Expansion of Captive Coal Power and Challenges for Emission Reduction in Indonesia's Nickel Smelting Industry

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Abstract

In Indonesia, the rapid expansion of nickel smelters has been driven by increasing global demand for electric vehicle batteries and by the government's downstream industrialization policy. Many smelters are located in regions without well-developed power grids, where on-site captive power generation is permitted and those plants are predominantly coal-fired. While this arrangement supports industrial growth, it also highlights a policy gap between the promotion of resource-based industries and national decarbonization objectives. This study examines the structural and policy factors behind the expansion of captive coal power and explores potential approaches for reducing associated emissions. It finds that current regulatory frameworks, such as the National Strategic Project (PSN) scheme, have allowed exemptions for coal-based generation outside the scope of national power planning. To better align industrial policy with decarbonization goals, policy measures should facilitate grid connection—where CO_2 intensity is comparatively lower—and promote the gradual decarbonization of captive power systems through improved efficiency, fuel switching, and mandatory disclosure of emission data.

Keywords: Indonesia, Captive Coal Power, Nickel Smelting, Industrial Policy

1. Introduction

In Indonesia, the world's largest producer of nickel ore (Figure 1), has in recent years positioned the expansion of downstream smelting industries—particularly for electric vehicle (EV) battery materials—as a national strategic priority. Nickel smelting processes require large amounts of electricity and heat, and most smelters are equipped with captive coal-fired power plants that operate independently from the grid of the state-owned power utility, PLN. These developments have proceeded in parallel with Indonesia's decarbonization policies, which include a moratorium on new coal-fired power plants and targets for reducing greenhouse gas emissions, thereby highlighting the dilemma between economic development and climate change mitigation.

To date, emission reduction plans and policy efforts targeting coal-fired power generation have focused primarily on grid-connected electricity supplied by PLN and independent power producers (IPPs). In contrast, captive coal-fired power smelters have expanded markedly since the early 2020s, while remaining insufficiently reflected in official power sector planning and emission reduction schemes. As the share of captive generation in total greenhouse gas emissions continues to increase, the importance of decarbonizing these sources has grown; however, policy responses and support frameworks have not kept pace with this trend.

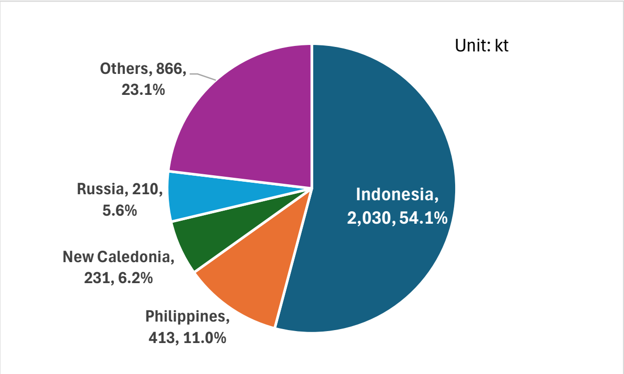

Figure 1. Nickel ore production by country (2023)

Against this background, this paper examines the expansion of captive coal-fired power generation in Indonesia and the structural factors underpinning this trend. It focuses in particular on captive power generation for nickel smelters, which has expanded in tandem with downstream industrial development, value-added policies in the mining sector, and National Strategic Projects (Proyek Strategis Nasional; PSN). The paper analyzes the challenges arising from the current institutional design, as well as the fact that such captive power systems largely fall outside the scope of international decarbonization support frameworks. Furthermore, in light of future emission reduction requirements and risks related to nickel's market access, this study discusses

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how captive coal-fired power generation can be positioned within pathways toward decarbonization.

2. Background

Indonesia is well endowed with coal resources, and coal-fired power accounted for approximately 69% of total electricity generation in 2023 (Figure 2). Electricity demand has increased rapidly in recent years and is projected to continue growing at an average annual rate of around 5%, with coal-fired power expected to still account for roughly 60% of generation in 2030[3]. Hence, coal-fired power remains the core of Indonesia's electricity supply, and achieving substantial emission reductions in the short term remains challenging despite the country's stated emission reduction targets.

