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NEED NICKEL? HOW ELECTRIFYING TRANSPORT AND CHINESE INVESTMENT ARE PLAYING OUT IN THE INDONESIAN ARCHIPELAGO

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"Need Nickel? How Electrifying Transport and Chinese Investment are Playing Out in the Indonesian Archipelago"

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Recent Context

On March 8, 2022, the London Metals Exchange (LME) abruptly halted trading in nickel, which had reached a stunning $100,000 per tonne. As noted in many news sources, the LME events were a consequence of positions taken by Tsingshan Holding Group, which features prominently in our case study, based on expectations of falling prices. We allude to those expectations in our analysis of Tsingshan's pursuit of nickel laterite deposits in Indonesia and their associated strategies for processing to obtain battery-grade material and building a battery metals value chain. Russia's invasion of Ukraine and other recent developments, not least post-pandemic recovery, undermined Tsingshan's short position, forcing the company to purchase nickel at increasing prices to cover their positions, and the LME to increase margin requirements for market participants. The extreme disruption in nickel trading and markets, while unusual, is an important signal for materials insecurities that lie ahead. The location of metals supplies, demographics of the mining and minerals processing industries, lack of depth in liquidity for metals markets and trading (with implications for credit quality and corporate and project financings), absence of open markets for many key minerals, and other shortcomings point to the extreme need for increased research, foresight, and oversight.

Introduction and Summary

The success of the global march toward "decarbonization" depends on the complicated logistics that support it, along with the convoluted strategies that form its underpinning. The process of shoring up supply chains is a prerequisite to sound strategic planning: Without robust supply chains, even the most elaborate blueprint for implementation will prove ostentatious in practice. The global push for electrification, as worthy a cause as it may be, is not immune to such realities. Indeed, the global push to electrify is creating new tensions and complexities that, if not properly managed and mitigated, will undermine the much-discussed "energy transition." Emerging markets and developing countries are central to the "decarb" and electrification push, and are themselves maneuvering to attain advanced country status and a higher quality of life for their citizens. ***Minerals and the materials derived from them are at the heart of energy transition strategies, and emerging markets and developing economies are the overwhelming providers.*** The industrialized world brushes these realities under the rug in favor of self-aggrandizing agenda-setting, and, in doing so, engenders critical supply risks and the potential for further environmental degradation.

Widely ignored, although gaining attention, is China's strategic positioning as a crucial gatekeeper to several key "green" technologies, including battery energy storage to support electric vehicles (EVs)—specifically, battery electric vehicles (BEVs)—along with stationary storage for power grids. China also dominates in other technologies including wind and solar components, controls, sensors, and communications—a gamut of industrial equipment, including much that is pertinent for defense. BEV designs have come to dominate the energy transition strategies of many governments along with those of large automakers and startups, since BEVs are regarded as providing the maximum reduction in tailpipe emissions. Having little of its own capacity for manufacturing traditional vehicles, and being a large (and growing) net importer of oil, natural gas, and petroleum products, China's government and business elites have emphasized EV designs and production.

China's powerful model of economic soft power has crept into commodity warehouses, EV factories, and everything in between, granting Chinese entities significant control over several links of these critical supply chains. In an era of unparalleled geopolitical friction, how China's dominance will affect emissions reduction goals in places like the United States and Europe remains to be seen. ***Reports of human rights abuses in Xinjian and the political status of Hong Kong and Taiwan are key issues that close the door for cooperation with China on climate change.***[1] Thus, the success of EVs, much less anything else in the energy transition hopper, cannot be divorced from the geopolitics of the day. China's inordinate influence over natural resource-producing and -exporting countries could translate to leverage in its revisionist power plays.

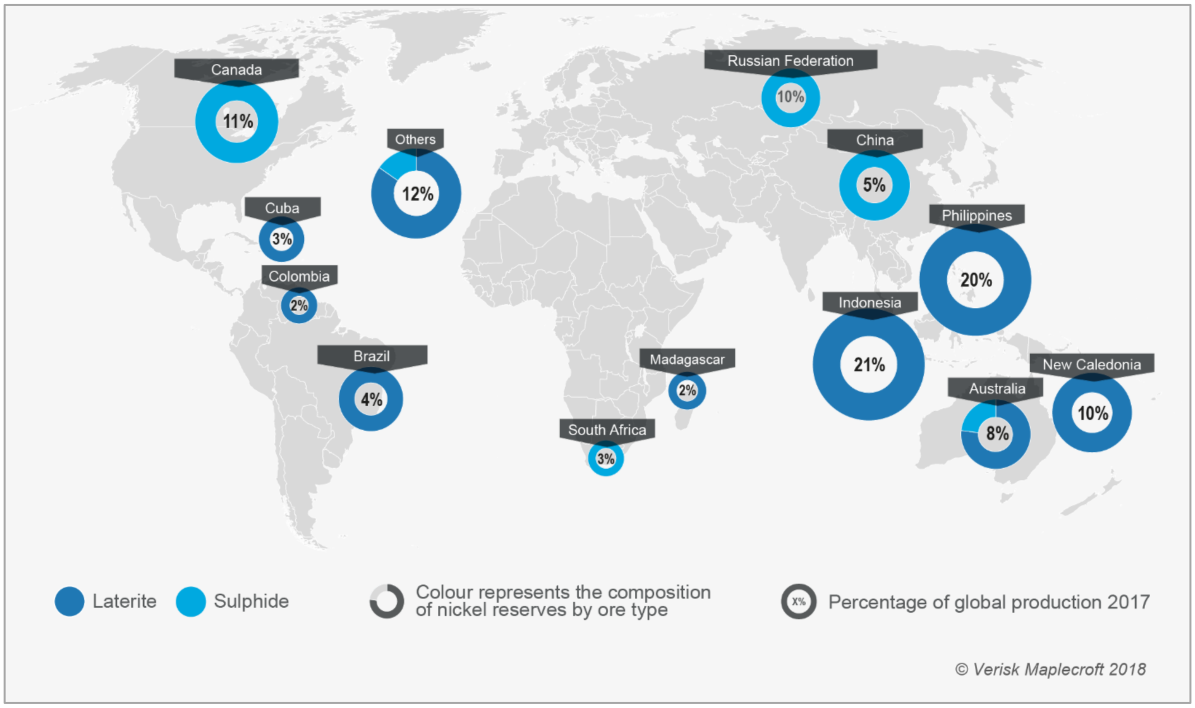
Accompanying the vigorous drive toward alternative energy technologies is the unavoidable pressure on the global supply of critical base metals. ***Nickel is no exception.*** In our report and case study we examine tensions in nickel supply and value chains within the context of broad aspirations to electrify transport.

Essential Information

Nickel[2] is now deemed a critical mineral by the U.S. Geological Survey (USGS) mainly by virtue of assessed trade and economic vulnerabilities.[3] Nickel is a key input for a host of industrial and consumer products and end uses, including the industry-standard cathode chemistry, NMC or lithium-nickel-manganese-cobalt-oxide ($LiNiMnCoO_2$). The NMC 811, a nickel-rich cathode chemistry used by the auto industry, incorporates up to 80% nickel and 10% each of manganese and cobalt. It provides significant cost savings, improved energy density and efficiency, and a more sustainable balance of battery metallurgies in comparison to competing cathode chemistries. Nickel-rich cathodes have become more commonplace as EV manufacturers (original equipment manufacturers or OEMs) and their powertrain vendors increasingly migrate toward those chemistries. ***However, battery designs are intensely competitive and could prove disruptive, with implications for nickel producers and large resource owners like Indonesia.***

Nickel production worldwide derives from two general occurrences: (1) ***laterites***, chemically weathered igneous rock (which now accounts for about 60% of global nickel resources) where nickel associates with iron, and (2) ***magmatic sulfides*** (about 40%) where it associates with sulfur (Figure 1). Laterites are mined for nickel from tropical soils in Indonesia, the Philippines, New Caledonia, and elsewhere using surface extraction (Figure 2, top row). Sulfides are deeply occurring, requiring much more expensive extraction, including underground operations in places like Russia (Figure 2, bottom right)

Figure 1. Global Distribution of Nickel Resources



Source: Open source image from Verisk Maplecroft.[4]

Figure 2. Typical Laterite (top) and Sulfide (bottom) Nickel Mining Operations


Sources: Top left—New Caledonia Tourism.[5] Top right—Mining-technology.com.[6] Bottom left—*GoContractor*.[7] Bottom right—Russia's Nornickel.[8]

The common chemical forms of nickel are carbonate (nickel, carbon, and oxygen, $NiCO_3$), chloride (nickel and chlorine, $NiCl_2$), divalent oxide (nickel and oxygen, NiO), and nickel sulfate (nickel, sulfur, and oxygen, $NiSO_4$).[9] ***Nickel sulfate is a key ingredient for cathode precursors for lithium-ion batteries.*** Batteries for EVs utilize high-purity nickel (more than 99%) and are typically termed "Class 1." Some stainless steel products, which comprise the largest existing use of nickel, can be made utilizing less pure, "Class 2" metal. Because nickel quality tends to be higher in sulfides, processing tends to be cheaper, creating an expensive-to-mine but cheaper-to-process proposition relative to laterite occurrences. However, lateritic deposits are more common and accessible. ***Our report incorporates an emerging strategy of upgrading nickel pig iron (NPI), a relatively new product obtained from laterites for steel production, to supply battery-grade material.*** Thus, global extraction and use of nickel going forward will entail distinct trade-offs between the costs of mining and processing and the purity for different applications. These also bear attendant and distinct environmental trade-offs. In all, the future will likely involve competition between established uses of nickel, such as for stainless steel, and new ones like batteries. On the supply side, expanding reliance on low-grade nickel resources for existing uses, and testing strategies to deploy expensive upgrading to reach higher purity levels for batteries, will dictate market dynamics going forward.

The main body of our report consists of three parts, briefly summarized below:

Electrification Ambitions—Part I

The expansive EV supply chains involved—from materials extraction to end use in vehicles and ultimate end of life—and their associated logistics are global, linking together a slew of producers and suppliers with their own, often disparate, agendas. ***Each node in these supply chains is accountable to the complex geopolitical realities that frame their commercial maneuverability, resulting in diverse contexts that often create conflict and misalignment.*** Thus, the chances of supply instability are great for the future of EVs, and opportunities for actors to extort strategic dependability come at a premium. Clearly, if every government pursues intense strategic competition for supply chain security, the risks of instability, disruption, and attendant consequences could spiral out of control.

In Part I we provide a survey of EV and EV battery (EVB) manufacturing and China's large presence in this field. Expectations for electrification of transport are high, driving strategies and planning that have implications for nickel and other battery metals. EV sales have been assertive but remain a very small portion of global passenger vehicle purchases (less than 8%) and an even smaller share of the global fleet (less than 1%). China represents the larger of both—more than half of 2021 global EV sales occurred in China, which is now the world's largest auto market. China's overt strategy and aggressive tactics to be the leading developer of electric transport options mean they control nearly 100% of overall battery manufacturing and, as best we can tell, have overt control of nickel-rich chemistries. Chinese control of minerals and mining capacity, including outbound investments, has evolved accordingly. But this also means that China's manufacturers and government overseers are exposed to any shortcomings in raw materials supply chains, just as other market participants and countries are.

Nickel Mining and Processing Backdrop—Part II

In Part II we provide details on nickel mining and processing. Investment in nickel production, as with anything, is driven by price and, more importantly, expectations about price. ***Rapid rises in the price of nickel and other key commodities since mid-2019 have garnered much attention, due to a combination of supply-demand imbalances and excitement about batteries and EV news.*** Announcements during 2021 of Chinese investments in Indonesia briefly pushed down the price of traded nickel. Releases from China's deep commodity stockpile were an overt attempt to stabilize prices and raw materials costs for manufacturers. Both actions—China's stockpile releases and Chinese investment activity—reflect anticipated supply-demand imbalances.

Against the backdrop of increasing demand are realities in mining and minerals processing. Ore concentrations (the amount of mineral captured per ton of material extracted) decline as prime properties reach maturity. Unless greenfield exploration can yield better opportunities, low-tier, high-cost reserves will come into inventory. Both are contingent upon commodity price. The situation for nickel is no different. ***Conditions like these can***

exacerbate large swings in price. The need for high-purity nickel to support efforts like the rapid expansion of EV output adds to market complexity and dynamics.

The Chinese Resource Play in Indonesia—Part III

Our Part III case study focuses on the growing Chinese presence in Indonesian nickel extraction and processing capabilities. China exemplifies strategic planning with an intense focus on supply chains and logistics, while Indonesia could play a strong role in breaking bottlenecks in battery-grade nickel supply, along with other Class 1 nickel end uses. Because of the importance of EVs in decarbonization strategies around the globe, Chinese control of critical upstream production and further expansion toward end-use production carries strong implications for geopolitical leverage. What could become a momentous energy and economic transition this century will be partially dependent on emerging, resource-rich economies like Indonesia that have a penchant for geopolitical and regulatory volatility. The importance of strategic positioning in these countries cannot be understated.

In short, important dynamics have emerged, with some worth noting in our introduction and others relegated to the discussion to follow. Indonesia is attractive to Chinese investment for several reasons. Most obvious, besides their geographic proximity, is the sheer abundance of nickel under Indonesian soil. Indonesia constitutes about one-third of global nickel production and a quarter of reserves—but again, quality matters. ***While Indonesia's resources do not constitute traditional battery-grade nickel feedstocks, Chinese investors are not afraid to push the envelope in their operations, attempting to consolidate battery-grade and lower-purity nickel feedstocks.*** Chinese companies with a decades-long historical presence in the Indonesian nickel mining ecosystem are situated to negotiate and, in some cases, influence the same erratic regulations that instill reluctance among investors from other countries. Through Beijing's support of their investments, Chinese firms in Indonesia enjoy inordinate protection from forces that prove detrimental to their competitors.

In the scheme of Indonesia's push for higher, value-added, nickel-based cathode production, Chinese presence, especially their capital and scaled operations, presents a jumping-off point for a burgeoning slice of Indonesian exports. Chinese capital also offsets many of the barriers facing Indonesian companies' growth in mining, processing, and battery-related businesses. For Indonesian officials, a sustainable balance is necessary: Their attempts to impose value-added, strategic industrial development for their local economy and industry could clash with China's already lopsided geopolitical leverage.

Along with these considerations are Indonesia's legal and regulatory regimes for mining and minerals processing—i.e., the country's "commercial frameworks" and how inviting they are for new and/or expanded investment. A slew of environmental issues surrounds mining, particularly laterite upgrading for battery-grade nickel. Debate is lively as to whether external pressures, in particular those being placed on battery supply chain customers, and internal governance can converge to satisfy ever-expanding sustainability criteria. Regional geopolitics—always testy—will add uncertainty to the picture.

Conclusions

Clearly, neither effective public policy nor corporate strategies as they relate to minerals and materials supply chains can be devised without full and proper understanding of occurrences, operations, logistics, and locational context.

Many factors can, and will, impinge on nickel supply-demand balances, including the activities of key players, Indonesia-China interactions, and geopolitical relations. The pace and timing of energy transition technologies, the success of related strategies, and the associated government policies are all important sources of risk and uncertainty. The availability of alternative sources of Class 1 quality nickel (such as seabed nodules), the use of substitutes (such as plastics for nickel steel in appliances), and the amount of nickel recovered through recycling (more than 80% is recovered from consumer products and steel scrap[10]) all affect future supply-demand balances.

From our case study and supporting analysis, it is becoming increasingly clear that China has positioned itself as a gatekeeper to the energy transition, with broad implications for strategic planning in the United States.

Table 1. Case Study Summary—Risk Assessment

Factor	Brief Overview	Risk Manifestation
Class 1 Nickel Supply Shortage	A battery-grade (Class 1) nickel global shortage is likely to affect EV supply-chains in the short-to-near term.	A global Class 1 supply deficit would engender significant disruptions, trickling down from upstream extraction to EV production.
Nickel Price Action	Nickel prices are currently nearing a five-year high. A bearish reversal in nickel prices could prove detrimental for the battery-grade supply expansions.	A bearish outlook for nickel prices would dissuade efforts to expand battery-grade nickel extraction, a key aspect of mitigating supply concerns for battery producers.
Capex Requirements of Processing	Nickel refining requires heavy capital expenditure, and intermediary refined products (e.g., nickel sulfate, briquettes, etc.) return slim margins.	Significant capex requirements limit the base of potential investors for the Indonesian government as they push to expand domestic nickel processing capabilities.
Environmental Concerns of Processing	The energy expenditure of nickel processing raises environmental concerns about the power sources feeding refineries.	Relying on carbon-intensive power sources to feed nickel refining could overshadow progress toward decarbonization in transportation, rendering EV initiatives futile in the aggregate.
Regulatory Fluctuation in Indonesia's Natural Resource Management	The Indonesian government's 2020 ban on nickel ore exports is a symptom of a highly fluctuating regulatory environment in the natural resource sector.	Indonesia's reliance on their natural resource endowment for government revenue makes regulatory fluctuation and uncertainty highly likely. Further fluctuation could upend mineral flows from Indonesia and the regulatory variables investors depend on for their decision-making.

Price Convergence	Utilizing low-grade (Class 2) nickel as a feedstock for battery manufacturing could force a convergence in Class 1 and 2 nickel prices.	Class 1 and Class 2 price convergence would effectively eliminate the price premium placed on battery-grade nickel, and would likely hamper Class 1 supply expansion.
Obsolescing Bargain	Nickel extraction projects prioritize higher-grade ore at the onset and move to lower-grade as the project matures, engendering higher processing costs per ton and diminishing revenue per ton.	Diminishing revenue as extractive projects mature could translate to financial difficulties permeating through several venues of Indonesian government expenditure. Through foreign divestment requirements, Indonesian entities will increasingly bear the brunt of diminishing ore quality as extraction progresses and divestment runs its course.
Regulatory Centralization of Mining in Indonesia	Over the past decade and a half, the Indonesian government has centralized the regulatory regime that oversees the natural resource sector.	Indonesia's recent centralization increases the potential for unilateral decision-making when ephemeral priorities conflict with the established permitting regime.
Indonesia's Reliance on Chinese Capital to Expand Nickel Processing Capabilities	Indonesia's rise as the top global nickel producer is in large part due to Chinese capital investment, and the same appears true for Indonesia's expansion of domestic nickel processing.	Indonesia depends on a narrow base of Chinese investors to expand domestic nickel refining, potentially resulting in unfavorable negotiation terms for the Indonesian government.
Geopolitical Gaming in the South China Sea	Indonesia's reliance on Chinese capital to expand nickel extraction and processing could become a lever for China to utilize in competition over the South China Sea.	Chinese leverage from developing Indonesia's domestic nickel processing capabilities could further imbalance negotiations surrounding rights to natural resources and logistical access to the South China Sea.
China Reining in 'Rogue' Capital in the Mining Sector	China's recent actions to re-centralize control over Chinese capital in the tech sector (as part of Xi Jinping's "common prosperity" policies) could bleed into the natural resource sector.	Such a move would likely alter the negotiating norms between Indonesian and Chinese mining sector entities with additional strings attached.
Critical Shipping Lane Closures in the South China Sea	Several chokepoints in the South China Sea create severe strategic vulnerabilities for commercial shipping.	In the event of a Chinese military invasion of Taiwan, traffic through the Luzon Strait would likely halt.

Part I. Context

Our case study is rooted in notable developments that have taken commanding positions in dialogues around the world. These include:

- **Shifting Transportation Paradigms:** There is growing anticipation of *fundamental shifts in transportation*, from liquid fuels to electrification, and China's position as the now-dominant domestic auto market.
- **"China Inc.":** China has a significant role and market power in *manufacturing and supply chains*.
- **The Role of Nickel:** *Nickel is one of the critical minerals* required to support the electrification of transport.

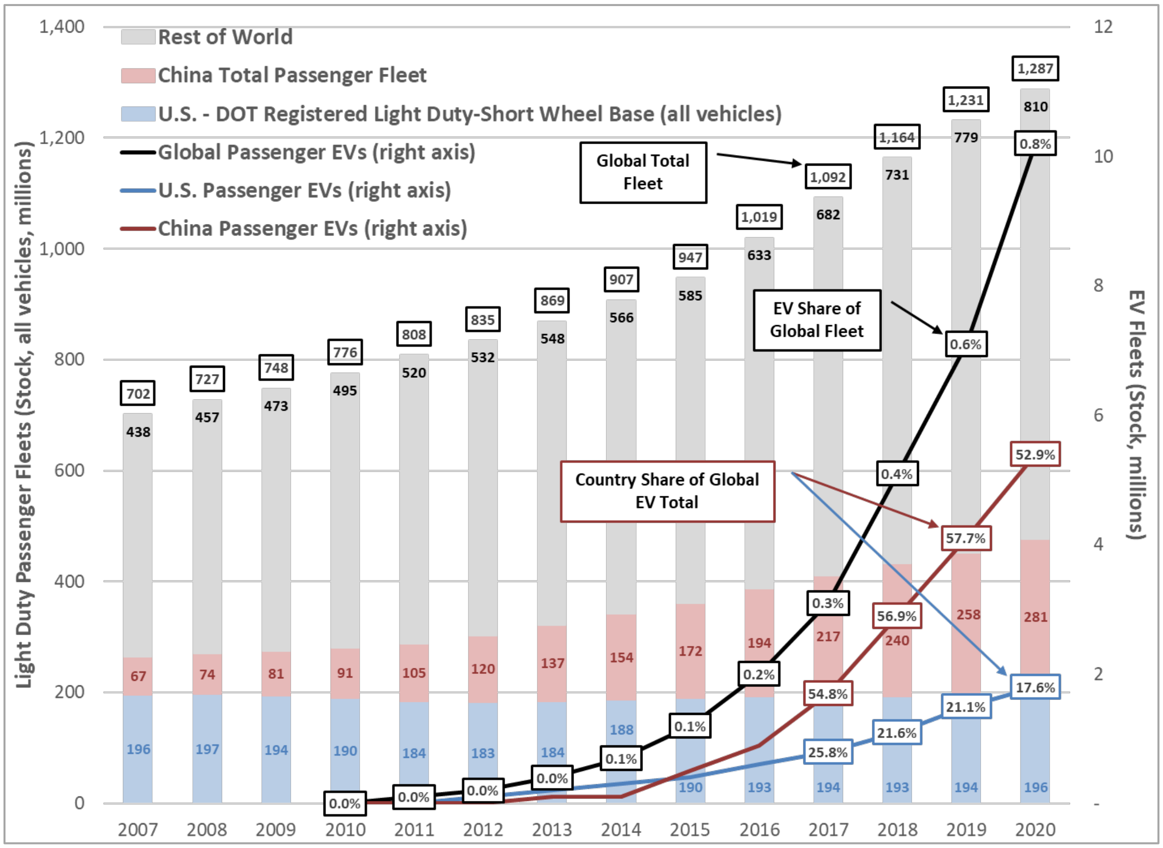
Shifting Transportation Paradigms

Central to our case study and ongoing research at the Baker Institute Center for Energy Studies (CES) are China's ambitions relative to emerging transportation technologies. Among these is China's commanding position in EV manufacturing, including the manufacture and assembly of electric vehicle battery (EVB) components. Chinese government and business elites clearly see electrification of transport (and all that it entails) as a strategic imperative for their nation's economic growth and competitiveness, as it provides options for domestic markets as well as huge and important export value creation.

We use data from Bloomberg New Energy Finance (BNEF), the International Energy Agency (IEA), and other sources here, and elsewhere in our report, to set the scene of transport shifts.

