Mapping the invisible: A satellite reveal of Indonesia's NO_x hotspots

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CREA
Centre for Research on Energy and Clean Air

CREA is an independent research organisation focused on revealing the trends, causes, and health impacts, as well as the solutions to air pollution.

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About CREA

The Centre for Research on Energy and Clean Air (CREA) is an independent research organisation focused on revealing the trends, causes, and health impacts, as well as the solutions to air pollution. CREA uses scientific data, research, and evidence to support the efforts of governments, companies, and campaigning organisations worldwide in their efforts to move towards clean energy and clean air, believing that effective research and communication are the keys to successful policies, investment decisions, and advocacy efforts. CREA was founded in Helsinki and has staff in several Asian and European countries.

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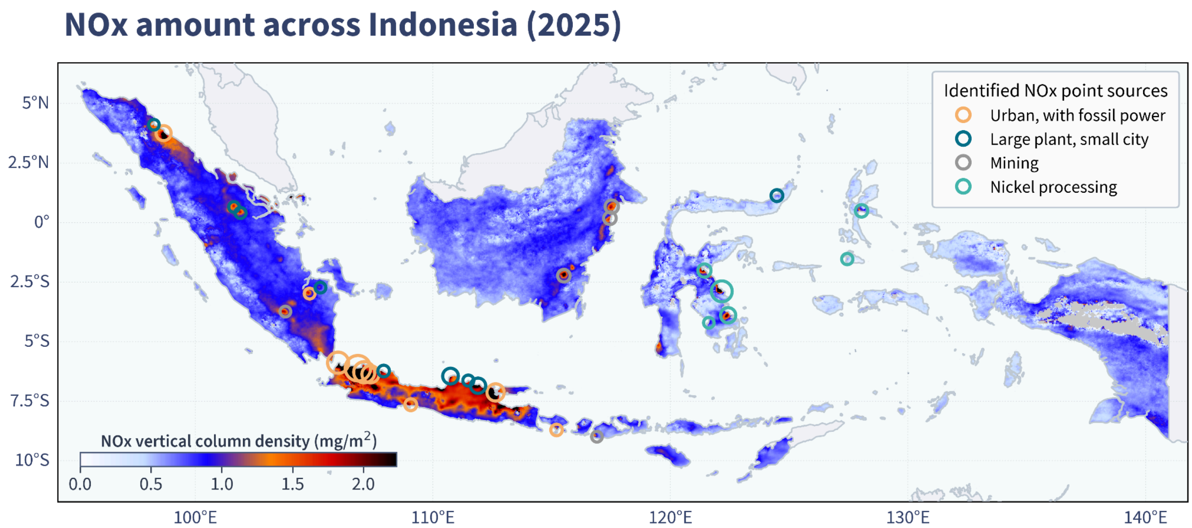
Mapping the invisible: A satellite reveal of Indonesia's NO_x hotspots

Key findings

- Driven by a failure to decouple transport, power, and industrial growth from fossil fuels, Indonesia's national NO_x (nitrous oxides) emissions have surged by more than 50% between 2010 and 2022. Yet, the country's relevant national annual air quality standard remains five times more lenient than World Health Organization guidelines.
- This study quantified 29 major NOx point sources across Indonesia, identifying the largest single emitters in the country — tripling the previous global catalogue.
    - **Nine of these hotspots sit in Indonesia's most densely populated cities** such as Jabodetabek, Surabaya, and Medan, stemming not only from local emissions, but also transboundary transport and heavily compounded by neighboring fossil power complexes and industrial boilers.
    - **Another nine sit in remote regions**: NO_x emissions from Java's coal power complexes and cement kilns alongside Sumatra's mega kraft pulp and paper mills is shifting the national air pollution burden onto local communities.
    - **Six hotspots are driven by Indonesia's aggressive nickel downstreaming**, whose booming captive coal power capacity—which has grown by over six-fold—is creating NO_x emissions in Sulawesi and North Maluku that eclipse those of the entire Greater Jakarta Metropolitan Area.
    - **The remaining five hotspots, mainly concentrated across the open-pit coal mining of Kalimantan**, are driven by massive diesel machinery fleets, haulage transport, and decentralized mine-mouth power grids. These operate under broad environmental management frameworks rather than standardised, enforceable point-source stack emission caps.
- To foster economic growth while safeguarding clean air, the government must transition from passive, non-transparent compliance tracking to assertive intervention by requiring comprehensive monitoring and public reporting for large single emitters.

- As the government implements its recently enforced emissions inventory and early warning system, policymakers must turn this data into active enforcement tools rather than mere advisories. Lasting air quality gains depend on prioritising strict standards over short-term fixes, mandating pollution control technologies, and maintaining rigorous compliance across all sectors.

Figure KF1 provides a visualisation of atmospheric NOx levels measured from the satellite, with the identified NO_x hotspots clearly standing out.



Source: NO2 TVCD from Sentinel-5P/TROPOMI, converted to NOx TVCD using ozone data from CAMS reanalysis.

Figure KF1 — Indonesia’s average Tropospheric NO_x Column Density in 2025

Contents

What are NO_x, and why are they relevant?

More than a regulatory parameter, NO_x are the fingerprints of fossil fuel combustion and a vital air quality indicator

Nitrogen Oxides (NO_x) is a collective term used to represent various highly reactive gases composed of nitrogen and oxygen molecules. The most environmentally significant and toxicologically relevant are Nitric Oxide (NO) and Nitrogen Dioxide (NO_2).

NO_2 — a pungent gas, brown in color — is of particularly high relevance due to its contribution to the creation of smog layers, and growing evidence of adverse health impacts from exposure (Yang et al., 2025). Studies link NO_2 exposure to heart and lung diseases, reduced lung development in children, breathing issues, increased emergency asthma visits, heightened allergic reactions, and premature deaths.

Besides its direct health impacts, NO_x converts into $PM_{2.5}$ particles in the atmosphere, significantly contributing to Indonesia's $PM_{2.5}$ pollution levels. Daylight photo-oxidation converts NO_2 via hydroxyl radicals (•OH) into gaseous nitric acid (HNO_3), which neutralizes ambient ammonia (NH_3) to form ammonium nitrate (NH_4NO_3) aerosols. This gas-to-particle condensation process forms secondary $PM_{2.5}$, and the reaction is governed by atmospheric conditions such as temperature, relative humidity, and solar intensity, as well as precursor gas availability (Zhang et al., 2015). It also causes ground-level ozone formation, coastal nutrient pollution and acid rain (De Vries, 2021).

The World Health Organisation (WHO) has provided guidelines for safe levels of NO_2 exposure and recommends that ambient NO_2 concentration levels not exceed 25 µg/m^3 in a 24-hour period and 10 µg/m^3 in the annual mean in the 2021 Air Quality Guideline (AQG) (WHO, 2021a). To note, there was a large reduction in the threshold set in the 2021 AQG compared to the previous 2005 AQG, in which an annual threshold of 40 µg/m^3 was set (WHO, 2021b). **This direction reflects the growing urgency to push for concerted global efforts in air pollution reduction, given the growing evidence for harmful effects on public health.**

The Indonesian government has also adopted national ambient air quality standards in 2021, specifying ambient NO_2 concentration, along with other major air pollutants, at 200 µg/m^3 in a 1-hour measurement, 65 µg/m^3 over a 24-hour period, and 50 µg/m^3 in the annual average (JDIH BPK, 2021).