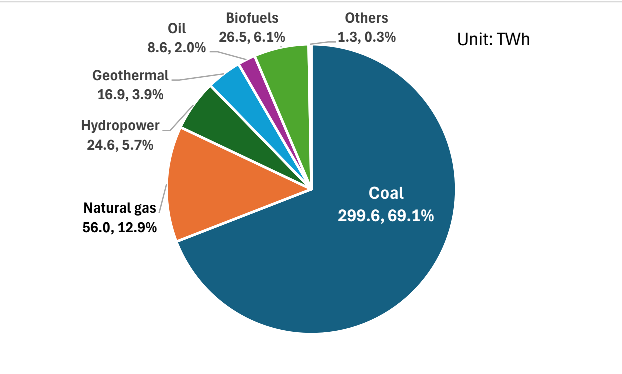

Figure 2. Electricity generation mix in Indonesia (2023)[2]

The Indonesian government has positioned the reduction of coal-fired power generation as a key policy objective. In 2021, the national power plan announced a moratorium on the development of new coal-fired power plants by the state-owned power utility, PLN, and IPPs. This was followed by Presidential Regulation No. 112 of 2022, which, in principle, prohibits new investment in coal-fired power generation[4]. In addition, the Ministry of Energy and Mineral Resources has identified 33 coal-fired power plants, with a total capacity of 16.8 GW[5], as candidates for early retirement, indicating a policy approach that takes longer-term emission reductions into consideration.

This institutional design reflects the continuity of Indonesia's core policy orientation despite changes in political leadership. Under the Joko administration (2014–2024), coal-fired power generation was maintained to a certain extent, while future restrictions were articulated, in order to balance climate objectives with industrial development. The Prabowo administration, which took office in 2024, has similarly announced commitments to decarbonization, the deployment of high-efficiency technologies, and emission reduction targets, while at the same time maintaining a permissive stance toward the domestic use of energy resources, including coal. What both administrations share is a policy structure that prioritizes industrial development while simultaneously responding to international climate-related commitments.

Table 1. Characteristics of coal-fired power plants in Indonesia by ownership category (as of July 2025)

	PLN (State-owned)	IPP	Captive
In Operation (GW)	16.2	22.1	14.2
Under Construction/ Planned (GW)	1.7	4.1	11.7
Suspended (since 2021) (GW)	7.0	12.0	4.1
Main Use	Electricity supply for the public	Power sales to PLN	Power supply for industry use (smelting, steel, etc.)
Ownership/Operators	PLN	Domestic firms and foreign investors	Local manufacturing firms and Chinese industrial majors
Policy and Regulatory Status	Subject to early retirement under JETP; and policy stance of no new construction.		New construction permitted; outside the scope of JETP.

In addition, the Indonesian government has promoted the "downstreaming" (hilirisasi) of its mining sector as a means of increasing domestic value added. Under the 2009 Mineral and Coal Mining Law (Law No. 4 2009), exports of unprocessed mineral ores such as nickel and bauxite have been prohibited since 2014, thereby requiring domestic smelting and processing[6]. As a result, the construction of nickel smelters has expanded rapidly, and many operators have introduced captive coal-fired power plants to secure a stable electricity supply. This trend has overlapped with the framework of PSN, ultimately creating a structural condition in which new coal-fired power generation continues to be developed.

The latest National Electricity Supply Plan (RUPTL)[7], published in 2025, indicates a more flexible stance toward new coal-fired power development compared with previous plans, alongside accelerated deployment of renewable energy and expansion of transmission infrastructure. This shift suggests that new grid-connected coal-fired power investments may once again be incorporated into Indonesia's power development trajectory, which had previously been viewed as centered on the expansion of captive generation. As a result, there is an increasing need to assess the role of captive power generation in relation to other power supply actors within the broader electricity system.

Table 2. Key developments in Indonesia's mining value-addition policy

Year	Law/Regulation	Provisions
2009	Amendment to the Mining Law	Mandated domestic smelting and processing of mineral ores within 5 years.
2014	Ban on exports of unprocessed	Prohibited the export of unprocessed mineral ore, including nickel and bauxite[8].
2016	Introduction of PSN	Designated projects critical to national development, including nickel smelting (as PSN[9]).
2017	Partial relaxation of export ban measures	Allowed limited exports of certain mineral ores for a five-year period, conditional on the construction of smelters[10].
2020	Nickel export ban brought forward	Implemented the ban earlier than originally scheduled, which had been planned for 2022[11].
2023	Ban on bauxite ore exports	Came into effect in June 2023[12].