China's economic surge since the dawn of this millennium coincides with growth in its domestic passenger vehicle fleet (Figure 3). In a world of almost 1.3 billion light-duty vehicles (passenger cars, sports utility vehicles or SUVs, and trucks), the U.S. fleet, while very large, has remained static for over a decade and is no longer the dominant vehicle market. China has taken the top spot, and is likely to remain in that position for the foreseeable future. Pre-pandemic, China constituted 22% of worldwide vehicles in use, compared to 15% in the United States. The roughly 10 million EVs in use worldwide represented about 0.8% of total global passenger vehicles in use in 2020. China's 5.4 million EVs comprised almost 54% of the global total passenger EV fleet (about 2% of its total passenger vehicle fleet) in the same year, and the 1.8 million EVs in the United States represented about 18% of the global EV total (about 1% of the domestic passenger vehicle stock).

Figure 3. Global, U.S., and China Passenger Fleets—Total Vehicles and EVs

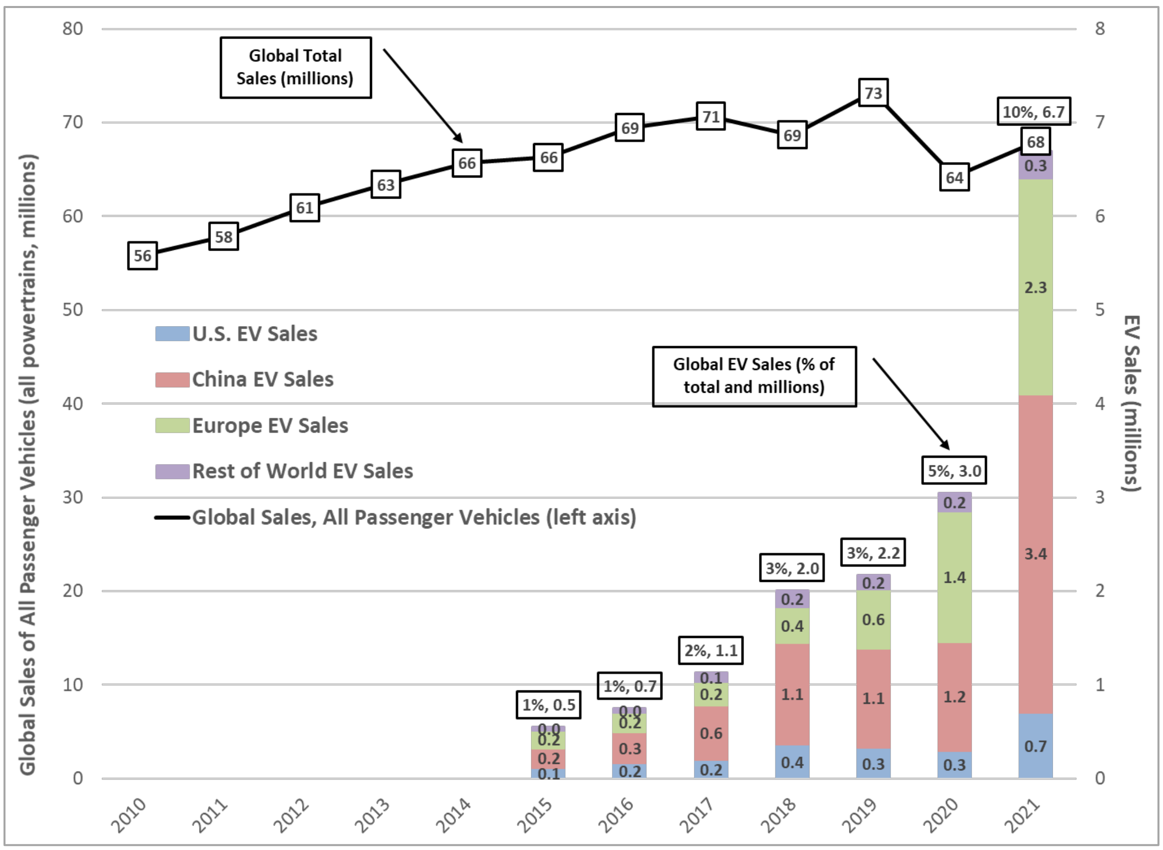


Note: The EV share of the total fleet for the U.S. and China is shown since 2017 for brevity.
Sources: Compiled by the authors from a variety of sources.[11]

EV sales roughly doubled during 2020-2021 as European and other countries moved aggressively to promote vehicle purchases. Globally, EV sales account for just over 40% of the 2019-2021 decline in traditional, internal combustion engine (ICE) powertrains (Figure 4). In a worldwide passenger vehicle sales market hit first by softening economic conditions in 2019 and then by widespread lockdowns due to the pandemic in 2020, the chunk of market share taken up by EVs got noticed. China made up just over half of 2021 global BEV sales, while Europe contributed about one-third, and the U.S. 10%. To a large extent, EV sales reflect an assortment of incentives provided by governments. If incentives are rolled back—as in China in 2019—sales quickly reflect the policy adjustment.[12] China's rollback of government support enabled Europe to pull ahead in market share. Assertive government promotion of EV sales is expensive from a public expenditure standpoint. While some governments have launched more aggressive approaches, in many cases, as part of post-COVID economic recovery, these promotions can easily crowd out other pressing needs and create myriad distortions. Policies to incentivize EV sales and mass-adoption are also hindered by inadequacies in supporting infrastructure. Current deficiencies are wide ranging: unstable raw materials supply chains; insufficient battery manufacturing capacity;

insufficient recharging capacity and access (along with numerous questions about ownership and financing of recharging infrastructure[13]); massively complex adjustments to electric power infrastructure to support EVs (and accommodate challenging, intermittent wind and solar); and many unanswered questions regarding how to finance road construction and maintenance given lost revenues from fuels taxes (and resistance to capturing road costs from electric power sales for EV recharging).

Figure 4. Total and EV Sales for Various Geographies



Sources: Compiled using data from the IEA's 2021 Global BEVs Outlook and the International Organization of Motor Vehicle Manufacturers (OICA).[14]

Much of the world gets around on two- and three-wheel devices. For instance, Bloomberg estimates that there are about 10 million passenger electric vehicles in stock—cars and trucks (compatible with the IEA's estimate)—and about 264 million electric mopeds, scooters, and motorcycles (electric bicycles or "e-bikes" are not included). Rounding out the electric vehicle fleets are about 1 million electric buses and commercial vehicles.

Bloomberg projects passenger EVs globally to grow more than 17 times to about 169 million by 2030.[15] The IEA projects EV stock in all forms and modes, including buses and trucks, to reach 145 million by 2030, with sales of 15 million in 2025 and more than 25 million in 2030.[16] The U.S. Energy Information Administration (EIA) goes further to put the global EV fleet at 672 million vehicles by 2050 out of a total global fleet of more than 2.2 billion.[17] Forecasts do not necessarily entail an increase in the share of EVs relative to the global passenger fleet. Newly produced ICE vehicles will continue to be sold, and existing ICE vehicles will enter pre-owned vehicle markets not only in high-income countries but low-income ones as well. Pre-owned cars and trucks have long been internationally traded and sold. Customers in countries with weak electric power systems and little ability to subsidize electric power or sales of EVs will continue to utilize ICE vehicles. The most assertive views call for EVs to constitute 100% of global passenger sales by 2035.[18]

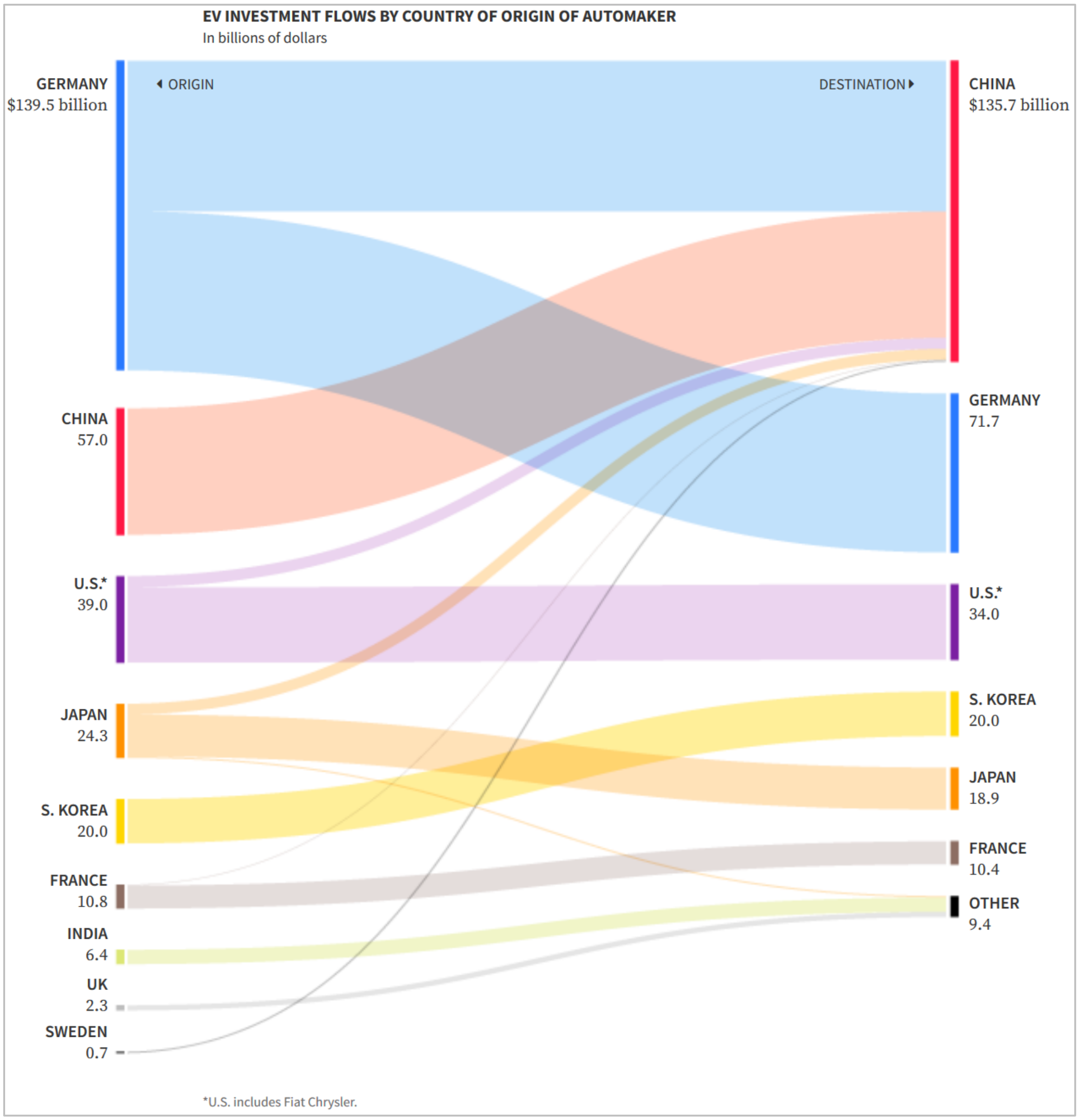
Any and all expectations imply a rapid and vast scale-up in minerals mining and refining, along with EV production and sales (including adoption by price-sensitive customers).[19]

Passenger vehicles are already "battery hogs," constituting about 53% of the lithium-ion battery market for 2020, with non-vehicle battery use (e.g., consumer electronics and stationary energy storage) taking up roughly 36%, and bus and commercial transport the balance. By 2030, BNEF has passenger vehicles dominating with about 67% of the battery market, while electrified buses and commercial transport grow to 24%. Non-transport uses shrink to 9% (including stationary energy storage, which does increase considerably by almost 13 times the 2020 estimate).[20] This means that passenger EVs will drive demand for lithium-ion batteries and thus battery metals into the future.

"China Inc."

EV sales and fleet growth in China reflect its ambitions for strategic positioning in EV and EVB manufacturing, including in its own domestic market. Indications are that China aims to electrify 25% of all new passenger vehicles in the country as soon as 2025.[21] An investment flow chart recently compiled by *Reuters* (Figure 5) reflects the heavy weighting of capital flows toward China, with Chinese interests commanding nearly half of the $300 billion in total investment. This is in large part due to their control of supply chains for critical materials inputs for EVs, control of EV technology (including intellectual property or IP associated with battery chemistries and packaging), and large EV and EVB manufacturing capacity.[22] Large automakers, the original equipment manufacturers (OEMs), and their powertrain vendors and partners are left with few options.

Figure 5. EV Investment Flows (2019)



Source: *Reuters*.[23]

Concerns stemming from limited options outside of China for automakers and vendors, along with other unfavorable investment flows, are heightened when the global inventory of battery manufacturing capacity is added to the mix. In Table 2 we summarize comparative estimates of EVB manufacturing capacity worldwide and in China, drawn from BNEF. If all of the current EVB plants under construction are complete and commissioned, and all currently announced projects are brought to fruition, worldwide capacity will reach 3,465 gigawatt hours (GWh) by 2030. By some measures, even that level of capacity will be insufficient to support global BEV manufacturing at the scale envisioned.[24] Of that potential global capacity, China would comprise 2,169 GWh, or more than 60%, even with strong efforts to build manufacturing in other countries. But the Chinese control of EVB manufacturing today is even more staggering: China's aggressive positioning has given it control of nearly 80% of current global EVB manufacturing capacity (fully commissioned plants). China accounts for nearly 90% of capacity that is under construction and close to half of announced projects, ensuring Chinese dominance over the subsector for years to come.

Table 2. World and China Battery Manufacturing with Status (GWh)

	World	China	China Share of World
All Chemistries			
Fully Commissioned	673	518	77%
Under Construction	957	838	88%
Announced	1,835	793	43%

Note: GWh is gigawatt hours, the common unit used for battery plant capacity.
Source: Compiled by authors using BNEF inventory, accessed via license.

The BNEF inventory data compares well with what we at CES have inventoried and mapped independently.[25] Our total of roughly 669 GWh of operating EVB plant capacity compares with BNEF's 518 GWh of fully commissioned capacity.[26]

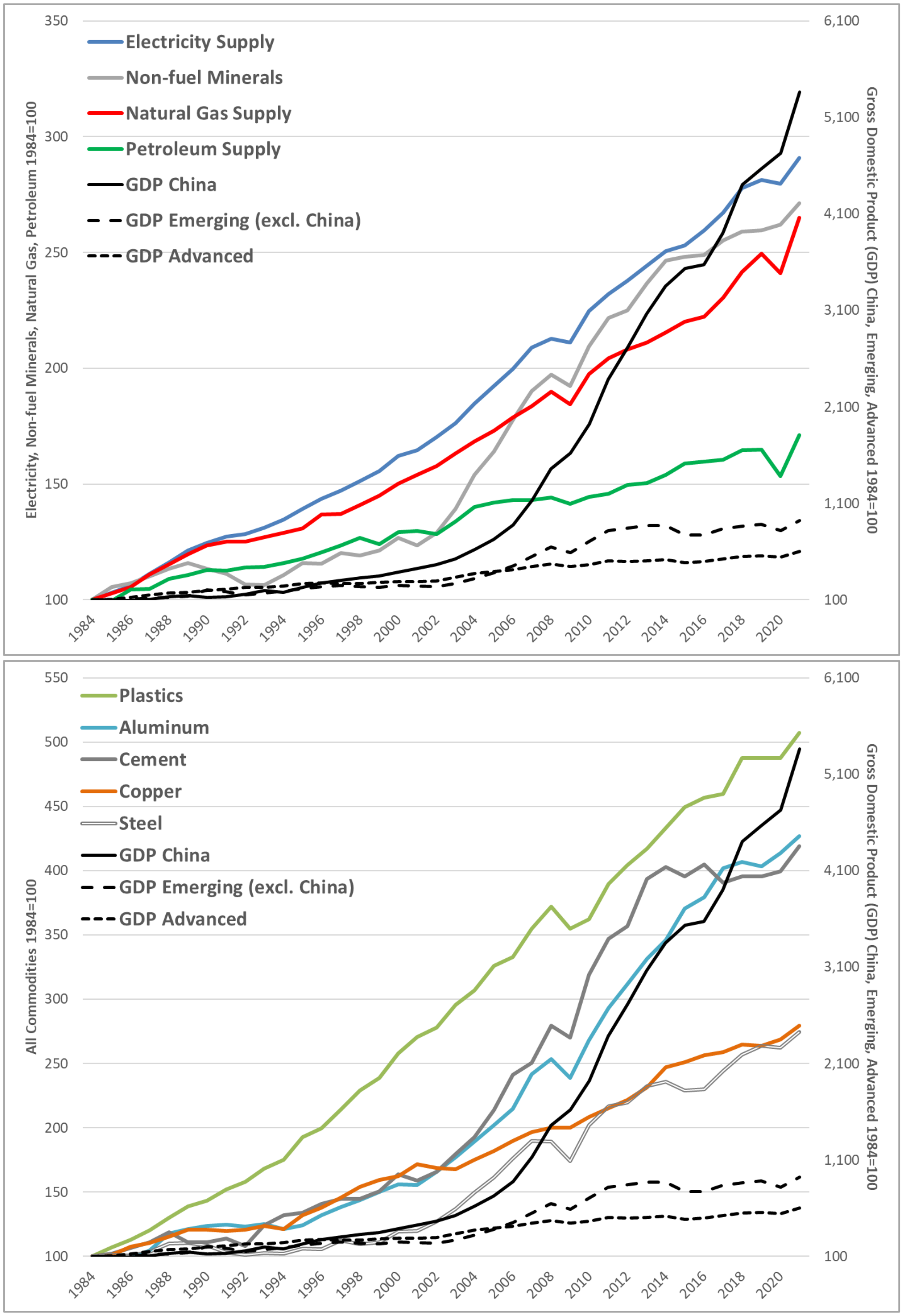
An important aspect of China's EVB manufacturing lies in how that activity resides within the country's overall energy infrastructure. The sensitive nature of EVB manufacturing requires a high degree of reliability for electric power production and delivery. A distinct conundrum for EVs is that they are only as "clean" as the energy sources used for manufacturing and recharging. China provides a good example of the trade-offs other countries face. The IEA puts coal use at roughly 64% of Chinese electric power production. Hydroelectricity contributes 17% of total power generation, of which Three Gorges is the largest facility by far (roughly 23 megawatts or MW of a total 356 MW installed). Nuclear contributes about 4% (based on the most recent information from 2019). An assortment of wind, solar, biomass, and other sources make up the balance.[27] While alternative generation sources such as wind and solar are fast growing, they constitute a very small share of power output and, as usual, are balanced by fossil fuel generation. Nuclear is also fast growing and is linked to China's expansion of its military capacity, including its push to host a "blue water" navy. Of interest is the convergence between energy infrastructure and manufacturing. Our mapping indicates the strong co-location of EVB manufacturing sites with major electric power generation units, the most ubiquitous of which are thermal (coal) power plants.[28]

The difficult energy and environmental trade-offs extend to raw materials and domestic extraction and processing. China's industrial base is distributed proximal to parts of the country that are rich in minerals.[29] In similar fashion to the United States, Europe, and elsewhere, China's industrial emergence has been marked by the convergence of manufacturing, energy and minerals processing, and refining with supporting infrastructure for access to domestic and international markets. As in many countries, Chinese hydropower supports metals refining and smelting. China's huge base of coal-fired power generation provides the bulk of support for domestic heavy industry and manufacturing.

China's model of soft power pervades virtually every sector of the global economy. This dominance has also resulted in excessive influence over energy and non-fuel minerals supply chains (such as those for nickel), which feed Chinese industrialization.

The influence of China's emergence as the "factory to the world" on energy, non-fuel minerals, and other key commodities is well-illustrated in Figure 6. Global petroleum, natural gas, and electric power generation supply and output all reflect China's surge in economic growth (represented by gross domestic product or GDP) with attendant industrialization and export-oriented schemes (Figure 6, top). Global output of important intermediate materials—plastics and resins, finished aluminum, hydraulic (Portland) cement, refined copper, and crude steel—parallels China's internal demand and outfacing production (Figure 6, bottom). Of note is that worldwide total non-fuel minerals tonnage (Figure 6, top) has increased at a faster rate than either oil or natural gas. This reflects intrinsic demand for a multitude of industrial and consumer applications *before* alternative energy or EVs entered the scene. Thus, total non-fuel minerals supply reflects demand emanating from existing legacy industries—everything from construction to telecommunications to food and textiles to the imperatives of global health care. Many supply-demand tensions that we expect to see in energy and non-fuel minerals markets and prices going forward, along with associated geopolitical backlash, will reflect the clash between existing and emerging applications. We can think of energy and non-fuel minerals consumption for legacy end-use applications, including both defense and non-defense, as the "baseload" demand. Emerging end-use applications associated with the push to add new, alternative energy technologies such as wind, solar, battery storage for power grids, EVs, and the like will add large tranches of incremental and perhaps highly variable load.