These values are unfortunately much less stringent than the lowest Interim Targets set by WHO as guidelines for governments, at 120 µg/m^3 in a 24-hour period and 40 µg/m^3 in the annual mean. **In other words, Indonesia's current national standards are 5x more lenient than global health-based guidelines, leaving a significant portion of the population exposed to levels the WHO deems unsafe.**

Top three NO_x emitters — transport, power, industry

NO_x is mainly generated through **fossil-based high-temperature combustion processes in various anthropogenic activities** such as transportation, electricity generation, and industrial operations, with lesser contributions from natural sources, including lightning and microbial activity in soils. Globally, electricity and heat production, as well as industrial processes (stationary sources), are the largest contributors, on par with the transportation sector (mobile sources), which includes road transport, shipping, and aviation.

Combustion of fossil fuels such as coal, oil, and gas — required to supply high amounts of energy for electricity production or industrial processes —- generates substantial quantities of NO_x as a byproduct of the high-temperature process. Emissions can be categorised as thermal NO_x — formed from nitrogen and oxygen in the air at high temperatures, and fuel NO_x — from nitrogen found in the fuel itself. Coal is particularly notorious for its high nitrogen content, which contributes significantly to fuel NO_x.

Being short-lived gases, NO_x undergoes chemical reaction transformations in the presence of sunlight within two to eight hours. For this reason, NO_x concentration decreases as the distance from its source becomes greater, making it vital to implement mitigation measures at that source. Because toxic pollutants are co-emitted alongside NO_x during fossil fuel combustion, estimating NO_x emissions serves as a reliable proxy for detecting these associated pollutants.

A city's population size can be a strong indicator of its NO_x emissions. The higher the concentration of people in a given area, the greater the demand for energy, transportation, and industrial goods — all being primary sources of NO_x. This relationship is generally revealed in satellite imagery, where the major NO_x hotspots would align almost perfectly with the most populous cities and urban regions. Historical trends available from temporal analysis of satellite images can indicate the rise in emissions, as well as the extent of strict air quality mitigation measures implemented to counter such trends.

Satellite data can pinpoint specific sources of NO_x, which often appear as distinct plumes or localised hotspots, and there are three key sectors that can be identified as major contributors. The most widespread is **road transportation**, with satellite maps showing elevated NO_x concentrations along major highways and in congested downtown areas.

Secondly, **power plants and industrial complexes** are significant pollution sources, with satellite data showing distinct, high-intensity hotspots. Emissions often appear as intense, localised spots of elevated levels that stand out from the broader, more diffuse urban pollution. Finally, **major transportation hubs** such as ports and airports also contribute substantially to urban air pollution, with satellite data showing elevated NO_x levels over these facilities and along major shipping routes.

According to the most recent data from both the Emissions Database for Global Atmospheric Research (EDGAR) for 2022 and the Community Emissions Data System (CEDS) for 2023, **transport and energy production have been identified as the consistent drivers of Indonesia's NO_x emissions**, though the two inventories diverge on specific sectoral weights (EU JRC, n.d.; PNNL, n.d.).

Both datasets agree that **transportation** is the primary culprit. EDGAR attributes the plurality of emissions to transport at nearly 30% (942 kt), whereas CEDS places it at a much higher share, representing nearly half of the nation's total (1,888 kt). For **power generation**, CEDS indicates a substantial 40% share (1,519 kt), while EDGAR estimates it slightly lower at 27% (855 kt). The most notable divergence is shown for **the industrial sector**, which EDGAR identifies as the single largest source of NO_x emissions at about one-third of the national total (1,037 kt), while CEDS evaluates industry as a minor contributor at just 5% (196 kt). Together, agriculture, buildings, waste, and other residual categories account for a minor fraction across both inventories for NO_x.

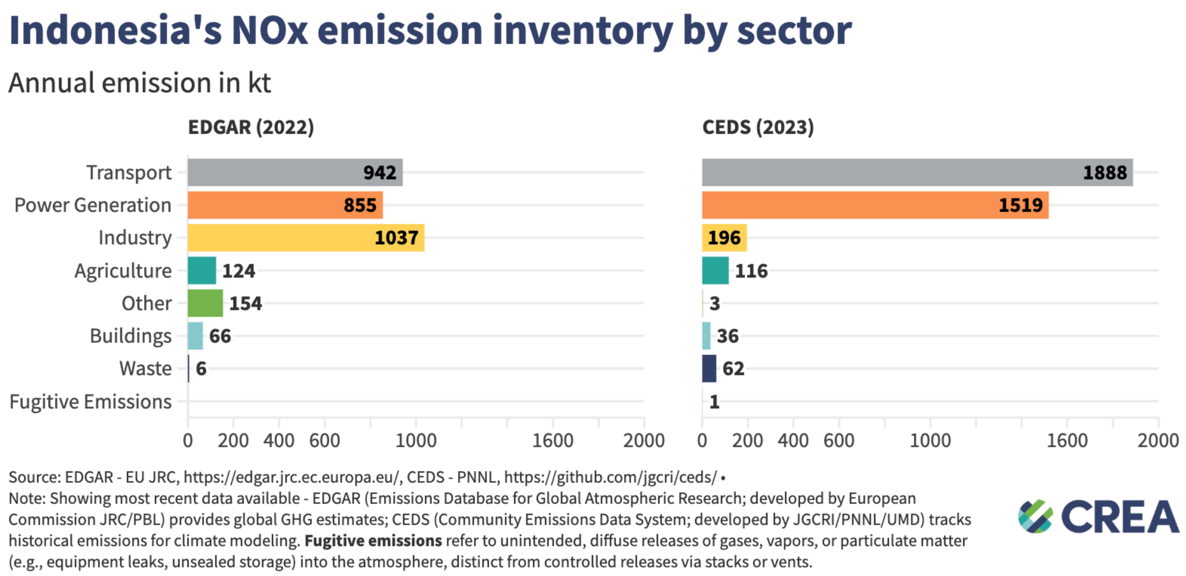


Figure 1 — Indonesia's breakdown of NO_x emissions by sector in most recent data from global emission inventories, EDGAR and CEDS

Over the past 13 years, Indonesia's national emissions of NO_x have seen a steady increase of 46% according to EDGAR (2010–2022) and 59% according to CEDS (2010–2023). This steady climb illustrates a broadening air quality crisis as the country's population and economy grow without sufficient decoupling from fossil fuel dependence or adequate air quality mitigation measures. As visualised in Figure 2, both datasets map a clear upward trend over the last decade, though they differ in overall scale and sectoral breakdown.

CEDS data shows total annual emissions climbing from approximately 2,400 kt in 2010 to nearly 3,800 kt by 2023. This trajectory is predominantly driven by sharp expansions in transport and power generation, accelerating after 2017. EDGAR tracks a lower overall volume, rising from just over 2,000 kt in 2010 to roughly 3,100 kt by 2022. While EDGAR also captures growth in transport and power, it attributes a much larger, continuous share of the trajectory to the industrial sector throughout the entire timeline.

