

Center for Global Sustainability Nickel Smelter Dataset:

Increasing transparency and traceability of nickel
smelter projects in Indonesia

December 2025



CENTER FOR
GLOBAL SUSTAINABILITY

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Suggested Citation

M. Schreier, D. Amin, K. Shah, J. Lou, C. Brown, A. Rader, R. Cui, N. Hultman. (2025). "Center for Global Sustainability Nickel Smelter Dataset: Increasing transparency and traceability of nickel smelter projects in Indonesia." Center for Global Sustainability, University of Maryland.

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Executive Summary

Countries across the world are eyeing critical mineral supply chains to support the deployment of energy transition technologies.

As Indonesia seeks to capture greater value from nickel processing supply chains, the Center for Global Sustainability Nickel Smelter Dataset provides a detailed stocktake of existing nickel smelter projects. The Center for Global Sustainability (CGS) has developed a comprehensive dataset of 106 nickel smelter projects as of 2025, through the compilation of existing resources and extensive research into the operational status, location, company ownership, processing type, and capacity. This verified, geolocated dataset offers a snapshot of Indonesia's nickel processing sector and illuminates several key trends:

- **Processing technologies reveal a clear shift away from blast furnace (BF) towards high pressure acid leaching (HPAL) smelters.** The majority of operational smelters in Indonesia are rotary kiln electric furnaces (RKEF) smelters (35 among 59 operational smelters), producing ferronickel (FeNi) and nickel pig iron (NPI) for stainless steel supply chains. There are 9 operational HPAL smelters, with an additional 8 HPAL projects in the planning or construction phases. This growing hydrometallurgical pipeline underscores the industry's move towards HPAL projects that require more capital expenditure, but produce higher-value products for electric vehicle (EV) battery supply chains.
- **Complex, multi-layered ownership structures, often concealing several layers of foreign investment behind a single listed operator,** underscore the value of our dataset in providing transparent, standardized ownership information and enabling robust environment and social accountability.
- **Seventy smelters within the dataset are located within industrial parks** enabling them to share resources from foreign investors, infrastructure, and supply chains.
- **Indonesia's nickel smelter sector remains heavily reliant on captive coal power,** with limited transparency on energy sources and only early proof-of-concept efforts of renewable energy, pointing toward the challenging but necessary task of decarbonizing high-temperature processing.
- **Five smelters hold 45% of the total output capacity, producing NPI and nickel matte.** This high concentration of production in a small number of facilities creates the challenges and opportunities for targeted decarbonization efforts.
- **Our finding that 21 nickel smelter projects have stalled showcases the limits of downstream policy interventions,** as many mining companies failed to follow through on development plans or secure the necessary investment. Five smelters stopped operating in 2025 due to the high cost of coking coal imports and low nickel prices.

The CGS Nickel Smelter Dataset offers policymakers, researchers, and companies the opportunity to take stock and identify opportunities for growth and impact mitigation. As a thoroughly documented resource, the dataset aims to inform future energy modeling and environmental impact assessment efforts.

1. Introduction

As countries across the world announce net zero emissions targets, the global demand share for nickel in energy technology is projected to increase to 40% in 2040 compared to 20% in 2024.¹ Furthermore, Indonesian share in global nickel refining is growing at a year on year 10% rate, surpassing China in refining capacity.¹ A significant portion of this demand is coming from primary supply of nickel as opposed to reuse. With higher focus on electric vehicles (EVs) for curbing transportation emissions and battery storage for countering renewable energy intermittency, nickel will continue to play a crucial role globally in achieving net zero targets.

Indonesia holds the largest share of nickel reserves in the world, estimated at 55 million tons of laterite nickel in 2024.² Historically, most nickel globally has been produced from sulphide ore, as laterite nickel ore has a lower concentration of nickel, making it more energy intensive and costly to process. As 54% of the global nickel deposits are laterite, mining companies began developing laterite nickel processing technologies in the 1970s. Indonesia's first nickel processing plant began operations at PT International Nickel Indonesia (PT Inco, now PT Vale Indonesia Tbk) in Sorowako in 1977.^{3,4}

In 2005, Chinese metal producers commercialized nickel pig iron (NPI) technology, enabling Chinese stainless steel producers to use Indonesian laterite nickel ore for stainless steel production at much cheaper cost than pure nickel.³ The demand for Indonesian nickel surged, with ore exports rising by 1649.77% from 2005 to their peak in 2013 (Figure 1, left panel), with the vast majority shipped to China.⁵ Domestic nickel mining expanded rapidly to keep pace.

During this period of increased demand, the Indonesian government passed the 2009 Mining Law, which required companies to process ore domestically before exporting. In 2014, the first mineral ore export ban was established, mandating that mining companies pay an export tax, meet domestic refining requirements, and commit to building metal smelters in order to retain their export licenses.^{6,7} While some export requirements were relaxed in 2017, a full export ban on nickel ore was reinstated in 2020. The Indonesian government has also designated many mineral processing projects as "National Strategic Projects," offering investors tax incentives, streamlined approvals, and other benefits to accelerate smelter projects.^{8,9}

As shown in Figure 1 left panel, nickel ore exports rose steadily until 2014, then dropped sharply following the initial ban, before recovering temporarily due to the 2017 relaxation as domestic smelting capacity expanded. The right panel of Figure 1 presents the free on board value of Indonesia (the cost reported by the exporting country), which shows that the prices of processed nickel have historically remained higher than ores (with some fluctuations) until around 2021.* In March 2022, the price of nickel increased by more than 270% on the London Metal Exchange (LME) over the course of only three days.¹⁰ The Russian invasion of Ukraine (among other factors) drove nickel prices upward in early 2022, causing a short squeeze for Tsingshan and

* It is important to note that this metric is used as a proxy here and is not always comparable to market value of commodities. The free on board cost refers to the cost of production within the exporting country while the market value will take into account other costs such as tariff rates, transportation etc.

other producers who had massive short positions. Nickel prices continued to rise until the LME suspended trading on March 8, 2022.¹¹ Indonesian nickel ore prices have remained volatile ever since, rising again in 2024 due to delayed mining permit approvals, the launch of the SIMBARA* tracking system for nickel which cut down illegal ore sales, and overcapacity in domestic nickel processing.¹³

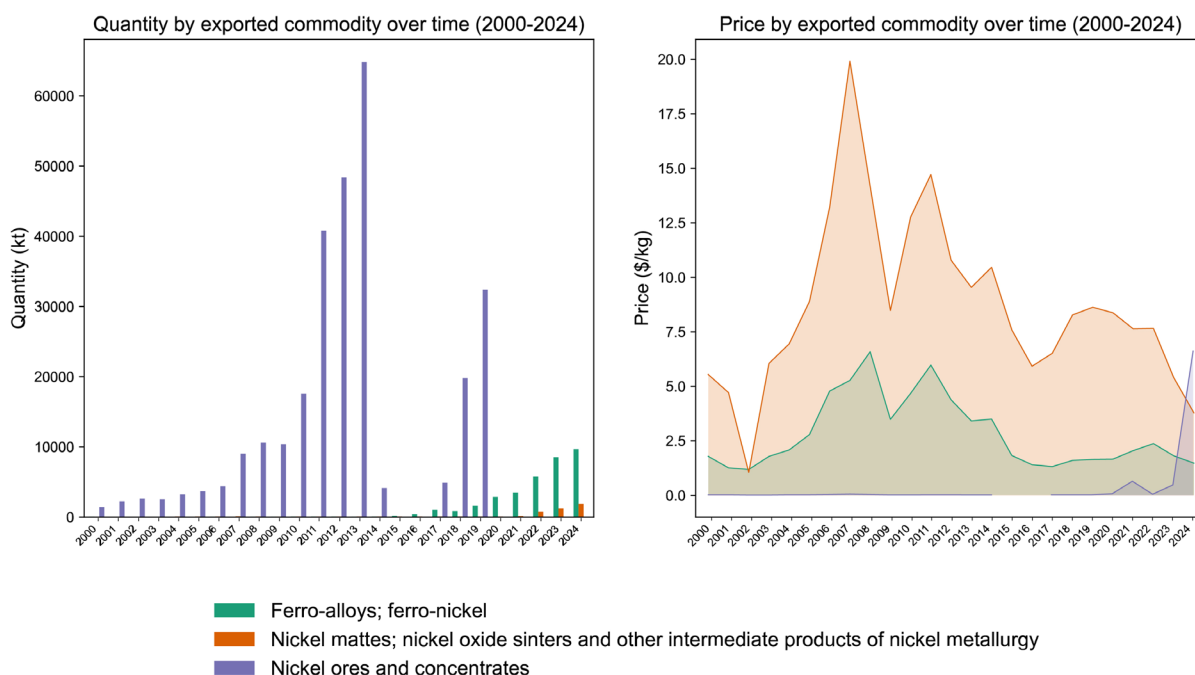


Figure 1. Quantity (kilotonnes) and free on board value (USD)/kg of exported nickel commodities over time (2000 - 2024). Source: UN Comtrade⁵

