrastructure, logistics, maintenance, and adjacent services — that generate jobs and additional economic linkages, thereby advancing the broader development goals of resource-rich countries.

The quest for value addition

Many resource-rich countries have historically seen intensive mining activity and raw material exports, with limited economic benefits and well-documented negative social and environmental consequences. Moving beyond raw material extraction to opportunities further down the value chain — i.e., toward more complex economic activities, in particular, those tied to EV supply chains — is therefore the subject of much debate and the stated goal of many resource-rich countries. Across all regions, stakeholders are converging on a multi-dimensional view of value addition, linking it to economic diversification, technology capabilities, and equitable benefit sharing, among other gains. While the motivations vary, the goal is clear, but the strategies to achieve this goal diverge.

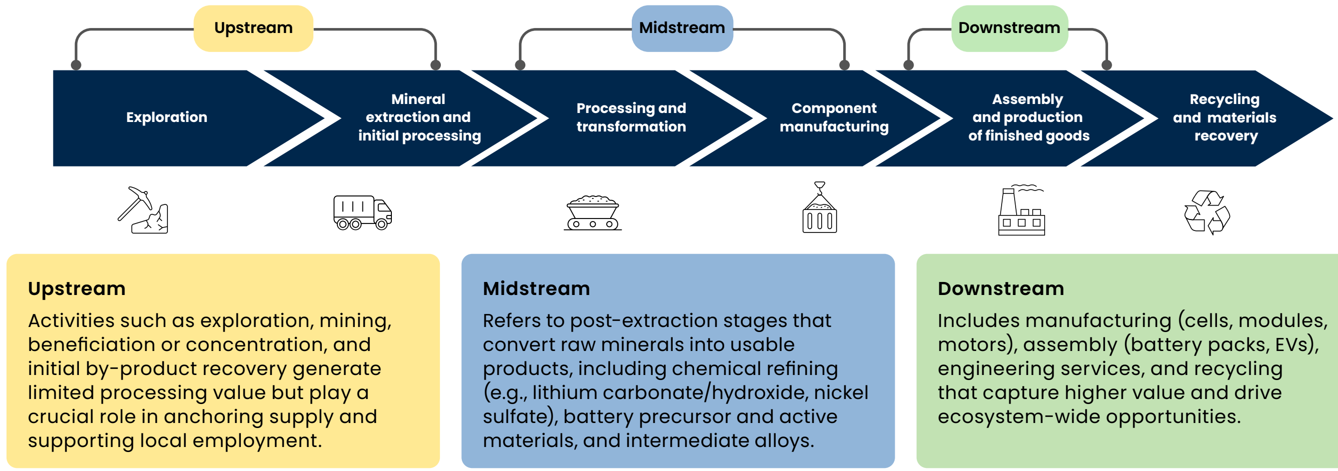
In **Africa**, the emerging regional agenda on "green minerals" explicitly seeks to move beyond extraction toward integrated, value-adding roles in global supply chains. The African Union's Africa's Green Minerals Strategy (AGMS), adopted in 2025, sets out a continental roadmap to shift from raw mineral exports toward value-addition activities, building on the Africa Mining Vision and leveraging the African Continental Free Trade Area to develop shared mineral corridors and processing hubs.[9] To get there, AGMS emphasizes common standards, local content, and joint infrastructure planning so countries like Ghana are not forced to "go it alone" when seeking to capture opportunities related to the EV supply chain. Instead, they can aggregate feedstock, pool demand, and coordinate policies at a regional level.

Southeast Asia is emerging as a key supplier region for nickel and other critical minerals, with regional cooperation as a priority for the Association of Southeast Asian Nations (ASEAN). The ASEAN Minerals Development Vision (AMDV) intends for ASEAN to be "a leading destination for minerals investment, including in critical minerals" by 2045. To move from vision to reality, ASEAN countries agreed on an action plan that will guide implementation, and which highlights the need for cooperation across the full value chain, exploring harmonized standards to reduce the risk of a race to the bottom and strategies to increase diversification. The AMDV seeks to build production and trade through technological advancement, sound governance, and best practices related to the environment, sustainability, and community empowerment.[10]

In **Latin America**, initiatives led by the Economic Commission of Latin America and the Caribbean, the Inter-American Development Bank, and the Latin American Energy Organization highlight the potential

9 African Minerals Development Centre. September 2025. African Green Minerals Strategy: An Explainer.
10 Assocaition of Southeast Asian Nations. ASEAN Minerals Development Vision.

Figure 3: Critical minerals value chain for EVs



Source: Developed by WDI

of developing a regional agenda for strategic minerals, leveraging lithium and copper reserves. This agenda also links Chile, Argentina, Bolivia, Mexico, and other countries to scale processing, test and deploy new technologies (including DLE), and increase their chances of engaging in downstream opportunities, such as battery materials and recycling. This vision underscores the potential of Latin American value-added clusters rather than fragmented national efforts.[11]

Since value addition is the goal, adopting robust metrics to assess how much value is created, how it is distributed, and who benefits is crucial. There is no single standardized value-addition set of metrics for minerals, but countries and regional initiatives often track combinations of export composition, GDP, investment, government revenue from critical minerals, local content, and employment metrics to assess the value created locally.

How is value created along the value chain? In general, mineral value chains are structured into three main blocks: exploration, mining extraction, and initial processing (upstream); mineral processing and transformation, also known as "beneficiation", i.e., refining, production of advanced materials, and semi-manufactured products (midstream); and assembly or production of end-use goods, as well as recycling and recovery of materials (downstream).[12] (**Figure 3**).

Progressing through these stages from the upstream requires increasingly sophisticated know-how and an enabling environment to support these operations, as this report demonstrates in subsequent sections. Engaging beyond upstream offers economic advantages: margins and capabilities rise significantly in the ***midstream*** — processed materials command significant price premiums and create more local value than unrefined ores, because additional labor, energy, and technology are embedded in them.[13] The ***downstream*** offers substantial opportunities for job creation through manufacturing and related services, drawing in suppliers, logistics, engineering, and maintenance activities that capture higher value and support broader local industrial ecosystems. At the end of the chain, battery recycling and materials recovery offer an opportunity to close the loop, with recovery rates from 60–95%[14] of the value from end-of-life EV batteries. Recycling can also create value addition through spillover effects, increase feedstock for local or neighboring manufacturing hubs, and can ultimately reduce the need for additional primary mining of these minerals.

While adding value through a range of additional economic activities linked to mineral resources can amplify economic benefits, raise domestic income, create jobs, and help diversify a country's economy, mining, refining, and processing these minerals often amplifies negative environmental impacts and creates serious social and economic disruption to local communities. Therefore, as countries pursue increased value addition, they must consider social implications and environmental impacts from the outset.

In some cases, these and other implications may mean that pursuing value-addition pathways may not be beneficial or viable for a particular country. If the pursuit of value addition from critical minerals is undertaken without understanding potential implications, including the associated negative consequences, the result could effectively negate the value added — running counter to the goal of expanding benefits from such minerals.

11 Siroit, G. Olade. 2024. Los minerales críticos para las transiciones energéticas de América Latina y el Caribe.
12 Jara, J. J.; Real, I. d., Guerrero Rojas, R.; and Hennings, B. BID. 2025. Minerales estratégicos de Chile.
13 International Renewable Energy Agency (IRENA). Geopolitics of the Energy Transition: Critical Minerals.
14 RMI. 17 January 2024. Understanding how EV battery recycling can address future mineral supply gaps.

Value addition strategies: Two minerals, four countries

Critical minerals can serve as an entry point for countries to engage in the EV supply chain and support broader development and industrialization goals. What value-addition strategies are resource-rich countries pursuing as the transition to EVs opens new opportunities around the world?[15] And, crucially, how are they navigating the dilemmas embedded in different strategies?

To explore these questions, we selected two minerals for our focus: lithium and nickel. They both play a crucial role in enabling EV battery production and offer interesting points of comparison and contrast.

In the following pages, we look at four countries that have these minerals in different deposit types and concentrations: Chile and Ghana for lithium, and Indonesia and the Philippines for nickel. All four countries are interested in capturing more local value from their minerals and attracting EV-related investments. Chile and Indonesia have tested and adopted different value-addition strategies with mixed results, while the Philippines and Ghana are earlier in their journeys toward pursuing value addition and are currently grappling with decisions that will determine their paths. This diverse grouping will allow us to examine how resource-rich countries are adding value or planning to do so across the value chain and how they are navigating the tensions and dilemmas that arise. We then present insights from these examples that could be useful for other countries as they consider their options.