Despite these structural differences, both inventories align on temporary plateaus around 2015 and noticeable dips during the 2020–2021 pandemic-related economic slowdowns, followed by sharp, immediate rebounds. The significant divergences in sectoral baselines between EDGAR and CEDS highlight the urgent need for efforts to improve and align emission data inventorying.

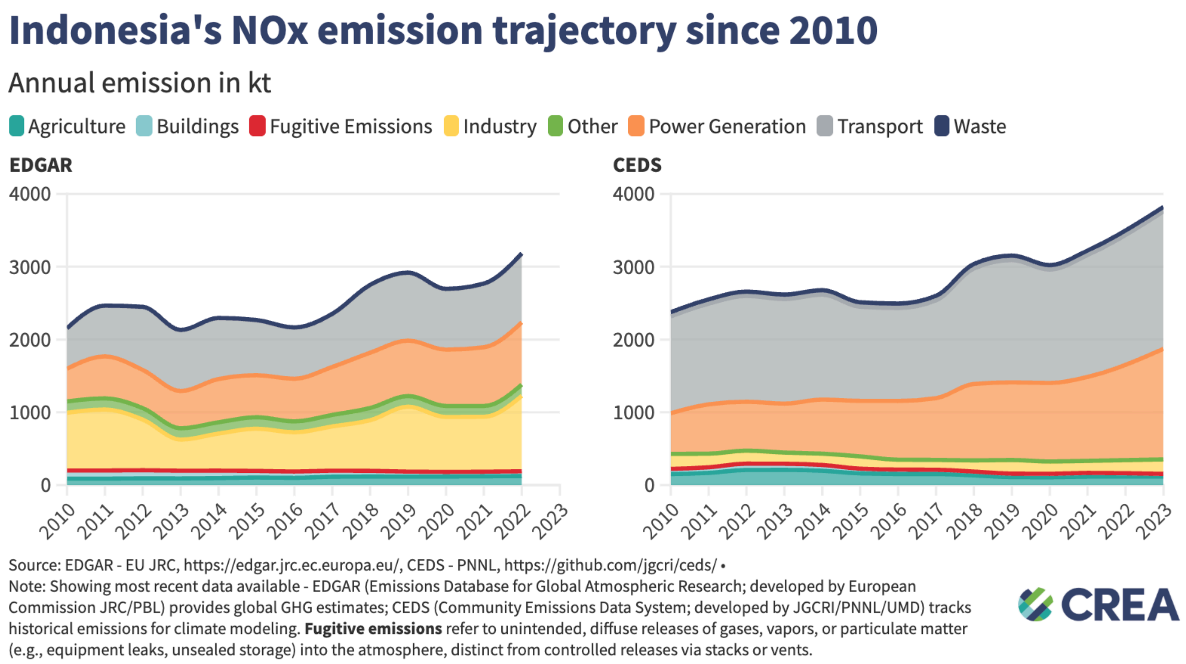


Figure 2 — Indonesia’s NO_x emissions historical trajectory by sector obtained from global emission inventories, EDGAR, and CEDS

Using satellite data to make Indonesia’s NO_x hotspots visible

In this study, CREA aims to utilise satellite-based remote sensing to bridge gaps in emissions inventory data and clearly map the real-world boundaries of the country's accelerating air quality crisis. While advanced satellite imagery serves merely as an initial signal to validate conflicting inventory trends and pinpoint NO_x hotspots across the country’s growing urban areas and industrial zones, targeted clean-air interventions must ultimately depend on reliable ground truth built upon the granularity and transparency of Indonesia’s national emissions reporting.

Methodology

Satellite-based methods for estimating NO_x emissions from large industrial sources have evolved significantly since the early 2000s. Thanks to advancements in satellite technology and ongoing methodological improvements, these techniques are now well-established and capable of estimating NO_x emissions with good accuracy (uncertainty of within 50% on average). CREA’s work in this analysis extends the Beirle et al. (2023) global NO_x point source catalogue, adding some recent developments for enhancing the NO_x emission detection and providing updated emission and new source estimates through 2025 (Beirle et al., 2023).

The top-down point source detection implemented in this study has revealed 29 point sources in Indonesia. The original catalogue by Beirle et al. contains nine point sources. The resulting emission estimates remain highly comparable to those derived by Beirle et al (*see the methodology report for further detail*).

The distribution of the 29 NO_x point sources identified in this study—alongside the nine sources previously covered by Beirle et al., is illustrated in Figure 3.

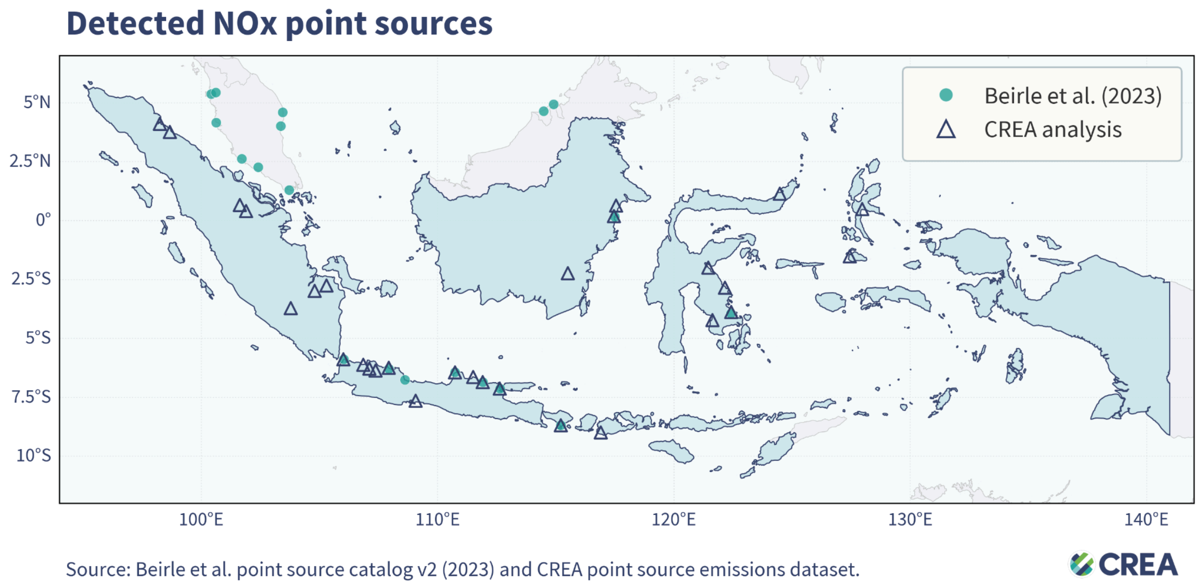


Figure 3 — Map of Beirle et al.'s detected NO_x point sources, and additional point sources revealed from updated methodology and extending estimates through 2025

These twenty additional point sources are distributed across Java, Sumatra, the Sulawesi and Maluku islands, and the Lesser Sunda Islands. In Java, a total of ten point sources were identified — five are new, five match the dataset from Beirle et al., and one from the original Beirle et al. list went unmatched. This single unmatched source near Cirebon, West Java, was initially detected but was excluded as it did not pass the strict quality control; however, it remains a point of interest for future tracking.