While many Chinese companies stockpiled Indonesian ore prior to the export ban, many also began investing in nickel smelters in Indonesia, often at large-scale industrial parks, such as Indonesia Morowali Industrial Park (IMIP) and Indonesia Weda Bay Industrial Park (IWIP). Since 2014, 14 nickel industrial parks have begun development, with 10 featuring Chinese company involvement at the manager or tenant level.¹⁴

* SIMBARA is a tracking system run by the Ministry of Finance since 2022 that integrates data across the Ministry of Energy and Mineral Resources, Ministry of Transportation, Ministry of Trade, Ministry of Industry, and Coordinating Ministry for Maritime Affairs and Investment to better monitor mineral and coal resources.¹²

2. Inside Indonesia's Nickel Industry

2.1 Nickel Smelting in Indonesia

Indonesia's build out of nickel smelters has largely featured pyrometallurgical nickel smelting, which produces NPI and ferronickel (FeNi) for the stainless steel industry. The initial 2014 ban on export of nickel ore accelerated this trend, with FeNi exports rising from 2015. In recent years, however, there has been a shift towards hydrometallurgical operations (e.g. high pressure acid leaching or HPAL plants) which utilize lower grade limonite ore to produce intermediate products for battery grade nickel sulphate.¹⁵ The International Energy Agency (IEA) estimated that 90% of nickel processing in Indonesia in 2023 occurred through pyrometallurgical routes. While the share of HPAL in production is projected to rise to 15% by 2040, the share of pyrometallurgical processing is projected to remain stable at 80% of production through 2040.¹⁶

2.2 Nickel Processing Routes

Pyrometallurgical routes such as rotary kiln electric furnaces (RKEF) and blast furnaces (BF) are used to produce low grade nickel alloys such as NPI and FeNi. These smelters can also produce nickel matte, which has a higher nickel content, through the addition of elemental sulfur. Alternatively, the preferred nickel sulphate intermediate for battery production is mixed hydroxide precipitate (MHP), which is produced through hydrometallurgy. High-grade saprolite ore, which also contains magnesium and silicate, is suitable for pyrometallurgical operations, while low grade limonite ore is suitable for the hydrometallurgical processing route.¹⁷

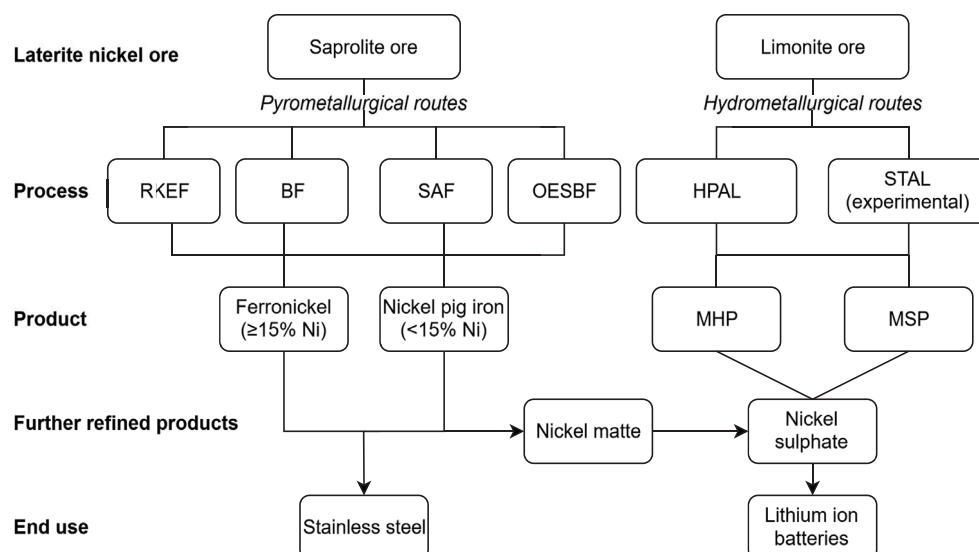


Figure 2. Flow chart of nickel processing routes in Indonesia, from ore type to end use.

The majority of nickel processing capacity in Indonesia is based on BF, RKEF and HPAL routes. However, several other routes are either operational or in pilot stages across the country in order to accommodate diverse ore types and achieve lower energy consumption. For instance, the submerged arc furnace (SAF) is similar to the conventional Electric Arc Furnace but differs in that the electrodes are buried within the charge, providing heat directly inside the raw material bed.¹⁸ Another emerging process, step temperature acid leach (STAL) technology, is currently being piloted in Indonesia for the production of MHP. STAL operates at higher temperatures but under atmospheric pressure, unlike the HPAL process, thereby reducing operating costs and enabling smaller mining concessions to become economically viable.^{18,19,20} The oxygen-enriched side blown furnace (OESBF), a technology patented by a Chinese company, is operational in Indonesia and producing nickel matte for the first time ever from laterite ore.^{21,22} Although currently in the early stages of commercial deployment, the oxygen enriched air injection has been found to support higher smelting efficiency and reduction in CO₂ emissions.²³ Collectively, these production routes underscore the evolving nature of the nickel processing landscape in Indonesia, characterized by both conventional and mature production routes as well as experimental routes aimed at enhanced energy efficiency and environmental performance.

In recent years, the Indonesian government has considered implementing a moratorium on RKEF smelters due to concerns of potential oversupply and the depletion of national nickel reserves.²⁴ In June 2025 the Indonesian government reinforced its downstreaming agenda by announcing that it would no longer issue Industrial Business Licenses for nickel smelter projects that produce intermediates (including FeNi, NPI, MHP, and nickel matte), unless the projects include plans for further domestic processing.^{25,26} This regulation aims to stimulate the production of nickel sulphate and battery production facilities, both of which remain limited within Indonesia.

2.3 Impacts of Nickel Processing

Energy, emissions, and land use intensity vary by the ore type (limonite vs. saprolite) and the processing type (RKEF, HPAL, STAL, SAF). RKEF generally has higher CO₂ intensity than that of HPAL smelters, driven largely by electricity generation.^{27,28} The most energy intensive processes include calcine reduction in RKEF smelters and acid plant activity in HPAL smelters.²⁹ Even in terms of the product, energy consumption across the process from mining to materials is highest for nickel oxides followed by FeNi and NPI.²⁸

Apart from energy intensity and greenhouse gas (GHG) emissions, waste product streams are an important consideration while assessing the overall sustainability and life cycle impacts of the smelter. In the case of RKEF processing, major waste streams consist of flue gas and slag, where the flue gas is typically recycled back into the production process for heat recovery.³⁰ HPAL processing produces tailings, or the toxic residue left after neutralizing the acid from the leaching step. A significant amount of wastewater is also produced from the leaching step and is a waste stream of concern.²³ These tailings are managed through engineered structures for holding the thickened slurry, called by some companies “dry-stack tailings storage.”³¹ Concerns persist for dry stack tailings disposal methods, as these facilities often fill up with

rain water and fail, exposing downstream communities to harmful waste.³² Several instances of tailing storage failure in Indonesia have led to increased concern for workers and communities nearby such structures.³³ With the increasing adoption of HPAL smelters in Indonesia, better tailings management is crucial, as HPAL plants generate 1.2-1.6 tons of waste per ton of nickel produced.¹⁵ Indonesia does not allow the disposal of tailings into deep sea tailings facilities owing to negative impacts on marine environment. Therefore, all HPAL facilities will require carefully designed solutions for the safe and effective disposal of hazardous waste without contaminating neighboring land and water resources.