Minerals profiles

ROLE IN ENERGY TRANSITION

Lithium's relevance to the energy transition is closely tied to EVs, as the current dominant EV battery chemistries are lithium-based, given this mineral's high energy density. While lithium's end uses vary from ceramics and glass to lubricating greases and air treatment, 87% of it is used for energy storage in batteries.[16]

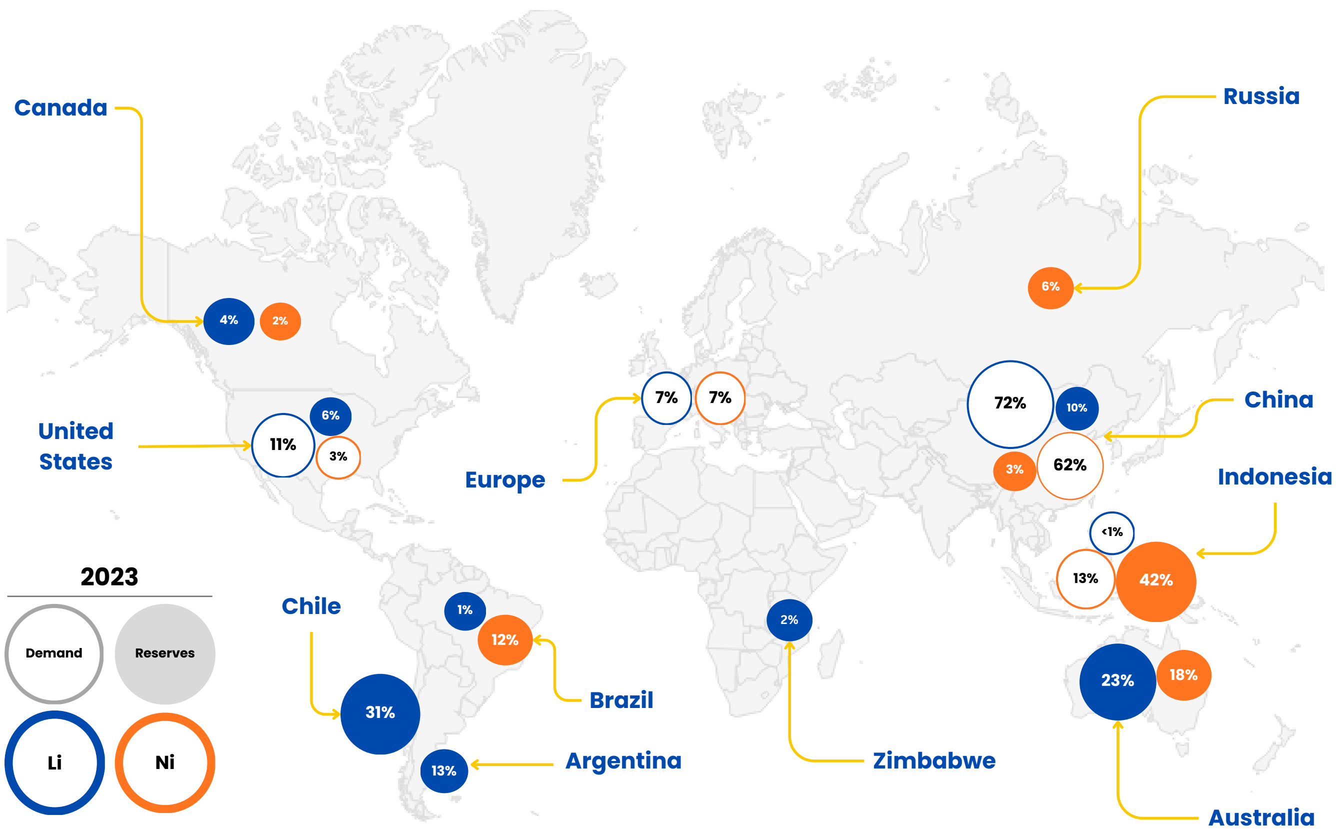
Nickel is important across multiple energy transition technologies, including EVs and battery storage (helping improve battery life and performance), geothermal, hydrogen, wind, concentrated solar power, and nuclear — and to a lesser extent, solar photovoltaic, hydropower, bioenergy, and electricity networks.[17] Nickel production is also linked to another critical mineral in the EV battery value chain: cobalt, which is a byproduct of certain nickel mining and processing methods.[18]

RESERVES

For both minerals, known reserves are highly concentrated geographically, as is demand and processing. As shown in the map below (**Figure 4**), nearly three-quarters of the known nickel reserves are concentrated in three countries: Indonesia, Australia, and Brazil. Nearly half are in Indonesia. Nickel is one of the few minerals that is

15 WDI has been generating insights and perspectives on the EV transition in low- and middle-income countries for the past several years. View some of our relevant work **here.**
16 Peñaloza-Pacheco, L.; Triantafyllou, V.; and Martínez, G. February 2026. The non-green effects of going green: **Local environmental and economic consequences of lithium extraction in Chile.**
17 IEA. **Mineral requirements for clean energy transitions.**
18 Benchmark. 15 September 2023. **Two-fifths of cobalt could come from nickel mines by 2030.**

Figure 4: Map of key reserves and countries driving demand for nickel and lithium (2023)



Source: Created by WDI based on data from Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (2023)

not almost entirely processed in China, and the balance is expected to continue shifting away from China as Indonesia's processing infrastructure grows. Lithium reserves are similarly concentrated, with two-thirds of known reserves in three countries: Chile, Australia, and Argentina. One-third are in Chile. China leads the market in terms of demand for these minerals, as well as for many other minerals not highlighted in this report.

MINING AND PROCESSING PATHWAYS

Lithium can be extracted from underground brine beneath salt flats or mined from hard-rock pegmatites and clay deposits. Most of the world's identified lithium reserves are concentrated in brine deposits beneath salt flats, notably in the "lithium triangle" of South America (Chile, Argentina, Bolivia). Most of the remainder sits in hard-rock pegmatites. Clay-hosted deposits represent a small but growing portion of the global resource base. Extracting lithium from brine is a process that relies on large evaporation ponds used to concentrate lithium over a long period of time, a process that involves multiple steps and is weather-dependent. The direct output of brine extraction is lithium carbonate, a standard input for lithium iron phosphate (LFP) batteries, but it must be processed into lithium hydroxide for use in other battery chemistries.

A novel technology, direct lithium extraction (DLE), promises to accelerate this process. Multiple analyses indicate that DLE could raise lithium recovery rates from the typical 40–60% to roughly 70–90% and enable the use of lower-grade brines.[19] Although there are several pilots in operation, this technology has not been commercialized at scale. Hard-rock lithium, found in Australia, China, Zimbabwe, and Ghana, among other countries, involves open-pit mining of spodumene-bearing pegmatites, following a conventional mining process. Hard-rock processing can produce either lithium carbonate (for LFP batteries) or lithium hydroxide directly. Lithium hydroxide is preferred for nickel manganese cobalt (NMC) and nickel cobalt aluminum (NCA) batteries.

Nickel is mined from two types of deposits: sulfide (found in Australia and Russia, among other countries) and laterite (found in Indonesia and the Philippines,

19 Li, Eyal; Sacco, Stefano; and Bieker, Georg. October 2025. International Council on Clean Transportation and Centro de Movilidad Sostenible. Expanding the lithium value chain in Chile: Mining, batteries, and recycling.

among other countries). These deposits are processed using different methods, for different end products, and with different environmental impacts. The majority of the global nickel market is driven by the stainless steel industry, accounting for more than 60% of demand in 2023. Still, the share used for EV batteries is increasing.[20,21] Sulfide nickel is a higher-grade ore that can be more easily processed into nickel for EV batteries, but the vast majority of global nickel deposits are lower grade laterite ores, which are generally processed into nickel pig iron (NPI), a crucial input to steelmaking. Laterite ores cannot be economically processed via traditional smelting into battery-grade nickel due to high iron and magnesium content. These ores are transformed into mixed hydroxide precipitate (MHP) to manufacture nickel sulfate for EV batteries through a process known as high-pressure acid leaching (HPAL).

HPAL has advantages, including the recovery of cobalt, which is not possible with other nickel processing technologies. It also has disadvantages, including high capex and environmental concerns arising from large volumes of toxic waste.[22] HPAL still represents a small share (<20% in 2024) of all laterite nickel processing, but that share is increasing as interest in capturing EV-related opportunities grows.[23] Reducing the environmental impact of mining and processing nickel is a major concern, and there is recent innovation in this space, for instance, by shifting to clean energy sources to power these processes or developing new methods to extract metals from ore or e-waste without high-temperature requirements.[24]