In Kalimantan, there are three point sources — one was previously identified in Beirle et al. Across Sumatra, there are seven point sources in total, and none were identified in Bierle et al. As for Sulawesi and Maluku islands, there are seven point sources — one was previously identified. In the Lesser Sunda Islands, there are two point sources — one in Bali was noted in Beirle et al, and one in West Nusa Tenggara is new.

Attributing point sources to emitters

To attribute the top-down-detected NO_x point sources to specific emitters, this analysis considered information on facilities known to emit considerable amounts of NO_x, available from Global Energy Monitor (GEM) and Climate TRACE. References include coal, oil, and gas power generation facilities in Global Coal Plant Tracker (GCPT), Global Oil and Gas Plant Tracker (GOGPT), other industrial and logistical facilities of GEM trackers,[1] and the Climate TRACE global emission map. This analysis includes **relevant sources of emissions referred to as emitters within a 15 km radius** from the most likely location of the detected point source as relevant contributors.

Contribution to ambient air quality

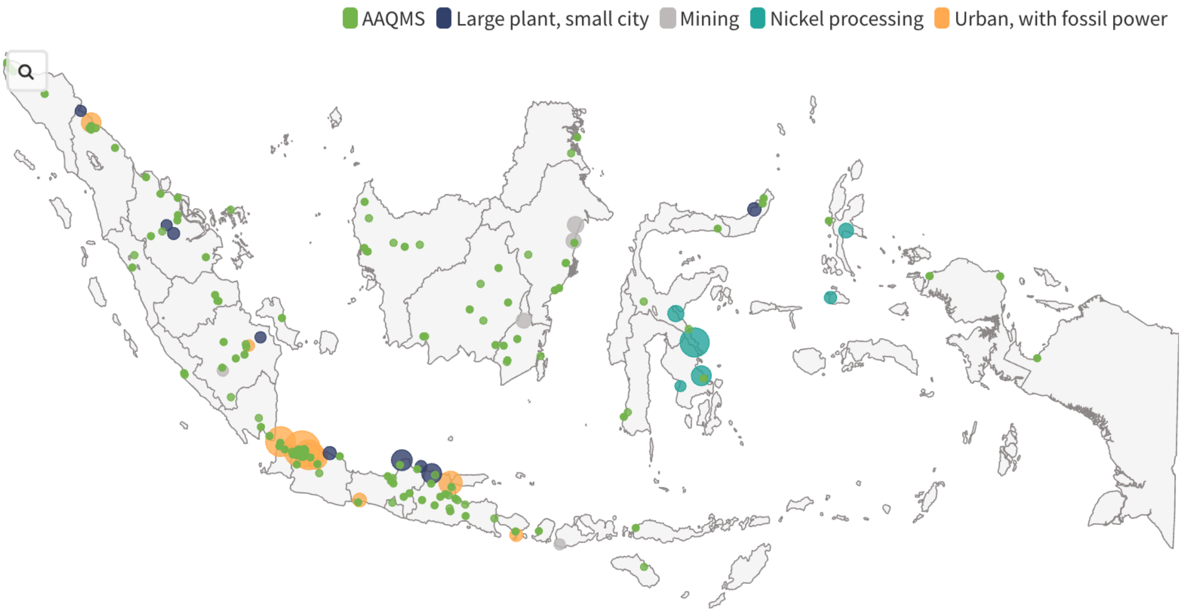
Advancements in satellite data have revolutionised the collective understanding of air pollution by pinpointing high-concentration areas, or hotspots for NO_x. The top-down view from the data enables experts to identify the major sources of these emissions, and more importantly, assess how these emissions contribute to ambient air quality on both local and regional scales. **NO_x emissions are not just a localised problem; they are a precursor to other harmful pollutants and can be transported over vast areas, impacting distances beyond their origin.**

A spatial analysis overlaying Sentinel-5P satellite-derived NO_2 concentrations against the existing network of 100+ points of official ambient air quality monitoring stations (AAQMS) maintained and operated by the Ministry of Environment and the Meteorology, Climatology, and Geophysical Agency could be used to reveal 'blind spots' in current air quality surveillance across Indonesia. This information can be used to inform further actions, for instance, guiding strategic expansion of the monitoring network to prioritise high-emission zones that are currently under-measured or not covered at all.

Figure 4 shows the distribution of AAQMS across Indonesia, against the 29 NO_x hotspots identified in this study. DKI Jakarta arguably has the best ground monitoring coverage, with 125 monitoring stations spread across the province (Udara Jakarta, n.d.). While 12 stations are considered reference grade and the remaining low-cost sensors, access to air quality monitoring is highly adequate for Jakarta. Moving outside the DKI Jakarta administrative borders, coverage dropped significantly, with only one single sensor in Bekasi, and none at all covering the West Karawang and Cikampek hotspot.

[1] The GEM trackers cited here cover facilities known to produce significant NO_x emissions, including the Global Cement and Concrete Tracker (GCCT), Global Coal Mine Tracker (GCMT), Global Chemical Inventory (GChI), Global Coal Terminals Tracker (GCTT), Global Bioenergy Power Tracker, Global Iron and Steel Tracker (GIST), and Global Gas Infrastructure Tracker (GGIT)

Ambient Air Quality Monitoring Station (AAQMS) plotted against the 29 NOx hotspots across Indonesia



Source: National ambient air quality monitoring stations maintained by Ministry of Environment (Kementerian Lingkungan Hidup, KLH) - https://ispu.kemenlh.go.id/webv5/#/ , Meteorology, Climatology, and Geophysical Agency (Badan Meteorologi, Klimatologi, BMKG) - https://iklim.bmkg.go.id/id/kualitas-udara-indonesia/, Regional low-cost monitors, from DKI Jakarta Environmental Agency - https://udara.jakarta.go.id/

Figure 4. Distribution of Indonesia's official ground air quality monitoring stations

Across Java, at least one official AAQMS is present near the identified hotspots, namely Cilacap, Tanjung Jati, and Rembang in Central Java, and Tuban and Surabaya in East Java. Suralaya in Banten has two sensors nearby — one located near the city of Cilegon, and the other near PT Krakatau Sarana Properti.

As for the other hotspots in outer Java, the following also have at least one AAQMS present: Medan in North Sumatra, Palembang and Muara Enim in South Sumatra, Denpasar in Bali, Kendari in Southeast Sulawesi, and Bontang in East Kalimantan. These hotspots are considered urban, except for Muara Enim, Bontang, and Kendari, where emission-intensive activities are prominent — coal mining, large industrial plant operations, and nickel processing, respectively.

Categorising Indonesia's NO_x hotspots

By analysing localised NO_x emissions calculated from satellite measurements, alongside identifiable infrastructure of thermal power plants and heavy industries, this study categorises Indonesia's **29 point sources** into **four distinct groupings — Urban, with fossil power; Large plant, small city; Nickel processing;** and **Mining**. A tabulation is provided in the Appendix, Table A1. This grouping is set to help bridge the gap between raw data and environmental realities, highlighting heavy concentrations in population centres and specific locations where major energy- and emission-intensive industries are located, as well as profound shifts and growing trends outside of Java.