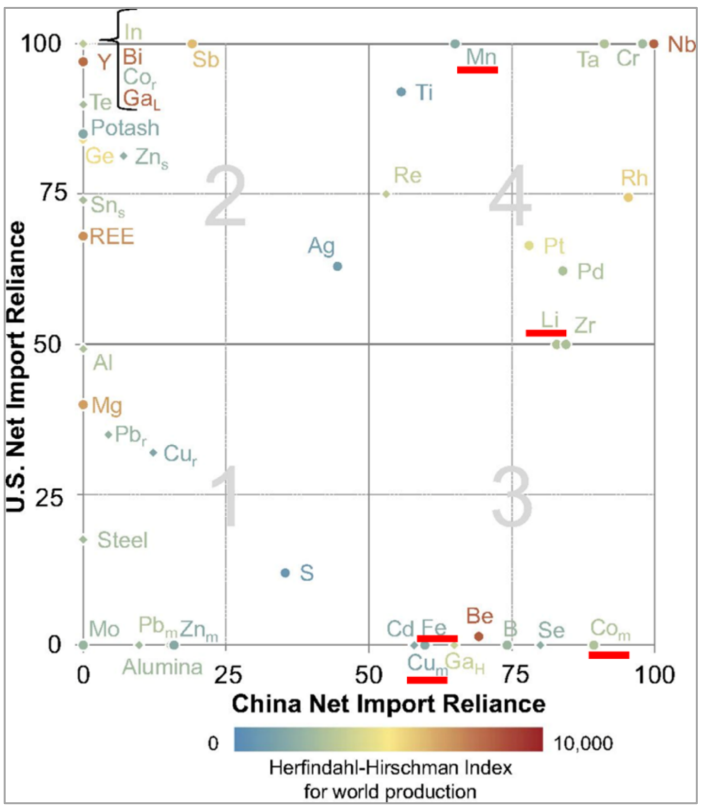
Figure 6. Global Energy, Non-fuel Minerals, and Key Commodities (left axis) with GDP for China, Advanced and Emerging Market Economies (right axis)



Sources: Prepared by authors using data from various organizations.[30]

With its huge domestic mining and minerals processing operations, China's output encompasses almost one-fourth of total global non-fuel minerals production tonnage.[31] Yet, China's dominance over several key mineral supply chains does not come close to satisfying domestic demand. Indeed, China's net import reliance (NIR) has been estimated by USGS specialists and is depicted with comparison to the United States in Figure 7. For battery metals (all indicated by red underlines in Figure 7), China relies heavily on imports of lithium, mined copper and cobalt (denoted with subscript "m" in Figure 7), manganese and iron, as well as other minerals essential to China's expanding industrial base. This places China at the forefront of international sourcing of vital raw materials, especially in light of China's command of EV and EVB manufacturing capacity. Importantly, nickel was not included in the USGS assessment, largely because it was not previously deemed a critical mineral for the United States. As noted in the introduction, this has changed and nickel now is included in the USGS listing. In its 2020 nickel minerals assessment, the USGS estimated U.S. nickel NIR to be 50%.[32]

Figure 7. U.S. and China Net Import Reliance (excludes Nickel)



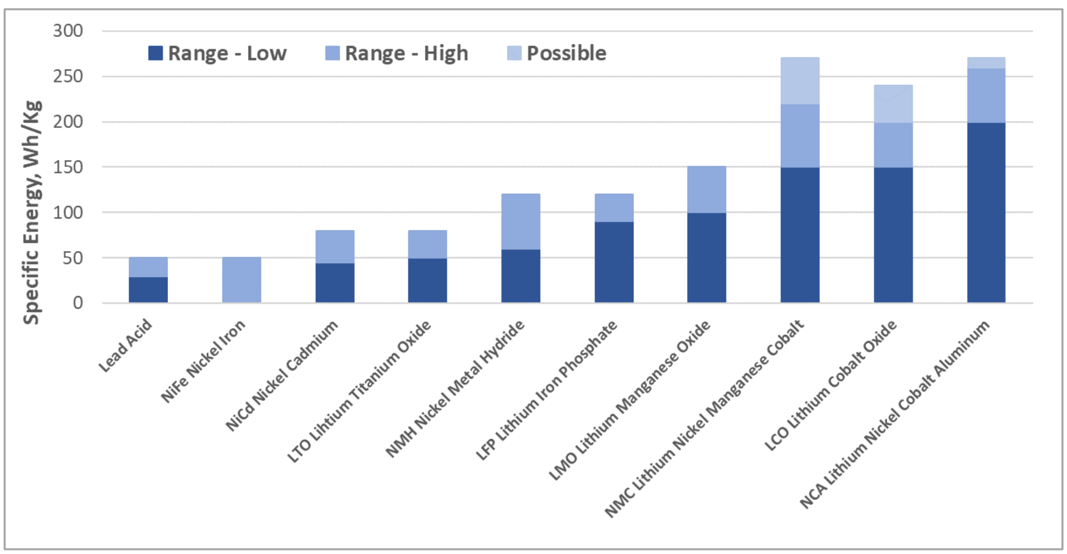
Note: The assessment did not include nickel.[33] Also note that the authors' analysis includes discussion of potential vulnerabilities for the U.S. for minerals over which China has market power, such as rare earth elements and niobium in Brazil. The "H-H" index is a common measure of market concentration. The higher the index, the higher the market concentration (less competition among suppliers and/or buyers). Key minerals for EV battery production are underlined in red.
Source: Andrew L. Gulley, Nedal T. Nassar, and Sean Xun.[34]

China is the world's largest importer of nickel, dwarfing other countries (nearly 15 times the next largest importer, Japan). As with other minerals, China is a large nickel and refined nickel producer courtesy of its domestic supply and overseas holdings.[35] Indonesia, the world's largest producer of nickel and located in China's neighborhood with long trade linkages, is an obvious target for Chinese outbound investment. Estimating China's NIR for nickel is made more difficult by the strategic shift away from imports of refined nickel and toward NPI.

The Role of Nickel

Prospective consumption of nickel is magnified by the strong push for EVs detailed above. However, ultimate demand for nickel derived from EVB manufacturing is contingent on battery chemistries, a fast-moving and shifting part of the EV landscape. As noted at the outset, much of nickel demand for BEVs is associated with NMC cathode designs. As NMC cathodes have progressed, with increasing nickel content (up to 80% or higher), developers have been able to increase specific energy (stored energy in watthours per kilogram or Wh/Kg). While specific energy is widely used to compare battery chemistries and as a gauge for performance (generally the greater the specific energy, the more stored energy and the longer the vehicle range), many attributes are sought—not the least of which is safety (cobalt has been key for stabilizing reactive lithium). Battery chemistries entail numerous trade-offs such as power and weight[36] and discharge-charge cycles. Vehicle designs, battery packaging, and many other considerations have bearing on expected performance. Comparable specific energy by mass, as in Figure 8, for gasoline is about 12,500 Wh/Kg.

Figure 8. Commercial Battery Chemistries



Sources: Prepared by authors using data from Battery University (https://batteryuniversity.com) and Nickel Institute (https://nickelinstitute.org).

In Table 3 we show battery manufacturing capacity for the NMC and the competing lithium-iron-phosphate ($LiFePO_4$ or LFP) chemistries (where identified in the BNEF inventory). LFP has drawn attention with the large Chinese manufacturer BYD's announcement of its "blade" design and Berkshire Hathaway's investment in the company.[37] Again, for both NMC and LFP, China's heft is the clear storyline.

Table 3. NMC and LFP Battery Chemistries and Status (GWh)

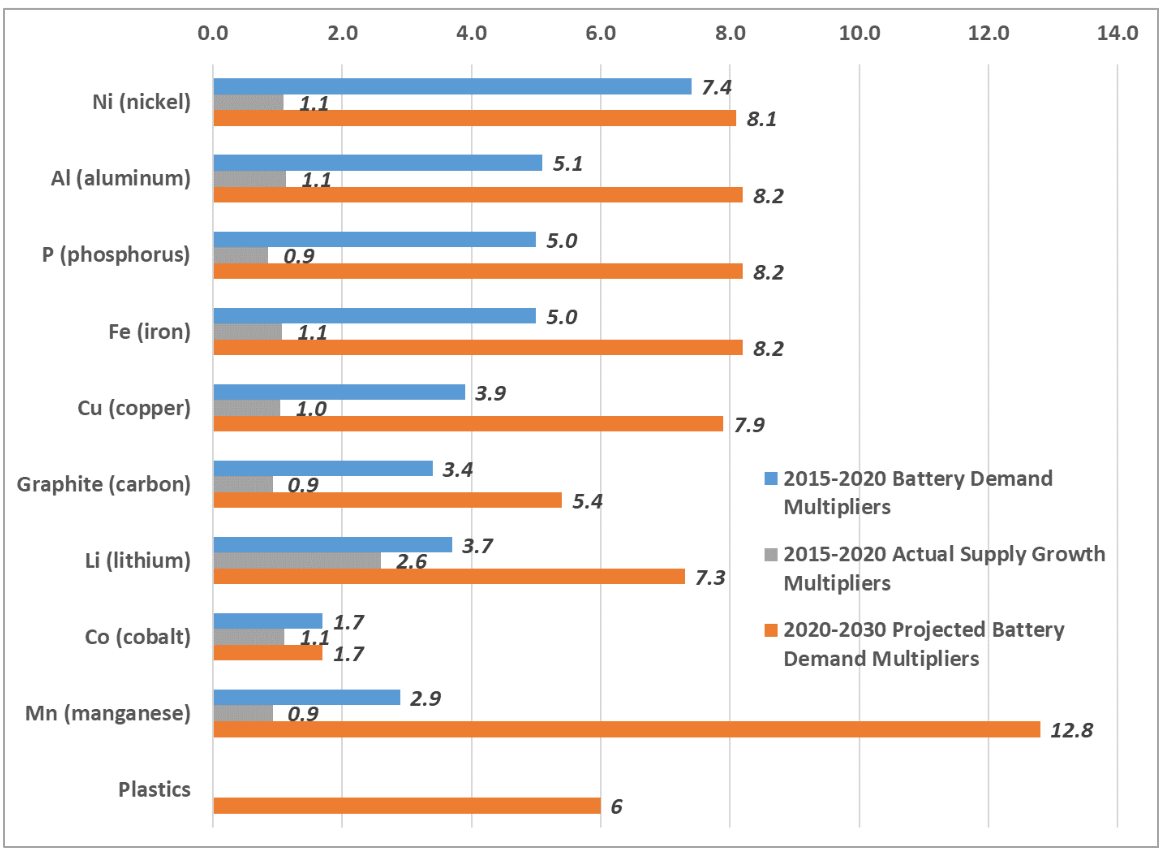
	World	China	China Share of World
NMC Chemistry (where known)			
Fully Commissioned	368	257	70%
Under Construction	299	252	84%
Announced	502	502	100%
% NMC of World, China Total Battery Chemistries (based on Table 2)			
Fully Commissioned	55%	50%	
Under Construction	31%	30%	
Announced	27%	63%	
LFP Chemistry (where known)			
Fully Commissioned	89	85	96%
Under Construction	164	164	100%
Announced	77	74	97%
% LFP of World, China Total Battery Chemistries (based on Table 2)			
Fully Commissioned	13%	16%	
Under Construction	17%	20%	
Announced	4%	9%	

Source: Compiled by authors using BNEF inventory, accessed via license.

EVB chemistries have been moving targets, complicating automaker strategies, raw materials sourcing, supply chains, and life-cycle management. The effort to establish competitive manufacturing platforms in order to defend the very large capital outlays moved the industry toward the NMC chemistry and the 811 format (see section on Essential Information) as the standard. Battery safety and fires are an impediment to EV adoption and the push for improved performance (greater energy density), while enhancing safety has been all-consuming and drives the competition between NMC and LFP battery chemistries. In particular, BYD is revitalizing the long-established LFP chemistry with new battery designs to enhance battery performance and safety. The LFP chemistry is associated with a form of battery packaging known as lithium polymerization or LiPo. The combination of LFP—which has the advantage of eliminating cobalt, an expensive and sensitive mineral component—with LiPo is thought to have advantages in safety and energy density, as well as cost reduction through both the removal of expensive cobalt and polymerization.[38] Whether and how much LFP/LiPo manufacturing increases in the future, and with what consequences for vehicle designs and output (and ultimately global raw materials supply and demand), remains to be seen. In recent news, Tesla, the closely-watched EV market leader, is offering prospective buyers a choice between its existing NCA (see Figure 8) and new LFP batteries.[39]

If the NMC chemistry remains dominant, forecasts of nickel demand are robust. We use BNEF long-term views for EVs and associated battery metals to show the potential increase in demand for metals in Figure 9. In the BNEF assessment, growth in nickel demand to 2030 driven by EV developments is more than eight times current (2020) tonnages.[40] Demand for other major metals for NMC and the competing LFP battery chemistries, as well as for wiring and other parts, is also expected to be strong. Importantly, plastics (see previous Figure 6, bottom) will continue to be used to offset weight and improve performance for EVs, as automakers have done with ICE vehicles for decades. Plastics are likely to be used in battery packaging and for other components in EVs. Currently, the plastic content for existing internal combustion engine vehicles is about 50%, and this is expected to increase to 60% or more as auto makers and battery power train developers strive to reduce weight, improve performance, and enhance battery safety.[41]

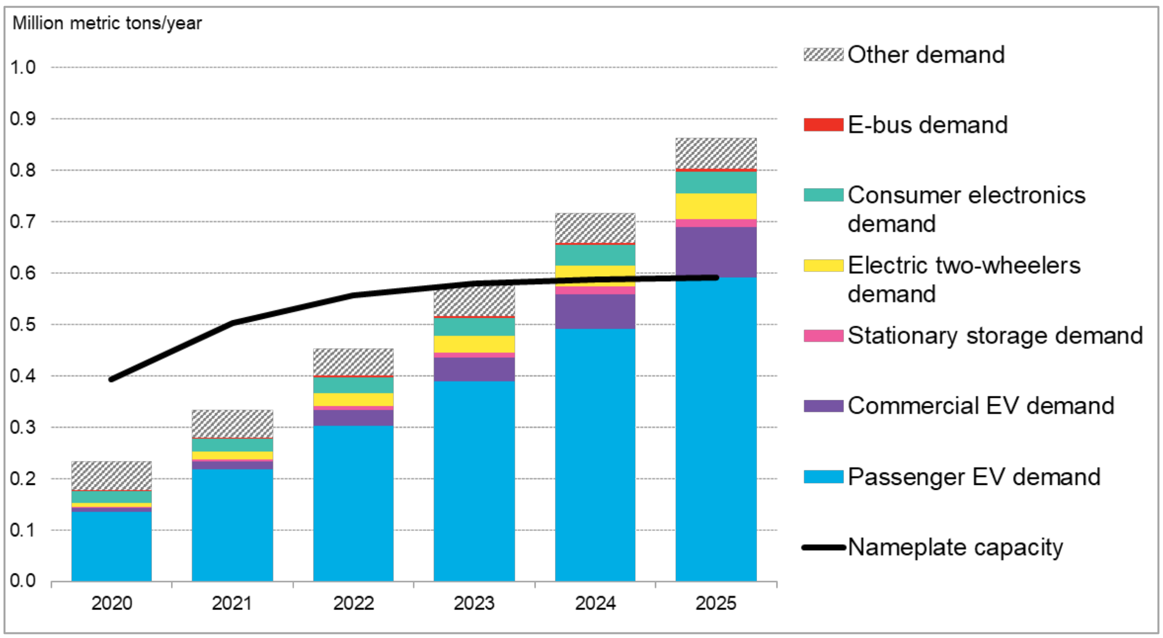
Figure 9. Demand for Battery Metals Associated with EVs



Sources: Compiled by the authors. 2020-2030 multipliers based on forecast data from BNEF.[42]

In Figure 9, we compare projected growth multipliers for 2020-2030 to 2015-2020 production gains (actual supply growth multipliers). The earlier time period was marked by relatively low levels of demand for battery metals and thus reflects nickel for other uses. Future nickel supply must grow not only to satisfy potential consumption for EVB manufacturing, but also to meet legacy needs. Thus, our comparison illustrates the difficulty of building minerals and materials supply chains to satisfy a future of electrified transport. On the back of optimism about metals demand, and if nickel-rich cathode chemistries remain commonplace, there are concerns that a significant deficit of nickel could loom as early as 2023 (Figure 10). As we show later, 2021 closed with a supply-demand imbalance.

Figure 10. Supply-Demand Outlook for Nickel with Transport Assumptions



Note: Nameplate capacity relates to mining and processing operations.
Source: Data from BNEF, accessed via license and used with permission.[43]

Given China's strategic positioning in the EV and EVB industries, their import reliance on critical minerals will only continue to rise. With such pressure, and with increasing competition from other large industrial countries for access to EV and EVB raw materials supplies, Chinese entities, public and private alike, will likely try to wield influence over global mineral flows to shore up their own critical mineral supply chains, threatening the growth of the home-grown battery/EV sector in the United States and the European Union (EU). China's entry into and prevailing control over critical mineral flows, together with its rapid buildup of EV and EVB manufacturing, sets the stage for our analysis of nickel supply and Chinese positioning in Indonesia.

Part II. Conditions in Global Nickel Markets and Indonesia's Role

Rising EV demand effectively creates a supply bottleneck for battery-grade nickel feedstocks. In order to meet optimistic market penetration targets, producers all along EV supply chains must wrestle to secure stable supplies of nickel. On the heels of mineral commodity price downturns in the early 2010s, which hampered efforts to expand battery-grade nickel extraction projects, EV producers around the world are searching for ways to open up new means of achieving secure nickel supplies—with some proposing rather experimental means of doing so. Indonesia's abundant laterite nickel ore reserves, which are thus far primarily feeding stainless steel end uses, may play a significant role in mitigating nickel supply concerns stemming from the EV industry. As such, we focus on the archipelago-nation, which may become a significant link in burgeoning EV supply chains, as the site of our case study on nickel. To assess whether Indonesian nickel can fill supply for EV cathode production, several notable pieces of context are important to consider:

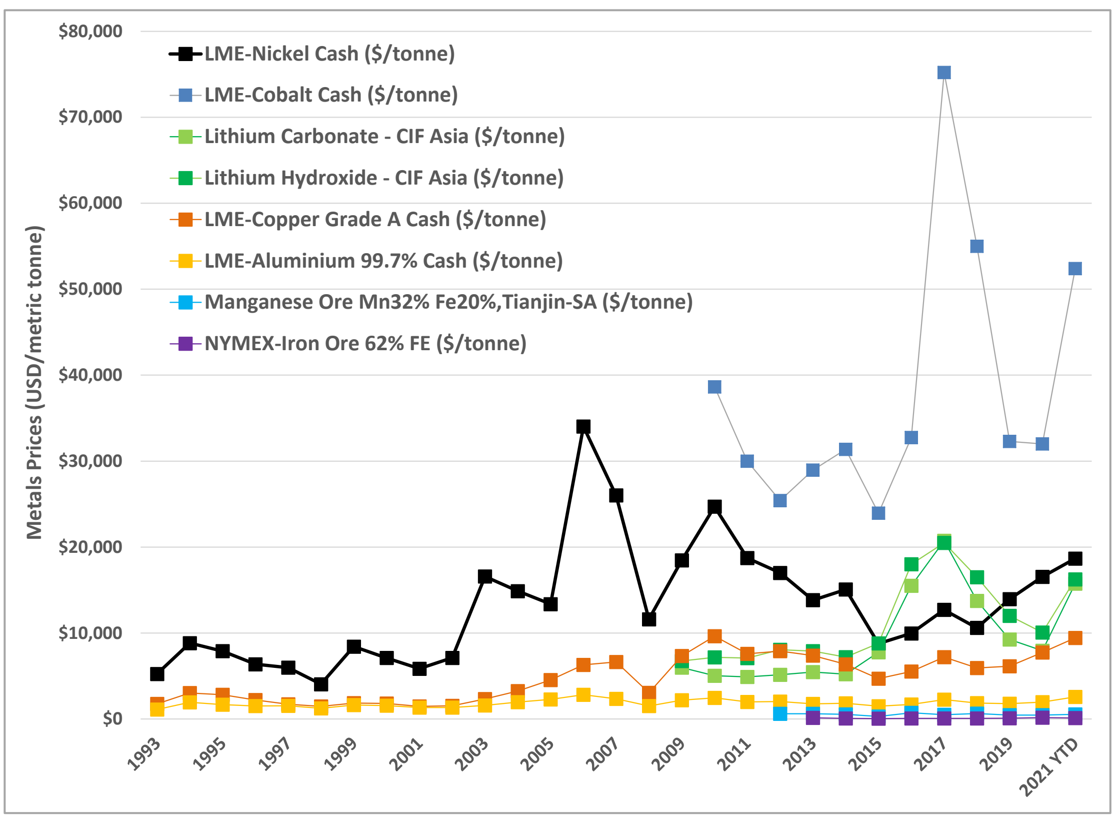
- **Nickel Market Dynamics:** Price trends reflect *shifting supply-demand balances* and other factors influencing investment decisions.
- **Nickel Mining Trends:** The considerations of quality and nickel purity are set against *broad trends in nickel mining* that are ultimately reflected in global supply curves and the underlying cost of production.
- **Quality Matters—Mining and Processing Trade-offs:** For battery-grade (Class 1) nickel, *quality matters,* with two principal ore types feeding distinct end uses. Historically reserved for stainless steel, lower-purity (Class 2) *Indonesian nickel* is not considered a feedstock for batteries. *Expensive processing* creates intermediate nickel products to bridge the purity gap between the two classes of nickel, although financial inefficiency calls into question whether Class 2 feedstocks can be systematically processed for use in EVBs.

Nickel Market Dynamics

Sharp swings in the price of commodities are the bane of extractives industries, including mining, oil and gas, and their associated midstream and downstream processing businesses and logistics. Commodity price trends reflect shifts in supply-demand balances and fundamentals such as underlying geology. The amount of a resource in place that can be technically recovered at a given price sets a harsh bar for performance. In the world of mining and minerals processing, ore grade and quality dictate realized prices, revenues, and returns to producers. As price takers, producers have little control over major influences, such as new tranches of production and supply from competing sources—much less pandemics and recessions. The ability of mining concerns to shift operations to locations where geology is more attractive is contingent on resource owners providing favorable terms and conditions for concessions (the most common arrangement for non-fuel mining, but one that no longer applies in Indonesia as we describe later). Investors become more sensitive to the cost of entry as geology becomes more challenging and as other considerations—such as cycle time from exploration to permitting to start of operations—become more pronounced. Over the longer term, producers can adjust more easily with technical and technology improvements. Until such adjustments can be made, however, robust demand in the face of short-to mid-term supply constraints can exact any number of disruptions.

As with many commodities, nickel is traded continuously "on the spot" for immediate delivery and through futures contracts and other derivatives for delivery at future dates. The main futures contract is offered by the London Metals Exchange or LME. Futures contracts and other derivatives are used by market participants to manage, or take advantage of, nickel price risk. A mining concern may use derivatives to hedge against a drop in nickel price and thus shelter its cash flows. As shown in Figure 11, apart from cobalt, nickel is the most expensive of the key battery metals (see Figure 9). The incentive for EV makers to move toward cheaper and more abundant materials such as iron and phosphorus is clear—so long as vehicle performance and safety can be sustained and materials for alternative battery chemistries and designs remain cost effective. However, investor interest has surged for all of the battery metals, as they make judgments regarding future supply and demand, especially incremental demand from EVs.

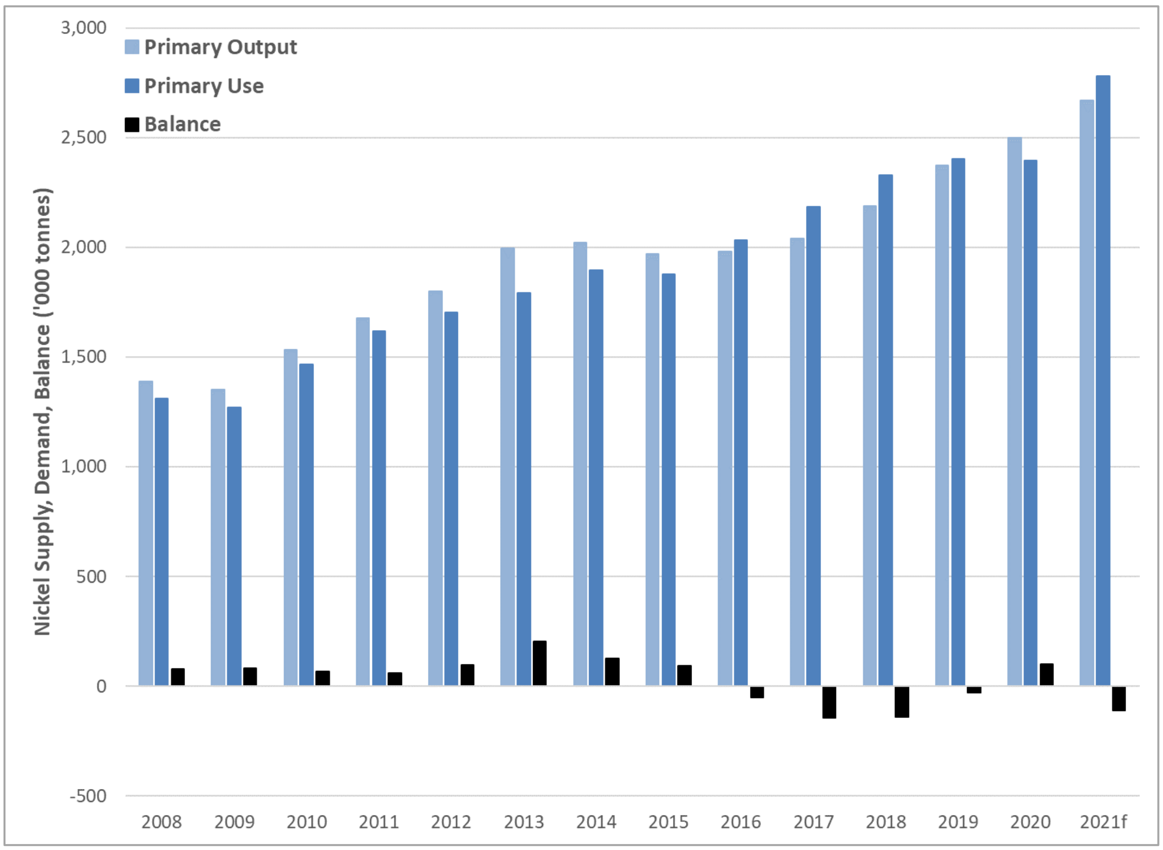
Figure 11. Nickel and Other Traded Battery Metals Prices



Note: LME is London Metals Exchange. CIF is cost, insurance, and freight to a receiving location (Asia). SA is South Africa (point of supply).
Source: SPGMI (S&P Global Market Intelligence), accessed via license.