Another concern is water contamination from chromium-6, a known carcinogen released during many manufacturing processes. Chromium-3 ions are naturally present in limonite and saprolite ores and generate chromium-6 ions when subjected to high temperatures during nickel smelting processes. Chromium-6 ions are then released in water bodies near nickel smelting sites causing significant concern for public health.^{34,35,36}

Lastly, deforestation around nickel smelters is occurring at a faster rate than in other parts of Indonesia. Studies have shown that deforestation nearly doubled between 2011-2018 in mining villages and that forest loss surrounding nickel smelter sites has continued to rise in recent years.^{37,38} The breadth of these environmental impacts underscores the need for improved monitoring and reporting of smelter development in Indonesia.

2.4 The Need for a Comprehensive and Verified Dataset

A comprehensive, verified dataset is needed to ensure consistent capacity metrics, well-documented operational, and transparency in ownership, preventing inaccurate assessment of production and improving accountability for environmental and social impacts.

First, a consistent dataset is essential to ensure comparability and traceability. While several government reports and media articles list smelters by capacity, there are inconsistencies in the metrics reported. For instance, some sources cite production capacity in terms of the final product, while others refer to contained nickel metal capacity. Moreover, these figures often differ from the capacities reported in the operator or parent companies' annual reports, adding another layer of inconsistency.

Second, within existing lists of nickel smelters, identifying the operational status of each smelter is crucial to fully understand the state of the nickel processing sector and the true scale of its processing capacity. Following the Indonesian government's ore export ban and the regulatory requirement for companies to build smelters domestically, many companies announced plans to construct facilities, resulting in their inclusion on official lists, but never moved beyond the proposal stage. In our dataset, we have analyzed company data, government and media reports, and satellite data to determine the operational status of each smelter.

Third, documenting the ownership structure of smelters helps achieve higher transparency in the nickel processing sector in Indonesia, avert supply chain risks and maintain effective governance standards. Several factors have led to a proliferation of complex ownership structures. Many Chinese companies invested in Indonesia's smelters to retain product ownership and capture the value of processed exports.⁹ However, many established subsidiary companies or partnered with domestic companies, making it difficult to track direct ownership of a smelter. Many countries in North America and Europe have also started avoiding the use of certain minerals (such as Chinese-owned and processed) in order to secure their mineral supply chains,³⁹ leading to new partnerships between Indonesian companies and investors from Japan, South Korea, and Australia.⁴⁰ Different naming conventions, frequent usage of holding companies, and frequently changing ownership structures make it challenging to trace the owner responsible for ensuring the mitigation of environmental and social impacts of smelter operation.

3. Methodology

To develop an exhaustive database of nickel smelters in Indonesia, we started our research with a review of gray literature including lists of nickel smelters in recent years, with the oldest source dating back to 2019. We combined 6 reports with the most overlapping names of smelters, which we considered as more reliable than other reports with fewer overlapping names. We used other media articles to verify the total number of nickel smelters currently operating in Indonesia and to further confirm the reliability of the 6 selected reports. We used these 6 reports (see Appendix I) to form the base of our list; we identified additional smelters from company materials and news articles.

Using details from the reports, we populated the CGS Nickel Smelter Dataset with as much information as possible, including smelter location, owner, operator, investor, refining process and product, capacity, class of nickel produced, power source, input ore quantity, and output product capacity.

To determine the location of each smelter, we consulted company materials with spatial references, Google Maps tags, Open Street Maps, and news articles with location descriptions. We then verified and mapped coordinates using a median cloudless Sentinel-2* composite of true-color imagery from January 1 to October 1, 2025 to assess the current status of a project site. In cases where we were able to identify the exact location of a smelter project, we assessed whether the site exhibited signs of mining, but no smelter development; construction of a smelter; or a completely-built smelter. While both mining and construction display bare ground, mining typically occurs in irregular shapes with no buildings or infrastructure, whereas construction features planned land clearing in regular shapes and some built-up infrastructure. For these smelters, we assigned a status of Mine - No Smelter, Construction, and Exact. In other cases, we

were able to identify the approximate location of a smelter within an industrial park that housed several smelters, but unable to determine the name of each smelter (leading to a status of Approximate Within a Group of Smelters) or unable to confirm a smelter location (Unconfirmed). While Google Maps displays high resolution satellite imagery as a basemap, this imagery is often several years old and does not accurately display the current conditions. We relied on 2025 Sentinel 2 imagery to capture recent land clearing and construction progress.

To identify the owner or parent company that operates each smelter, we first assumed that the smelter's name corresponded to the operating company. We then used the Nexis Company Dossier database** to gather information on each company, including parent companies, subsidiaries, mergers and acquisitions, and other relevant public records. Subsequently, we cross-referenced this information with media articles and additional public sources to identify other investors in the smelter.

The operational status of each smelter was decided through the collection of news articles, company materials, and other reports. Relevant excerpts from sources are compiled in reverse chronological order in the Status 2025 Notes field to develop a timeline of development progress or setbacks. In several cases, sources provide conflicting information; we provide a summary and reasoning behind the status determination at the top of the Status 2025 Notes field.

Data on input ore quantity and output product capacity were primarily drawn from Indonesia's Ministry of Energy and Mineral Resources (ESDM) reports from 2019 and 2021, with the 2021 data prioritized in cases of discrepancy. Whenever available, we verified or replaced capacity information using sustainability and annual reports from the respective owner or operating companies. For full methodology, sources, and field definitions, see Appendix II.

* Sentinel-2 is a satellite run by the European Space Agency with a 10 meter resolution.

** Nexis Company Dossier is an online database of companies that gathers information across public sources including financial and legal company records.

4. Results

4.1. Tracking the Smelter Development Pipeline: From Announcement to Operation and Everything in Between

The CGS Nickel Smelter Dataset provides a verified snapshot of Indonesia's nickel processing sector, combining in-depth operational status research and geolocated site verification. This dataset identifies 106 smelters across the country, of which only 59 are operational as of 2025 (see Figure 3). The remainder are in the planning or construction phases, or classified as Stalled, No Longer Operational, or Unclear. Stalled smelters are described in documents and news articles as planned, but then fail to progress for at least three years. No Longer Operational smelters were once operational, and have completed facilities, but have stopped processing nickel.