3. Expansion of Captive Coal Power

According to the Global Coal Plant Tracker (as of July 2025)[13], a total of 72 captive coal-fired power plants, with an aggregate capacity of approximately 14 GW, have been newly constructed since 2015. These plants are concentrated in regional industrial estates, including Morowali in Sulawesi and Weda Bay in Maluku, and many operate off-grid, remaining disconnected from the PLN grid. For example, in the Morowali Industrial Park, multiple power plants built by Chinese companies have a combined capacity around of 2 GW, equivalent to roughly half of the total capacity connected to the grid on Sulawesi Island.

Most newly constructed captive coal-fired power plants are owned and operated by Chinese companies. Chinese capital, led by firms such as Tsingshan Group and Jinchuan Group, has expanded into Indonesian industrial parks as part of the One Belt One Road Initiative, developing smelters and power generation facilities in an integrated manner. Although the Chinese government announced in 2021 that it would cease support for new overseas coal-fired power projects[14], captive power plants within industrial parks and capacity expansions of existing facilities have been treated as exceptions. As a result, coal-fired power exports have effectively continued, and the Indonesian smelting industry has become increasingly reliant on Chinese companies for financing, technology, and equipment supply.

Figure 3. Distribution of captive coal-fired power plants for nickel smelters (as of January 2025)
(Red: in operation; Blue: planned / under construction)

Most captive coal-fired power plants are not connected to the PLN transmission network and operate as independent systems. This is due not only to physical constraints such as geographic conditions and underdeveloped infrastructure, but also to the lack of economic incentives for selling surplus electricity to PLN. While the government and PLN have encouraged captive power operators to connect to the grid and sell excess power, actual grid integration has made little progress. In many regional areas, physical connection is difficult due to insufficient transmission infrastructure, and institutional purchase price caps—set at 90% of the regional Biaya Pokok Pembangkitan (BPP), or benchmark generation cost—remain too low to provide meaningful incentives for captive operators. As a result, although policy frameworks formally prioritize grid connection and treat captive generation as an exception, in practice, these regions continue to rely predominantly on captive power generation.

In summary, captive coal-fired power generation in Indonesia is characterized by the following features: (1) rapid expansion as an industrial power source, particularly for nickel smelting; (2) geographic concentration in regions with underdeveloped grids, such as Sulawesi and Kalimantan; (3) development led by

Chinese companies in an integrated manner alongside smelting facilities; and (4) the predominance of independent, off-grid operation due to limited incentives for connection to the PLN grid. Together, these factors make captive coal-fired power generation difficult to incorporate into existing decarbonization frameworks and international decarbonization support schemes.

4. Institutional and Policy Challenges

Since 2021, the Indonesian government has adopted a policy to halt the development of new coal-fired power plants by PLN and IPPs; however, industrial captive power generation has remained outside the scope of this policy. As a result of this institutional treatment, a large share of captive power plants—particularly those associated with smelting operations—continues to fall outside both domestic emission reduction policies and international support frameworks (Table 3).

Table 3. Policy framework for coal-fired power plants

Policy Framework	PLN/IPP	Captive
Reflected in the RUPTL	Yes	No
Designated as PSN	Yes	Yes (indirectly)
Application of emissions reduction policies	Yes	Limited

The government and PLN have stated a policy intention to utilize surplus electricity from captive power plants through grid connection. In practice, however, actual grid integration has made little progress due to a combination of factors: (1) physical constraints in remote and island regions; (2) weak economic incentives arising from low purchase price caps and limited profitability from electricity sales; and (3) operational constraints, as smelters typically utilize electricity and heat in an integrated manner with on-site power generation, making grid connection and surplus power sales difficult to implement.