Between 2010 (post-recession) and 2021, nickel usage grew almost 90%. This surge occurred mostly in China and was largely driven by consumption of steel. Chinese use comprised roughly 60% of global demand in 2020, compared to about 40% in 2010.[44] About 72% of current nickel use is for stainless steel, with an average growth of about 5% per year. Batteries comprise about 7% of demand, but, to our earlier point, this could potentially increase by 800% or to about one-third of global nickel consumption in 2040.[45]Also during 2010-2021 world nickel output increased about 74%, from 1.5 million metric tonnes (MT) to 2.7 MT. In spite of expanded supply, global balances have mostly been in negative territory since 2015.

Figure 12. Global Primary Nickel Supply, Demand, and Balance

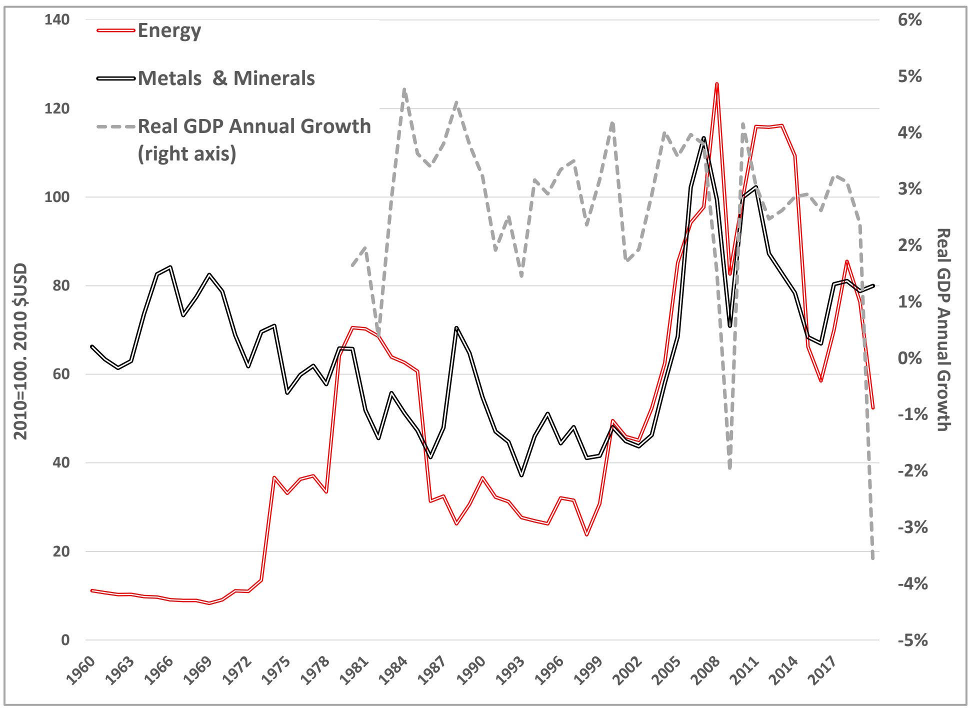


Source: Based on SPG Nickel Commodity Briefing Service, accessed via license.

The nickel marketplace is defined by two dominant themes. The first is influence from legacy use, namely steel (stainless steel, in particular). The second is shifts in nickel production—the move to monetize lower-grade, abundant laterite sources and to capture premiums in converting lower-quality nickel to battery-grade metal.

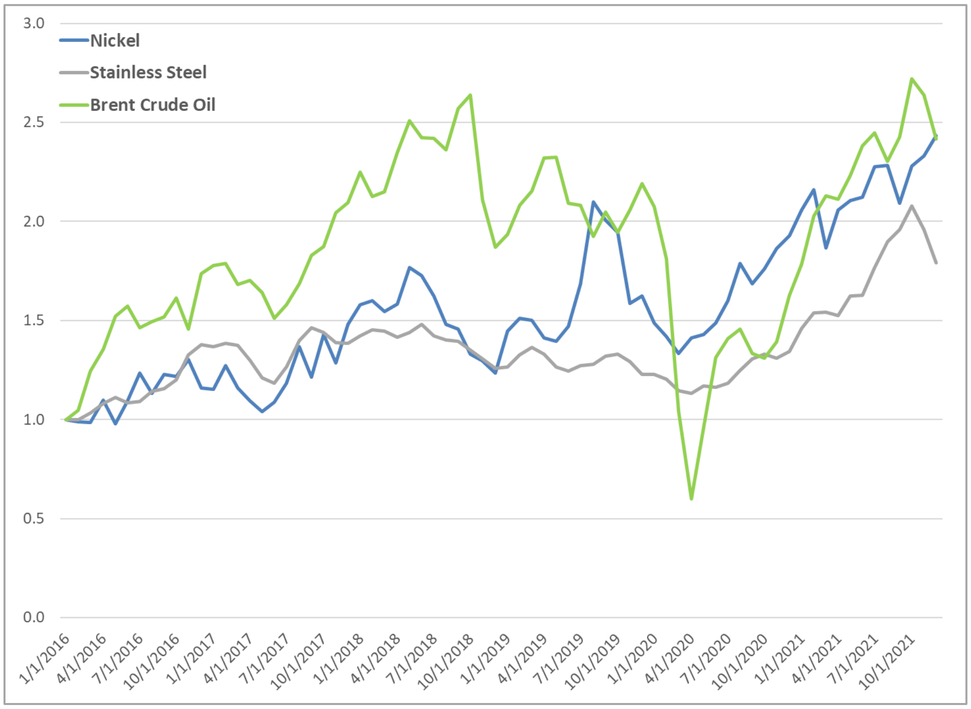
When it comes to legacy uses, looking at the big picture reveals that metals are increasingly linked to global GDP and have converged with energy (in Figure 13, oil is the dominant component of the World Bank energy index). Consumption of energy and materials such as steel tends to wax and wane with the global economy. Oil, natural gas, and coal are key energy inputs for mining and steelmaking; energy businesses are major customers of metals. The link between oil and steel prices is well established. Given the reliance on nickel for stainless steel, prices of stainless steel products will translate to nickel raw material.

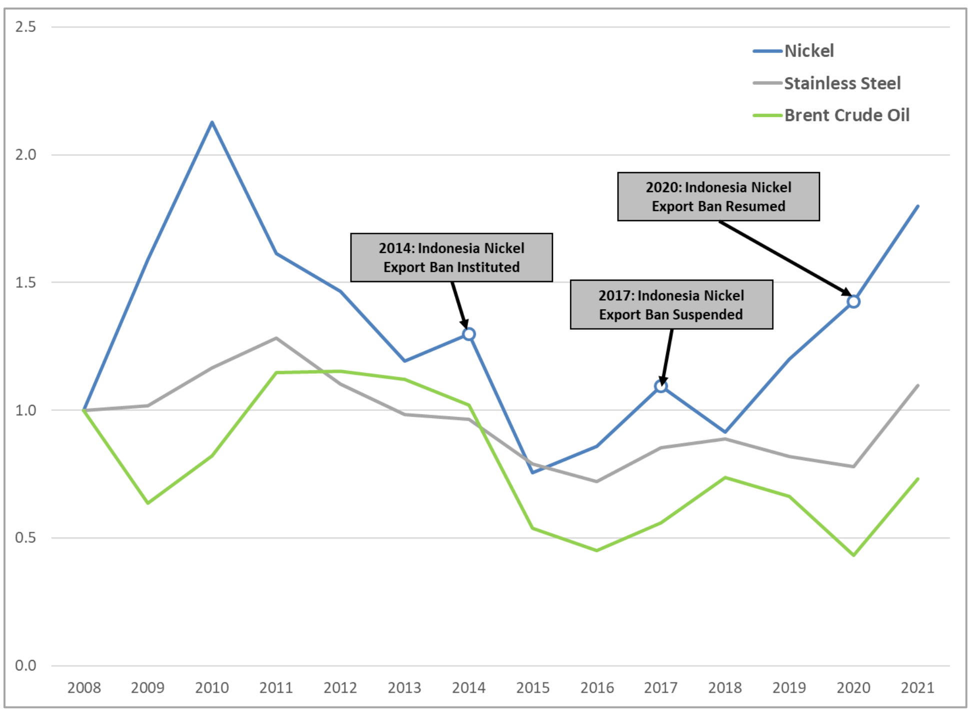
Figure 13. Long-term Trends in Energy, Metals and Minerals, and GDP



Sources: World Bank "pink sheet" commodities indexes (based on real prices);[46] IMF (International Monetary Fund).[47]

Figure 14. Indexed (2008) Monthly (top) and Annual (bottom) Nickel, Stainless Steel, and Oil Prices





Sources: SPGMI (LME nickel price); Bloomberg average steel producers' price (accessed via license); CME/NYMEX for Brent (accessed through U.S. Energy Information Administration).[48]

Within the nickel marketplace, two important shifts are at work. A new development was China's production of NPI beginning in 2005 in "different forms and grades."[49] As we discuss later, it is the added processing to attain high-quality nickel from laterite ores that offers the potential for increasing battery-grade production, with the possible implication of narrowing the difference between Class 1 traded nickel prices (minimum of 99.8% purity[50]) and the lower-value Class 2 form (and perhaps suppressing nickel prices overall). From 2008 to 2014, the expansion of NPI production depressed nickel prices, rattling traditional nickel producers. NPI output went from essentially zero to 500 kilotonnes (KT). By 2020 NPI stood at about 900 KT, roughly half of all nickel supply.[51] The sharp upward surge in nickel prices since mid-2020 was triggered by reactions that exemplify market expectations, especially growth in EVB usage, and potential supply chain tensions going forward. In spring 2021, Tsingshan, a Chinese company that primarily manufactures stainless steel products and is expanding into battery supply chains and manufacturing, announced that it would supply nickel matte from NPI to Chinese battery makers and expand investments in Indonesia. This triggered the sharpest nickel price drop since 2016.[52] The Tsingshan announcement reflects fundamental realities—the predominance of lower-grade ore supply (lateritic deposits) and the premiums perceived for higher-purity metal (thus the cost of converting NPI to matte for battery-grade material). Meanwhile, China's stockpile release in June, intended to provide additional price relief, represents acute dilemmas for price-sensitive customers. The smaller than expected auction failed to move markets.[53]

Over the long term, events can intervene in commodities markets, but so can governments. Indonesia's effort in 2020 to resume 2014 restrictions on nickel ore exports in order to force investment in domestic value-adding processing (with ambitions of domestic battery manufacturing) triggered a review by the U.S. International Trade Commission (USITC) and a request by the EU to establish a World Trade Organization panel to review the restrictions.[54, 55] We discuss Indonesia's nickel export policies in more detail in Part III.

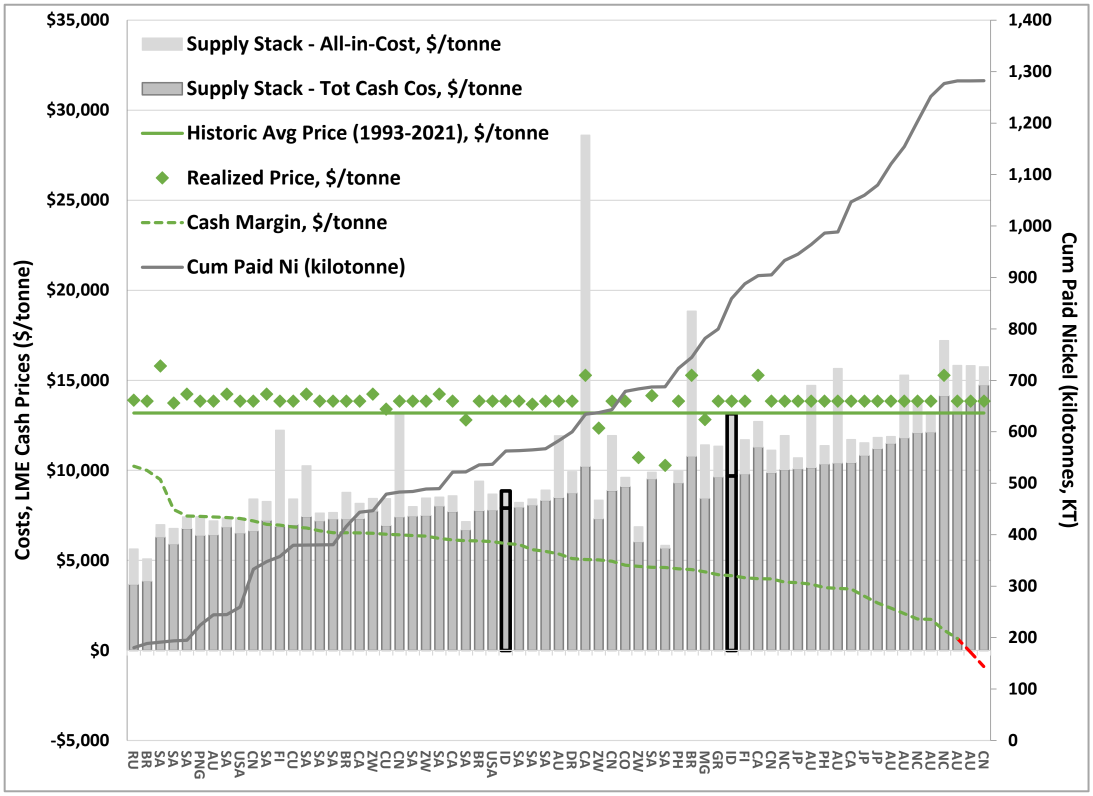
Nickel Mining Trends

As with all mining and minerals processing businesses, nickel producers operate within the bounds of "above ground" risk and uncertainty, including market conditions, pricing, and the reality of subsurface or "below ground" geology and technical requirements. Miners hold reserves but, as with all commodities, tend to produce from the richest, lowest-cost locations first. Higher prices serve to lure less attractive locations into the mix. Overall, for all of the battery and many, if not most, other critical metals and minerals of interest, *ore grades* (the concentration of minerals) have deteriorated.[56] Mines in operation are maturing. Periodic discoveries of new resources and evaluations to prove up new reserves replenish the global minerals and metals "pie," but exploration and appraisal are slow processes. It can sometimes take 10-15 years for commercial development—from concept to final investment decision (FID).[57] For nickel, overarching views are that the lack of exploration and development of sulfides, in particular, could contribute to supply-demand imbalances, especially given the costs of underground operations. Offsetting those concerns is the story of growth in NPI, which has led to increased dependence upon lower-quality nickel for both legacy and, with additional processing, new uses and applications that require higher purity. Additionally, the potential for recycling or breakthroughs, such as commercial extraction of minerals from seabed occurrences, could alter the picture.

Using information from S&P Global (SPG) Market Intelligence, we built a picture of nickel mine operations to serve as a backdrop for our Indonesia case study. The SPG dataset consists of 64 properties accounting for 50% of global recovered nickel production. The data spans several countries and includes laterite and sulfide extraction.

As with all commodities, a logical global supply curve for nickel can be constructed that reflects tranches of supply from ever more expensive sources, given prevailing and expected prices. In Figure 15 we show the global supply curve based on cumulative *paid nickel* (metal that producers can immediately sell after milling) in kilotonnes (KTs). We rank all projects according to highest *cash margin* (operating profit). Supply comes to the market first from the most profitable projects. For comparison, we include *all-in-cost* (adding capital expenditures or capex) for completeness and *total cash cost* (operating expenses or opex) for each project. We use co-product accounting so that costs are allocated against all minerals of commercial value (not only nickel). Cash margins deteriorate rapidly across the projects in our database. The largest and most profitable producer in our sample is Russia's Norilsk (sulfides), but Russia is not a major exporter of raw ore. The two Indonesia projects in our sample (laterites, shown with heavy outlines in Figure 15) are not at the cheapest end of the global supply curve. The least profitable project is Alex (underground with copper as the primary metal) in China. The cumulative total paid nickel in our supply curve of 1.28 MT derives from the 1.34 MT of recovered nickel for a payability of 95% (about 5% of metal is lost in milling). We stated that the SPG sample represents about 50% of global nickel production. The global total recovered nickel production for 2020 from World Mining Data (WMD) stood at 2.7 MT while USGS estimated 2.5 MT.[58] The difference is mainly in the global coverage of each source. Both USGS and WMD place Indonesia as the largest producer, by far, with 760 KT for USGS and 1 MT for WMD; the USGS counts nickel concentrates, while WMD reports recoverable metal content. For each, the Philippines ranked second but with about half of Indonesia's output. Later in Figure 25 we provide cost details for the major laterite producing locations.

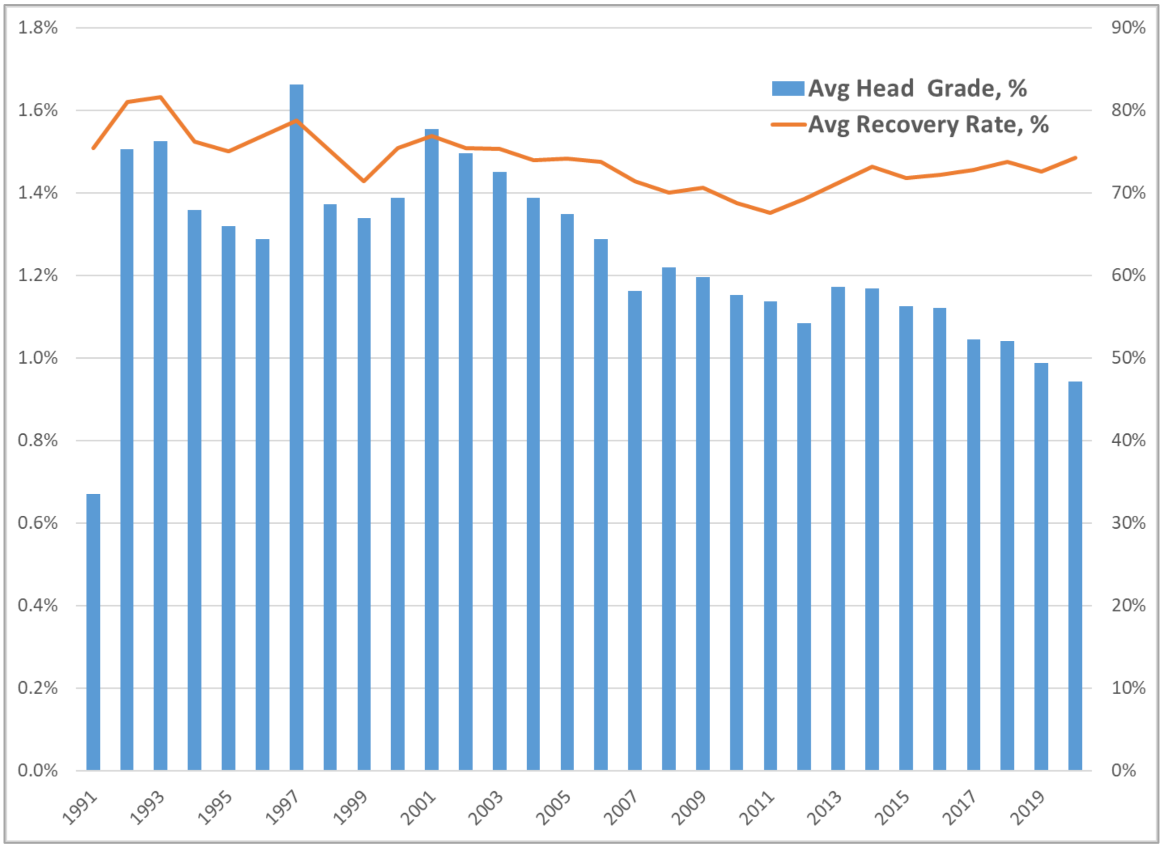
Figure 15. 2020 Cumulative Nickel Supply Curve with Cash Costs, Cash Margins, and Realized Prices



Note: Indonesia projects in the dataset are Pomalaa (26 KT) and Sorowako (59 KT).
Source: Compiled using information from SPGMI, accessed via license.

Underlying any commodity supply curve is the quality of producing assets. *Head grades* for nickel—the amount of metal per tonne of rock mined and destined for mill processing—have been offset by *recovery rates*—the actual metal content after processing loss (Figure 16). We use arithmetic means based on reported head grades and recovery rates for ease of data extraction and analysis. Recovery rates have been helped by investment in processing. Lower head grade reflects maturity of properties but also the addition of properties or expansions of existing properties with lower ore grade. Lower head grade also means more tonnage is extracted for a given commercial quantity of metal. More tonnage extracted implies more waste that must be handled at mining and processing locations (discussed later), as well as larger energy inputs and emissions outputs. The difference between arithmetic means and weighted averages can be shown using our dataset. For our SPG time series sample, the mean head grade is 0.98%. The mean recovery rate is 75%. As of 2020, the total of about 257 MT of ore treated for the 64 properties yields about 1.6 MT of mined, recoverable metal based on the tonnages of treated ore and head grades reported for each property. Given the total 1.34 MT of reported recovered nickel across the SPG properties, the *weighted* recovery rate is 81%.

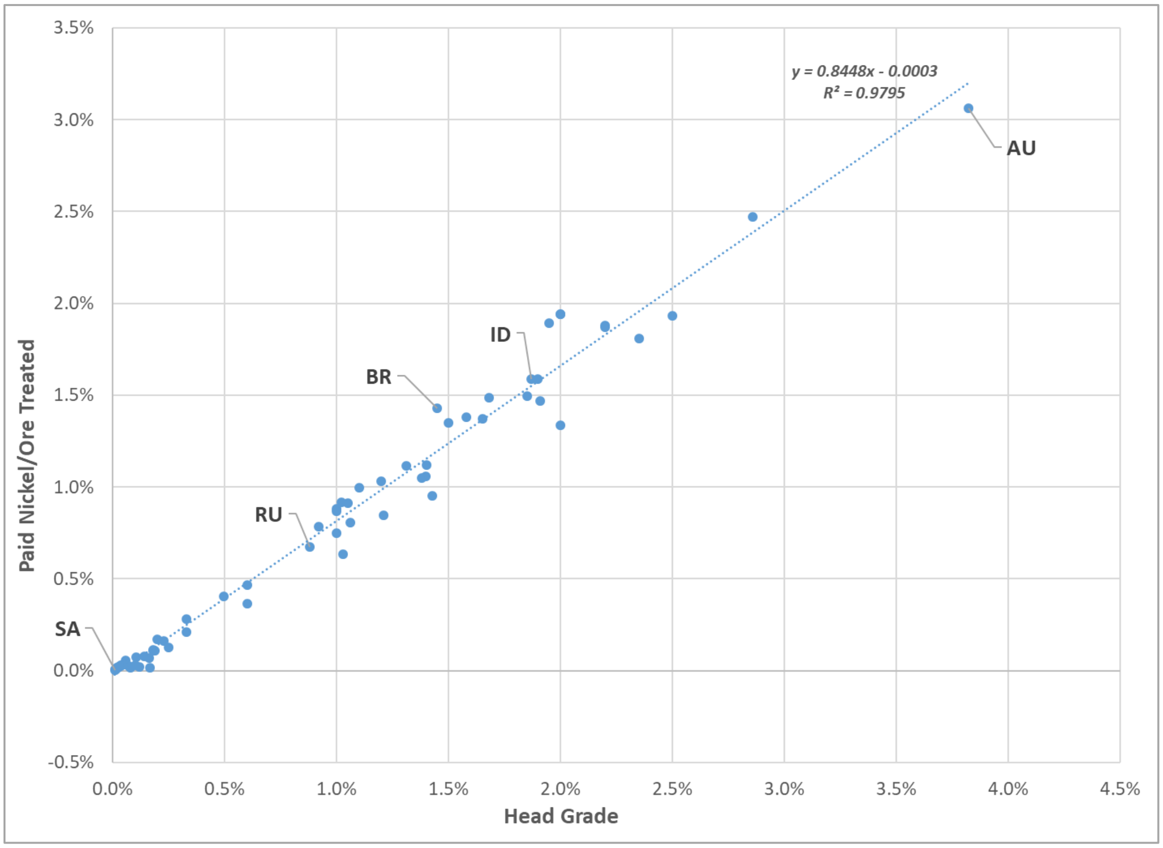
Figure 16. Annual Mean Head Grade and Recovery Rate for Nickel Properties Worldwide



Source: Compiled using information from SPGMI, accessed via license.