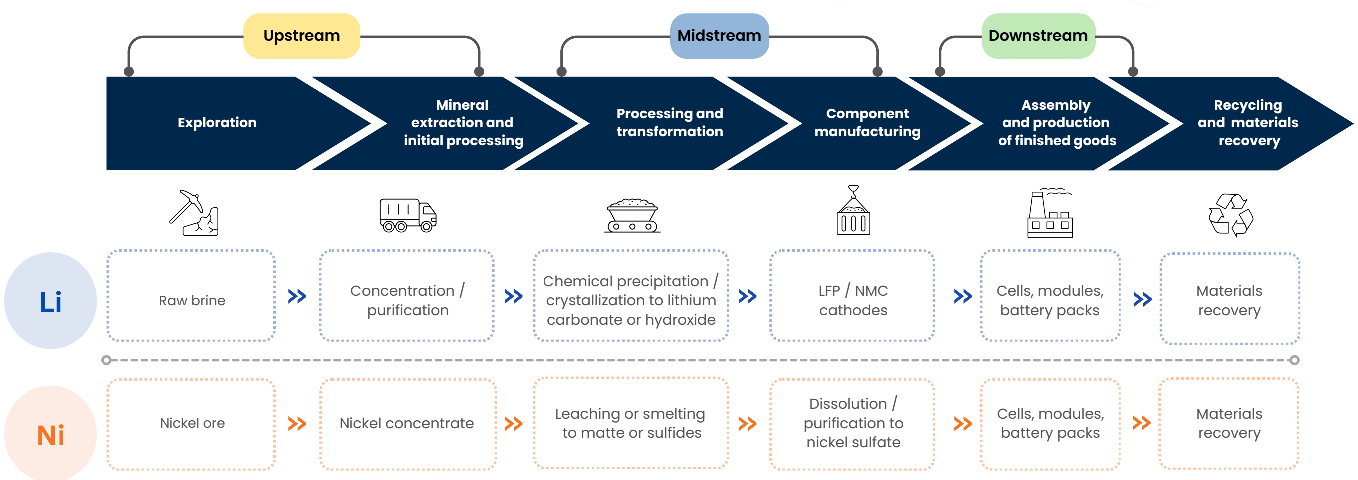
PRICE VOLATILITY

After major surges through late 2022, lithium prices fell by around three-quarters in 2023, while nickel and cobalt prices declined by roughly 30–45%, reflecting a combination of new supply, slower-than-expected EV growth, and changes in battery chemistry choices.[25] These sharp swings in lithium and nickel prices have made the financing and timing of new processing and manufacturing investments more challenging in recent years. This volatility increases the risk that value-addition strategies launched in boom years will stall or backfire when prices fall, leaving producing countries with stranded assets, fiscal gaps, and unfulfilled promises to their communities.

VALUE CHAINS

For both minerals, moving down the value chain means transforming the raw commodities into products of greater economic value,[26] from brine and ore to finished products. This includes battery cells that eventually power EVs and are then, ideally, recovered and repurposed or recycled to feed into new products (**Figure 5**).

Figure 5: Lithium and nickel value chains leading to EV batteries



20 Benchmark. 11 July 2023. Nickel demand for batteries to overtake stainless steel in late 2030s.
21 Azevedo, Marcelo; Goffaux, Nicolas; and Hoffman, Ken. McKinsey & Co. 11 September 2020. How clean can the nickel industry become?
22 S&P Global. 3 March 2021. Rising EV-grade nickel demand fuels interest in risky HPAL process.
23 Zheng, Z., et al. 25 January 2025. China Geology. Nickel extraction from nickel laterites: Processes, resources, environment and cost.
24 IEF. 9 January 2024. Nickel - a mineral with a challenging role in clean tech.
25 IEA. 17 May 2024. Global Critical Minerals Outlook 2024.
26 United Nations Conference on Trade and Development. October 2024. Structural transformation through domestic value addition in commodity-producing developing countries.

Country profiles

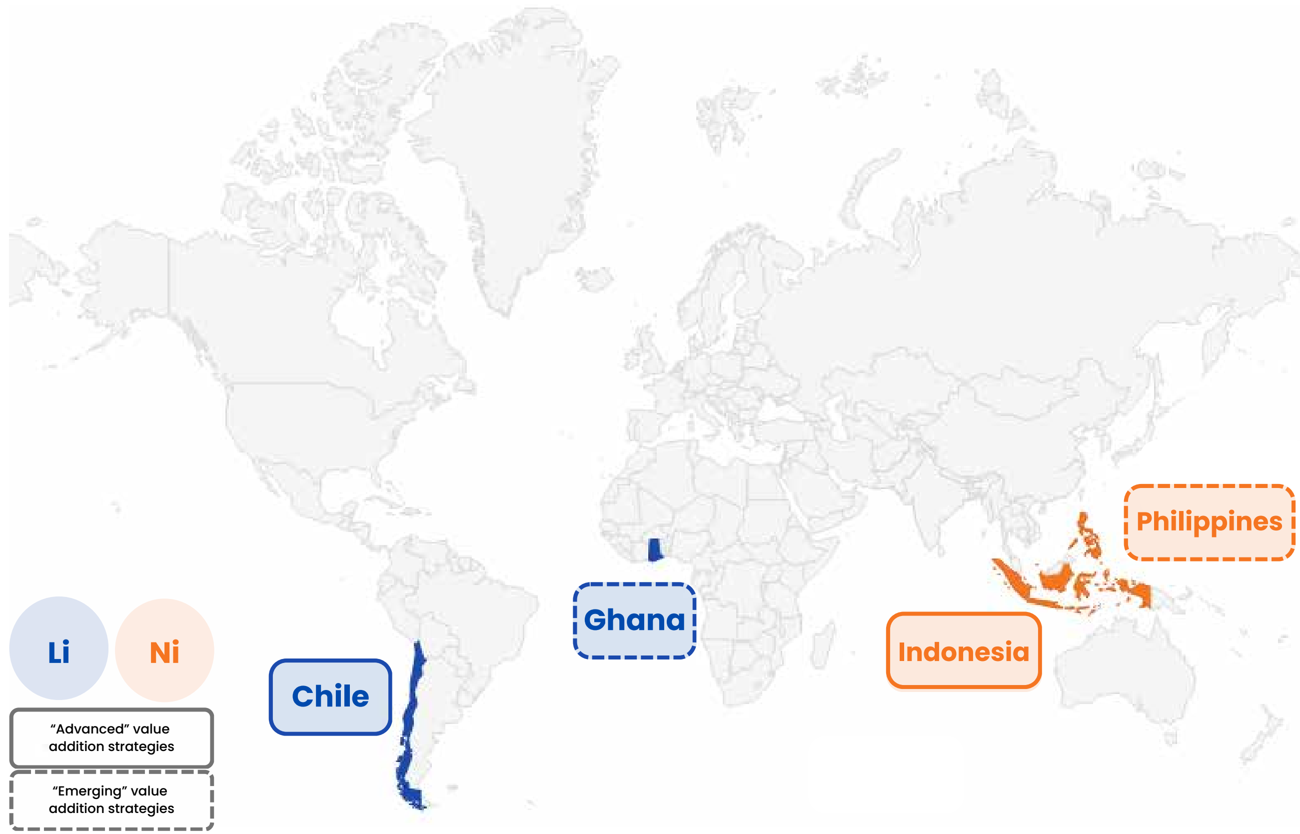
The countries we selected (**Figure 6**) are diverse in terms of the minerals and types they have, their political economy and overall value-addition goals, and the strategies they have pursued to advance such goals. Since many of these strategies are fairly recent and their implementation is ongoing or not yet in effect, their impact is difficult to assess. Instead, examining the experiences of these countries helps us identify early lessons and implications for others pursuing similar pathways.

Since conducting an exhaustive assessment of each country is beyond the scope of this report, we focus on key aspects that paint a picture of each country's context and approach to creating value from its critical minerals. In turn, the picture that emerges will help illustrate how these countries are navigating the **five core dilemmas** we outline in this report: pursuing a realistic position in the EV value chain; balancing control and governance with investment attractiveness; reconciling speed with appropriate standards and social license; reducing market dependence and expanding diversification; and managing innovation and technology risks.

In the vignettes that follow, we focus on each country's governance framework for resource development, the high-level strategies they have adopted, and novel mechanisms or policy tools they have designed to pursue value addition, as well as downstream EV market opportunities currently available to them and key challenges and constraints.

Why are these factors important? The **governance framework** for resource extraction and development profoundly shapes each country's ability to leverage its resources for broader economic development, by either enabling or hindering high-quality investment, value creation and retention, and social license, for example. These frameworks open up a range of **strategies** resource-rich countries can use. The selected strategies, and, crucially, their implementation, will in turn determine how successful countries are at creating added value. While there are commonalities in the strategies, countries are using different **policy tools** to affect their desired outcomes. As they pursue their strategies, it is important to keep in mind the available **downstream market opportunities** related to the EV supply chain and dynamics. Finally, each country's pathway exposes it to a different set of **challenges**, illuminating lessons and insights that can be helpful to other countries considering their options.

Figure 6: Focus countries and minerals



LITHIUM

Chile

IN BRIEF

Chile has a well-established mining industry; it is the top copper producer and the second lithium producer globally.[27] The mining industry contributes 13.6% of Chile's GDP.[28] Currently, Chile produces more than 20% of global lithium and holds 31% of global reserves.[29] Chile's lithium is produced from brine found in salt flats and is concentrated in the Atacama desert. [30] It has the lowest production costs for lithium in the global market.[31]

Two major companies produce lithium in Chile from a single deposit, the Salar de Atacama: Sociedad Química y Minera, known as SQM (Chile-owned with Chinese investment) and Albemarle (U.S.-owned). Chile processes most of its lithium into battery-grade lithium carbonate and to a much lesser extent lithium hydroxide. Lithium carbonate is exported mainly to China, then South Korea and Japan, while the smaller hydroxide stream goes to South Korea with some flows to Europe and the U.S.[32] In 2025, nearly all of the lithium mined in Chile was expected to be refined domestically.[33] There is no battery component production in Chile, so many opportunities remain to be captured further down the value chain.

Chile aims to double lithium carbonate equivalent production by the end of the decade, but recent research implies there is a gap between ambition and currently announced projects,[34] meaning achievement depends on accelerated approvals, financing, and successful new projects developed in the next few years.