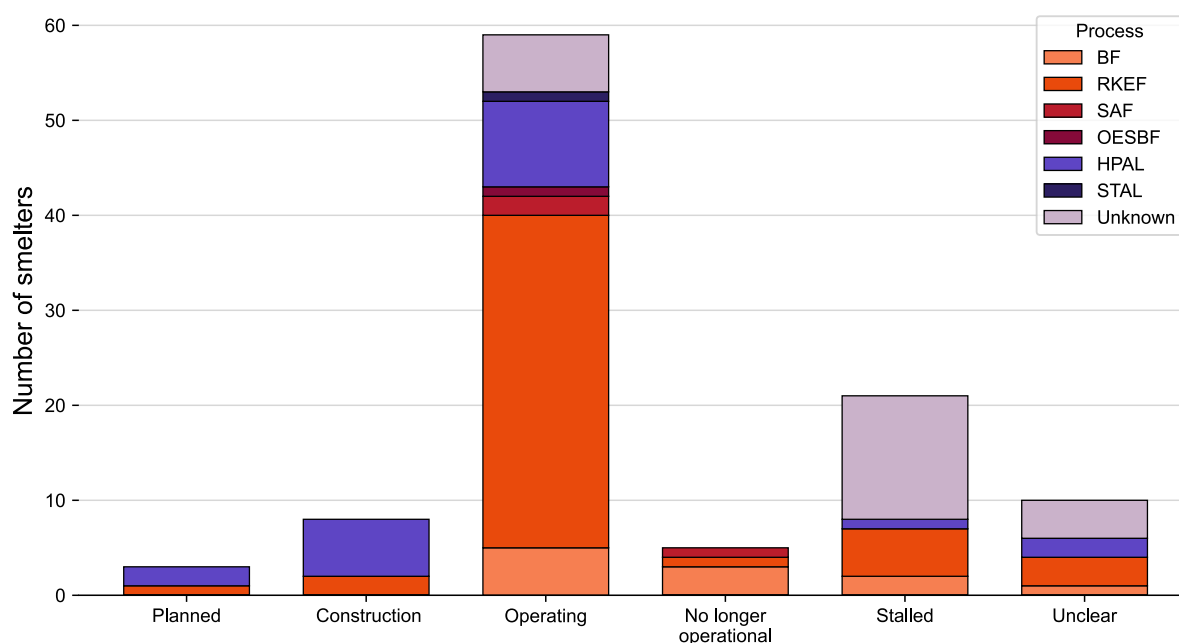


Figure 3. Number of smelters by operating status and process.

Our dataset identified 21 stalled smelter projects that never entered operations. In several cases, nickel mining companies announced plans to build smelters in the wake of the 2014 ore export ban, but never followed through. Three smelters in our dataset (Surya Saga Utama, Genba Multi Mineral, and Integra Mining Nusantara) had their export licenses revoked by the Ministry of

Energy and Mineral Resources in 2019 due to the lack of progress in developing smelters;⁴¹ and we found no evidence of smelter development at these sites as of 2025. Through our location verification process, we identified 8 smelters where we observed only mining activity at their locations, with no sign of smelter development. An additional 10 smelters are classified as having Unclear operational status due to a lack of publicly available information or several conflicting sources. Of the 5 smelters we identified as No Longer Operational, 3 are BFs, while the remaining 2 smelters are RKEF and SAF. Several sources mentioned the high price of importing coking coal and low FeNi and NPI prices as reasons behind their closure.^{42,43,44}

As we further examine the processing technologies of converting nickel ore to the final products, Figure 3 shows the 2025 status of the smelters by technology and highlights a clear shift away from BF towards HPAL smelters. We identified 59 operating nickel smelters, dominated by RKEF (35) and HPAL (9). Among smelters in the pipeline, there are 8 HPAL facilities planned or under construction, but only 3 planned RKEF smelters. Even within the pipeline, some planned facilities may switch to HPAL; for example, Central Omega Resources has indicated that its planned CORII RKEF smelter may be converted to another technology to better support the EV battery industry.⁴²

4.2 Complex Smelter Ownership Reveals Investment Trends

Nickel smelting in Indonesia is dominated by foreign-owned mining, processing, and investment companies. More than 90% of these companies are privately owned and about 30% are entirely untraceable. The companies that are traceable are of 4 main types: operating companies, owner companies, holding companies, and investment companies. Operating companies manage the day-to-day operation of nickel smelters. Owner companies are the largest shareholder in the operating company. Our analysis has shown that several companies often create a new company for the operation of a specific smelter, either as a subsidiary of its own company or along with shared investment from another company. Investing companies make significant investments in the operation and management of the smelter.

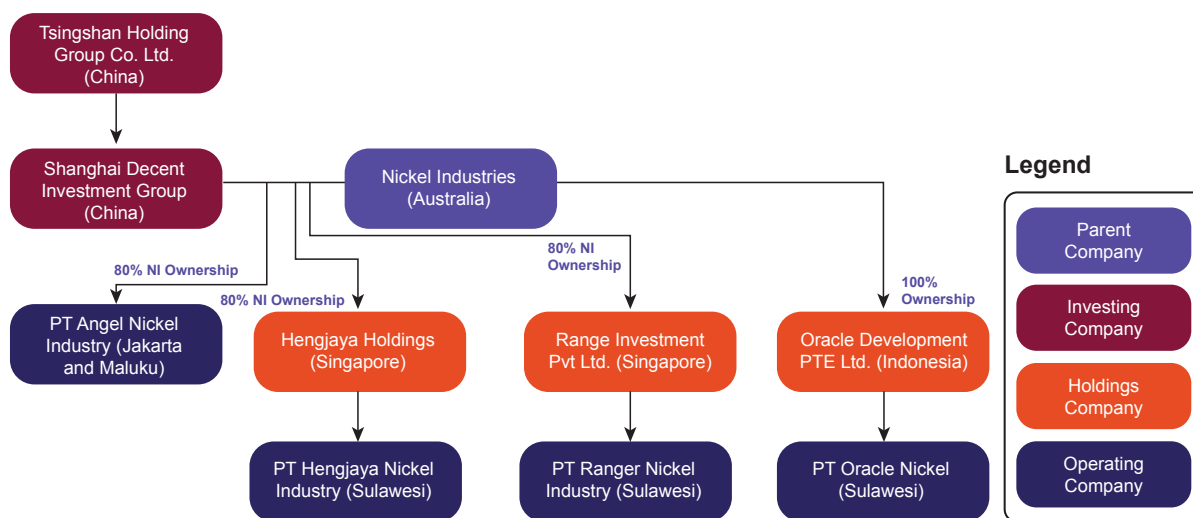


Figure 4. Ownership hierarchy of Nickel Industries and three subsidiary smelters, along with co-investing companies.

Figure 4 illustrates a case study of Nickel Industries' corporate structure in Indonesia. The company owns subsidiaries operating 4 smelters located in Jakarta, Maluku, and Sulawesi, operated by PT Angel Nickel Industry, PT Oracle Nickel, PT Hengjaya Nickel Industry, and PT Ranger Nickel Industry. While Nickel Industries is the ultimate owner of the four subsidiaries, the ownership arrangement differs across entities. Nickel Industries, previously called Nickel Mines, acquired an 80% ownership stake in PT Angel Nickel Industry, PT Hengjaya Nickel Industry, and PT Ranger Nickel Industry throughout 2021-2025 from PT Shanghai Decent Investment Group, which maintains a 20% share as an investor.⁴⁵ PT Shanghai Decent Investment Group is a subsidiary of Eternal Tsingshan Group,⁴⁶ a major China-based metallurgical enterprise. Except for PT Angel Nickel Industry, both PT Hengjaya Nickel Industry and PT Ranger Nickel Industry are registered as subsidiaries of 2 holding companies namely Hengjaya Holdings and Range Investment Pvt Ltd, respectively, according to the Nexis Company Dossier Database. The same database mentions that Nickel Industries has set up a holding company named Oracle Development PTE Ltd that owns the PT Oracle Nickel smelter in Central Sulawesi. As a conclusion, even when a single company is listed as the smelter's owning and operating company in public records, multiple layers of foreign investment can be concealed within the ownership structure, in this case, we identify three layers. Our dataset underscores the importance of a transparent and standardized dataset to trace ownership and provide the right tools to assess environment and social accountability.