It should go without saying that nickel head grade and the ratio of paid nickel to ore treated reflect the brutal reality of the resources. We provide visual impact in Figure 17, highlighting the lowest-ranked project (South Africa's Platinum Mile, a tailings re-treatment facility and an example of efforts to extract metals from low-grade waste) and the highest-ranked project (Australia's Forrestania) in our sample. We also show the highest-ranked Indonesian property (Pomalaa), Russia's Norilsk, and Brazil's Codemin laterite, which is the next most profitable property after Norilsk, in Figure 15.

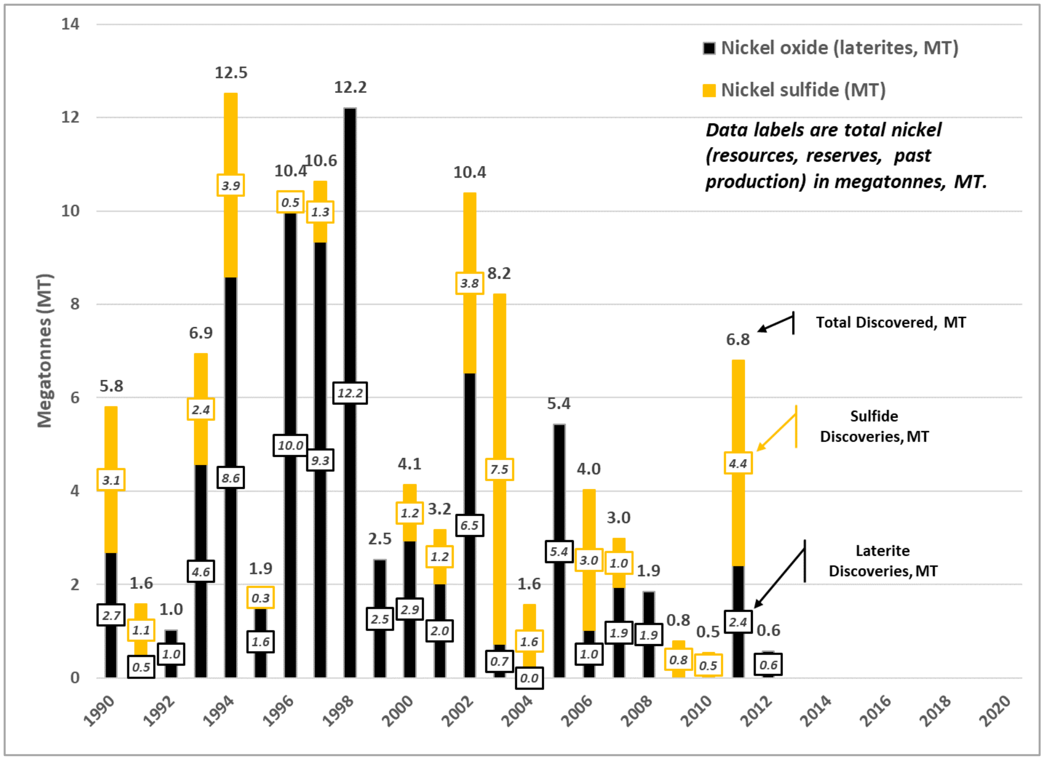
Figure 17. Relationship between Nickel Head Grade and Ratio of Paid Nickel to Ore Treated



Source: Compiled using information from SPGMI, accessed via license.

Periodic improvements in head grades in Figure 16 reflect discoveries made many years prior. The global nickel resource and reserve base for production has benefitted from important discoveries, but a long drought in exploration and commercial results has been underway. No significant discoveries have been reported since 2012 (Figure 18). As noted, much of the focus has been on laterites, which are typically cheaper to mine than sulfide deposits. Indonesia contributed the largest new mine project since 1990 (Table 4). Weda Bay, with discovery confirmed in 1996 (reported in 1997, Figure 18) and an estimated 9.3 MT of producible reserves, serves as a good illustration of cycle time. From the point of discovery, which entailed prior years of drilling and testing, the property only entered operation in 2020, some 25 years later, with 0.0235 MT produced that year. Figure 19 illustrates variability in ore grades reported by the SPG. While sulfides yield nickel of higher purity, as we have noted, they occur less frequently in the earth and are not necessarily characterized by higher head grades.

Figure 18. Major Nickel Discoveries (1990-2020)



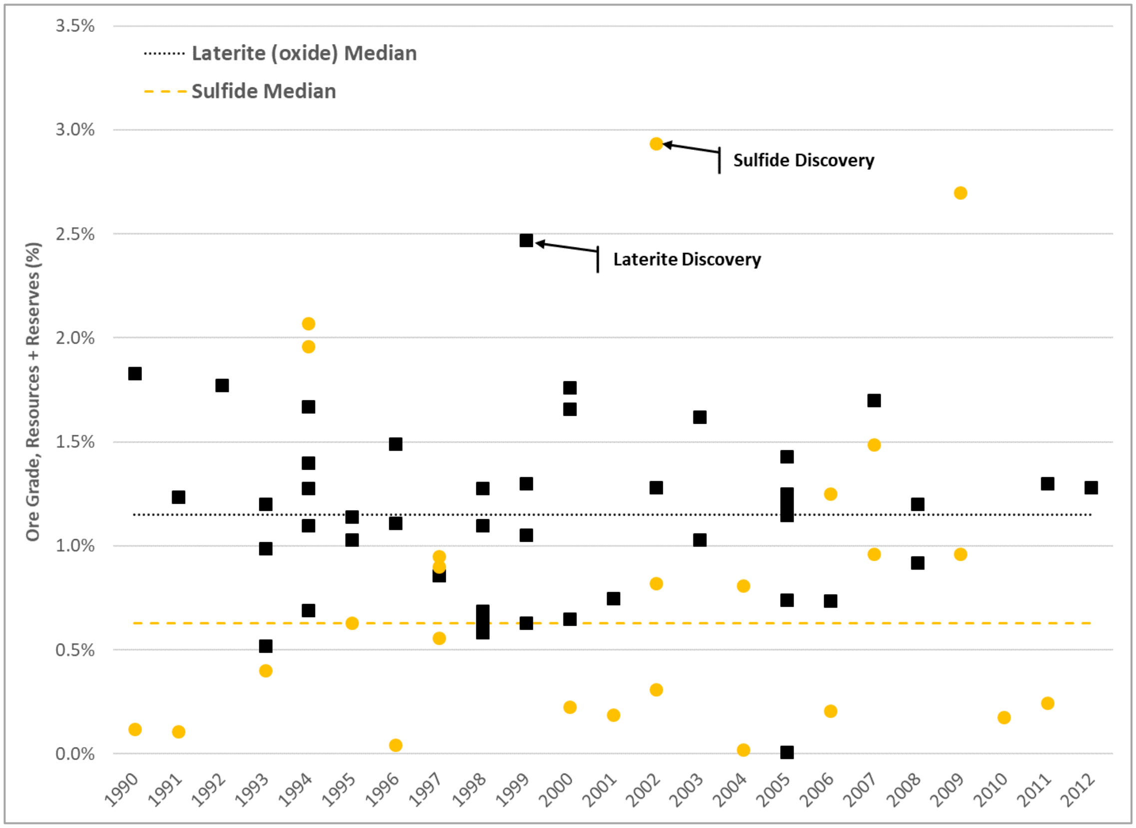
Source: Compiled using information from SPGMI, accessed via license.

Table 4. Highlighted (Top Ten) Major Nickel Discoveries

Discovery	Discovery year	Discoveredby	Country (ore type)	Total Nickel (MT)
Weda Bay	1996	Strand Minerals Pty. Ltd.	Indonesia (laterite)	9.3
Iisko-Tagulsk	2003	Norilsk Nickel	Russia (sulfide)	7.5
Kalgoorlie	1998	Heron Resources Ltd.	Australia (laterite)	4.8
Pinares de Mayari	1994	BHP Billiton Nickel West Pty. Ltd (65%) Commercial Caribbean Nickel (35%)	Cuba (laterite)	4.4
Zebediela	2011	URU Metals Ltd.	South Africa (sulfide)	4.0
Jacare	2002	Anglo American PLC	Brazil (laterite)	3.9
Koniambo	1998	Falconbridge Ltd.	New Caledonia (laterite)	3.6
San Felipe	1998	QNI Ltd. (75%) GeoMinera SA (25%)	Cuba (laterite)	3.3
Decar	1990	Viceroy Resources Ltd.	Canada (sulfide)	3.1
Murrin Murrin	1993	Anaconda Nickel NL	Australia (laterite)	3.0

Note: Data as of June 25, 2021.
Source: Compiled using information from SPGMI, accessed via license.

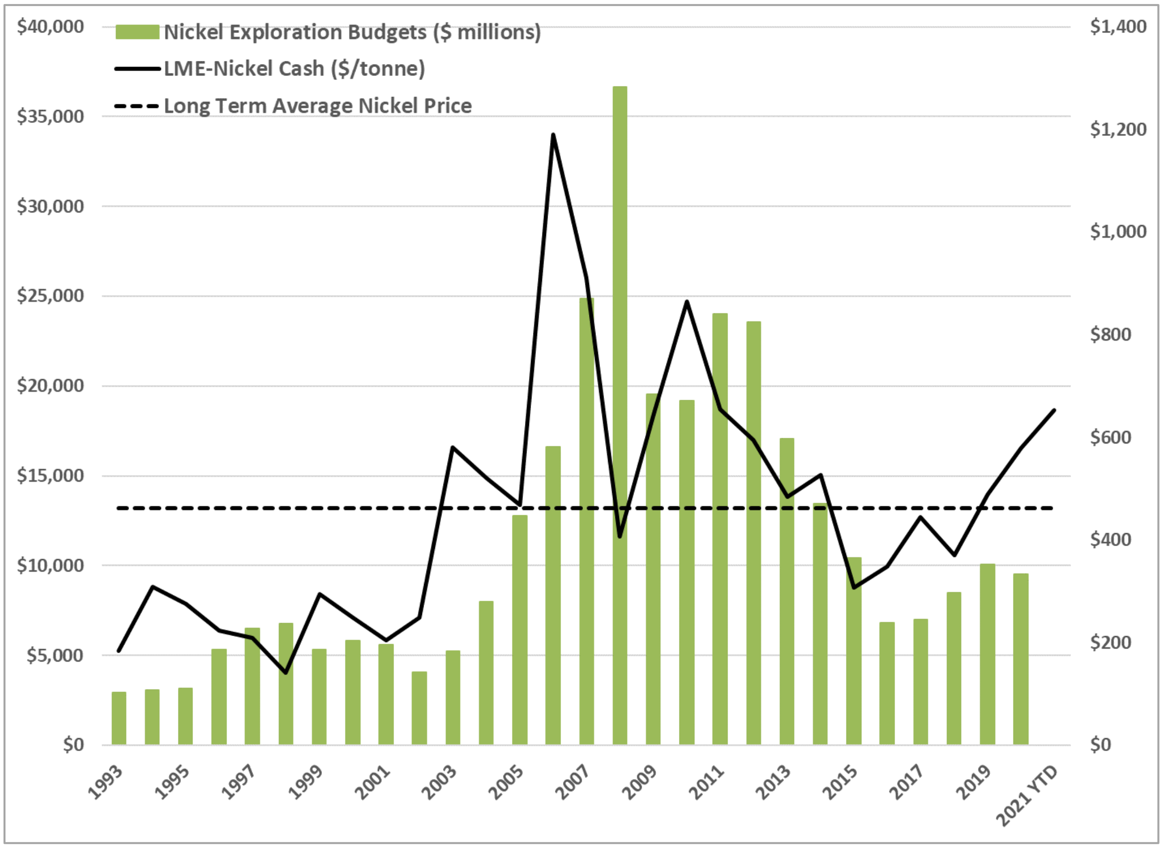
Figure 19. Ore Grades for Nickel Discoveries (1990-2020)



Source: Compiled using information from SPGMI, accessed via license.

Discoveries flow from exploration spending. Exploration budgets follow commodity prices, with a lag, returning us to market dynamics. The pattern for nickel stands out sharply, as shown in Figure 20. The lag in capex decision-making means many projects originate on the downside of price cycles. Given long lead times from concept to test drilling, as well as the time needed for appraisal and FID for mine and processing development, falling or low budgets imply prospects for future supply-demand imbalances.

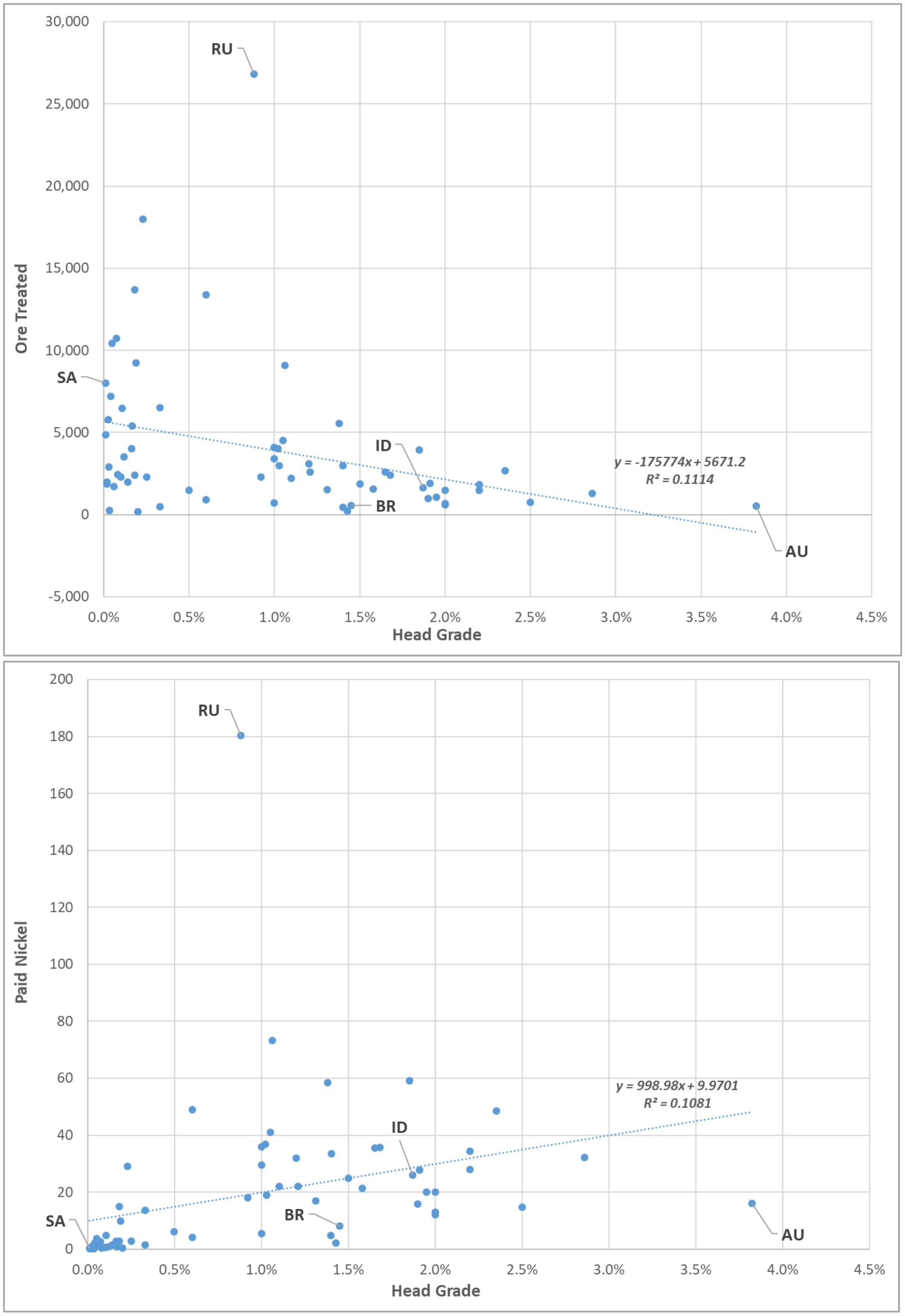
Figure 20. Nickel Exploration Budgets and Prices



Source: Compiled using information from SPGMI, accessed via license.

The bane of the mining business is waste. As we mention relative to the Figure 17 relationship, the industry engages in efforts to procure additional metal from *tailings*. In Figure 21 we push the relationships a bit further to illustrate how small the portion of paid metal (nickel) is to the amount of ore that must be extracted and treated. Higher head grades help improve recovered metal-to-waste ratios (previous Figure 17), but those projects also tend to be smaller (in Figure 21, projects with the highest head grades also have some of the smallest tonnages of paid metal). Miners can achieve technical economies of scale with less attractive head grades if other business parameters are enabling. These range from terms and conditions in government concessions, permits, or other arrangements, including myriad incentives, to labor and materials costs and proximity to large markets (for example, Canada relative to the U.S. and nickel mining in Brazil relative to that country's large steelmaking industry). In many countries, governments promote "national champions" in order to keep mining operations as going concerns.

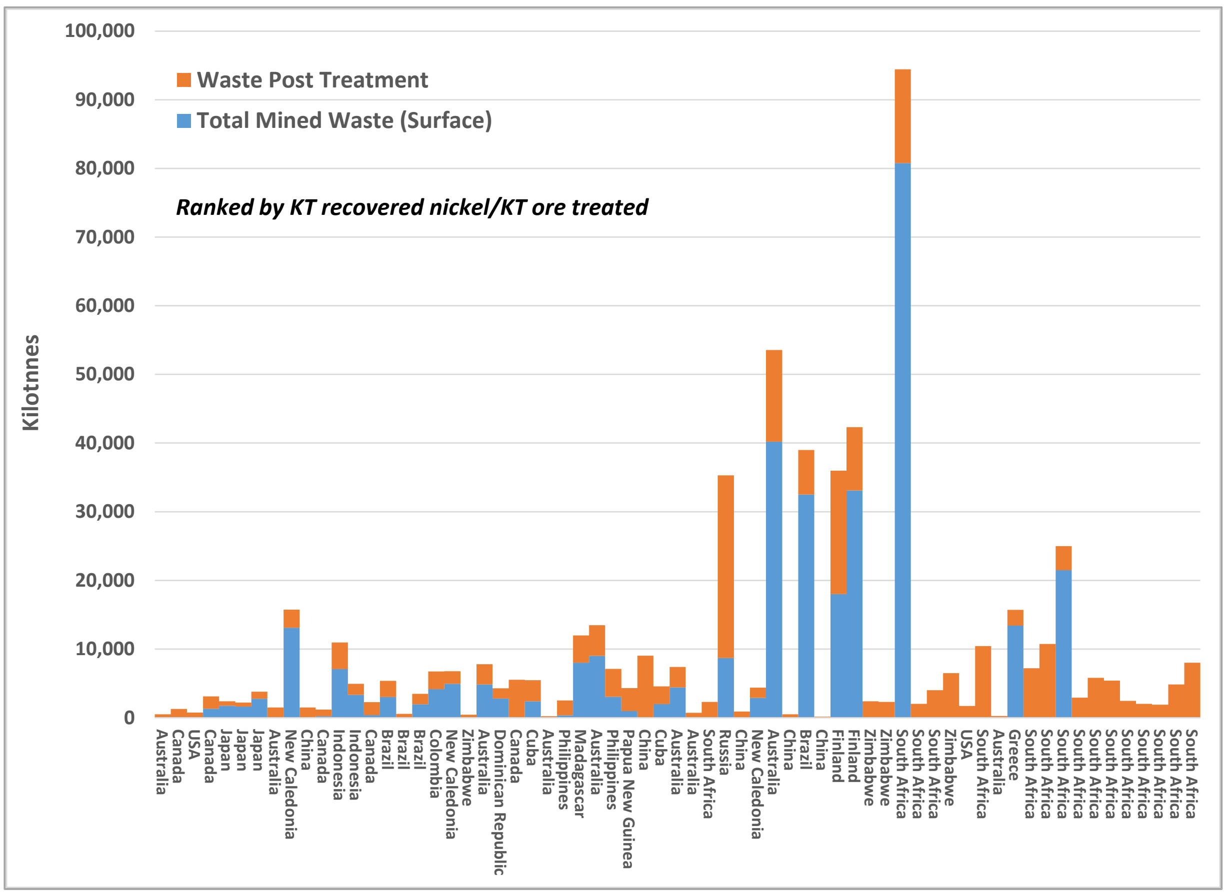
Figure 21. Head Grade and Ore Treated (top) and Paid Nickel (bottom)



Source: Compiled using information from SPGMI, accessed via license.

In Figure 22 we provide a snapshot of the waste-to-paid-metal ratio by ranking projects on the amount of metal recovered relative to total ore treated. This depiction provides a distinction between efforts to recover nickel from waste (the South Africa tailings facilities) and waste from both mining and treatment. Ultimately, waste must be treated and isolated from surrounding communities. Tailings disposal is a major issue for the mining industry, and Indonesia's government has been pressured to step up its oversight of mining and minerals processing because of the increased focus on tailings management. The January 2019 collapse of the Vale tailings dam at its Brumadinho iron ore operation in Brazil, which led to the deaths of 270 people in the surrounding area, was a major occurrence for an industry in which tailings-related incidents with injuries and deaths occur almost yearly.[59]

Figure 22. Mining and Processing Waste Ranked by the Ratio of Recovered Nickel to Ore Treated



Note: KT of nickel recovered per KT of ore treated diminishes to the right. South African projects include tailings treatment facilities.
Source: Compiled using information from SPGMI, accessed via license.

Along with traditional imperatives to minimize waste, improve mine safety (especially related to tailings management), and mitigate environmental impacts, new pressures are mounting. Monitoring and reporting environmental, social, and governance (ESG) metrics add to the gamut of above-ground risk and uncertainty factors for mining companies. “Climate smart” EVs, which are definitively an improvement over ICE vehicles in terms of life-cycle impacts, dictate “climate smart mining,” with more assertive goals for “net-zero” mining and minerals processing (a distinct and costly endeavor to limit energy use and mitigate greenhouse gas emissions).[60] The “social” and “governance” parameters include relations with host communities (especially indigenous communities) and transparency around operations, including how mine operators interact with host governments.

ESG considerations have emerged as a concern for expanding Indonesian laterite and NPI production and for strategies of upgrading NPI to high-purity nickel. We touch on these later.