GOVERNANCE FRAMEWORK

Chile classified lithium as a "strategic" and "non-concessionable" mineral in 1979 based on its potential applications for nuclear technology. This historical designation means that, unlike copper or most other minerals, new private mining concessions cannot be granted for lithium. The state retains control and can only allow production through specific legal mechanisms. Chile's current model therefore requires private companies to form joint ventures with the state or obtain special operating contracts, rather than holding standard mining concessions. Chile launched its National Lithium Strategy in 2023, which categorizes the country's salt flats to determine who can develop them and under what terms. It also determines which salt flats are off-limits, with the goal of balancing conservation with state-led value capture.

27 International Trade Administration. 2025. Chile Country Commercial Guide.
28 OECD Rural Studies, 2023; International Trade Administration, 2023, cited in ICCT/CMS. Expanding the lithium value chain in Chile: Mining, batteries, and recycling.
29 ICCT. 8 October 2025. How Chile can expand from lithium mining to a Latin American center of battery production.
30 Jara, J. J.; Real, I. d., Guerrero Rojas, R.; and Hennings, B. BID. 2025. Minerales estratégicos de Chile.
31 Jara, J. J.; Real, I. d., Guerrero Rojas, R.; and Hennings, B. BID. 2025. Minerales estratégicos de Chile.
32 OEC. Lithium carbonates in Chile.
33 ICCT. 8 October 2025. Expanding the lithium value chain in Chile: Mining, batteries, and recycling.
34 ICCT. 8 October 2025. Expanding the lithium value chain in Chile: Mining, batteries, and recycling.

Specifically, 30% of all salt flats will be "protected" by 2030, and thereby excluded from extraction. "Strategic" salt flats require state majority ownership (50% +1), and "open" salt flats can be developed through competitive tenders by private companies without state equity.

The strategy sets a state-led, public-private model with majority state control in salt flats deemed "strategic." Initially, the country's existing state-owned copper companies, Codelco and Enami, will play leading roles in lithium development for strategic areas by partnering with private companies. The strategy also calls for the establishment of a National Lithium Company, pending congressional approval that has not been granted yet.

In late January 2026, Chile launched its new National Critical Minerals Strategy, which includes recommendations under five strategic pillars: production and diversification; responsible mining; development opportunities from critical minerals; international engagement and mineral diplomacy; and enabling capacities for implementation. Though implementation falls to the incoming Kast administration—which may recalibrate priorities once in power—the strategy establishes differentiated policy trajectories by mineral group and reveals Chile's clear intent to capture more value through midstream processing, subproduct recovery, and circular economy measures.

> Key strategies for value addition include focusing on sustainability, leveraging innovation, anticipating future opportunities, and developing the local ecosystem.

KEY STRATEGIES FOR VALUE ADDITION

Sustainability focus: Chile is positioning itself as a player with a more sustainable, responsible, and higher value-add mining industry, betting that sustainability can command a premium on the market. For example, Chile developed a climate change plan for the mining sector in 2024 to help the sector adapt to and mitigate adverse climate effects. In 2024, renewables supplied about 70% of Chile's electricity,[35] a trend that is expected to grow and support the sustainability goals of the mining industry, which makes up 30% of electricity demand. The high share of renewables also means that Chile can produce lithium-ion batteries with a lower GHG emissions footprint than other major battery producing regions,[36] giving the country another competitive edge.

Leverage innovation: Chile's lithium strategy emphasizes the use of new extraction technologies, particularly DLE, to optimize production and reduce environmental impacts. The performance of planned DLE projects in the country will be crucial to prove this new technology.

Anticipate future opportunities: Battery recycling is seen as an important future opportunity to create local value, and Chile is taking steps to prepare for this. Its Extended Producer Responsibility laws designate lithium batteries as priority products, creating a regulatory framework to encourage battery recycling and circular economy practices, though more investment is needed in this area.[37]

Develop local ecosystem: Enami, one of Chile's state-owned mining enterprises, has a mandate to promote small- and medium-scale mining, which creates upstream and services opportunities for local suppliers and contractors tied to this industry. The National Lithium Strategy opens smaller salt flats for Enami and Codelco partnerships with private firms, creating potential opportunities for its supplier ecosystem in lithium-related services.

NOVEL MECHANISMS OR POLICY TOOLS

Preferential pricing and secure supply agreements to incentivize downstream investment: Select "specialized producers" can buy lithium from SQM and Albemarle at a reduced price if they commit to building value-adding projects (e.g., developing cathode production facilities in Chile).[38] While two Chinese companies (Yongqing Technology and BYD) had signed agreements in 2023 to build such projects, they later withdrew as lithium prices collapsed and project risks mounted, citing unviable market conditions, difficulties securing land and local approvals, and contractual constraints that made alternative locations more attractive despite access to discounted Chilean lithium.

Earmarked contributions from mining: Chile has deployed various efforts to channel resources from mining to R&D. For example, SQM and Albemarle are contractually required to make earmarked R&D and "public goods" contributions for the creation or readjudication of centers and institutes. These include four entities:[39]

35 Ember. 10 January 2025. Chile surpasses 40% wind and solar for the first time in December.
36 ICCT. 8 October 2025. Expanding the lithium value chain in Chile: Mining, batteries, and recycling.
37 IEA. 5 November 2024. Law 20920. Establishment of a framework for waste management, extended producer responsibility and recycling.
38 Jobet, Juan Carlos; Moerenhout, Tom; and Rivota, Diego Rivera. Center on Global Energy Policy at Columbia SIPA. 8 August 2024. Chile's State-Centric Lithium Policy May Deter Investment.
39 Obaya, Martín and Asinsten, Julián. Inter-American Development Bank. September 2025. Oportunidades y desafíos para América Latina y el Caribe en el nuevo contexto global de la industria del litio y la transición hacia la electromovilidad.

- The National Institute of Lithium and Salt Flats aims to advance knowledge and technologies related to lithium extraction, processing, and applications to foster sustainable development and innovation.
- The Institute for Clean Technologies, in the Antofagasta region, where the Atacama desert is located, is a center for innovation and technological development that promotes sustainable solutions for industry, especially in mining, energy and lithium.
- The Center for Sustainable Acceleration of E-mobility, supported by the government, is aimed at accelerating EV adoption through applied R&D, pilots, and industry partnerships. It is positioned as a national platform for sustainable transport innovation.
- The Technological Center for Circular Economy seeks to power the transition to a circular economy and generate economic, social, and environmental value.

DOWNSTREAM EV MARKET OPPORTUNITIES

With no automotive production domestically or in neighboring countries, Chile lacks proximity to an end market. China has historically been the key buyer of Chilean lithium, but in 2025 its purchasing decreased while countries such as South Korea and Japan have been buying more lithium from Chile. This is, in part, due to U.S. tariffs and shifting global EV market dynamics.[40]

KEY CHALLENGES

Expanding lithium production sustainably to capture more of the global market will require streamlined permitting and approval of new projects and new investments. These are stated priorities of the new government administration, but this expansion will also necessitate:

- securing social license amid concerns around appropriate consultation of indigenous communities residing in the Atacama region and
- addressing environmental concerns associated with lithium production, in particular regarding water consumption and its impact on local communities and ecosystems.

Additionally, Chile is betting on DLE as a technology that will help optimize lithium production with lower environmental impact. However, DLE remains in pilot stage and is untested at large scale.

In terms of downstreaming efforts, the cancelled projects by the two Chinese companies — and a previous effort in 2018 that did not materialize either — raise questions around the viability of Chile's strategy and underscore the difficulty of this endeavor.

40 Argus. 8 August 2025. **Chile's Jan-Jul Li exports hint at trade shift.**

LITHIUM

Ghana

IN BRIEF

Ghana has long been active in the extraction of several minerals, including gold, diamond, manganese, and bauxite. Mining accounts for approximately 14% of Ghana's GDP.[41] Despite greater levels of undeclared gold production, especially from artisanal and small-scale mining, the country remains Africa's leading gold producer and sixth in the world.[42] The mineral riches of the country have not led to a commensurable form of development, and Ghana has pursued limited value-addition strategies or industrial policies in its extractive sectors over the years.[43]

In 2023, after years of exploration, Ghana announced the country's first commercial discovery of lithium in the Ewoyaa pegmatite field in the Central Region. These are hard-rock deposits of lithium, unlike the brine deposits found in Chile. They are extremely small in comparison to Chile's lithium. Ghana's entire identified lithium represents an estimated approximately two percent of Chile's reserves.

In October 2023, the Government of Ghana signed a 15-year lease with Barari DV Ghana Ltd, a subsidiary of the Australian-based Atlantic Lithium, to develop the Ewoyaa project and produce lithium spodumene concentrate. Still, parliamentary ratification remains pending at the time of publication amid repeated delays and withdrawals. A December 2023 moratorium on farming and construction across approximately 5,000 hectares of concession land to preempt land disputes remains in effect, threatening farmers livelihoods and impacting many communities. In April 2025, Atlantic sought royalty cuts due to lithium price crashes, leading to a revised deal that reached Parliament in November 2025 but was withdrawn in early December amid civil society backlash over fiscal concessions. The deal was modified again and resubmitted to Parliament in mid- December for consideration in early 2026.