In Indonesia, several international transition support schemes have been introduced, including the Just Energy Transition Partnership (JETP), the Asia Zero Emissions Community (AZEC), and the Energy Transition Mechanism (ETM). However, these initiatives primarily target grid-connected thermal power plants owned by PLN or IPPs and do not explicitly cover captive coal-fired power generation.

The international policy environment surrounding decarbonization has also become increasingly uncertain. The U.S. administration, inaugurated in 2025 adopted a more skeptical stance toward the Paris Agreement and the JETP, and formally withdrew from JETP in March of the same year. Although the Indonesian government stated that the impact would be limited due to the modest scale of expected funding, concerns have emerged regarding the sustainability of international support. At the same time, the European Union’s Carbon Border Adjustment Mechanism (CBAM) has heightened risks to the export competitiveness of nickel and aluminum products with high dependence on coal-fired power. In particular, smelting based on the Rotary Kiln–Electric Furnace (RKEF) process, which is associated with relatively high emission intensities, has been identified as potentially facing a pronounced loss of competitiveness in European markets.

In sum, captive coal-fired power generation in Indonesia has not been sufficiently integrated into either domestic institutional frameworks or international support schemes, resulting in a structural condition in which effective emission reductions are difficult to achieve. While government policy formally emphasizes the reduction of coal-fired power, captive generation continues to be permitted through mechanisms such as PSN and policies promoting smelting industries, while simultaneously remaining outside the scope of international transition frameworks. This coexistence of policy objectives and exemptions constitutes a key structural challenge for Indonesia’s decarbonization efforts.

5. Technical Options for Low-Carbonization

In Indonesia, advanced technologies such as ultra-supercritical (USC) boilers and carbon capture, utilization, and storage (CCUS) have been discussed as options for the low-carbonization of coal-fired power generation. However, these technologies are generally designed for large-scale, grid-connected power plants and are difficult to apply to captive power facilities, which are smaller in scale and typically designed for combined electricity and heat supply. CCUS, in particular, faces significant challenges due to its high implementation costs and substantial infrastructure requirements, making near-term deployment unlikely.

For captive power facilities, fuel-switching options such as conversion to liquefied natural gas (LNG) and the co-firing of ammonia or biomass in coal-fired power plants have also been explored. However, actual deployment remains very limited. This reflects several constraints, including (1) the high costs associated with equipment modification; (2) insufficient fuel supply infrastructure; and (3) a lack of incentives for operators to adopt new technologies. In addition, because smelters typically utilize electricity and heat in an integrated manner with on-site power generation, fuel switching entails risks to the stable supply of electricity and heat as well as to the quality and continuity of smelting operations. In particular, co-firing with ammonia or biomass presents technical challenges related to combustion characteristics, making it difficult to control furnace temperatures and output. As a result, facilities that require continuous operation—such as smelting processes—have tended to adopt these options only with caution. Consequently, while pilot or experimental applications have been observed in limited cases, such measures remain exceptional rather than widespread.

As short-term and relatively feasible options for low-carbonization, incremental measures such as efficiency improvements to existing equipment and operational optimization can be considered. Examples include improving boiler combustion efficiency and optimizing operating schedules, which, while modest in scale, can deliver emission reductions in a relatively short time frame. These measures are generally applicable even at the scale of captive power facilities, and when combined with appropriate institutional incentives, they can be expected to achieve measurable emission reduction effects.

Rather than imposing a blanket prohibition on captive coal power generation, an alternative and potentially effective approach is to promote grid connection for projects that meet specific institutional and physical conditions. Revising the terms of power purchase agreements (PPAs) with PLN—such as contract duration and pricing—could encourage grid integration, enabling greater utilization of more efficient generation sources and facilitating integration with renewable energy, thereby contributing indirectly to emission reductions. However, in remote and island regions, significant physical constraints remain, including the high costs of transmission line construction, the need for voltage stabilization equipment, and challenges related to load variability. As such, a region-specific prioritization of grid connection efforts is required.