CREA has launched **EmisiMap (https://emisimap.energyandcleanair.org/)** to accompany this study as **a visualisation tool for mapping geospatial pollution data directly alongside known energy infrastructure** — such as fossil-based power plants, metal smelters, and industrial parks — to bridge the ground-monitoring gap and attribute satellite-detected emissions to their probable sources.

Urban, in close proximity to major power and industrial facilities – 9 hotspots

"Urban, with fossil power" grouping encompasses nine major hotspots concentrated within or adjacent to Indonesia's most densely populated metropolitan areas, where baseline emissions from high-density transportation and domestic activities are heavily compounded by major power stations and industrial facilities. This structural overlap creates severe air quality crises across shared airsheds, revealing **nine urban-nature hotspots across major metropolitan centres including Jabodetabek (35+ million residents), Surabaya (3.3 million), and Medan (2.3 million)**.

Shown in Figure 5, five of the ten highest hotspots within this grouping are concentrated in Java, demonstrating a strong correlation between high-density cities and intensive fossil fuel usage. This bivariate map illustrates the intersection of NO_x concentrations and population density, highlighting the severe exposure risks surrounding key industrial and power nodes.

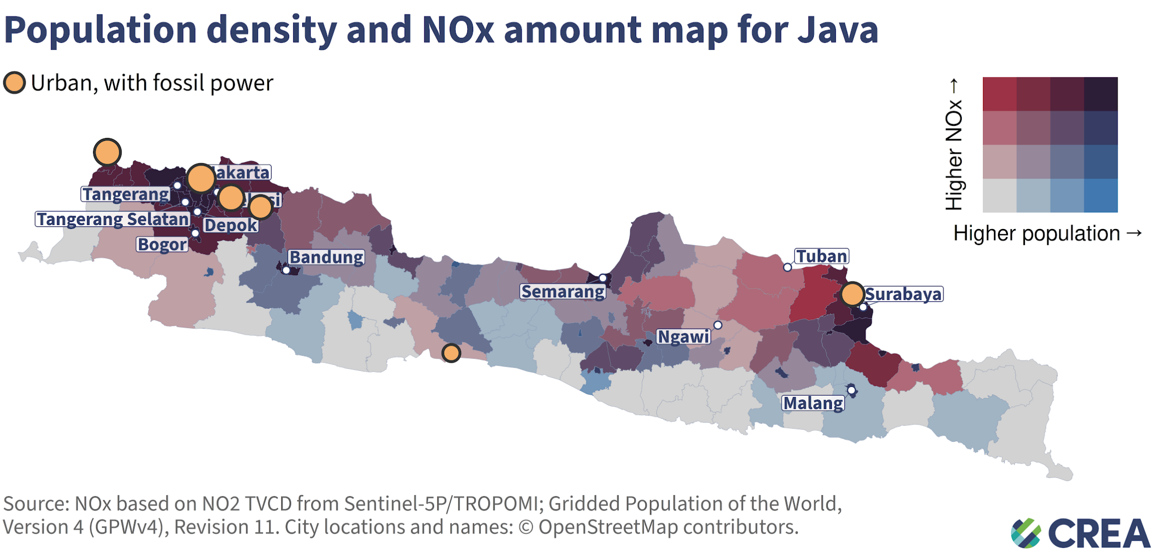


Figure 5 — Five highest NO_x-emitting urban hotspots near fossil power facilities

The most critical reveal is the massive airshed encompassing Jakarta and satellite cities surrounding it, with North Jakarta and Outer Bekasi in West Java shown not only as the top two highest in these groupings, but also in the entire national list**.**

The North Jakarta coast hosts major gas-fired power stations adding up to 5 GW (2.8 GW in Tanjung Priok and 2.1 GW in Muara Karang), operating directly adjacent to areas housing nearly 2 million people. Not to mention, heavy clusters of industrial complexes beyond the Jakarta administrative city limits, spanning across **Bekasi to West Karawang and Cikampek**, are continuously emitting air pollutants from boilers and other thermal equipment reliant on fossil fuel, as well as from their dedicated gas power stations reaching nearly 1 GW (864 MW Jababeka Industrial Estate gas power station; 130 MW Bekasi gas power station).

There is also the unquestionable transboundary transport of air pollution, where secondary particulate matter from over 100 km away are transported to surrounding suburban and highland regions, from the neighbouring province of Banten. As the third highest NO_x hotspot in Indonesia, **a subdistrict named Suralaya in Cilegon, Banten** hosts massive fossil-based power generation totaling over 8 GW — coal power amounting to 6.8 GW (6 GW Banten Suralaya; 660 MW Banten Serang; 120 MW Merak) and gas power 1.4 GW (740 MW Cilegon, 520 MW Cilegon KDL; 120 MW Krakatau), along with heavy manufacturing industries of iron and steel (Krakatau Steel and Krakatau Posco), cement (Sun Fook and Conch Cements), and chemicals (INEOS Aromatics and Lotte Chemical) clustered in nearby complexes.

Figure 6 shows the visualisation of the average NO_x emission distribution across the identified hotspots of Suralaya, Banten; North Jakarta, DKI Jakarta; Outer Bekasi, West Java; and West Karawang & Cikampek, West Java (ordered from west to east).

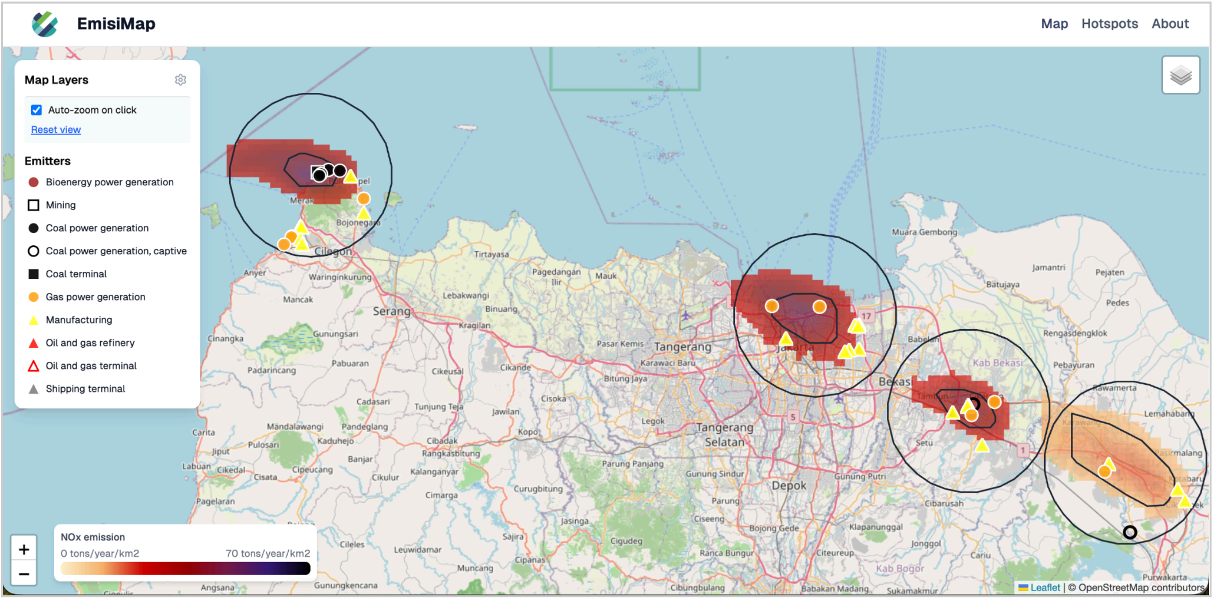


Figure 6 — EmisiMap visualisation of average NO_x emission distribution and proximal emitters within a 15 km radius in four top hotspots across DKI Jakarta and West Java