GOVERNANCE FRAMEWORK

Ghana's mining framework is predominantly private-led with the state holding a non-contributory 10% "free carried" equity interest in all large-scale mining leases, alongside fiscal take through royalties and taxes. The 10% free carried interest means the government gets a 10% ownership stake in the mining company automatically upon granting a mining lease, and the government may negotiate additional participation. There are also policy tools like local content rules requiring progressive procurement, employment, and technology transfer for mining operations, along with a sovereign minerals fund to manage state equity and royalty flows from mining.[44]

41 Trade Economics. 2025. Ghana GDP from Mining.
42 SwissAid. 11 June 2025. African Gold Report: Ghana.
43 Abdulai, A. G. (2017). Competitive clientelism and the political economy of mining in Ghana.
44 Ghana Minerals and Mining Act, 2006.

> Key strategies for value addition include seeking higher royalties and requiring lithium refining.

Ghana's sovereign fund, the Minerals Income Investment Fund, invested in the Ewoyaa project and intends to leverage the country's automotive policy and the lithium reserves to support the development of a domestic battery and EV ecosystem.[45]

A Green Minerals Policy that targets lithium, bauxite, cobalt, and other minerals to maximize value addition and local participation was approved in 2023, but it has not been published. Several sources indicate that the policy prohibits the export of unprocessed spodumene concentrate or raw lithium ore, requiring that any lithium mined in Ghana undergo further beneficiation or processing locally.

KEY STRATEGIES FOR VALUE ADDITION

Higher royalties: As part of the original agreement with Barari DV Ltd, the government negotiated a 10% royalty rate, higher than the country's usual 5%. Subsequent iterations of the deal set royalties at a 5% adjustable scale first,[46] and moving later to a sliding-scale royalty between 5 and 12%, allowing royalties to rise or fall automatically depending on global commodity prices.[47]

Lithium refining requirement: The agreement with Barari DV Ltd also requires the company to build a refinery to process lithium concentrate within Ghana, though this commitment hinges on positive findings from a scoping assessment that the firm will undertake itself.[48] If the company cannot build its own refinery, it must supply concentrates to alternative Ghanaian facilities under terms negotiated between the parties. Although the feasibility studies by Barari DV Ltd have not been published, it is rumored that the studies concluded that a processing plant was not feasible unless there were three more lithium developments of comparable scale or if the government were to offset costs significantly.[49] Other independent analysis modelled potential costs and benefits of building such a refinery, concluding that this project would be unlikely to generate much benefit for Ghanaians, and advising decisionmakers to ground their strategy on economic feasibility, market outlook, and a rigorous cost-benefit analysis.[50]

NOVEL MECHANISMS OR POLICY TOOLS

Byproduct recovery and local use requirements: The mining operator Barari DV Ltd must complete a comprehensive feasibility assessment for producing secondary materials, such as feldspar and kaolin. These minerals have application in multiple value chains: feldspar mainly in glass and ceramics, and kaolin both in ceramics and as a common industrial filler. Recovering these minerals from lithium pegmatites can boost local manufacturing opportunities and add revenue streams beyond lithium alone. These byproducts are earmarked for Ghana's domestic market unless export approval is granted due to factors like inadequate local demand.

Taxation reforms for an enabling environment: Ghana's government is eliminating a value-added tax (VAT) on minerals processing as of January 2026, arguing that this tax had discouraged investment in mineral exploration for over two decades. The 15% VAT, applied especially to exploration activities, increased upfront costs during the high-risk early phase of mining projects. Its removal aims to revive investor confidence, stimulate new exploration projects, and enhance the long-term sustainability of Ghana's mining sector.[51]

DOWNSTREAM EV MARKET OPPORTUNITIES

Though Ghana currently does not have battery or large-scale EV manufacturing value chains, it aspires to build them. The Ghana Automotive Development Policy is under review to formally integrate electric and hybrid vehicles and establish a regulatory framework to enable the development of EV value chains. There are some companies manufacturing vehicles and batteries for EVs or stationary storage in Africa, and although the domestic and regional market for both is poised to grow, it would be limited in the near future. In the meantime, buyers of Ghana lithium products would likely come from China, Europe, South Korea, Japan, or the U.S. — all of which are top importers of lithium and seeking to diversify their supply chains.

45 Sustainable Energy For All; Africa Renewable Energy Manufacturing Initiative. March 2025. **Ghana Green Manufacturing Policy & Investment Guide.**
46 Ghana Webbers. 17 November 2025. **Lands Minister lays lithium deal before Parliament.**
47 Kwarteng, Fredrick A. The High Street Journal. 21 December 2025. **Inside the 3rd Lithium Agreement Laid Before Parliament: All the Major Adjustments to the New Deal.**
48 *Republic of Ghana. 2023. Mining lease agreement between the Government of the Republic of Ghana and Barari DV Ghana Ltd* (File No. APL-M-93). Ministry of Lands and Natural Resources.
49 IMANI Center for Policy & Education. **The Atlantic Lithium (Ewoyaa Project) Deal: Why Ghana's Parliament Should Not Ratify a Flawed Agreement.**
50 Scurfield, Thomas and Adjei, David Sefa. Natural Resource Governance Institute. 31 March 2025. **Refining the Strategy: The Economics of Lithium Value Addition in Ghana.**
51 Mining Technology. 17 November 2025. **Ghana mineral exploration tax reform aims to boost sector investment.**

KEY CHALLENGES

There are serious concerns around the process followed to implement the Ewoyaa project, including limited consultations with host communities before signing the 2023 lease and the effects of the continued extension of the moratorium on farming on these communities.

The delay on this project has had multiple ramifications for key stakeholders involved:

- **Communities:** Delays mean that the lives of community members around the Ewoyaa concession remain in economic limbo leading to hardship and the need for relief.
- **Company:** For now, Atlantic Lithium faces prolonged uncertainty given the delays and must keep spending to hold its concessions while reassuring potential investors that Ghana remains a viable destination. The delay in ratification has led the company to cut staff and scale back operations.
- **Workers:** In October 2024, the company employed 167 workers along its operational chain, including geologists, laboratory technicians, drivers, electricians, and other support staff. One year later, in November 2025, the company had laid off more than 100 workers as a result of the delays.[52]

Ewoyaa's paralysis signals high governance risk for investors and communities, jeopardizing the country's lithium ambitions. Ghana will have to resolve these issues if this first lithium project is to be viable — all while navigating the geopolitics of supply and demand and revising its value-addition strategy accordingly.

52 Business Ghana. 5 November 2025. Lithium mining venture in limbo: Atlantic Lithium lays off over 100 workers due to delayed lease...

NICKEL

Indonesia

IN BRIEF

Indonesia is the top nickel producer in the world, accounting for approximately half of global production. It also has by far the most reserves, accounting for 42.3% of the world's supply.[53] This advantage gives Indonesia a unique position, which anchors its value-addition strategies. Mining for nickel and other minerals comprised 11.9% of Indonesia's GDP in 2023.[54]

Indonesia's nickel is found in laterite deposits, which generally have lower and more variable nickel grades than sulfide ores, making Indonesia's deposits most suitable for stainless steel production. Indeed, the vast majority of historic and current nickel production has served that industry. However, in recent years the government has been prioritizing a shift to align more nickel production with battery-grade nickel sulfates used in cathodes for NMC batteries via high-pressure acid leaching (HPAL), which comes with social and environmental concerns.[55,56] Indonesia possesses most of the HPAL processing capacity in the world, though the share of HPAL processing is low compared to more traditional forms of smelting.[57]

Through strict policies, export bans of raw nickel ore, and incentives spanning several years, Indonesia has achieved an integrated, albeit nascent, ore-to-EV value chain. Its approach is largely recognized as a success story in terms of promoting local value addition, though it is not without its limitations. The country's strategy to engage in downstream activities has led to a proliferation of nickel processing infrastructure for both the EV battery and stainless steel sectors. As of early 2025, Indonesia had 44 operational nickel smelters, with 21 more under construction; up from just two in 2014. The downstreaming strategies also brought a jump in its global share of nickel refining, which increased from 23% in 2022 to 37% in 2023 and is projected to expand to 59% by 2040.[58]

Indonesia's approach is, however, not necessarily replicable given its major market dominance and unique set of policies and circumstances. Its downstreaming success has also come with associated environmental and social concerns related to the speed, scale, and manner in which nickel production and processing has increased. Negative impacts have included biodiversity loss, air and water contamination, community displacement, and other challenges.[59]

53 Baskaran, Gracelin. Center for Strategic & International Studies. 11 July 2024. **Diversifying Investment in Indonesia's Mining Sector.**
54 Business Indonesia. 26 May 2023. **Indonesia's downstreaming policy gives its mining sector significant room for growth.**
55 Inside Exploration. 15 April 2024. **Nickel Sulphides vs. Nickel Laterites: Which is Better for Batteries and Why?**
56 Ribeiro, Henrique; Holman, Jacqueline; and Tang, Lucy. S&P Global. 3 March 2021. **Rising EV-grade nickel demand fuels interest in risky HPAL process.**
57 Rahmaditio, R., et al., World Resources Institute. 6 January 2026. **Nickel's Climate Cost and Indonesia's Push for Cleaner Production.**
58 Salyid, Amena H. Cipher News. 29 May 2024. **Nickel illustrates China conundrum on critical minerals.**
59 Centre for Research on Energy and Clean Air. 20 February 2024. **Debunking the Value-Added Myth in Nickel Downstream Industry: Economic and Health Impact of Nickel Industry in Central Sulawesi, Southeast Sulawesi, and North Maluku.**

Certain regions have seen very high economic growth in recent years, largely driven by nickel, but there is evidence of increasing inequality there too.[60] Indonesia's downstreaming approach has also been contested in the market; the European Union challenged Indonesia's export restrictions with the World Trade Organization, arguing they distort global markets.[61]

GOVERNANCE FRAMEWORK

The central government has exclusive constitutional oversight of all mining activities, including issuing and managing mining permits, which are issued to a wide range of public and private entities, such as state-owned enterprises, SMEs, cooperatives, and others.[62]

There are two major state-owned entities involved in the nickel industry (upstream and midstream) in Indonesia. These and other small players capture a small portion of the market compared to Chinese private companies, which control about 75% of Indonesia's nickel refining capacity.[63] While Indonesia does not have a comprehensive national nickel strategy, there are a number of policies and targets relevant to value addition in mining and in nickel production specifically.