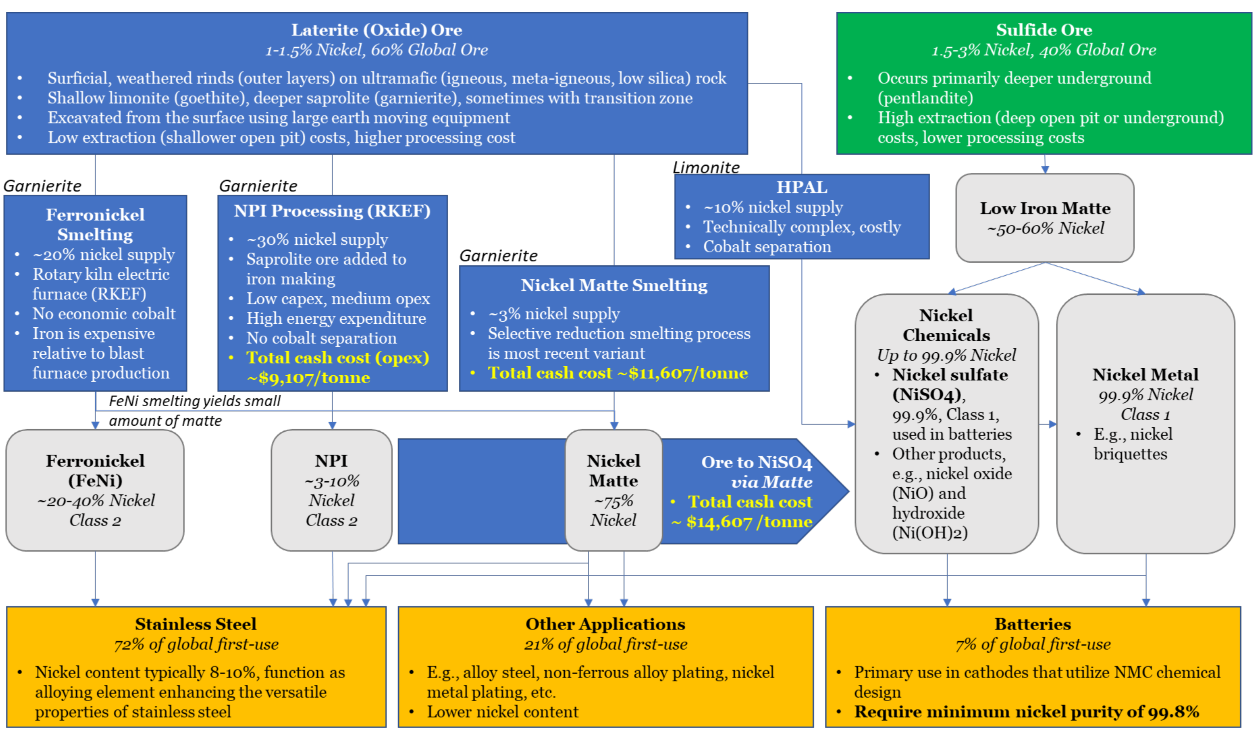
Quality Matters—Mining and Processing Trade-offs

Global supply-demand balances for commodities often bear inherent complexities in quality. That is, supply and supply chains to meet demand are contingent not only on resources, but also on the chemical form and quality of the resource base and the implications for processing, refining, and logistics. A common example is “heavier” oil, which has a higher specific gravity (relative to water) than “lighter” crudes and is typically high in sulfur. Heavy oil is usually sold at a discount to prevailing traded crude oil price indexes based on lighter crudes, because it requires costly upgrades in refining complexity to gain incremental volumes of useable products, especially for gasoline and jet fuel. If sufficient investment is made to refine heavy oil, it can compete more effectively with lighter oils. One result is a better price to producers and sellers of heavy oil. Another is the expansion of supply available to the marketplace, keeping the overall price of petroleum products affordable to customers.[61]

Analogies abound in non-fuel minerals and metals. Nickel purity, or quality, is an important consideration for future supply-demand balances. We explained earlier that sulfides yield Class 1 nickel, a nickel sulfate that is high in purity (more than 99.8% nickel by weight) and price and requires less processing to attain metal quality suitable for stainless steel and battery cathodes. The lack of exploration and investment in sulfide deposits has triggered emphasis on laterites. Laterites generally yield “Class 2” nickel, which is lower in quality and price but not suitable for applications such as battery cathodes. Class 2 nickel can be processed to attain “Class 1” purity—but at a cost.[62] Thus, positioning to extract nickel more cheaply from laterites—but with more expensive processing to attain purity sufficient to support battery cathode manufacturing and capture nickel price premiums—is an underlying theme in nickel markets and our case study. Expanding processing of laterite-sourced nickel to achieve Class 1 nickel quality might expand overall nickel supply and close the price gap between Class 1 and 2 nickel. Or, it may only shift output of nickel to Class 2 for premiums. It also may be that companies attempt to use their processing capacity to swing between Class 1 and 2 with shifting market conditions.

In Figure 23 we summarize much of our discussion thus far related to sources and uses of nickel and indicate some of the processing complexities. To make things more complicated, laterites are distinguished by depth, which has many implications for mineralogy. Shallower *limonites* (the main nickel-bearing mineral is *goethite*) are iron rich, magnesium poor, and usually processed using hydrometallurgy (aqueous solutions for recovery of metals) after laterite dewatering and upgrading (often using high pressure, high temperature acid leaching or HPAL). Deeper *saprolites* (the main nickel-bearing mineral is *garnierite*) are iron poor, magnesium rich and usually processed using pyrometallurgy (heat to extract and purify metals). Rotary kiln electric furnace (RKEF) is the common approach with Class 2 nickel as the yield. We include typical nickel content of various nickel products and typical end uses. The most common mineral occurrence for nickel in sulfide ores is *pentlandite*. Sulfide ores are crushed, ground, and floated to achieve concentrate and flash smelted to matte. Hydro- or pyrometallurgy with *electrowinning*—the recovery of metals using electrolytic chemical reactions—or hydrogen reduction, are commonly used to produce high-purity nickel from *mattes* (smelted ore and/or concentrates to reduce iron content; either sulfide ore or laterite garnierite) and from sulfide precipitates (laterites goethite after HPAL). Metals (ferronickel, NPI, matte, nickel metal) are typically delivered as ingots, briquettes, or powders, while nickel chemicals are delivered as crystals or powders.

Figure 23. Nickel Sourcing, Processing, Supply, and End Uses



Sources: Prepared by the authors using data from various organizations.[63]

In Figure 23 we also show estimates of incremental opex to transform laterite ore to NPI, to nickel matte and, via the NPI-to-matte upgrading, to battery-quality material. Technical reviews suggest that nickel is lost in the NPI-to-matte conversion.[64] Ergo, HPAL is an emerging focus to take laterite ore directly to higher-purity nickel. In sum, Figure 23 lays out the essential themes—the already-established production of NPI from laterites to expand nickel supply for primary end uses like steel, and the ambitions to transform lower-grade laterite ores into high-purity battery-grade material—to support our review of China's Tsingshan positioning in Indonesia.

Part III. Case Study: Indonesian Nickel—The Story of a Chinese Backstop

On the back of global "green optimism," demand for high-purity Class 1 nickel could quickly outpace supply over the next half decade, raising prices in the process. A significant battery-grade nickel supply shortfall would be detrimental to EV market penetration efforts worldwide. Weakness in battery materials supply and supply chains and Chinese dominance has begun to rattle investors and market valuations.[65] To supplement overall supply of nickel for steelmaking and other uses and to mitigate the dearth of mining projects yielding high-purity nickel, several notable nickel producers, led by China's Tsingshan Holding Group, have positioned themselves to expand production from laterites. They have also proposed processing lower-purity nickel into intermediate products for further refining into battery-grade nickel (refer to Figure 23). Such a highly experimental strategy, while metallurgically feasible, is highly inefficient in terms of cost. It also raises environmental concerns because of the significant amount of energy required to power processing facilities.

Indonesia's abundant laterite reserves make nickel the ideal site to test the replicability of their novel approach. If Tsingshan's recently announced moves can be proven replicable, cost effective, and environmentally conscious, there would be significant implications for EV supply chains worldwide. Dilemmas reside in the Indonesian government's push to lure investment in battery-making in order to optimize value creation around the country's nickel resources.[66] While Indonesia offers a cost-competitive business environment, numerous uncertainties exist, including export policies and their impact on pricing. In light of the already pervasive influences of economic activity and energy on metals and minerals prices, government policies in Indonesia vis-à-vis trade and pricing could exacerbate global supply-demand balances and impact costs for businesses and consumers.

Several factors paint a clear picture, where Tsingshan's interests overlap with the Indonesian government's push for increased value-added production from their natural resource sector:

- **China's Mining Legacy in Indonesia:** Chinese companies, especially Tsingshan, have a *strong historical presence* in Indonesia—to which Indonesia owes much of its recent prominence in nickel extraction.
- **Breaking the Bottleneck through Class-Convergence:** *Tsingshan's novel refining technique* is part of a broader push for a fully integrated EV supply chain, and if

proven replicable, it could have a consolidating effect on Class 1 and Class 2 nickel prices, potentially erasing Class 1 price premiums.

- **Filling a Void—Geopolitical Leverage and Strategic Dependence:** Chinese firms are using Tsingshan's legacy in Indonesia as a jumping-off point to kick-start their own operations within the country, creating a strategic dependence on Chinese capital for Indonesia's plans to expand domestic nickel processing.
- **Overcoming Slippery Slopes—ESG Pressures:** In this section, we discuss the increasing scrutiny of sustainability issues associated with Indonesian laterite nickel production and upgrading.
- **Resource Politics—"Commercial Frameworks," "Obsolescing Bargains," and the Region:** To flesh out our case study, we consider a number of analytical themes ranging from Indonesia's legal and regulatory regime for mining and minerals processing to various regional dynamics.

Our case study analyzes the merits of Tsingshan's strategy as a means of mitigating global battery-grade nickel supply concerns from EV demand. We examine Chinese firms' historical presence in Indonesia, their market entry and growth within the country, and their resulting geopolitical leverage. Our review serves as a lens to discern Chinese firms' strategies in solidifying EV supply chains and their efforts to scale up production.

Despite abundant laterite resources that remained untapped until the early 2000s, Indonesia currently accounts for almost 30% of the world's nickel production and about 22% of reserves.[67] Behind a significant government-led push for higher value-added exports, especially in the scheme of end-to-end battery production, some experts believe Indonesia's dominance in world nickel production could be improved further with the introduction of HPAL to recover additional nickel from waste.[68] For nickel, this approach—HPAL combined with electrowinning (as for nickel recovery from limonites in Figure 23)—would mimic the effect of solvent extraction with electrowinning (SX-EW) for copper.[69]

Deployment would coincide with the government's push since 2014 to prevent the export of raw ore and achieve more processing and value-adding at home.[70] To say the Southeast Asian archipelago nation is critical to the global energy transition would be an understatement, and Chinese firms are well positioned to expand on their historically strong place in Indonesia's nickel ecosystem.

China's Mining Legacy in Indonesia

In truth, Indonesia owes much of its current success in nickel mining to Chinese firms, especially the Wenzhou-based and privately held Tsingshan Holding Group Co. Tsingshan braved Indonesia's largely unproven nickel reserves in the 2000s by purchasing a nickel ore mine on the island of Sulawesi to serve as its fundamental nickel supply center in 2007.[71] Further investment in downstream refining in the years since earned Tsingshan a place as a mainstay in Indonesia's flourishing nickel production and refining sectors.

Today, Tsingshan operates the world's largest nickel syndicate—including nickel ore mining, nickel refining, purification, ferronickel production, crude steel production, logistics, port management, trading, and transportation.[72] Of particular importance to EV supply chains are the Tsingshan-run NPI plants and other nickel processing plants in their industrial park on the Indonesian island of Sulawesi. These facilities complement their broader plans to expand further downstream into lithium-ion battery production.[73] With passenger-vehicle electrification in its crosshairs, the company announced in April 2021 its plans to open a $1.6 billion lithium-ion battery plant in southern China.[74]

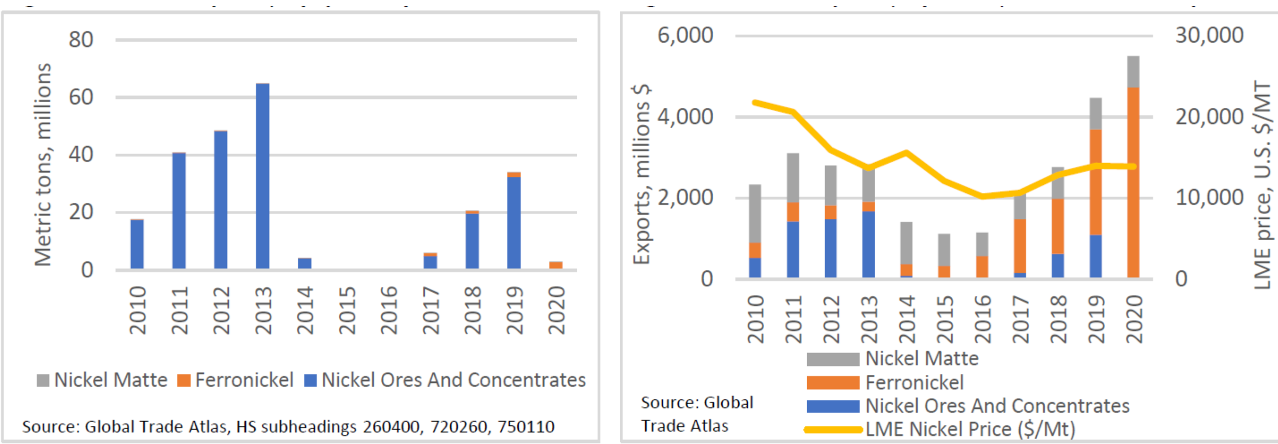
The extent to which Tsingshan's operations in Indonesia are vertically integrated deserves special attention. Their case illustrates how a firm's historical presence in a country with high regulatory uncertainty can paradoxically serve as a jumping-off point for relatively stable downstream expansion. In 2017, the company acquired fellow Wenzhou-based Ruipu Energy to handle the production of advanced lithium-ion battery technology.[75] In September 2018, Tsingshan joined GEM, Brunp Recycling, and Hanwa in signing yet another joint venture (JV) agreement for the construction of a plant to produce nickel sulfate crystals from laterite nickel in Indonesia.[76] Only a month later, the group entered into a JV with Guangzhou Automotive Corporation Group and Guangxin Holding Group to invest in a new vertically integrated company for battery production.[77] Even further downstream, Tsingshan inked a 5.5 billion yuan (US$850.73 million) deal with Xuzhou Construction Machinery Group Co. Ltd. in January 2021 to invest in a new energy vehicle project.[78] Altogether, Tsingshan forecasts nickel equivalent production of 600,000 tonnes in 2021, 850,000 tonnes in 2022, and 1.1 million tonnes in 2023, but they have not yet revealed 2020 production figures.[79] Not only does such an expansively integrated supply chain equip Tsingshan with the flexibility necessary to regulate uncertainty, but it also grants them significant influence in the dealings of a government looking to expand end-to-end development in the same vein.

On the back of foreign capital investment, Indonesian officials aspire to capitalize on emerging BEV markets by targeting a full nickel supply chain, from extraction further downstream to intermediate products like nickel sulfate and full vehicle assembly.[80] In the short term, they recognize the need to develop stronger domestic nickel processing for higher value-added production for export. Notable recent export controls on nickel lend credence to this push. In January 2020, the government reinstituted a ban on nickel ore exports, effective January 1, 2020.[81] The export ban was first instituted in 2014 by then-President Yudhoyono and put significant pressure on already thinly stretched indigenous refining operators.[82] Bearish nickel markets in the mid-2010s were the nail in the coffin for the policy initiative. Thus, the ban was swiftly relaxed in 2017, facing the reality that burgeoning Indonesian processors were unwilling and often unable to make the necessary capital-intensive investments, especially given the rather slim margins involved. As they reinstate the export controls, Indonesian officials are especially attuned to prerequisite capex to expand nickel processing. Lessons learned from the failures of the original ban—including the importance of foreign investment to expand nickel processing—reinforce the strategic positioning of Chinese firms looking to expand in the country.

Chinese companies like Tsingshan with vertically integrated operations can mitigate vulnerabilities arising from heavy capex requirements. These entities are well equipped to fill Indonesia's nickel refining void. Capitalizing on already historically strong influence in Indonesian mining regulatory formulation, Chinese influence is likely to grow even further as Indonesian processing continues to expand. Given that high regulatory uncertainty poses a key barrier to foreign direct investment in Indonesian mining and processing, China's strong position and flexibility to navigate instability is especially important in the scheme of EV market penetration. Sitting at the top of end-to-end EV battery supply chains and expanding further downstream, Chinese investors can employ highly speculative means to face battery-grade nickel supply issues, which may require regulatory cradling to mitigate some of the associated risks.

Since the 2014 ban was first implemented, several key trends have emerged regarding Indonesia's nickel exports (Figure 24). While nickel exports by quantity decreased substantially over the ban's implementation period, nickel exports by value soared despite relatively stable nickel prices. The data in Figure 24 suggest Indonesia's export portfolio is slowly maturing from primarily raw ore to processed nickel.

Figure 24. Indonesia Exports by Volume (left) and Value (right)



Source: USITC, 2021.[83]

To further expedite downstream export capacity growth, the Indonesian Investment Ministry is reportedly considering export levies on products containing less than 70% nickel, according to a speech delivered by Minister Bahlil Lahadalia at a conference in September 2021.[84] These regulatory considerations display the Indonesian government's resolve to achieve full coverage of nickel value chains, with a possible end goal of achieving a full domestic EVB supply chain.[85] Yet the clear downside to pursuing such aggressive trade policies is that they may "cause uncertainty and may scare off the more cautious investors."[86] Indonesia must toe a fine regulatory line given their reliance on foreign capital to grow their domestic processing capabilities. In addition, restricting exports on products with less than 70% purity would hamper Indonesia's growing NPI exports, which fill the revenue gap from halted ore outflows and would simultaneously boost the allure of China's NPI. Deliberately targeting nickel for EVB feedstocks, the Mining Ministry and Indonesian Parliament discussed limiting the construction of NPI and ferronickel smelters in a series of June 2021 meetings.[87] The government would prioritize nickel sulfate production over the latter two products to better optimize nickel ore use for higher state revenue, although no details have been clearly defined.[88]

Although the export ban put Indonesian NPI companies in a difficult position, especially those without vertically integrated NPI or ferronickel operations, Indonesia recently surpassed China as the world's leading NPI producer following the ban.[89, 90] Experts warn this hierarchical inversion may simply be a product of rather ephemeral market conditions and thus likely will not hold for long. But the Indonesian government is taking further steps to expand their indigenous nickel processing capabilities in an effort to solidify the trend. Among several additional policies, the Indonesian government passed a law in May 2020 encouraging downstream facility development and approved environmental impact studies in January 2020 for proposed factories producing battery-grade nickel chemicals in the Morowali Regency of the Central Sulawesi Province.[91] Three nickel-refining plants are under construction in Indonesia to begin operations by 2023, based on information from the Ministry of Energy and Mineral Resources. Additionally, four state-run companies across different sectors, ranging from mining to electricity, set up the Indonesia Battery Corp. in March 2021.[92, 93] While some growing pains are inevitable as Indonesian smelting capacity still needs some time to catch up, when these smelters do start production, they are likely to export most of their ferronickel and NPI output directly to China without further processing into stainless steel, regardless of whether it originated from Chinese or Indonesian-owned assets.

When it comes to Indonesia's control over (and possible restrictions on) nickel ore exports, a distinct new caveat lies in Chinese ownership of the LME. Chinese ownership extends to most of the physical warehousing for major traded metals of the LME, granting Chinese entities significant influence over commodity supply.[94] As we noted in the "Nickel Market Dynamics" section of Part II, when Indonesia restricted nickel exports in 2020, China released inventory into the marketplace to cool prices.[95] Producers such as Tsingshan with operations on the archipelago clearly would prefer to have their nickel production be profitable. But Chinese battery manufacturing thrives on cheap feedstock and materials, and the much larger global footprint for China is their intermediate and final output in EVB content. This puts China's own minerals producers in tough positions, unless they are able to attain value-added opportunities such as battery-making proximal to their mining and minerals processing operations. And while all other global customers also benefit from cheaper inputs, lower prices present a huge problem for upstream investors, particularly new entrants, who are sorely needed as the world approaches a nickel supply bottleneck. Any entity counting on increasing forward metals prices to support new capex faces the risk that China will intervene to cool things off.

As we completed this report in January 2022, the LME nickel cash price had exceeded $24,000/tonne, a rich price for Chinese manufacturers relative to the recent low of just under $11,000/tonne in March 2020. While the current cash price is far better than the roughly $34,000/tonne peak in 2007 (see previous Figure 11), it has sent shock waves through the steel and auto industries. Along with other things, aggressive price movements for nickel and other battery metals could undermine the many assumptions regarding battery affordability (see previous discussion in Part I: Shifting Transportation Paradigms).

Breaking the Bottleneck through Class-Convergence

Detecting a bottleneck to meet surging nickel demand from the EV sector, China's Tsingshan Holding Group Co. upended the nickel market in March 2021 announcing it would start providing nickel matte to battery-materials producers.[96] The firm announced a week later that the Indonesian facility, which would first convert NPI to matte for further processing into battery-grade material, would be powered entirely by alternative energy. The bulk of the facility's power would be hydroelectric, which of course comes with its own set of above-ground risks and therefore long project lead times. Indeed, even with their announcement claiming to have already started investing in a 2 GW clean energy project in their industrial parks at Morolawi, a three-to-five-year project lead time entails a choice: either to produce matte using their current high-polluting, carbon-intensive technology, or to postpone the "matte-to-cathode" initiative until it can be supported by clean energy.[97] We add that this trade-off between development cycle and energy choice will be faced by most, if not all, critical materials suppliers the world over through the coming years and decades.

The feasibility of Tsingshan's plan depends on several variables: energy intensity, financial viability, and environmental concerns. Notwithstanding, Tsingshan's preferential position vis-à-vis Indonesian entities that can assist such a speculative strategy should not be overlooked. Whether their unorthodox processing pipeline concretely mitigates impending nickel supply issues can only be determined over the next several years, likely after the nickel supply bottleneck has already materialized. If the strategy somehow proves financially replicable and environmentally sustainable, it could have massive implications for Class 1 and Class 2 nickel supply and pricing, which could converge.

An added factor is Tsingshan's over-arching positioning strategy. Entering a low-cost resource play with a high-cost processing aim would appear risky. The ultimate prize, of course, is not simply to gain nickel supply, but also to secure an important slot in the global EVB mix. Analysts at SPG observed that "Although Tsingshan's nickel matte production could be less profitable than its NPI output, we anticipate that the group may see its nickel matte strategy as a first step into the lithium-ion battery value chain. It could then move up to produce higher-value-added, nickel-containing, battery-related products in the longer term. Tsingshan's next move may be to convert its nickel matte into nickel sulfate, a component of such batteries."[98] For Tsingshan, the bet appears to be that Indonesia's mining and processing will be a loss leader in pursuit of bigger game.