Unsurprisingly, sustained exposure to the high-density emissions from continuous power generation and industrial activity inflicts a severe public health toll on the surrounding population. Jakarta's chronic air pollution crisis impacts at least 10.7 million residents and over 30 million more across the Greater Jakarta area. This crisis is statistically linked to nearly 2,500 deaths annually, over 7,000 adverse health outcomes in children, more than 10,000 premature deaths, and over 5,000 hospitalisations from heart attacks, stroke, lung cancer, and respiratory diseases (World Population Review, 2026; Syuhada et al., 2023). In neighbouring Bekasi, heavy exposure to vehicular exhaust, coal plants, manufacturing, and residential emissions reduces average life expectancy by up to 5 years (Aulia, 2024).

Meanwhile, about 100 km west of Jakarta, environmental degradation is reported to extend deeply into coastal ecosystems, where severe marine damage and dwindling catches have displaced traditional fishing livelihoods (Dialogue Earth, 2021). Ranked among the nation's Toxic20 most polluting coal plants, the Banten Suralaya complex elevates annual PM2.5 concentrations across northern Banten, exposing 13 million residents, and is linked to 1,063 premature deaths and USD 1.04 billion in economic costs annually (CELIOS et al., 2025; CREA, 2023b). This regional public health threat has further intensified following a major 2 GW expansion at the end of 2025 (CNN Indonesia, 2025).

Because air pollution does not remain within administrative boundaries, addressing it is not only a local priority but a regional and national urgency. Acting decisively to reduce emissions benefits not only primary metropolitan residents but millions of people across the wider shared airsheds, emphasising the critical need for coordinated inter-regional, multi-sectoral interventions targeting time-bound air pollution reduction.

Within **the Greater Jakarta Airshed, encompassing the Jabodetabek region**, coal-based power generation and industrial emissions frequently drift beyond source points into surrounding regions such as Tangerang, Bogor, Depok, Bekasi, and even the highland areas of Puncak and Cianjur. Under specific meteorological conditions, plumes can travel hundreds of kilometres to impact South Sumatra, Lampung, and Central Java.

CREA's 2020 spatial analysis verified that regional clusters of industrial facilities directly overlap with the major NO_x and SO2 emission hotspots across Java. Furthermore, atmospheric modelling of Jakarta's most severe pollution episodes confirms that prevailing wind trajectories pass directly through these dense industrial corridors in Banten and West Java before blanketing the capital (CREA, 2020).

Figure 7 shows a visual of the most recent average NO_x emission dispersion over the area.

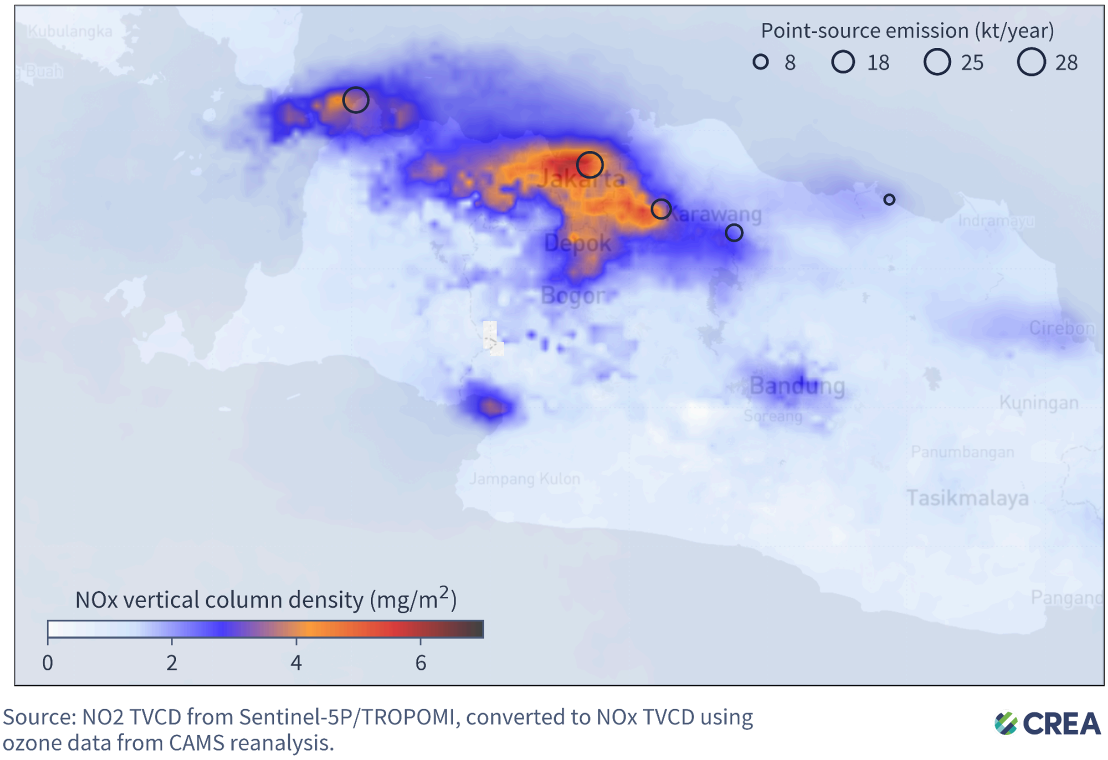


Figure 7 — Average NO_x amount over the Jabodetabek region in 2025

Beyond Jabodetabek, urban NO_x hotspots identified for Surabaya, East Java, as well as Medan, North Sumatra, and Palembang, South Sumatra — Indonesia's second, fourth, and ninth most populous cities, respectively — demonstrate clear structural overlaps where intensive industrial point sources directly compound urban exposure. Figure 8 displays the NO_x emission distribution of these airsheds.