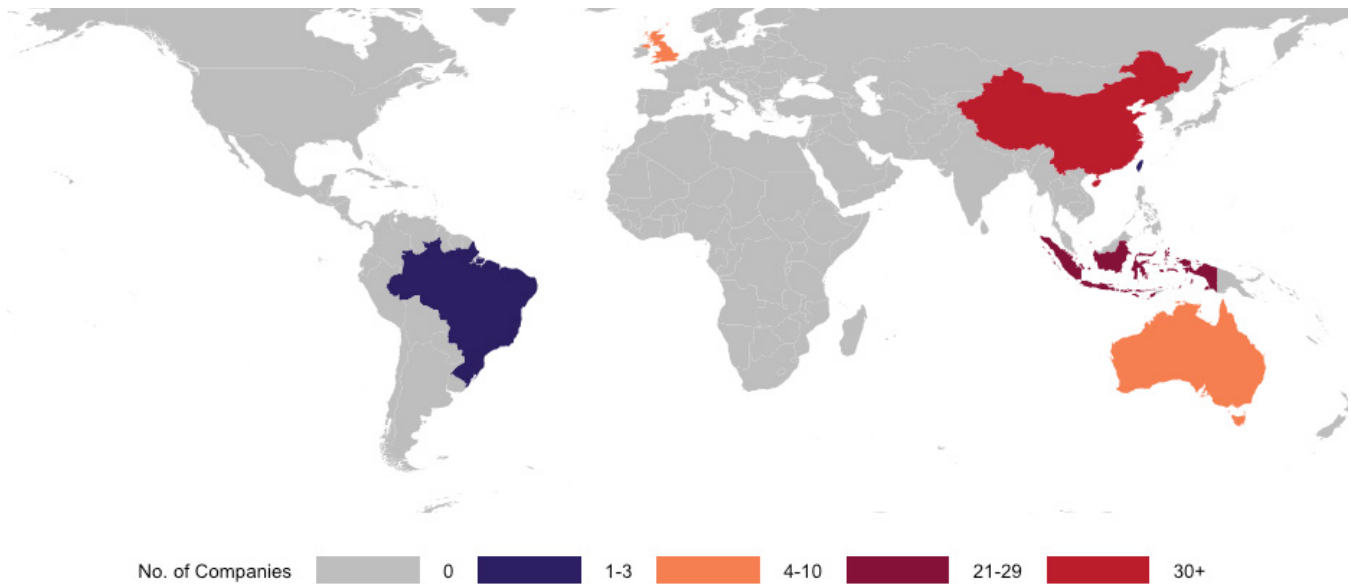


Figure 5. Map of headquarters country for investors in Indonesian nickel smelters.

Our dataset highlights these kinds of ownership discrepancies. We have traced the parent owners of 78 smelters in Indonesia and identified high-level investors for 32 of them. Several companies operate or finance multiple smelters, including Eternal Tsingshan Group, Harita Nickel, Nickel Industries, Zhejiang Huayou Cobalt, Ifishdeco, Harum Energy, CNGR, Vale Indonesia, and Silkroad Nickel. The majority of investments through company ownership come from China (30), followed by Indonesia (26), Singapore (10), UK (4), Australia (4), Brazil (3), and Taiwan (1) (shown in Figure 5).

Nearly all companies operating these smelters are privately owned, except for 3 smelters that are owned by Aneka Tambang which is a state owned enterprise and 2 smelters owned by Central Omega Resources.

4.3 Smelter Development Hotspots Are Spread Across Sulawesi and Maluku Islands

Nickel smelters are present in 8 provinces across Indonesia (Central Sulawesi, North Maluku, Southeast Sulawesi, South Sulawesi, Banten, East Java, West Java, and East Kalimantan, from most to least number of smelters present). Figure 6 exhibits clear hotspots of smelter development in Central Sulawesi, hosting 35 smelters, and North Maluku, hosting 32 smelters. Southeast Sulawesi hosts 20 smelters, but 11 of these are stalled. Seventy smelters are located within industrial parks. Indonesia Morowali Industrial Park in Central Sulawesi contains the most smelters in the dataset (22), followed by Indonesia Weda Bay Industrial Park (19) in North Maluku, Kawasan Industri Bantaeng (6) in South Sulawesi, and Obi Island Industrial Park (5) in North Maluku.

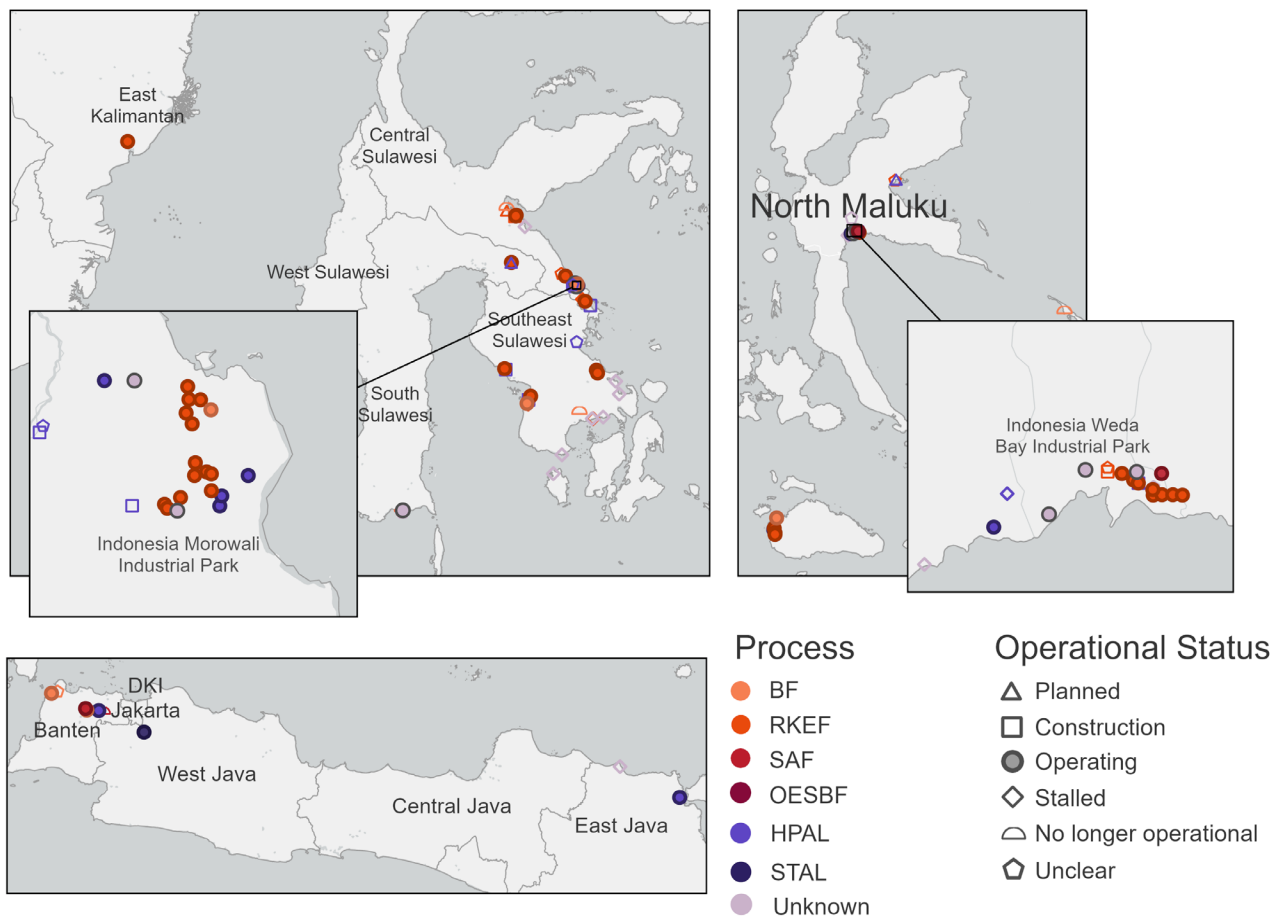


Figure 6. Map of nickel smelters, with nickel smelting process represented by color and operational status by shape. Operating smelters are filled in, while all other statuses are outlined.

4.4 Production Pathways Are Dominated by a Few Class 2 Nickel Producers

Our dataset identifies smelters producing ferroalloys such as NPI and FeNi, intermediates such as nickel matte and MHP, and high purity final products such as nickel sulfate crystals. The majority of smelters are focused on producing NPI and FeNi. Figure 7 shows the number of smelters that are operational for each kind of output product. For the smelters that are still under construction, the picture shifts to focus on the hydrometallurgical route to produce Class 1 intermediates and nickel sulfate.