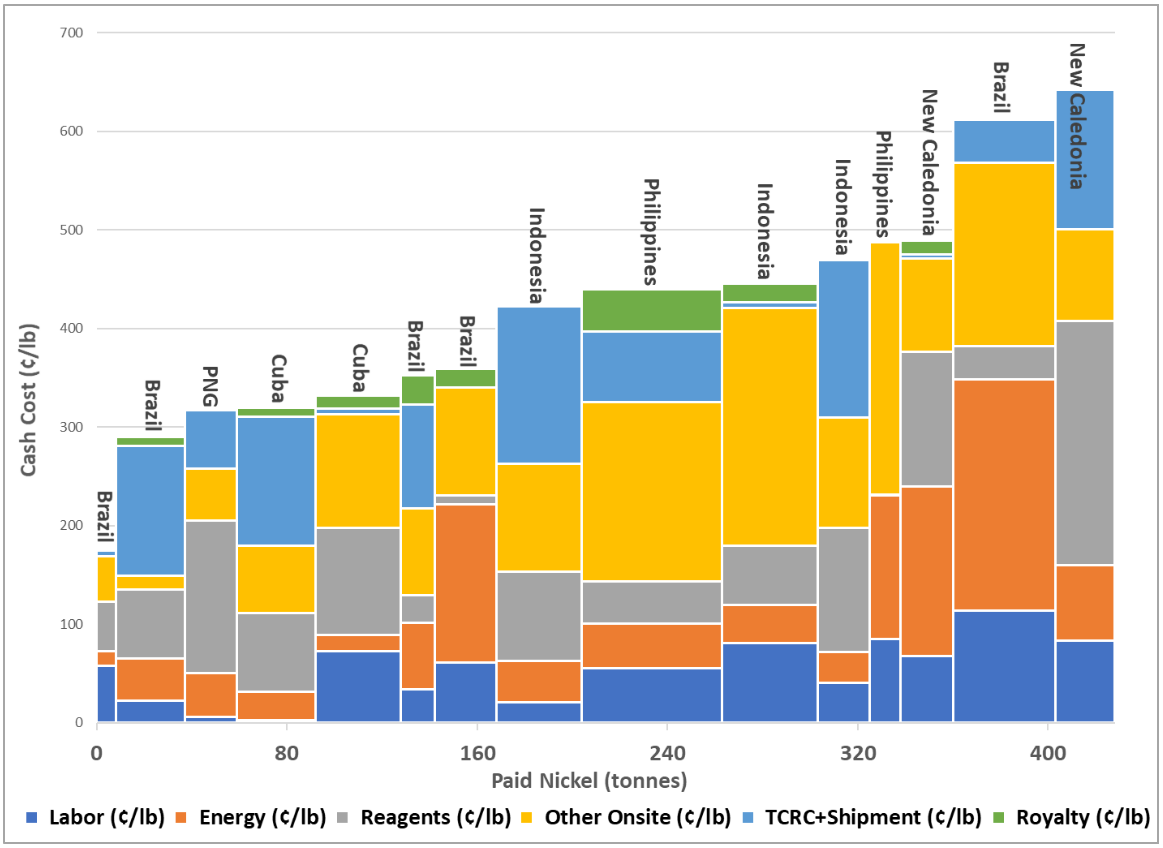
From a market perspective, at first glance the announcement may seem like a lifeline as the world faces an impending Class 1 nickel supply crunch. Yet upon further analysis, it may in fact prove detrimental because of the potential consolidating effect on nickel prices. Eliminating the premium for higher-grade nickel is dangerously reminiscent of the early 2010s nickel price action that is partially to blame for today's Class 1 supply uncertainty. Alternative scenarios are possible, as others have pointed out and as we mentioned earlier. Diversion of lower-grade Class 2 nickel for processing into higher-grade Class 1 product impacts the amount of nickel available for non-battery uses. It could raise the price of lower-grade nickel feedstock and so put pressure on processing margins. Increased use of high-quality nickel metal for batteries sets up competition with stainless steel producers and creates any number of consequences for other end uses, including EV manufacturers. Or, companies like Tsingshan that are investing in upgrading might choose to use their capacity to swing between end-use customers to take advantage of pricing.

Two structural factors remain especially key to the dynamics of nickel pricing over the long term. First, growth in nickel demand over the next several decades will come largely from the EV sector and ambitious efforts to integrate these vehicles into decarbonization initiatives.[99] Second, current industry standards in nickel processing solidify the divide in battery-grade Class 1 and lower-grade Class 2 feedstocks for distinct end-use markets. Experts indicate that demand for Class 1 nickel may become so intense that a structure of two independent prices for Class 1 and Class 2 nickel may prove necessary to incentivize investment in Class 1 feedstocks.[100] On the other hand, utilizing Tsingshan's methods to produce matte for supplemental processing into nickel sulfate, could promote further convergence in pricing mechanisms for Class 1 and Class 2 feedstocks.[101] One observation was that "the [EV] market outlook remains good, but Tsingshan's new technology means more raw material choices for [nickel sulfate] producers to choose from, and this may reduce market share of Class 1 nickel, mainly nickel briquettes and powders."[102] Unless Tsingshan can prove a replicable model for their extremely speculative processing technique in the near term, which is virtually impossible from a practical standpoint, their novel approach will be inadequate to fill the impending void in battery-grade nickel supply. Since consolidation of Class 1 and Class 2 nickel pricing would hinder further investment in the former's feedstocks, implementing Tsingshan's speculative technique could widen the likely Class 1 supply deficit.

For the time being, disparities in ore grades between laterites and sulfides remain some of the most important distinctions inherent in answering supply-related questions for battery-grade nickel. Whether such a strategy presents a structural remedy for the impending supply bottleneck will take several years of patiently grinding down lead time and operational costs. On the periphery, the vertical integration of expansive supply chains (which present significant hurdles at each node) will also take years to optimize before they can figure into any long-term strategic industrial planning.

Even in an ideal world, replicating such a model of utilizing traditionally Class 2 feedstocks for end use in EV battery production is a prohibitive enterprise. Referring to the high prerequisite capex and relatively slim margins inherent in nickel refining, several structural considerations are key in determining a firm's ability to withstand such barriers. These barriers must be taken in the context of sometimes volatile exchange-traded nickel prices and their impact on cash flow. In Figure 25 we use SPG data to compare project-level total cash costs to produce deliverable refined nickel for major companies operating in laterite-rich countries (Brazil, Cuba, Indonesia, New Caledonia, the Philippines, and Papua New Guinea).

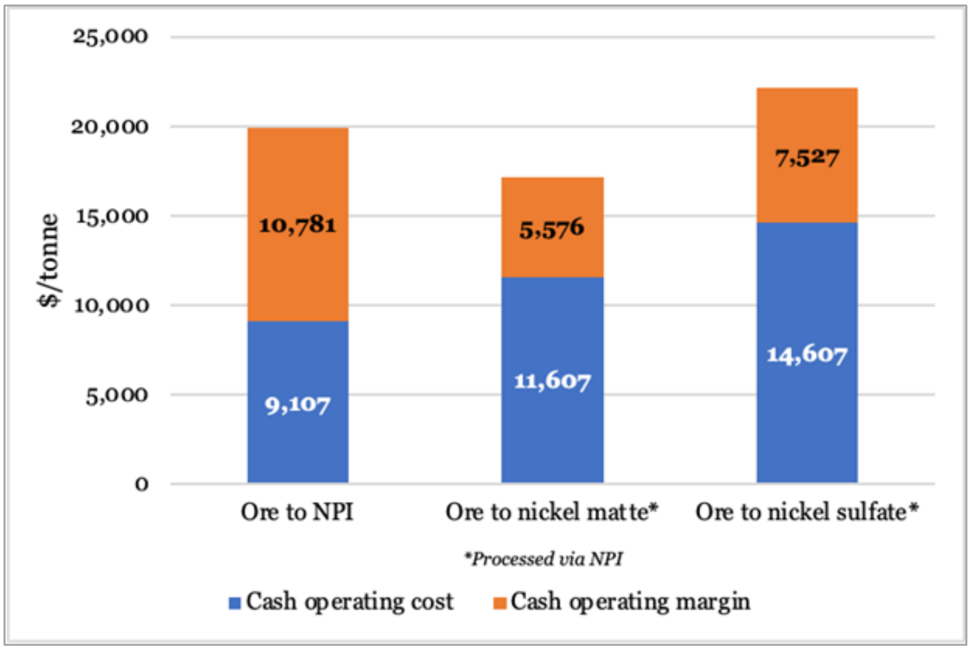
Figure 25. Nickel Production Cash Costs for Major Laterite Producing Countries



Source: SPGMI, accessed via license.

With scale (typically higher in companies represented by wider bars in Figure 25), reagents and labor are typically more cost efficient as total output rises. Thus, mitigating slim margins is a by-product of property size and the scale of operations. Withstanding periods of market downturn for sustained output depends on vertically integrated operations to minimize logistical and transactional costs where possible, and to shift the burden of decreased cash flow to other sides of a broad industrial portfolio. Figure 23 includes incremental opex for the various process streams—laterite ore to NPI, ore to nickel matte, and upgrading from NPI to nickel sulfate for the EVB market. While the estimated margin for the risky upgrading to nickel sulfate looks promising, the capex outlays are substantial, and sufficient scale must be achieved to provide an attractive price to EVB manufacturers and, ultimately, to produce affordable vehicles for the EV marketplace.

Figure 26. Estimated Laterite Ore Nickel Processing Opex and Margins



Source: Provided by SPG analysts.

In summary, feasibility outlooks for nickel processing ventures must consider the cyclical nature of commodity pricing. The expectation is that breadth and scale will be rewarded, which translates to influential positioning for navigating the global push toward EVs.

Filling a Void—Geopolitical Leverage and Strategic Dependence

Considering the tough financial barriers for expanding processing capabilities, Chinese firms are filling a void in Indonesia to meet production goals for refined nickel. Unable to directly import ore, China's imports of stainless steel and NPI from Indonesia rocketed in July 2021, with the former surging by a spectacular 443.6% on year to 141,000 tonnes, while the latter increased by a "pedestrian" 74.6% to 201,822 tonnes over the same period.[103] Uniquely positioned to navigate regulatory uncertainty and the structural barriers inherent in nickel processing, several ventures with significant Chinese backing recently appeared in Indonesia. In 2019, Chinese producer Delong Holdings' Indonesian JV Dexin Steel started operations in Indonesia.[104] Chinese lithium producer Jiangxi Ganfeng Battery Technology Co. and Indonesian resources firm Silkroad Nickel entered into an exclusive term sheet in January 2021.[105] The agreement looks to fund their expansion projects for upstream and downstream battery materials and, more broadly, sets up a strategic partnership initiative in EVB markets. In April 2021, China's Changsha-based CNGR Advanced Material Co. announced it would set up a JV in Indonesia to produce Ni matte with Singapore-based Rigqueza International, with expected output nearing 30,000 tonnes of nickel matte per year.[106] As Chinese firms further expand downstream, Indonesian capabilities will likely follow with a firm grounding in Chinese capital investment.

Chinese firms with processing facilities in Indonesia are also stepping into agreements to purchase ore from Indonesian producers who can no longer sell their products for export. In January 2021, Jiangxi Ganfeng and Silkroad Nickel agreed to a 10-year offtake deal to buy laterite nickel ore from Silkroad, which will supply a minimum of 10 million tonnes of nickel ore from its mine in Indonesia.[107] Only a few months later in March 2021, Tsingshan signed a two-year offtake agreement for 2.7 million dry metric tonnes of nickel ore from Silkroad Nickel.[108] The importance of Chinese investment for the expansion of Indonesian capabilities for nickel processing cannot be understated, a reality that Indonesian regulators will keep in mind in their strategic resource management policies.

In this regard, Chinese firms' position in Indonesia is incredibly strong. Because of Indonesia's importance in global nickel supply chains, the Chinese position carries broad geopolitical implications for strategic planners looking to shore up end-to-end stability of EV battery supply chains. PRC officials clearly have been willing to engage in practices that strengthen Chinese energy companies, both state-owned and sometimes semi-private, and, as already noted, can attempt to influence global commodity prices of critical metals with calculated releases of its key commodity reserves.[109] Consequently, these companies enjoy greater protection from market-rattling events and higher political and economic maneuverability to further solidify their strong position.

A momentary positive interjection: Chinese investment efforts and their broad-based success, from an industry standpoint, are encouraging investors from countries outside of China to get involved in Indonesian nickel processing. German chemical company BASF and France's Eramet are reportedly considering building a nickel and cobalt refining complex in Indonesia to begin operations in the mid-2020s.[110] The complex would supply an annual 42,000 tons of nickel and 5,000 tons of cobalt for use in cathode materials for lithium-ion batteries. Japan-based Sumitomo Metal Mining also plans to bring an Indonesian refinery online mid-decade, an investment that is possibly worth billions of dollars and would produce 40,000 tons of nickel annually.[111] Finally, major corporations related to EV production, including LG Chem, Tesla, and Contemporary Amperex Technology (CATL) have expressed interest in helping to create an Indonesian battery supply chain, according to the Indonesia Investment Coordinating Board.[112] These opportunities should not be overlooked by Indonesian officials, as they could help diversify Indonesia's dependence on Chinese capital to develop their domestic capabilities downstream.

Overcoming Slippery Slopes—ESG Pressures

Two key aspects of nickel processing pose significant ESG risks, especially given the Indonesian mining sector's rather turbulent history with environmental stewardship: energy expenditure and tailings disposal. Generally speaking, the production of Class 1 nickel from sulfide ore is much more energy efficient than utilizing laterite ore as a feedstock, which requires almost three times the amount of energy to produce one tonne of nickel.[113] Given Indonesia's historical reliance on coal power, which comprised just over 63% of the country's energy consumption in 2020, efforts to expand domestic nickel processing capabilities will likely entail commensurate increases in pollution from coal plants.[114, 115] While the hope remains that utilizing renewable energy, such as hydropower in Tsingshan's case, could mitigate pollution concerns, long lead times to construct renewable power facilities indicate that fossil fuels will likely underpin nickel processing in Indonesia over the short-to-medium term. Furthermore, hydropower in Indonesia has not been without controversy. It requires significant land use, can degrade water quality, and can reduce biodiversity, raising even more ESG concerns.[116]

Hydrometallurgical nickel processing through HPAL generates toxic waste that is extremely difficult to manage. Methods of tailings disposal such as tailings dams and dry stacking (literally consolidating and compacting waste mounds on designated pads with ultimate revegetation) require significant amounts of land—risking land conflicts, deforestation, and hazardous waste spills during earthquakes, which are common due to Indonesia's proximity to the "ring of fire."[117] Indonesian nickel producers previously lobbied for a shift to deep-sea tailings (DST) disposal, a controversial alternative method that could pose significant dangers to marine ecosystems.[118] DST disposal is especially detrimental to the Coral Triangle, a zone of ocean waters surrounding eastern Indonesia that is home to the most highly concentrated and endangered coral reefs.[119] In view of these controversies, the Indonesian government will no longer issue permits for DST for any future mining projects.[120] Albeit an improvement in tailings management from an environmental perspective, the deficiencies of current land-based tailings disposal practices still leave room for a host of ESG risks, unless disposal can be made significantly more efficient and sustainable. Social unrest from unequitable land use, potential groundwater pollution, and erosion tied to tailings disposal are likely the most concrete ESG risks for expanding nickel processing capabilities.

Indonesia's recent centralization of mining oversight and permitting capabilities also raises significant concerns for social and environmental activists. The 2020 Omnibus Law on Job Creation is especially problematic in this regard, with provisions granting the state unilateral authority over land acquisition and rights to waive environmental restrictions on a case-by-case basis. Considering Indonesia's troubled history with corruption in natural resource governance, the regression of its regulatory oversight toward a less transparent and unrestrained regime creates a slippery slope where important social and environmental boundaries may be tested.[121]

However, pressure from foreign companies can spur positive regulatory adjustments. A recent example is Tesla's apparent influence on the Indonesian government's early 2021 decision to disallow DST disposal for new mining projects. But other issues remain, such as the acceptability of sourcing nickel and other materials from smelters supported by coal-fired power, the disposal of mine waste laden with heavy metals, and the unpredictability of interactions between government officials, environmental and civil society groups, and industry stakeholders (including mining and minerals processing operators and automakers), all of whom are under increasing pressure to demonstrate that EVs can be "green."[122, 123] Each company is accountable to a highly diverse customer and ownership base, some of whom may view weak institutional efficacy in Indonesia as a means to cut costs by bypassing commonly held ESG standards. In other words, the Indonesian government will have to drive regulatory liberalization and sustainability, at least in part, as their standards and enforcement will set the practical floor of ESG measures for entities operating within their borders.

Resource Politics—"Commercial Frameworks," "Obsolescing Bargains," and the Region

In 2020, Indonesia's mining sector contributed about 5% to the country's GDP, about 15% of total exports, and more than one-third of the country's tax revenue.[124] All of these metrics increased from 2016 due in part to the surge in nickel pricing, albeit with ups and downs influenced by Indonesia's ore export restrictions.[125] Indonesia generally is regarded as a resource-rich country with a resource-dependent economy, marked by a long history of engagement with multinational companies (MNCs). In fact, the first-ever production sharing contract (PSC) for petroleum was created and instituted in Indonesia.[126] These relationships span Indonesia's important petroleum and natural gas businesses and mining and minerals processing. The combination of internal politics related to policy and regulatory approaches for industry, as well as historical tensions in a volatile region, make for any number of risks and uncertainties.

<u>"Commercial Frameworks"</u>

Historically, tensions between Indonesia's government and MNCs have run high. Tensions surrounding the huge Grasberg gold and copper complex, owned by Freeport McMoRan and operated by subsidiary PT Freeport Indonesia, reflect pressure for increased government control over the natural resource sector. Initial efforts to extract more in economic rents from mining operations in the country led to changes in the rules on ownership and fiscal terms (royalties, taxes, and other mechanisms) in 2012[127] and culminated in the recent (2018) nationalization of Grasberg.[128] This event, in turn, triggered revisions to mining laws and regulations—the "commercial frameworks" that underlie nickel extraction and processing today.

The Indonesian central government is prioritizing the expansion of nickel processing as a central tenet of their policies on strategic industry and resource management. The Committee for Acceleration of Priority Infrastructure Delivery (*Kemenko Perekonomian melalui Komite Percepatan Penyediaan Infrastruktur Prioritas*, KPPIP) selects a list of strategic projects deemed essential to increase Indonesia's economic growth, and the government takes concrete steps to accelerate projects falling within this priority grouping.[129] Coupled with the recently enacted ban on nickel ore exports, the inclusion of nickel smelters in the Indonesian government's list of national strategic projects is a signal of its commitment to advancing infrastructural development in minerals processing.[130]

As a country rich in resources—ranging from oil and gas to coal and critical minerals—government regulations of these natural resources carry extraordinary implications for foreign investment and government revenue. It is not surprising, then, that regulatory policies over the various resource subsectors are a highly charged and somewhat turbulent matter, with frequent changes in national priorities that create a somewhat erratic regulatory environment. In similar fashion to government regulations over petroleum, regulatory oversight of mineral resources is cyclical, with periodic reversals in trends toward more liberalized and transparent regulatory oversight. Indeed, to capitalize on "green" optimism and favorable critical minerals prices, the Indonesian central government is reasserting control over mineral production management. In doing so, they hope to ensure greater alignment between lower levels of government and national priorities in the mining subsector.

Several recent changes in regulatory oversight of mining are worth noting, as they are instrumental to the central government's grip on mineral mining and processing. Indonesia's 1967 mining and foreign investment laws reflected an "open door" policy on access to the country's resources for exploitation.[131] The centralized legal regime for metals mining in Indonesia was reframed with the introduction of Law No. 4 (Law 4/2009) on Minerals and Coal, or the Mining Law. Law 4/2009 shifted the industry from the model of a concession operated through a negotiable contract of work (COW, essentially a work program for mining projects) to a system of licenses. Under this law, foreign-owned Indonesian companies are now eligible to be license holders. Holders of COWs had to migrate these to the new law.[132] Under Law 4/2009, different licenses are awarded for different operations. For instance a mining permit (*Izin Usaha Pertambangan,* IUP) might be assigned for exploration or production, a different permit is issued for small-scale (artisanal) operators (*Izin Pertambangan Rakyat,* IPR), and a special mining permit is needed for specific metals (*Izin Usaha Pertambangan Khusus,* IUPK).[133] Under the previous COW regime, the state's position was considered insufficiently senior to that of contractors. For instance, arbitration was allowed under the COW regime, while under the Law 4/2009, license regime disputes associated with permits are only resolved in Indonesia's high court (*Peradilan Tata Usaha Negara*, PTUN).[134] COWs also included tax stability throughout the life of the project or termination of the contract. Law 4/2009, meanwhile, stipulates that operators are to make tax and non-tax payments "in accordance with prevailing laws and regulations," meaning that revenue obligations may be subject to change.[135]

Law 4/2009 also requires companies to process ore locally before shipping it abroad. To that end, the 2014 nickel ore export ban was instituted as part of the implementation of Law 4/2009, although, as we state relative to Figure 14, it was briefly relaxed from 2017-2019 before coming back into full force in January 2020. The implementation of the 2014 ban was meant to preserve the country's mineral resources for a growing domestic stainless steel market, while also encouraging investment in downstream value-added production.

Indonesia has long struggled with governance across the diverse and complicated archipelago. Law 4/2009 decentralized Indonesia's mining industry in line with Law 32/2004 on regional autonomy. Subnational provincial, regent, or city jurisdictions were accorded significant power. However, Law No. 23 of 2014 (Law 23/2014) on Regional Government revoked the previous Law 32/2004 and brought about another significant change in mining regulations, transferring the authority to issue and manage mining permits from regent or municipal governments to the provincial or central government.[136] This change was intended to optimize centralized state supervision and control of mineral production, reduce discrepancies in regional regulatory governance, and decrease opportunities for localized corruption in permit issuance. While Law 23/2014 was broadly applicable across several economic sectors, Ministry of Energy and Mineral Resources (*Kementerian Energi dan Sumber Daya Mineral*, MEMR) Regulation No. 11/2018 clarified the shift in authority to issue mining permits from the regent and mayors to the MEMR or relevant provincial governor.[137]

An amendment to Law 4/2009, ratified by the Indonesian House of Representatives in May 2020, returned power to the central government.[138] The amendment removed the authority of sub-jurisdictions to issue licenses as a strategy to improve ease of doing business, but it "allow[ed] the central government to delegate authority to regional governments for the issuance of local community-based mining licenses."

The 2020 amendment also added new permitting categories for rock and radioactive material mining under the purview of the central and provincial government. It removed the requirement that COWs be converted to IUP or IUPK licenses. Instead, holders of expiring COWs will receive IUPKs with extensions.[139]

In light of the Grasberg controversy, the 2020 amendment also ushered in changes to the Law 4/2009 divestment rules. Originally, foreign companies were required to divest 51% of their holdings in Indonesia by the end of the 10th year of production. Divested shares could pass to the central government and/or regional governments, state- and region-owned enterprises (SOE, ROE), and Indonesian privately held companies. Divested shares could also be released to the Indonesian stock exchange.[140] The regulations to the 2020 amendment, as released in November 2021, lift the foreign ownership cap of domestic IUP and IUPK holders (to 100%), while maintaining the 51% divestment target but with a longer timeframe, up to the 25th year of production. The timeline is linked to the type of operation (surface, underground, non-integrated, or integrated with processing and refining). The regulations add a novel twist in allowing foreign-owned (more than 49%) domestic license holders to transfer those shares to a third party before divestment, so long as they are first offered to an SOE. If not done, MEMR will not grant approval for third-party share transfer.[141] Almost certainly the more accommodating stance on an often-divisive issue between MNC investors and host governments has to reflect the reality of the mega investments underway and being considered for Indonesian metals.