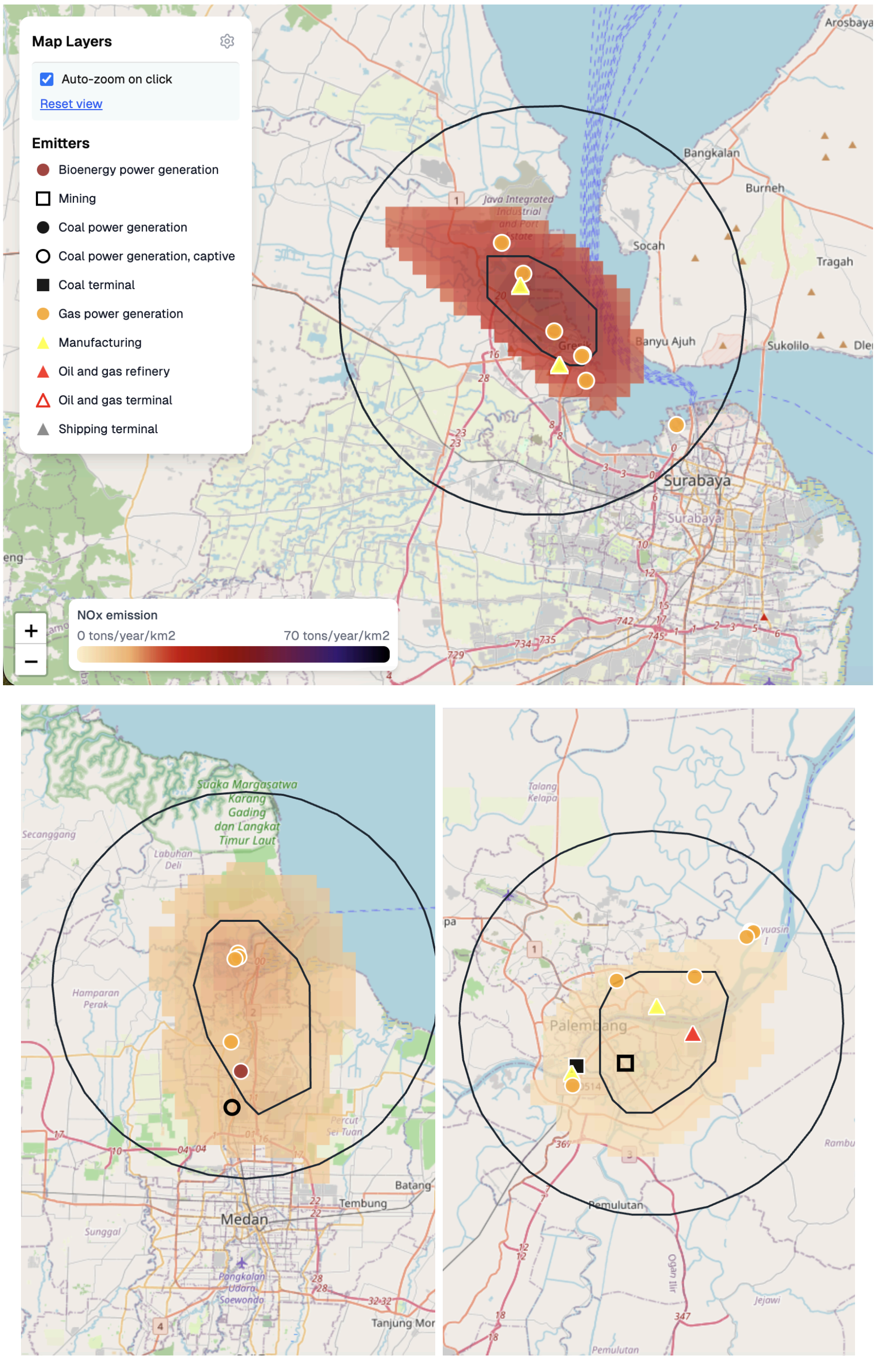


Figure 8 — NO_x emission distribution over Surabaya, Medan, and Palembang

In **the Greater Surabaya Airshed of East Java**, the high-density urban core of Surabaya, home to 3.3 million residents, acts as a compounding sink for intensive maritime shipping emissions and heavy urban transit, heavily exacerbated by the proximal industrial zones of Gresik and Sidoarjo. The close geographic clustering of coastal thermal power generation and gas-fueled manufacturing creates a highly continuous, high-density emission that carries pollution far inland along dominant wind axes.

Conversely, **the Greater Medan Airshed in North Sumatra** reveals a distinct transboundary dynamic affecting its 2.3 million residents. Here, localised emissions from manufacturing, bioenergy facilities, and steel mills coincide with urban transportation, further exacerbating air pollution. As captured by the satellite data, NO_x plumes frequently breach municipal borders, spreading the heavy pollution burden away from the urban centre and directly into surrounding peri-urban agricultural districts.

In **South Sumatra, the Palembang airshed** serves as a major focal point for energy infrastructure, where gas power generation facilities, oil and gas refineries, and coal terminals form an intensive industrial ring around the city borders. The spatial distribution of these emissions demonstrates how concentrated industrial processing and fossil-fuel power grids trap the expanding urban population within a localised pollution envelope.

Large plant, small city – 9 hotspots, and Mining – 5 hotspots

"Large plant, small city" (9 hotspots) and "Mining" (5 hotspots) groupings are structurally unified by a shared spatial characteristic — **massive, resource-intensive operations located in peri-urban, remote, sparsely populated regions, or coastal areas where local human populations are relatively sparse**.

Despite lower baseline population densities, these industrial and extraction complexes generate localised point-source emissions at a scale that can be similar to or even exceed major metropolitan areas. This distribution reflects a broader dynamic where energy- and emission-intensive projects are strategically sited near resource reserves or deep-water shipping corridors, frequently relying on dedicated or captive energy networks rather than grid electricity. Therefore, these clusters inevitably shift the nation's air pollution burden onto local communities and regional airsheds currently invisible to urban tracking arrays.

Figure 9 illustrates the distribution of these 14 combined point sources, revealing sector-specific footprints across the major islands. **Public utility coal power combined with heavy manufacturing dominate the island of Java, chemical pulp and paper operations anchor Sumatra, and heavy mineral extraction dominates Kalimantan.**

Figure 9 — Distribution of satellite-verified NO_x point sources within the "Large plant, small city" and "Mining" categories in EmisiMap

Java, home to major coal power complexes and the nation's cement footprint

Despite Java's high average population density, its largest base-load emitters are frequently relegated to remote coastlines to facilitate raw material transport. This category captures **four major coal-fired facilities included on the Toxic 20 list of most-polluting coal power complexes**, namely 990-MW Indramayu in Sukra, Indramayu, West Java; 4.64-GW Tanjung Jati B in Jepara, Tanjung Jati, Central Java; 630 MW Rembang in Rembang, Central Java; 700 MW Tanjung Awar-Awar in Tuban, East Java (Figure 10). Combined, these facilities alone account for nearly 7 GW of coal-based power generation that is attributable to 680 premature deaths and USD 481 million health-related economic burden annually (CELIOS et al., 2025).