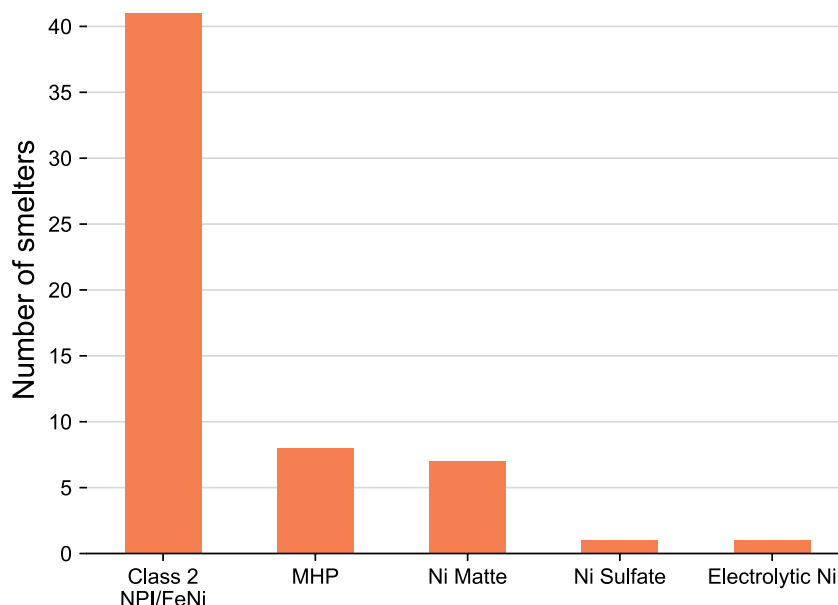


Figure 7. Number of operational smelters by output product.

Based on their number of production lines, smelters vary widely in terms of their output capacity. Currently, 45% of the total output capacity is through 5 smelters, 4 that produce NPI and 1 that produces nickel matte (shown in Figure 8). This however, does not account for the total production capacity of nickel metal equivalent owing to the differences in nickel content for nickel matte and NPI. The 5 smelters with the largest output capacity are Obsidian Stainless Steel, Gunbuster Nickel Industry, Virtue Dragon Industry, Nadesico Nickel Industry, Halmahera Jaya Ferronikel.

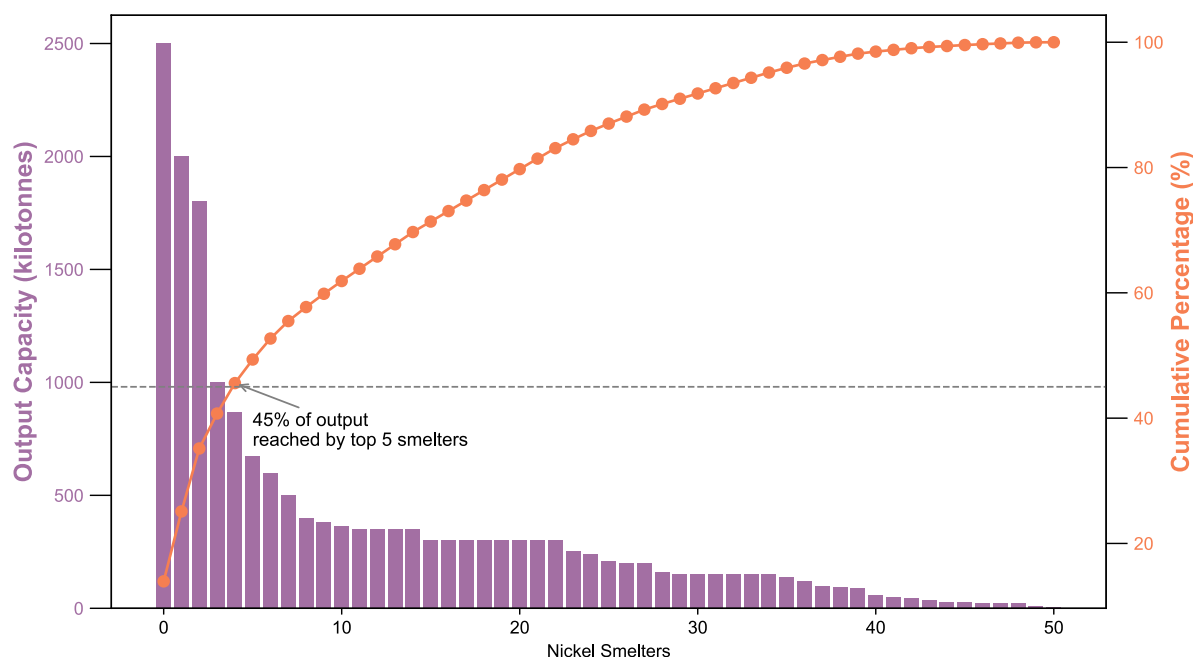


Figure 8. Pareto chart displaying the output capacity (by product)* of nickel smelters (from most to least), and the cumulative percent of smelters per total output capacity.**

4.5 Slow Shift Away From Captive Coal Power Requires Policy and Investment Push to Drive Decarbonization Initiatives

Out of the identified 106 smelters for nickel, 42 lack publicly available information about energy sources. Among the facilities with reported data, captive coal remains the dominant energy source for nickel processing (shown in Figure 9). A shift towards gas based power is visible in the smelters that are currently under construction. Only one smelter, Vale Sorowako RKEF project, uses hydropower,⁴⁷ leading to a lower GHG intensity. Currently, none of the projects have integrated solar capacity to support smelting operations. However, there are plans to install solar capacity. For instance, Nickel industries announced a 200 MW solar project integrated with battery storage to support its processing operations.⁴⁸ Considering the challenges of decarbonizing high temperature smelting operations with intermittent renewable sources such as solar, an integrated project like this could be a step towards establishing a proof of concept for decarbonizing processing.

* This is different from the quantity of nickel contained in the final product.

** This chart does not include smelters where the output capacity information was not available.

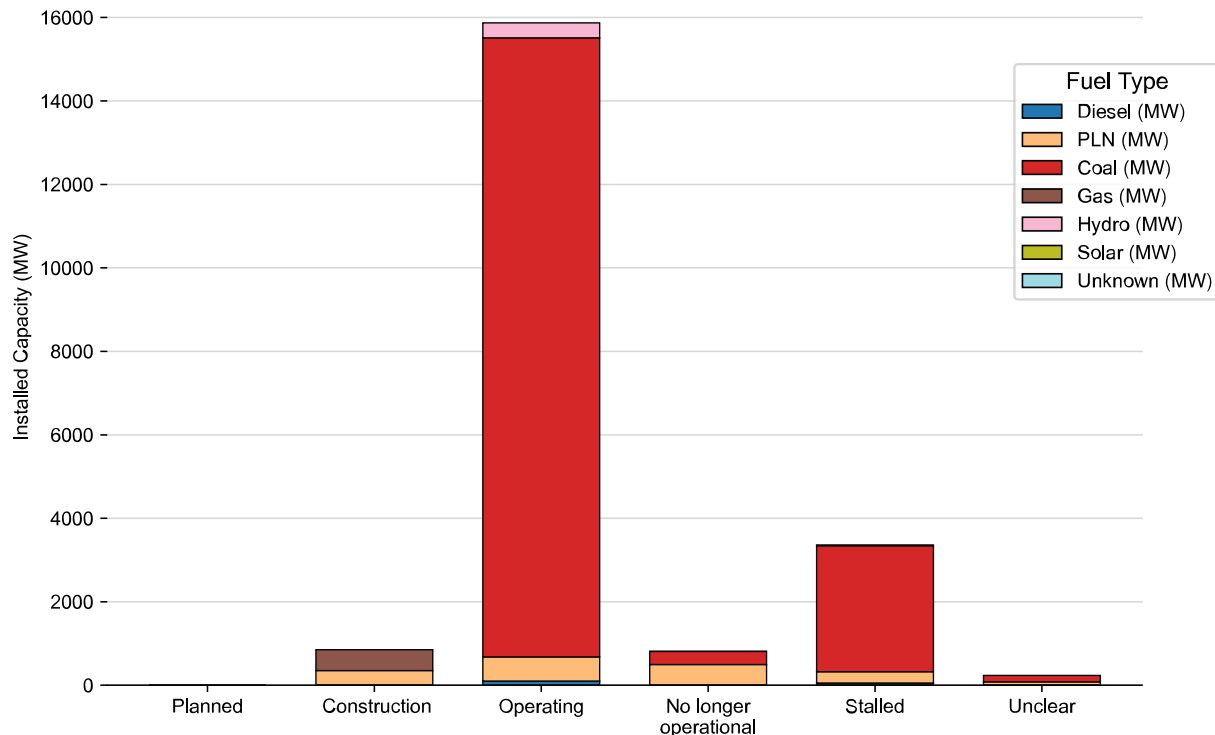


Figure 9. Installed electricity capacity by nickel smelter operational status and fuel type.