KEY STRATEGIES

Connecting to EV value chain: Though nickel production for stainless steel remains dominant, Indonesia is integrating some of its nickel supply chain with local EV battery production. The government is also encouraging local EV manufacturing and other downstream activities by ending incentives for completely built-up EVs starting in 2026, as well as other measures.[64]

Leveraging dominant position in the mineral market: The government actively manages the supply of nickel (through production quotas and output cuts) and adjusts royalties to exert influence over the global market, mitigate risk from market volatility, and maximize local value.[65]

Attracting foreign investment in midstream and downstream: China, as the dominant player in the global battery EV value chain, was already deeply involved in the Indonesia nickel supply chain prior to the first export ban in 2014. Following the ban, China (and other countries, to a lesser extent, such as South Korea) have made massive investments in midstream and downstream nickel operations to comply with the regulations and keep a stake in this value chain. To date, Chinese companies have constructed over 90% of Indonesia's nickel smelters, including some HPAL processing plants.[66]

Innovation in battery recycling: In 2021, the Indonesian government declassified nickel waste as hazardous material, and a Presidential Regulation addresses recycling end-of-life batteries, encouraging innovation in recycling, reuse, and circular economy approaches to create additional value and complement other strategies upstream.[67]

NOVEL MECHANISMS OR POLICY TOOLS

Export ban and taxes: Indonesia enacted an export ban of raw nickel in 2014, partially relaxed it in 2017, and enacted it again in 2020. There are also export taxes on certain processed nickel products in the upstream and midstream to further incentivize higher value addition locally.

Significant government investments and incentives: To complement the export ban, the government has created special economic zones; provided tax holidays to investors; provided financial incentives for the construction of smelters and refining plants; and

60 Bria, Emanuel et al. 16 May 2025. A holistic framework for examining complex problems in energy transition solutions.
61 The EU initiated the dispute in 2019. The WTO ruled against Indonesia in 2022; the country then appealed. The ruling is still pending and could have implications for Indonesia's downstreaming strategy and that of other resource-rich countries. (Bria, Emanuel; Kemp, Deanna; Kuswati, Riska A.; Sturman, Kathryn; Saputra, Muhamad Risqi U.; and Lechner, Alex M. One Earth: A Cell Press journal. 16 May 2025. A holistic framework for examining complex problems in energy transition solutions.)
62 Baskaran, Gracelin. CSIS. 11 July 2024. Diversifying Investment in Indonesia's Mining Sector.
63 Reuters. 5 February 2025. Chinese firms control around 75% of Indonesian nickel capacity, report finds.
64 Johnson, Peter. Electrek. 20 January 2025. BYD is about to open another massive EV plant overseas with 150,000 vehicle capacity.
65 Indonesian Business Council. 2025. Indonesia's EV Ecosystem in 2025: Progress and Regional Leadership Prospects.
66 Guoping, Luo and Jia, Denise. Caixin. 5 December 2023. Chinese nickel miners in Indonesia face threat from falling prices.
67 Huber, Isabelle. CSIS. 4 February 2022. Indonesia's Battery Industrial Strategy.

incentivized the creation of industrial parks near mining sites to reduce logistics costs and attract investment in processing and manufacturing.

Local capture of benefits: The government has also put measures in place to capture new value created locally, especially in a sector that is dominated by foreign investment. For example, foreign-owned mining companies in Indonesia are required to gradually (generally over 10-25 years) divest at least 51% of their shares to Indonesian entities, either public or private.[68] There are also regulations to hold nickel-related earnings in the country for longer periods of time.

DOWNSTREAM EV MARKET OPPORTUNITIES

The government is introducing targets as well as fiscal and non-fiscal incentives[69] to leverage its nickel to spur a domestic EV industry. The country has the goal of producing 2.5 million BEV passenger cars by 2030, which would represent a major scale-up of the entire automotive manufacturing sector as well as a shift to EVs, as total car production in Indonesia (all vehicle types) was just under 1.2 million in 2024.[70]

Domestic EV production is starting to take place. For example, Toyota began producing EVs in Indonesia in 2025 and BYD is investing $1 billion in an EV plant with a planned capacity to produce 150,000 cars annually starting in 2026.[71] Indonesian nickel is already used in batteries manufactured locally.[72] A Hyundai joint venture with LG already produces battery cells with locally sourced and processed nickel sulfate. Additionally, the Indonesia Battery Integration Project, comprised of multiple stakeholders and announced in mid-2025, covers the full value chain and aims to produce batteries for 200-300,000 EVs annually. This project is expected to be a full closed-loop ecosystem across nickel mining, smelting operations, materials production, and recycling, and it will roll out progressively over the next five years. [73]

KEY CHALLENGES

Single offtaker dependency: Nearly all (95-100%) of Indonesia's mixed hydroxide precipitate (MHP) and nickel sulphate exports have gone to China in recent years, where they support battery cathode production.[74] At a time when diversification strategies are crucial to mitigate risks, dependence on a single offtaker creates significant vulnerabilities for Indonesia.

Demand risk: Technological innovation (through, for example, material substitution and efficiency improvements) and evolving market trends have impacted the previously anticipated demand for nickel, putting Indonesia's potential for long-term value addition at risk.[75] In 2020, NMC and similar nickel-based chemistries supplied over 90% of the global EV battery market. However, by 2024, these chemistries were substantially displaced by LFP batteries. LFP batteries rose in prominence to represent almost half of the market by 2024, up from 10% in 2020.[76]

Government control vs. market dynamics: There are drawbacks to the wide range of measures of government control that Indonesia has employed, including several cancelled midstream and downstream projects over slowing demand (including, for example, the 2024 cancelation of a planned $2.6B HPAL processing plant);[77] stringent traceability rules in key export markets; and policy volatility, which deters investors and raises questions about the country's path ahead.

Environmental, social, and governance (ESG) concerns: Indonesia's mining and value-addition activities, especially related to increasing numbers of HPAL processing and captive coal power plants, have had deleterious effects on communities and ecosystems, which weaken the social license to operate and diminish legitimacy more broadly in global markets.[78] As ESG considerations grow in importance for companies globally, and in key export markets for Indonesia such as the U.S. and E.U., addressing these concerns will be crucial.[79]

> Key strategies for value addition include connecting to EV value chain, leveraging dominant position in the mineral market, innovation in battery recycling, and attracting foreign investment in midstream and downstream.

68 Baskaran, Gracelin. CSIS. 11 July 2024. Diversifying Investment in Indonesia's Mining Sector.
69 Kristiana, Tenny. ICCT. 22 August 2025. Policies to Help Indonesia's New President Champion Electric Vehicles.
70 Business Indonesia. Automotive.
71 Oshikiri, Tomoyoshi. Nikkei Asia. 23 July 2025. Toyota to start making EVs in Indonesia this year.
72 Hills, John. Electric Drives. 3 July 2024. Hyundai and LG complete an advanced EV battery plant in Indonesia, boosting local production goals.
73 Bo-yu, Lin. Recessary. 1 July 2025. CATL breaks ground on $5.9 billion new battery plant in Indonesia.
74 Mysteel. August 2025. FLASH: Indonesia's nickel product export data for July 2025
75 IRENA. Geopolitics of the Energy Transition: Critical Minerals.
76 IEA. June 2025. Global Critical Minerals Outlook 2025.
77 Climate Rights International. 5 July 2024. OPED: Cancellation of Nickel Investments Should be a Wake-Up Call for Indonesia.
78 Anindya, Michelle. Rest of World. 3 February 2025. Indonesia, home to the world's largest nickel reserves, struggles to achieve its EV dreams.
79 BloombergNEF. 12 November 2022. China's Battery Supply Chain Tops BNEF Ranking for Third Consecutive Time, with Canada a Close Second.

NICKEL

Philippines

IN BRIEF

The Philippines is the world's second-largest nickel producer and ranks 6th globally in terms of nickel reserves. With around 66% of global production to the Philippines' 9%, Indonesia holds a commanding lead. The Philippines has historically relied heavily on exporting raw nickel ores, but there is growing momentum and government interest in promoting downstream processing.