Separately, in November 2020, President Joko Widodo passed an omnibus bill aimed at addressing overregulation by reforming the “bureaucracy, investment realization, development of human capital, infrastructure development, and the efficient use of the state budget.”[142] Several elements of the omnibus bill made foreign investment in Indonesia more attractive by expediting action by the regulatory bureaucracy. Nonetheless, some provisions that grant the state unilateral authority over land acquisition, as well as rights to waive environmental restrictions and the authority to supersede local zoning laws, are worrisome to local environmental and social activist groups.[143]

Altogether, the recent changes in mining oversight in Indonesia increase the central government’s control of mining practices for greater alignment with national priorities; move the country toward streamlining its complex bureaucracy for natural resources; and, in the end, at least on paper, strike a balance between risky capital outlays for mining, processing, and value adding with government control. Through these combined reforms, the central government has the right to bypass many key regulatory barriers to catalyze foreign investment in strategic infrastructure. The changes also suggest mining authority is concentrated among a narrowing group of individuals at increasingly higher levels of government. In a more practical sense, Indonesia’s re-centralization of mining oversight could diminish the government’s ability to respond to conflicts in or around mining operations.[144]

And there are plenty of opportunities for concerns to manifest. Nickel processing is often a high-polluting process, especially in Indonesia given the low grade of their laterite ore. As we noted earlier, disposal of tailings, the byproduct of nickel refining, and the energy-intensive refining process to transform low-grade nickel into battery-grade nickel, emerge as potential negatives for investors seeking clean nickel supply chains in Indonesia. Indeed, the intensive laterite-refining process uses “more energy, pollutes more water, and has a greater negative impact on biodiversity.”[145] Recentralized control over mining oversight will make it easier for officials to circumvent these environmental and land-use concerns in favor of streamlining mineral delivery, as they did in North Morowali’s Lake Tiu, which now runs “brownish red” according to residents.[146] In the all-too familiar trade-off in resource management, the Indonesian government is clearly prioritizing a more efficient and expeditious regulatory regime over decentralized control and independent oversight. Their strategy could become a double-edged sword for foreign investors, given the rapidly changing nature of national interests in the Indonesian resource sector.

<u>“Obsolescing Bargains”</u>

“Obsolescing bargains” imply that host governments increasingly wield the power in negotiations as project development proceeds: Once committed, the multinational investor has less and less clout. This happens immediately once capex is sunk, with investor control diminishing over time as the sovereign “learns” and becomes more adept both technically and financially. The notion of obsolescing bargains is an old one, coming into its own during the heyday of resource nationalizations in the 1970s-80s.[147] A typical outcome is “creeping expropriation,” in which the sovereign, resource-owning government imposes ever more onerous policies to capture economic rents and/or limit foreign ownership. In the extreme, a sovereign resource owner can move to fully expropriate assets. A classic case is Saudi Arabia's nationalization of Saudi Aramco, a process that began in 1980, when the Saudis took 100% control of the company, and was completed in 1988 with the creation of Saudi Aramco. Chile's nationalization of its huge copper consortium Codelco in 1976 is another example. By the time those nationalizations occurred, both countries had become quite adept in regard to their natural resource sectors.

As projects mature, with increasing opex and the prospect of capital outlays in order to sustain operations in the face of, say, declining ore grades (or, for oil and gas, depleting reservoir pressures), governments can take more accommodating stances. Host government treasuries are impacted as diminishing production leads to declining revenues from hard currency exports (low-price periods to which ageing assets are more vulnerable). Social priorities like employment become expensive and difficult for operators to sustain. In these cases, governments discern the financial risks to their coffers and liberalize their regimes to encourage continued operations and/or new investment. After all, resource-owning host governments that are dependent upon exports of their commodities for income and hard currency need to sustain investment and production, or they run the risk of dangerously depleted treasuries. One example of a country facing that dilemma amidst many sociopolitical stresses was Colombia. Colombia moved in 2003 to reform and liberalize its hydrocarbons sector, fostering partial privatization of its national oil company, *Empresa Colombiana de Petróleos* or Ecopetrol, to create a more competitive fiscal regime with an independent regulator and competitively bid licenses for exploration and development.[148]

We observed in Part II: Nickel Mining Trends that declining head grades and overall ore quality are prevalent across the major minerals and metals, not just for nickel. The maturity of assets in operation, the lack of exploration and new discoveries, difficulties originating new projects, and, as highlighted in our report, shifts to resources that are of a lower grade and quality and require more expensive treatment are all combining to create a challenging set of conditions relative to new demand being created by EVs and other end uses. We might expect resource-owning and revenue-dependent governments to take more welcoming stances. The more flexible stance on divestment, embedded in the late 2021 Indonesian regulations to implement the 2020 amendment, appears to reflect business realities.

That said, how can the era that we seem to be entering—of governments positioning in the opposite direction by attempting to impose tougher terms in spite of less competitive positions in ore grades and maturity of assets—be explained?[149] An answer may lie in rapidly escalating commodity prices driven by speculative trading around "green" energy ambitions, as we pointed to earlier for nickel and other battery metals. A lack of good alternatives and substitutes for nickel and other metals, and a dearth of attractive locations for investors, also play significant roles in host government positioning, at least in the short run.

Another factor is "ESG activism," which is increasingly used to oppose projects worldwide. Environmental impacts, energy use, emissions, land and water requirements, and, increasingly, agitation among local communities (in particular, indigenous communities) are all combining to add new layers of complexity to resource politics. ESG activism has become firmly entrenched as a form of resource nationalism, including in the United States.[150]

Distinct questions surround the role of Chinese investment worldwide, much less in Indonesia, and its major players. Can Chinese investors counteract "resource nationalism" that could manifest in a new, materials-sensitive age? Are they better positioned than other global players? Is there a set of dynamics around Chinese outbound investment that has and will continue to fundamentally alter the picture for natural resource industries and sovereign owners? The latter is a persistent question given the new ways the Chinese state is positioning itself globally.[151] How Indonesia-Chinese relations might be affected by the former's strategic dependence on the latter is a key consideration.

<u>Regional Geopolitics and the Indonesia-China Axis</u>

Chinese capital is the hidden foundation upon which Indonesia's strategic push for increased nickel processing depends. The high capital costs for nickel processing increase the barriers to entry into this segment of value-added industry, favoring vertically integrated companies that can spread the financial burden over their broader portfolios. Integrated companies are also less vulnerable to price shocks in metals markets. Both considerations increase Indonesia's strategic reliance on Chinese capital from companies like Tsingshan.

Within this picture, the apparent Chinese strategy is to couple huge upstream minerals commitments with downstream battery-making in attempts to manage unit costs via overall scale and value creation from battery sales. This general strategy will likely apply to other projects and for other minerals and materials, as well as other locations within Southeast Asia and beyond. Chinese companies like Tsingshan, which back Indonesian nickel processing, still carry a considerable financial risk burden, despite being able to spread that risk across a host of different ventures. To mitigate these risks, Chinese companies are coupling their considerable upstream commitments on ore purchases with downstream manufacturing to manage the per-unit costs of EVBs via scaled operations. While these dynamics are especially poignant in the nickel subsector, they also hold true for Chinese outbound investment across other critical mineral subsectors, with copper as a prime example.[152] With the overall view of increasing their footprint abroad, Chinese companies seek cheap nickel feedstocks for end uses ranging from stainless steel to EVBs. Even with shifts to a more service, consumption-oriented economy, the Chinese domestic market is likely to account for a significant portion of demand increases across several end-use cases, as we described previously. For upstream investors targeting opportunities in nickel mining, China's influence on global supply should not be understated, given their ability to cool nickel prices (at least momentarily) by releasing portions of their strategic reserves into the common market. Even discussion about possible stockpile releases could have a dampening effect. Any forecast of future prices must consider this potential lever, which Chinese resource managers enjoy.

Indonesia's reliance on Chinese capital to expand nickel processing should also be analyzed in the scheme of the Chinese government's aggressive actions in the South China Sea (SCS). Resource nationalism over the SCS is a historical point of contention for Sino-Indonesian ties. China's formal diplomatic relationship with Indonesia began in 1950, was suspended a decade-and-a-half later after a regime change in Indonesia, and officially resumed in 1990. Since then, tensions have been cyclical in nature, although recent years have seen unprecedented confrontation and resource nationalism in the SCS. In 2010, Indonesian officials started arresting incursive Chinese fishing vessels. This resulted in an intense showdown in 2013 between an Indonesian patrol boat and PLA Coast Guard vessels over detained Chinese fishermen.[153] A similar incident occurred a few years later in 2016, and the Indonesian military has been making consistent upgrades to its marine defense assets as a result of the confrontational turn in Sino-Indonesian relations.[154] Tension peaked in late 2019 because of recurring incursions by the Chinese Coast Guard and fishing militias into Indonesia's exclusive economic zone (EEZ) in the Natuna Sea. During the incident, Indonesia dispatched warships and F-16 fighters, and called for Indonesian fishing boats to relocate to the area.[155] Friction between China and Indonesia to determine ownership of the South China Sea's abundant economic resources shows no signs of abatement. The most recent months-long standoff near Natuna in Indonesia's EEZ, which began in June 2021, is unusual in that it is the first time Chinese coast guard vessels have shadowed Indonesian offshore exploration in the enormous territory claimed by China as part of its own South China Sea EEZ.[156, 157] In addition, the two countries have long had disputes over fishing rights in the area.[158]

Yet in terms of geopolitical leverage, the two countries are not on equal footing. Indonesia's strategic reliance on China goes well beyond the natural resource sector. The Indonesian government has recently downplayed the significance of SCS events, likely because President Widodo has pressed for warmer relations with China, in recognition of the fact that China is Indonesia's largest trading partner.[159] And although Indonesia has a long history of anti-Chinese ethnic violence,[160] going back to Maoist China's attempt to spark a communist revolution there in the 1960s, economic relations between the two countries are generally good. In fact, Chinese President Xi Jinping's predecessor, Hu Jintao, advocated for easing restrictions over bank loans to help Indonesia during the 2008 economic crisis.[161] Beijing also backs several key infrastructural development projects in Indonesia as part of the Belt and Road Initiative. For example, Chinese officials announced in April 2021 that a major milestone had been reached in their construction of the Jakarta-Badung High-Speed Railway.[162] Indonesian officials are reportedly considering further infrastructural investment from the Chinese on projects such as the Lambakan Dam in East Kalimantan.[163] In the scheme of the COVID-19 pandemic, Indonesia has also benefited from China's Sinovac COVID vaccine diplomacy.[164]

It is thus likely that President Widodo will continue to strongly resist China's incursions into Indonesia's EEZ, but at the same time downplay Chinese aggression and malpractices, especially in the realm of human rights. President Widodo faces criticism from democratic opponents for not opposing China on its mistreatment of fellow Muslims in Xinjiang, and if he is seen as being weak on opposing China on gas exploration around Indonesia's largest gas fields, he risks both resource nationalist and anti-Chinese ethnic riots.[165] Although no longer a member of OPEC, since it is a net importer of oil, Indonesians have a strong memory of previous decades when they were one of the largest exporters of oil and liquefied natural gas in Asia. China's aggression around Natuna may be adding insult to injury for a former energy resource powerhouse such as Indonesia.[166]

A familiar picture thus emerges, where Indonesia, along with many of China's neighbors, are left to toe a fine line. They aim to sustain critical Chinese investment and economic ties while also resisting China's territorial expansion over disputed portions of the SCS. Regarding the SCS, the PRC employs "salami-slicing" tactics, which involves isolating claimant states in the SCS from one another in diplomatic negotiations and thereby complicating efforts for them to align and pool their leverage when they face Beijing.[167] In one-on-one negotiations with Indonesia on contentious SCS issues, PRC officials could very well use the former's reliance on Chinese capital for their critical infrastructural development as additional leverage to subdue counter-pressure from the Indonesians. While the two countries' interests converge on several issues, especially on critical minerals supply chains, their increased alignment does not suggest that it will inevitably translate to appeasement on other critical friction points. Indonesia is typically one of the most vocal opponents of China's incursive activities in the SCS, and critical economic ties to the PRC will likely not overshadow major disagreements like the SCS.[168]

<u>Xi's "Common Prosperity" and Emerging Strings</u>

Like children in a candy store, Chinese companies looking to solidify EV supply chains in Indonesia will have plenty of opportunities to satisfy their appetites, facing weak oversight and a permitting regime more likely to encourage further excess instead of restraint. When it comes to maneuverability, the barriers posed by the Indonesian government are few. However, taking a peek at Beijing's recent onslaught on the Chinese tech sector,[169] the Chinese Communist Party's (CCP) push for "common prosperity" and greater oversight of strategic industries could bleed into the natural resource sector and thus into Chinese nickel operations in Indonesia.

According to President Xi Jinping, "common prosperity" is an essential requirement of socialism and Chinese rejuvenation.[170] In theory, the umbrella term refers to a people-first governance model that corrects the inefficiencies of a Western-style capitalist model, working to erase extreme wealth disparities and the structural vulnerabilities of a market-based economy.[171] Following Xi's meeting with the CCP Central Committee for Financial and Economic Affairs on August 17, 2021, the committee called for the redistribution of excess incomes and a return to socially oriented rather than purely profit-motivated business decisions. In practice, regulatory crackdowns on the tech sector in 2021 erased over $1.5 trillion of the sector's market value.[172] Shareholder confidence has been plummeting in the face of forced changes to highly profitable, data-driven business models that capitalized on synergies in the broader Chinese big-tech ecosystem. Highly publicized examples of recent crackdowns include the release of the June 2021 Data Security Law, which mandates government restrictions on data collection, storage, usage, provisions, and disclosure, and the decision to pull the ridesharing app *Didi* from app stores in China over data-use concerns.[173] Besides correcting perceived inefficiencies, the crackdowns were meant to spur further development of "hard technologies," such as semiconductor chips and artificial intelligence—especially as China's relationship with the United States continues to sour and economic decoupling continues at pace.[174]

Given the strategic impetus of EVs for China, it would not be surprising for Chinese regulators to set their crosshairs on the mining sector. Stable EV supply chains are a necessary component of China's decarbonization efforts, and thanks to such efforts in other countries, they are also a formidable tool of geopolitical leverage. Under premises such as the push for further development of hard technologies, Beijing may seek more oversight of companies with significant influence over EV value chains. Thus, companies like Tsingshan in Indonesia could be "reigned in" for greater alignment with Beijing's industrial policies, losing some of their maneuverability in the process.

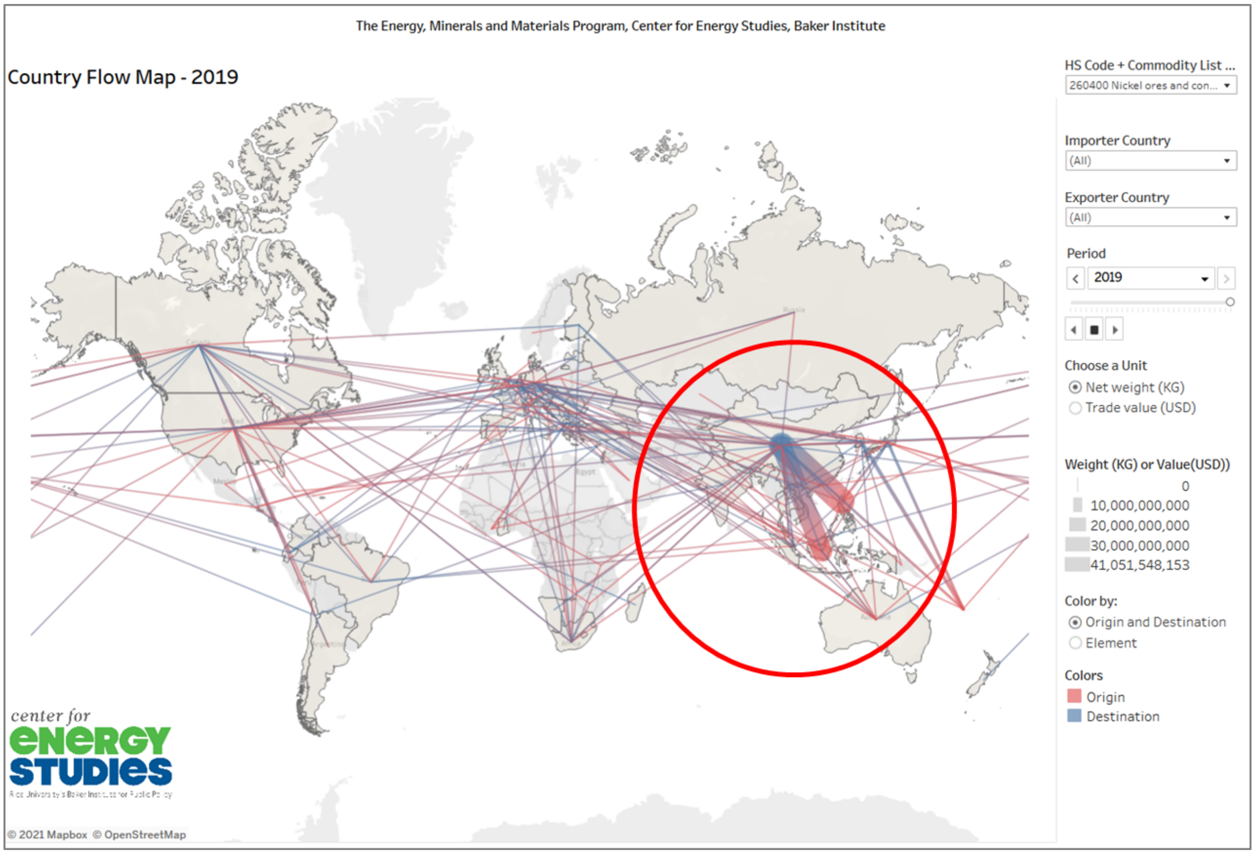
<u>Geopolitical Choke Points</u>

With the SCS already a flashpoint of concern, Indonesia's position as the largest external supplier of nickel to China (Figure 27) would be a key focus. The country exported about 245 KT of nickel ores in 2020 with about 76% of that tonnage (187 KT) shipped to China, giving Indonesia a roughly 40% share of the Chinese market. Logical questions could arise regarding actions to block trade intentionally or the fragility of trade routes as a byproduct of other conflicts. In the case of overt strategies, who would stand to gain?

China certainly holds more of an upper hand, since Chinese interests are major investors in Indonesia, and Chinese customers the major buyers, by far. Indonesia would hurt itself most if trade became entangled in other disputes with China. Severe conflict in the region would hurt both countries, as well as other large suppliers to China (such as the Philippines). The roughly 25% of nickel that Indonesian producers sell to customers other than China could create tensions for those buyers, depending upon supply-demand balances.

Rather than overt trade dislocations, the major risks lie more in other consequences of the Indonesia-China bilateral arrangement. These could range from internal strife within Indonesia related to Chinese businesses and presence (akin to historical quarrels in the 1960s[175]) to both implicit and explicit Chinese influence on Indonesia that might rub against Indonesia's relationships with other countries (including the U.S.) and regional balances of power, or beyond.[176]

Figure 27. Global Nickel Trade and Chinese Dominance



Source: CES worldwide minerals trade visualization, https://www.bakerinstitute.org/global-minerals-trade-dashboard.

Conclusions

Clearly, neither effective public policy nor corporate strategies as they relate to minerals and materials supply chains can be devised without full and proper understanding of occurrences, operations, logistics, and locational context. A number of themes emerge from our report.

Overall, while growth in nickel use for a variety of consumer and industrial applications is well established and set to continue, the focus on electrification of transport is creating a long-term, disruptive environment. Whether this gives advantages to Indonesia's nickel resource endowment is an open question. Indonesia clearly needs Chinese investment. Nickel supply challenges and price sensitivities would seem to strengthen Indonesia's hand. Yet Indonesia's nickel resource base is complicated and expensive to process into battery-grade material. Caveats abound—persistently high nickel prices could drive the auto and battery-making industries away from nickel-rich chemistries and toward alternatives like LFP batteries. Longer-term, more attractive nickel prices could help launch major new resource plays such as deep-sea mining. More onerous prices and more expensive batteries could undermine enthusiasm for EVs, triggering rollbacks in commitments, government support, and consumer adoption and upending all of the assumptions we have covered in our report for a new transportation paradigm. ESG concerns could prove to be deal killers. In short, in these early days, anything can happen. Our survey and case study are intended to provide a realistic picture of the resource and industry fundamentals underpinning nickel supply and demand, and resource owner and investor dynamics.

A major issue for all nickel investors and commodity markets is that the rush to upgrade processing of laterite sources depresses Class 1 prices—i.e., so much supply enters the market that Class 1 prices depreciate. We note expectations that Class 1 and 2 prices might converge. The premium for Class 1 could shrink or even vanish. Such outcomes would have severe implications for Class 1 nickel producers, including for new projects. We also acknowledge opinions that processors may utilize capacity so as to "swing" between nickel classes to take advantage of pricing either way. Supply-demand balances will depend on whether overall nickel production increases or whether feedstocks are diverted away from legacy uses, which could create tensions in industries like steel as EVB manufacturing attracts more nickel.

China's interests and intents in materials supply chains are clearly different than those of other investors, and they have a huge advantage in battery manufacturing—especially over newcomers and even legacy ventures looking to expand. Chinese companies like Tsinghan are coupling cheap laterite nickel with more expensive processing for large-scale battery production. Tsinghshan and other companies appear to be taking the risk of positioning themselves as "loss leaders" in mining and processing in order to pursue the bigger prize of EVB manufacturing and continued market dominance for China. Few investors and even fewer governments would be willing and/or able to pursue comparable strategic positioning. When it comes to the bigger picture of regional geopolitics, as the dominant importer of nickel and other minerals, China needs open sea lanes for trade, including in the SCS. This reality presents an interesting counterpoint to the many worries about that particular geographic flashpoint.

What are Indonesia's interests? The country is a classic resource-dependent economy. Indonesians benefit more from higher rather than lower nickel (and other commodity) prices. This explains their actions to restrict exports and attempt to push up prices. Yet, the country is clearly positioning itself strategically through the use of export controls and other measures to force foreign mining companies to proceed with value-added processing and ultimately EVB manufacturing at home. Given that the apparent Chinese strategy is an entirely different proposition, what does "China Inc." imply for Indonesians? The alignment of Indonesian and Chinese interests appears to be in place, but any number of tensions could arise, including ESG-related scrutiny and pressures.

In the past, Indonesia benefitted enormously from obsolescing bargains in its natural resources industries (they moved up the learning curve rapidly to gain the upper hand over multinational oil and metals companies). Indonesia must now tread cautiously, so as not to be perceived as working against investor interests. The country harbors a low-quality, though abundant, resource with much of the value being created and monetized elsewhere. Ambitions to build end-to-end battery manufacturing are one thing; execution is another. Capturing added value for their resource endowments has proven difficult, most times impossible, for typical resource revenue-dependent governments to control or even attain. How much capital are investors really willing to expose? That remains to be seen.

As an aside, our case study presents many analogies to bauxite, alumina extraction, and aluminum smelting. These businesses are also well defined for Indonesia. At one point in its history, Indonesia attempted to control regional bauxite trade and value creation at the smelter. That effort did not succeed. In tropical regions, both the refined nickel and aluminum industries and their value chains entail large-scale mining of low-grade resources and utilize vast amounts of coal-fired and hydroelectric power.[177]

Endnotes

[1] "Mirroring broader trends in its foreign relations, China's climate policy has evolved from one that emphasizes cooperation with foreign powers, especially the United States, to one increasingly centered on economic and geopolitical competition." From Scott Moore, "China's New Climate Pledge: Is Geopolitical Competition Good for the Climate?" *Lawfare* (blog), October 4, 2021, https://www.lawfareblog.com/chinas-new-climate-pledge-geopolitical-competition-good-climate.

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