5. Conclusion

With the rise in strategic importance of nickel reserves for Indonesia as well as for the rest of the world, there is a need for a comprehensive and publicly available inventory of nickel processing operations across Indonesia. While several sources previously identified certain characteristics of smelters, our dataset captures key components of the supply chain (including location, ownership nameplate capacity, and energy source) and operational status, which were not previously available. Our documented methodology and verification process will allow scientists to assess the environmental impact of nickel smelters, adapt the dataset to their specific needs, and craft more holistic life cycle assessments of products made with Indonesian nickel. Policymakers and corporate actors can utilize the dataset to track the impact of regulation, identify patterns in domestic and foreign investment, and inform future regulations. As Indonesia moves towards a new stage of nickel downstreaming closer to domestic battery production, the CGS Nickel Smelter Dataset illuminates past successes in the build out of new supply chains, while also highlighting areas for policy makers and companies to improve inefficiencies and increase traceability to move towards higher environmental standards.

Appendix I

Table of data sources used to compile a list of smelters and several fields.

Dataset source	Year of Publication	Dataset description	Data available
Betahita Indonesia ⁴⁹	September 2022	Betahita is a news outlet in Indonesia focused on covering issues related to natural resources and the environment.	Name of the smelter, process, product, operation status 2021, capacity and location
PT Maybank Sekuritas Indonesia ⁵⁰	January 2023	An investment banking company in Indonesia.	Company name, Output product, output capacity (tons of Ni), Year of completion, location and nickel class (1 or 2)
Report of EITI Indonesia 2019-2020, Extractive Industries Transparency Initiative [Prepared by the EITI Ministry of Energy and Mineral Resources Secretariat team ⁵¹	2019-2020	EITI is a multi stakeholder initiative based in Norway and focused on transparency in the management of oil, gas, and mineral resources.	Recommendation holder name, company name, location, and commodity
“Debunking the Value Added Myth in Nickel Downstream Industry”, Center for Research on Energy and Clean Air (CREA) ⁵²	February 2024	CREA is an independent research organization registered as a non profit organization in Finland.	Company name, commodity, output product type, output capacity, year of commercial operations start, and power source (in MW)
Electricity Requirements for Refining Facilities ⁵³	December 2019	Directorate General of Minerals and Coal Ministry of Energy and Coal Resources.	PE Record holder name, company name, commodity, location, input capacity, output product capacity, power source, development progress in percent
Indonesia Minerals Yearbook (2020-2021), United States Geological Service (USGS) ⁵⁴	2025	USGS Minerals Yearbook provides updates on the mineral industries of over 180 foreign countries	Smelter name, commodity, location, and annual capacity

Appendix II

Table of data fields, description, methodology, and commonly used sources for the CGS Nickel Smelter Dataset.

Field Name	Methodology	Field Values or Units	Commonly-Used Sources
Smelter Name	Name of the smelter, as described in company materials or government reports.		
Industrial Park Name	The name of the industrial park / kawasan industri the smelter is located in.		Company materials, news articles, Google Maps, CGS Industrial Parks dataset (2024)
Nexis Dossier Keyword	The name of the smelter is used as the keyword. Owner company names mentioned in Indonesia's EITI report (2022) are also used. The Nexis Dossier database was chosen because it records both publicly available and unavailable information from sources such as - Judgments and Liens, Secretary of State filings, Uniform Commercial Code filings, U.S. and Canadian business finder directories, Dun & Bradstreet Global Market Identifiers Worldbase, Experian Business Reports, Fictitious Business Name Information (DBA or doing business as), Dun & Bradstreet Federal Employer Identification Numbers, the Franchise Index, an inactive business index, tax liens, Securities of Exchange Commission Form 4 abstracts, FAA aircraft registrations along with credit headers.	Includes the name of the company operating the smelter	Company Nexis Dossier
Public Ownership	Boolean column for if the company is privately or publicly owned. Retrieved from each company's page on the "Company Nexis Dossier" database.	0 - Private company 1 - Public company N/A - Undetermined	Company Nexis Dossier
Investor Notes	Investors are defined as those companies that own a stake in the company that operates the smelter. While these shares can be of a large percentage, the parent owner company of the smelter and the investor company are not the same. Investors in smelters were identified using global news sources, and legal asset transfer/investment records.		

Field Name	Methodology	Field Values or Units	Commonly-Used Sources
Headquarters	We used 2 methods to identify the headquarters location: a) Company Profile -> "Company Information" -> "D&B Corporate Hierarchy" and "CA Company Hierarchy". We examined the company hierarchies to identify the direct owner, sub-owner, and immediate subsidiaries. We noted the direct owner and made a note of 1 direct subsidiary-owner and the owner company, noting the headquarters location of the broad owner. b) Sustainability reports of mining/mining technology companies mention their subsidiaries. We used the sustainability reports to enlist the subsidiaries and made a note of the headquarters. c) We verified this information by referring to news articles reporting on investments and ownership, and legal archives (if available).	Includes the name of the country where the owner/largest investing company is based out of.	Company Nexis Dossier, news articles, company websites and annual reports/sustainability reports
Headquarters Notes	Any additional information about the headquarters such as combined company investments, multiple owners, contradicting information, etc, is noted in this column.		
Operating Owner	The name of the company that owns the smelter company. In some cases where the owner of the smelter is a holding company or no information is available, the name of the smelter (or closest subsidiary owner) is provided. Otherwise, methodology is the same as that for identifying the headquarters.		
Latitude Longitude	Coordinates in WGS84.		
Address Regency Province	Address provided by Google Maps (including Plus Code) for the coordinates, with additional columns for regency and province.		

Field Name	Methodology	Field Values or Units	Commonly-Used Sources
Location Status	A status value regarding our ability to a) determine the location of a smelter and b) verify the location. For smelters where we identified plausible coordinates from company materials, news articles, and Google Maps tags, we evaluated that site on Sentinel 2 imagery to assign a 'Location Status' value. Locations without coordinates have been assigned a value of 'Unconfirmed.'	Exact: the coordinates are at the exact location of the smelter, as verified by Sentinel 2 and Google satellite imagery. Approximate within a group of smelters: the location of the smelter has been confirmed to the vicinity of several smelters (typically at an industrial park), but we are unable to confirm the names and ownership of individual smelters. Mine - No Smelter: the location mentioned by news reports and company materials only displays signs of open-pit mining, with no evidence of smelter construction. Construction: Evidence of smelter construction exists at the project site determined through news articles and company materials. Unconfirmed: we were unable to determine the smelter's location, resulting in a lack of coordinates, or coordinates that do not appear to correspond to a smelter site.	Company materials, news articles, Google Maps tags, Google Maps basemap, Sentinel-2 composite (January 1 - October 1, 2025), Google Earth
Coordinate Notes	A description of the sources used to determine the coordinates and location status of the smelter. In addition to using company materials, news articles, and Google Maps tags, we consulted Google satellite imagery and a median cloudless 2025 composite of Sentinel 2 true-color imagery to evaluate site conditions. The Cloud Score Plus algorithm was used to develop a cloud-free composite with fewer cloud fragments. ⁵⁵ Google Earth was also consulted to view higher resolution imagery, however the temporal availability varies by location.		Company materials, news articles, Google Maps tags, Google Maps basemap, Sentinel-2 composite (January 1 - October 1, 2025), Google Earth