Similar to Indonesia, the country's deposits are for nickel laterite, requiring HPAL processing to feed into the EV value chain. The Philippines currently has two operational HPAL processing plants: the Coral Bay Nickel Corporation facility and the Taganito HPAL plant, operated by companies like Sumitomo Metal Mining and Nickel Asia Corporation. Three more HPAL plants are expected to come online by 2028.[80] Still, processing is minimal. Most of the Philippines' raw nickel and processed nickel exports are to China (80%), where it is used for stainless steel and EV battery production, followed by Indonesia (20%),[81] whose refining capacity and import needs have grown in the past few years. Nickel production in the Philippines is susceptible to market dynamics in the region. As Indonesia increased production, leading to oversupply and declining prices, the Philippines saw mine curtailments and a drop in production of an estimated 20% in 2024.[82]

Citing Indonesia's nickel value addition strategy as a model, the Philippines Senate passed a bill to ban nickel ore exports in early 2025 and create more value addition locally. The proposed legislation allowed a five-year transition period before a ban would take effect, aiming to give market players time to adapt and invest in necessary infrastructure. Still, the bill faced significant opposition from the mining industry amid concerns about local hurdles, such as high electricity costs, policy complexity, and infrastructure challenges. It was ultimately removed from the final reconciled fiscal mining law ratified in June 2025.[83]

Local communities have historically faced serious health, livelihood, and environmental harms from mining (e.g., polluted water, reduced harvests, and deforestation). Benefits from mining have been limited and often do not compensate for these negative effects, raising concerns about a potential expansion of nickel mining in the country.[84]

80 South East Asia Iron and Steel Institute. 1 August 2024. **Philippines remains largest nickel ore, concentrate exporter to China.**
81 Argus. 12 June 2025. **Philippines axes planned ban on nickel ore exports.**
82 U.S. Department of the Interior U.S. Geological Survey. March 2025. **Mineral Commodity Summaries 2025.**
83 Argus. 12 June 2025. **Philippines axes planned ban on nickel ore exports.**
84 Climate Rights International. 3 November 2025. Philippines: **Nickel Mining Causes Abuses, Increases Climate Risks.**

GOVERNANCE FRAMEWORK

All mineral resources are constitutionally owned by the state. Exploration, development, and utilization are under state control and supervision. Private sector involvement is enabled through mineral agreements, with foreign ownership generally restricted to a maximum of 40% unless the investment qualifies for a Financial or Technical Assistance Agreement — when the investor commits to at least USD $50 million in a single mining unit, provides technical expertise, and meets other criteria — which can be fully foreign-owned.[85]

The Philippines passed a new mining law in September 2025, Republic Act No. 12253, to reform fiscal aspects such as royalties, windfall taxes, and fiscal transparency. While the law does not contain explicit provisions mandating value addition, it is framed as part of the government's broader efforts to strengthen the Philippines' role as a key player in the global mineral supply chain.

KEY STRATEGIES

Mining "renaissance": The Marcos Jr. administration, since being elected in 2022, has prioritized revitalizing and expanding the mining sector to drive economic recovery and long-term growth, reversing previous restrictive policies. Nickel is seen as a key part of this renaissance, with associated risks and opportunities for value addition.

Responsible positioning: The Philippines is developing a "Responsible Nickel Roadmap" focused on environmental sustainability, value-added processing, and economic benefit for the country. Key goals include attracting investment, creating a stable business environment, and ensuring high standards for environmental and social impact. While recent developments show that responsible nickel could realistically compete on price through emerging sustainability premia, achieving this goal requires significant upfront investments and certification to capture them.[86] If implemented well, this could help the Philippines carve out a niche for its nickel, even if total volumes remain far below Indonesia's.

NOVEL MECHANISMS OR POLICY TOOLS

Export ban: The cancelled export ban underscores the structural hurdles the Philippines faces for value addition and shows that policy tools that have been effective in some contexts do not necessarily apply in others.

DOWNSTREAM EV MARKET OPPORTUNITIES

China and Indonesia are top purchasers of nickel produced in the Philippines, feeding their stainless steel and EV battery industries.

While EV production is relatively low in the Philippines, it is present and growing. In 2024, there were 15 local EV assemblers and manufacturers with an installed production capacity of 200,000 units per year. EV production has grown an average of 7.7% annually in the past 10 years.[87]

KEY CHALLENGES

Major social and environmental concerns associated with mining activity must be addressed. Value addition efforts are likely to fail otherwise.

Enablers for value additions, including affordable and reliable power, infrastructure, incentives, and predictable regulation and enforcement, remain challenging. For example, industrial electricity prices in the Philippines are nearly double those in Indonesia, making energy-intensive processing uneconomic without substantial subsidies. Additionally, poor port and road networks lead to higher logistics costs for companies and fragmented supply chains.[88]

85 Philippines Supreme Court. 1992. DENR Administrative Order No. 63, December 12, 1991.
86 Jaber, S. Metalshub. 21 October 2025. How Metalshub Enables Verified Sustainable Metals Pricing with the London Metal Exchange.
87 Electric Vehicle Association of the Philippines. October 2024. About EVAP.
88 Carbon Credits. 23 May 2025. Philippines' Nickel Export Ban and U.S. Tariffs: What's Happening in the Nickel Market Now?

These four countries, Chile, Ghana, Indonesia, and the Philippines, illustrate diverse strategies for capturing value from critical minerals in EV supply chains, each shaped by their resource endowments, governance models, and market realities.

Indonesia, an early player in nickel ore bans since 2014, has captured downstream markets through mineral market dominance and state-led strategy, forging an ore-to-battery supply chain that has come with high environmental and social costs. In contrast, Chile has deployed a more measured approach to lithium development, focusing on sustainability and retaining strategic control of key resources while prioritizing new technologies and the use of renewables as a competitive advantage. However, its ambitions to move into cathode manufacturing have not yet materialized.

Ghana and the Philippines are earlier in the process, still negotiating first projects and debating how far, how fast, and in what way to pursue downstream activities. Though the scales of their endowments are smaller than in Chile and Indonesia, they can still tap into value-addition opportunities by better navigating market dynamics and overcoming project execution challenges.

Across the board, the dilemmas each country faces can be seen as design choices that will determine whether value-addition efforts deliver durable benefits or lead to missed opportunities.

From ambition to reality: Navigating key dilemmas

The experiences of the four countries highlight dilemmas and questions across five domains that are interrelated and come into play in the context of value addition, particularly concerning EV-related opportunities: realistic position in the EV value chain; control, governance, and investment attractiveness; speed, standards, and social license; market dependence and diversification; and technology and innovation risks.

1 **Realistic position in the EV value chain:** How far down the value chain, and at what scale, is realistic and viable?

The scales of reserves in Chile and Indonesia justify their investments in refining and producing battery materials (midstream), but questions remain about how to achieve deeper downstreaming into battery cells and EVs in Chile, and how to keep scaling to reach ambitious targets without risking overcapacity in a shrinking and more ESG-sensitive market in Indonesia. If managed well, calibrating how and where to go downstream can help these countries strengthen their roles midstream and still move into higher-value activities if markets and capabilities evolve in their favor. Ghana and the Philippines have smaller reserves and EV demand. Developing full battery and EV value chains may be unrealistic in the short term, so midstream niches or byproducts might deliver more value. Looking to the end of the value chain may be worthwhile too: battery recycling would complement mining.

For all countries, embracing regional strategies may also offer advantages. Critical minerals value chains are complex and require a diverse set of specialized capabilities and assets that are often not fully available in a single resource-rich country. Regional cooperation can boost competitiveness, but it requires short-term trade-offs in control and gains for partners. Additionally, geopolitical and other potential tensions must be navigated. For Ghana, with limited lithium scale, aggregating feedstock with other countries in the region could help make projects more economically viable. Sharing infrastructure costs and benefits across assets in the region could enable favorable logistics for the Philippines. In Chile, combining complementary assets with countries in the lithium triangle could help build a bigger market, lower the risk of pilots, and support a more comprehensive downstreaming strategy.

2 **Control, governance, and investment attractiveness:** How much control should the state exert, and through which tools, without restricting investment?

While all four countries exert some measure of government control given the strategic nature of critical minerals, their approaches vary significantly. State-led models that prioritize rapid scale and value capture, such as in Indonesia, may be successful if endowments, market, and governance conditions align. However, rapid scale can lead to high environmental and social costs, and high regulation can deter private investment.

Models with greater private-sector participation, like those in Ghana and the Philippines, might deliver significant foreign direct investments if the enabling conditions are present, but they may limit local value addition. Gradual measures are useful in that they can more easily allow for course correction, but they may take longer to deliver tangible results related to value addition. If designed and implemented carefully, policy tools can be used to crowd in long-term, high-quality investments that can catalyze and support each country's goals and vision for value addition.

3 **Speed, standards, and social license:** How quickly can projects move without compromising environmental and social safeguards for long-term sustainability?

The "race" rhetoric for critical minerals and value addition signals that stakeholders value — and will reward — speed. Prioritizing speed, however, may lead to the dilution of standards, appropriate consultations, and safeguards. Relevant to all countries, weaker environmental oversight and community engagement drive public backlash and can increase the risk of stranded assets in the longer term, effectively negating the thesis behind value-addition efforts. Adhering to stricter standards valued in export markets can provide a competitive advantage, but it is also true that it can add complexity to operations (including, for example, switching to clean energy sources if not used already). This can result in slower progress or weaker competitiveness in the short term, but it will support value-addition goals over the long term, enabling countries to develop projects with robust safeguards and standards that will attract capital and avoid the risk of disruptions or cancellations later.