Japan has been involved in supporting high-efficiency technologies, co-firing technologies, and transmission network development through existing international support schemes; however, these efforts have primarily focused on grid-connected power generation owned by PLN and IPPs, making direct support for captive power generation difficult. Nevertheless, there remains scope to explore support for captive power systems by targeting realistic options such as efficiency improvements and fuel switching, in combination with the design of appropriate institutional incentives. Looking ahead, attention will be required not only for the nickel-dependent structure of captive power generation but also for the emergence of new industrial power sources, including aluminum smelting. As emission sources continue to diversify, institutional frameworks and support schemes are expected to become increasingly complex.

6. Issues and Implications of Captive Coal-Fired Power

Nickel smelting, which has expanded rapidly in response to growing demand for EV batteries, is internationally viewed as a key industry supporting the transition toward a low-carbon society. However, the reliance on captive coal-fired power as the primary electricity source for the smelting process creates a degree of divergence from the clean image associated with the EV industry. As assessments of carbon footprints across entire supply chains become more stringent, this gap may pose a potential risk to the market competitiveness of Indonesian nickel.

With regard to emissions from captive coal-fired power generation, detailed data disclosure by government statistics and plant operators remains insufficient, making it difficult to fully grasp the actual scale and characteristics of emissions. The lack of a well-established system for monitoring and disclosing emission data may become a vulnerability in the context of emerging international carbon regulations. Under the European Union's CBAM and the EU Battery Regulation enacted in 2023, disclosure requirements related to the carbon footprints of batteries and metal products are being introduced in a phased manner. Although direct exports of nickel from Indonesia to the EU remain limited, concerns arise that the high emission intensity associated with Indonesian production could undermine competitiveness when Indonesian nickel is used as an input for batteries or stainless-steel products supplied to European markets. In other words, the market access risks that Indonesian nickel industry faces are characterized less by export volumes themselves than by the application of carbon-related regulations across entire supply chains.

JETP and AZEC are intended to support Indonesia's decarbonization efforts; however, they have not sufficiently covered areas that fall outside existing institutional frameworks, such as captive power generation. In particular, the scaling back of U.S. engagement and the withdrawal from JETP under the Trump administration have introduced additional uncertainty regarding the financial sustainability of such support. As a result, there is a growing need to reconsider the definition of eligible support targets to include captive power generation, as well as to adopt more flexible designs with respect to both the scope and the modalities of international assistance.

As discussed above, Japan has played a role in supporting coal-fired power through measures such as efficiency improvements, co-firing technologies, and transmission network development;

however, most of these efforts have been directed toward coal-fired power plants owned by PLN and IPPs. With respect to captive power generation, there remains scope to explore forms of support that take into account country-specific conditions, focusing on short- to medium-term options such as emission data disclosure and efficiency improvements. How the international community can engage with Indonesia in addressing the dilemma between industrial development and emission reduction represents an important issue for future consideration.

7. Conclusion

In Indonesia, captive coal-fired power generation has expanded rapidly since the early 2020s, driven by policies aimed at increasing value added in the mining sector and by the designation of PSN. Many of these facilities operate independently without connection to the PLN grid, resulting in a structural condition in which they are prone to falling outside formal institutional oversight.

Although the government has articulated policies to halt new coal-fired power development and to reduce existing capacity, industrial captive power generation has continued to be permitted. As a result, challenges have become increasingly apparent in aligning captive coal-fired power with decarbonization policy objectives, and these systems have remained difficult to incorporate into international decarbonization support frameworks.

From a technical perspective, options such as conversion to LNG, co-firing with ammonia and biomass, and efficiency improvements have been examined; however, their deployment remains limited due to cost constraints and insufficient incentives. In the short term, efficiency improvements and expanded grid connections represent more practical responses, while over the longer term, fuel switching and integration with renewable energy sources emerge as key challenges.

In light of these findings, a key issue is how captive coal-fired power generation should be positioned within broader low-carbon strategies, and how emission data disclosure and institutional oversight can be strengthened. At the same time, international support frameworks will need to adopt more flexible designs that explicitly include captive power generation, and there remains scope for the international community—including Japan—to engage through support for efficiency improvements and assistance in institutional design.

Looking ahead, it will be increasingly important to strengthen data availability on emissions from captive power generation, to reconsider existing institutional arrangements, and to respond to carbon footprint assessment requirements in international markets. Building effective transition strategies that reconcile economic growth with decarbonization will be essential going forward.

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