Field Name	Methodology	Field Values or Units	Commonly-Used Sources
Google Maps Tag	Links to Google Maps tags related to the smelter. As Google Maps links frequently change, in some cases the link may no longer lead to a tag, but instead the coordinates of the tag. Zooming in on the location should reveal the tag in question.		Google Maps
Metal	The metal that the smelter processes. We use two documents from the Ministry of Energy and Mineral Resources, Directorate General of Mineral and Coal: Electricity Requirements for Refining Facilities (2019) and Grand Strategy for Minerals and Coal (2021) to determine the metal type. In smelters not listed in these documents, we identify the commodity from other sources listed in the 'Status_2025_notes' and 'Links' columns.	Nickel	Electricity Requirements for Refining Facilities (2019) Grand Strategy for Minerals and Coal (2021) Company materials, news articles
Process	Process information was first taken from the Betahita Indonesia (September 2022) media source. Company materials consulted. In some cases where the specific process was not provided, pyrometallurgical smelters are assumed to be RKEF and hydrometallurgical smelters are assumed to be HPAL.	RKEF: rotary kiln electric furnace BF: blast furnace SAF: submerged arc furnace OESBF - oxygen enriched side blown furnace HPAL: high pressure acid leaching STAL: step temperature acid leaching Unknown	Betahita Indonesia (2022) Company materials, news articles
Input Capacity (Tonnes)	We primarily use two documents from the Ministry of Energy and Mineral Resources, Directorate General of Mineral and Coal: Electricity Requirements for Refining Facilities (2019) and Grand Strategy for Minerals and Coal (2021) for tonnes of nickel ore in input capacity. For smelters not listed in these documents, we identify the input capacity from other sources listed in the 'Status_2025_notes' and 'Links' columns.	Tonnes of nickel ore	Electricity Requirements for Refining Facilities (2019) Grand Strategy for Minerals and Coal (2021)
Output Product	We primarily use two documents from the Ministry of Energy and Mineral Resources, Directorate General of Mineral and Coal: Electricity Requirements for Refining Facilities (2019) and Grand Strategy for Minerals and Coal (2021) for the output product. For smelters not listed in these documents, we identify the output product from company materials listed in the 'Status_2025_notes' and 'Links' columns.	Electrolytic Ni FeNi: ferronickel MHP: mixed hydroxide precipitate MSP: mixed sulphide precipitate Ni Matte Ni Sulfate NPI: nickel pig iron	Company annual/financial reports Electricity Requirements for Refining Facilities (2019) Grand Strategy for Minerals and Coal (2021)
Output Capacity (Tonnes)	Same as output product	Tonnes of output product	

Field Name	Methodology	Field Values or Units	Commonly-Used Sources
Nickel Metal Equivalent (Tonnes)	We use company reports and media sources where it is explicitly mentioned that the unit is “contained Ni basis in product”.	Tonnes of nickel	
Power Source (MW) and Notes	For the power source, we use ESDM Electricity Requirements for Refining Facilities (2019) source. Any additional supplemental sources used are available in “Status_2025_notes” column. Power source column is bifurcated as - Diesel, PLN (grid power), Coal, Gas, Hydro, Solar, and Unknown.	Megawatts (MW)	Electricity Requirements for Refining Facilities (2019)
Links	Collection of sources used to determine the operational status of the smelter. Numbered from oldest to newest. All links have been archived with the Way-back Machine, a project of the Internet Archive. When links break, they are replaced with their archived version.		
Status 2025	Operational status of smelter, based on consensus of news articles, company materials and reports, and location status. Our determination of location status is linked to operational status. “Under Construction” smelters must have a location status of “Construction”, “Exact”, or “Approximate within a group of smelters.” Smelters with an operational status of “Operating” or “No longer operational” must have a location status of “Exact” or “Approximate within a group of smelters.”	Planned: announced within the last two years / or signs of progress within the last 2 years. Construction: facilities currently under land clearing or construction, with no facilities operational yet. Operational: facilities constructed and production lines have started operating. Stalled: lack of progress. No evidence of construction or progress within the past 3 years. No longer operational: refers to a smelter that demonstrably operated, but no longer does, often based on market conditions. Unclear: sources provide conflicting information on operational status, or unable to find sufficient information to determine operational status.	

Field Name	Methodology	Field Values or Units	Commonly-Used Sources
Status 2025 Notes	A compilation of sources used to determine the status, provided in reverse chronological order. Source numbers correspond to the source list in Links. Relevant excerpts of sources are provided, as well as a summary and explanation of how the operational status was determined.		

Appendix III

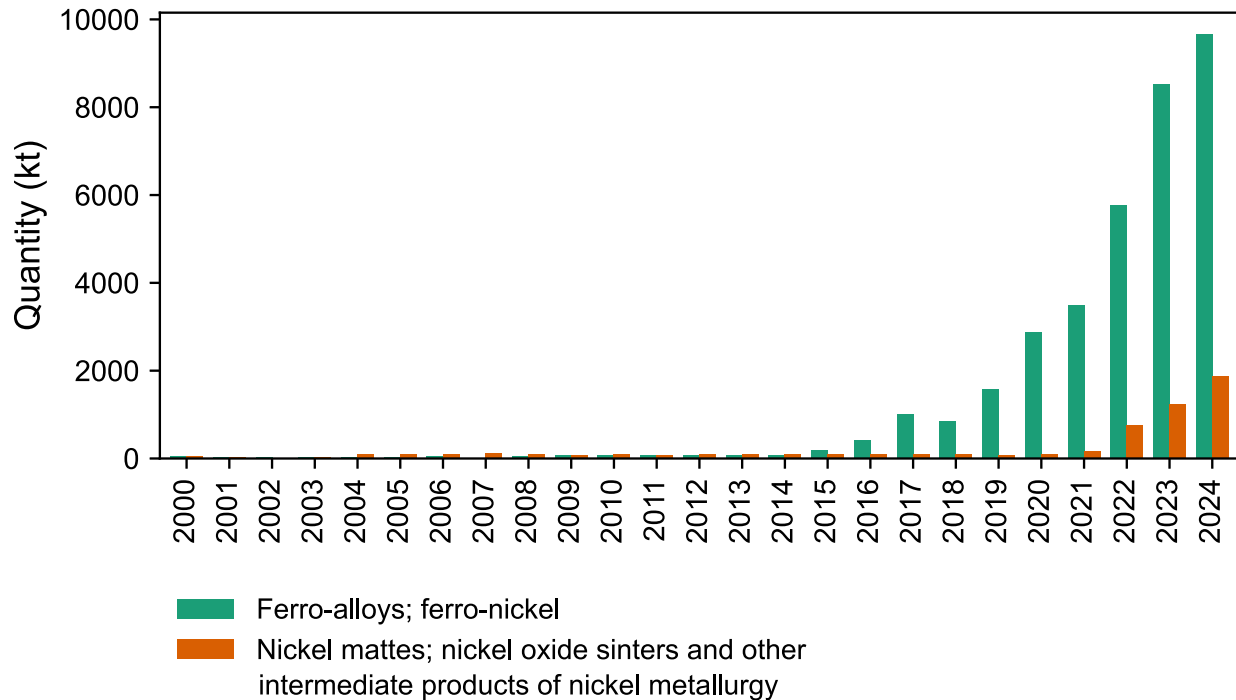


Figure 10. Quantity (kilotonnes) of exported nickel commodities from Indonesia over time (2000 - 2024), as seen in Figure 1 with nickel ore exports removed. Source: UN Comtrade

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