4 **Market dependence and diversification:** How can countries pursue downstreaming without becoming overly reliant on a small number of buyers?

A key risk and dilemma in downstreaming relates to deepening exposure to volatile dependencies. Indonesia's nickel success relies heavily on exports to and financing from China, amplifying vulnerability and potentially locking the country into long-term, asymmetric relationships that make diversification more difficult. Chile's exports are also concentrated in a few Asian markets, and Ghana's single lithium project leaves it exposed to both market cycles and the decisions of a small number of players. Mitigation demands diversification across all dimensions — more buyers, more product types, more regions — but gets more difficult as market concentration rises. Battery recycling, for example, offers a strategic diversification lever: countries that invest in developing this capability would be well positioned to capture value from end-of-life batteries while avoiding the risks and volatilities embedded in other downstreaming activities.

5 **Technology and innovation risks:** How far should countries bet on specific technologies and innovation approaches given rapidly-evolving dynamics?

Countries pursuing value addition must invest in and align with emerging technologies that promise a competitive edge and can help them move down the value chain — DLE in Chile and cleaner refining in the Philippines and Indonesia, for example. Such capabilities will strengthen their position and optimize their resources. However, in a fast-paced global market, technological shifts in chemistries and innovations related to recycling and substitutes may quickly erode the value propositions their strategies are built on, reducing the anticipated benefits and risking their investments. Smart, sequenced bets on new technologies with associated investments can help strengthen local innovation ecosystems that ultimately lead to broader, more enduring benefits and opportunities.

Figure 7 on page 28 maps these core dilemmas across the four countries to show how different pathways confront similar trade-offs in distinct ways.

Figure 7: Core country dilemmas

	1 Realistic position in the EV value chain	2 Control, governance & investment attractiveness	3 Speed, standards & social license	4 Market dependence & diversification	5 Technology & innovation risks
CHILE LITHIUM	• Large, low-cost brine reserves; global incumbent in lithium carbonate equivalent exports • Realistic midstream focus; full EV ecosystem constrained by tiny auto base and distance from larger markets	• Lithium non-concessionable; state majority in "strategic" salt flats via JVs with state-owned enterprises • Strong control reassures sovereignty, but complex rules and politics slow new private investment	• Slower, more consultative approach; strong environmental and water use scrutiny and frequent challenges from indigenous communities in the Atacama • Social license constitutes a key factor for potential expansion and downstream bids	• Heavy reliance on a small set of Asian buyers • Exposed to shifts in trade policy and demand from a few key importing countries	• Betting on DLE and low-carbon processing to sustain competitiveness and ESG premia, even though most DLE remains at pilot stage and unproven at scale • Faces uncertainty around performance, costs, and how quickly rival chemistries might erode lithium demand
GHANA LITHIUM	• Single emerging hard-rock lithium project (Ewoyaa) with very small reserves relative to Chile • Pressure to mandate refining despite uncertain scale and weak feasibility for a standalone plant	• Private-led regime with 10% free carried interest plus new Green Minerals Policy and local-refining conditions • Renegotiations, moratoriums, and parliamentary withdrawals signal high political risk to investors	• First lease agreement was passed with limited early community engagement; moratorium froze farmland while terms remain unsettled • Delays now jeopardize livelihoods and undermine trust in both state and operator	• Entire lithium strategy hinges on a single project and limited buyer options in the short term • Exposure to lithium price cycles and limited bargaining power	• Considering local refining and byproduct recovery (feldspar and kaolin) whose viability depends on process efficiencies and the availability of downstream industrial users • Limited institutional capacity and market depth increase the risk of stranded or under-utilized midstream investments
INDONESIA NICKEL	• Massive reserve base and dominant share of global mining and refining output • Pursuing full ore-to-EV value chain but risks over-build as chemistries and demand shift	• Centralized permitting, ore export bans, Special Economic Zones, and divestment rules give the state strong steering power • Policy volatility and trade disputes create uncertainty despite large FDI gains	• Very rapid build-out of mines, smelters and HPAL plants under compressed permitting and weak enforcement • Generated jobs and exports but severe ESG impacts threaten legitimacy and future market access	• Highly dependent on Chinese capital, technology, and offtake • Diversification of buyers, technologies, and recycling lags behind pace of investment	• Doubling down on HPAL for battery-grade nickel despite high capex and environmental concerns • NMC-centric strategy is exposed to rapid innovation in LFP, sodium-ion, and eventually recycling that could reduce future nickel demand
PHILIPPINES NICKEL	• Second-largest producer but much smaller than Indonesia; mostly ore exporter • Limited case for full EV ecosystem; more realistic to target HPAL/MHP and services niches	• Constitutional state ownership with high private operator role; 2025 fiscal reform focuses on royalties and transparency, not mandates • Cancelled ore ban showed limits of this tool and sensitivity to private sector	• History of environmental damage and community conflict constrains public support for mining expansion • Emerging "responsible nickel" framing aims to tighten standards, but implementation challenges and electricity costs hinder projects	• Export dependence on China and Indonesia for ore and intermediates • HPAL and responsible positioning face both chemistry risk and competition on cost from cheaper, high-emissions supply from Indonesia	• Expanding HPAL capacity and pursuing a responsible processing narrative despite high electricity costs and limited engagement in advanced midstream technologies • Faces similar risks that emerging lower-nickel or nickel-free chemistries could undercut these investments before they fully mature

From dilemmas to direction: Charting the path forward

For many resource-rich countries, local value addition from minerals is viewed as an opportunity and a promise to escape the trap of raw-material exports. While some countries may achieve this, as we have shown in this report, value addition is not a goal to be pursued in isolation but rather a set of interrelated choices with trade-offs that can either reinforce or break previous patterns. Those choices can lead countries to capitalize on or miss new opportunities. Each chosen path brings potential gains and exposes governments and other stakeholders to different risks. No strategy, policy tool, or regulation is implemented in a vacuum. Each will have system-wide effects that hinder or enable value-addition goals for these countries.

In all four countries studied here, as well as in other resource-rich countries, decisions made today to move further down the value chain will have long-term effects on their development and economic growth. Taking a broader view of value addition by seeing downstreaming as useful when it helps improve a broader set of outcomes, for a broader set of stakeholders, can help reframe the dream of value addition into achievable gains connected to more expansive, sustainable development.

The experiences of Chile, Ghana, Indonesia, and the Philippines are presented as illustrative pathways that reveal patterns and illuminate the questions that should be asked when seeking value addition: why, how, when, and for whom. They underscore core dilemmas that country decision-makers must confront: What role can they realistically play in the EV value chain? What is the best balance of state control and market-led approaches? To what extent should a country pursue speed vs. enforce standards? How can a country anticipate and respond to market dependence, diversification, and innovation and technology risks?

A more expansive vision of value addition highlights the spectrum of possibilities that may arise from resource development, but it requires a deeper, evidence-based understanding of the trade-offs at the policy level. Resource-rich countries aiming to create more value will need to confront these dilemmas explicitly, weigh them against their goals, assets, and constraints, and design and implement strategies to chart a path on their own terms.

The task for policymakers is to position their countries along these spectra in ways that reflect their geological, governance, and market realities, rather than chasing the downstreaming imperative based on a uniform model. Doing so means defining value in multidimensional terms, sequencing reforms and investments to build capabilities over time across their ecosystems, and using regional cooperation to leverage complementarity, mitigate volatility, and open additional opportunities, for example. Doing so can help resource-rich countries translate their minerals into more durable, inclusive development gains.

From the experiences of the countries analyzed, we can derive key questions for decision-makers to consider as they grapple with each dilemma:

1. **Realistic position in the EV value chain:** Does the value addition strategy identify the most viable segment or niche in the value chain where mineral resources, current capabilities, market access, and dynamics align, rather than pursuing any or all downstreaming?
2. **Control, governance & investment attractiveness:** Where along the spectrum of state-led to market-driven does it make sense to anchor value-addition strategies, given each country's political economy and unique goals?
3. **Speed, standards & social license:** Do the strategies include governance, environmental protection, and social license as strategic and integral to long-term downstreaming success and sustainability?
4. **Market dependence & diversification:** Do these strategies deepen dependence on a small set of players, technologies, or products? Or do they retain the possibility of pursuing multiple pathways that can lead to a broader set of opportunities?
5. **Technology & innovation risks:** Will these strategies advance economic diversification, technological development, and capabilities?

Looking ahead

There is much attention being paid to critical minerals and the quest for value addition at global, regional, and local levels. As this report illustrates, there are no simple takeaways or easy solutions to achieve value addition — and there are many areas warranting further exploration and work. These areas are diverse and can benefit from additional research, training, simulations, and stakeholder engagement. For instance, developing metrics for evaluating progress toward value addition from critical minerals, further unpacking innovative country-level policies, testing and evaluating concrete regional strategies, and understanding what investments can be most catalytic of value added along the critical minerals value chain in different contexts would all be useful in advancing this field.

We invite you to collaborate and follow as we extend our work to these and related areas.

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