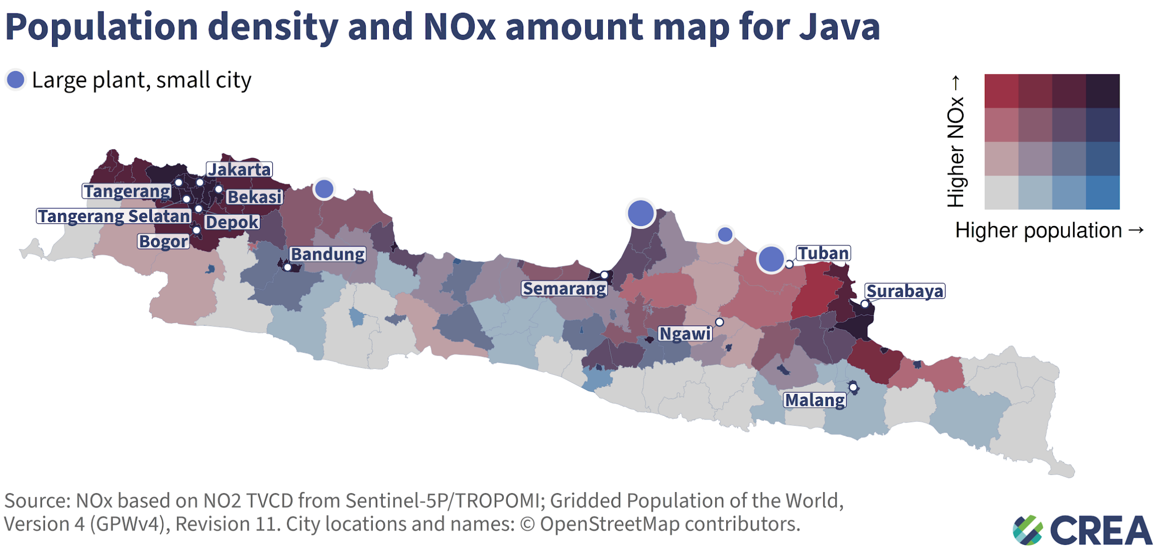


Figure 10 — Four "Large plant, small city" hotspots identified in the island of Java

This utility grid is heavily compounded by Java's intensive cement industry, a sector responsible for nearly 5% of global industrial energy consumption, and one of Indonesia's top three most energy-intensive manufacturing subsectors alongside steel and petrochemicals (Climateworks Centre, 2025). Producing lime requires heating limestone in massive rotary kilns to temperatures exceeding 1,400°C, a process that generates substantial thermal NO_x and demands roughly 200 kg of coal per tonne of output (Soomro et al., 2023).

Major production lines operated by state-owned Semen Indonesia Group's facilities in Tuban (11.9 Mtpa) and Rembang (3 Mtpa) show an apparent footprint in the satellite data.

While producers have attempted to lower coal consumption by deploying Thermal Substitution Rate programs using Refuse-Derived Fuels (RDF), these waste streams are often composed of up to 50% plastic waste. Without advanced pre-sorting and strict stack controls, burning RDF risks releasing toxic dioxins and replicating the severe odour and localised air deterioration that recently led to the public-enforced closure of Jakarta's trial RDF burning (Mongabay, 2025d; Tempo, 2025).

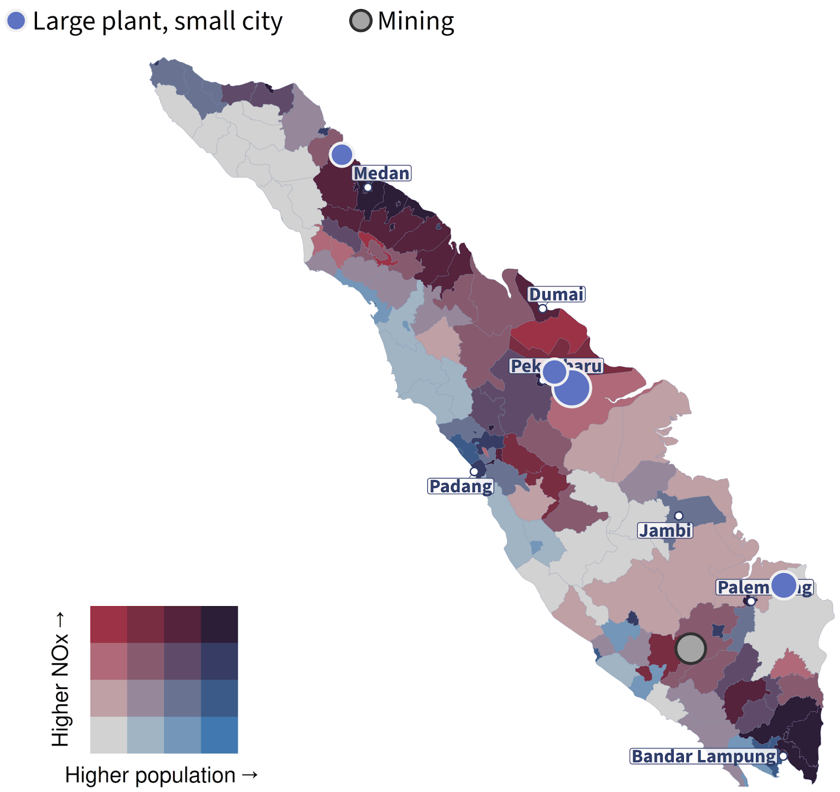
Sumatra, captive biomass burning and kraft-pulping centres

Outside of Java, the pulp and paper industry stands as the primary driver of non-urban NO_x emissions, operating as one of the world's five most energy-intensive sectors (Barrios et al., 2026). Generating wood pulp requires massive continuous blocks of thermal steam and electricity for chemical processing, typically supplied by large on-site boilers. High-temperature combustion within these systems yields prominent NO_x plumes, while the underlying chemical kraft pulping process emits volatile organic compounds and sulfur derivatives.

Sumatran mega pulp and paper complexes — including Riau Andalan Pulp & Paper (RAPP) in Pangkalan Kerinci Timur, Pelalawan, Riau; PT Indah Kiat Pulp & Paper Tbk (IKPP) in Tualang, Siak, Riau, and APP's OKI Pulp Mill in Ogan Komering Ilir, South Sumatra (Figure 11) — rely on extensive hybrid fuel arrays to meet their massive baseload thermal and electrical power demands. These integrated operations leverage large-scale bioenergy infrastructure, such as the 535 MW Kerinci Mill bioenergy power plant and the Sinar Mas OKI Paper Mill bioenergy power plant, by twin 110 MW biomass gasifiers, utilizing pulping byproducts like black liquor, bark, and bio-sludge.

However, fossil fuels remain deeply embedded in the regional industrial energy mix. Facilities such as IKPP Perawang operate dedicated captive fossil units, including the 755 MW Perawang Mill coal power plants, while auxiliary coal combustion at RAPP's Kerinci complex still accounts for 18% of its 147,257 TJ energy profile (APRIL, 2026). As Indonesia's national paper output is projected to reach 29 Mt by 2060, these industrial complexes stand as permanent, high-volume emission nodes requiring rigorous regulatory oversight and targeted decarbonization pathways (LBNL, 2024).

Population density and NOx amount map for Sumatra



Source: NOx based on NO2 TVCD from Sentinel-5P/TROPOMI; Gridded Population of the World, Version 4 (GPWv4), Revision 11. City locations and names: © OpenStreetMap contributors.

Figure 11 — Four "Large plant, small city" hotspots and one "Mining" hotspot identified in the island of Sumatra

Kalimantan, coal extraction and mine-mouth power plants

In South Kalimantan's Tabalong Regency, PT Adaro Indonesia operates major open-pit concessions — including the Tutupan Coal Mine and the Wara Coal Mine — which supply coal directly to adjacent power infrastructure such as the 200 MW Tabalong power station and the 60 MW Tabalong Wisesa power station. In East Kalimantan, the extraction footprint is dominated by PT Kaltim Prima Coal's (KPC) mega-scale KPC Operation Coal Mine in Sangatta and Bengalon, alongside significant regional operations including the TMR Coal Mine and the Elynda Jaya Coal Mine (Figure 12).

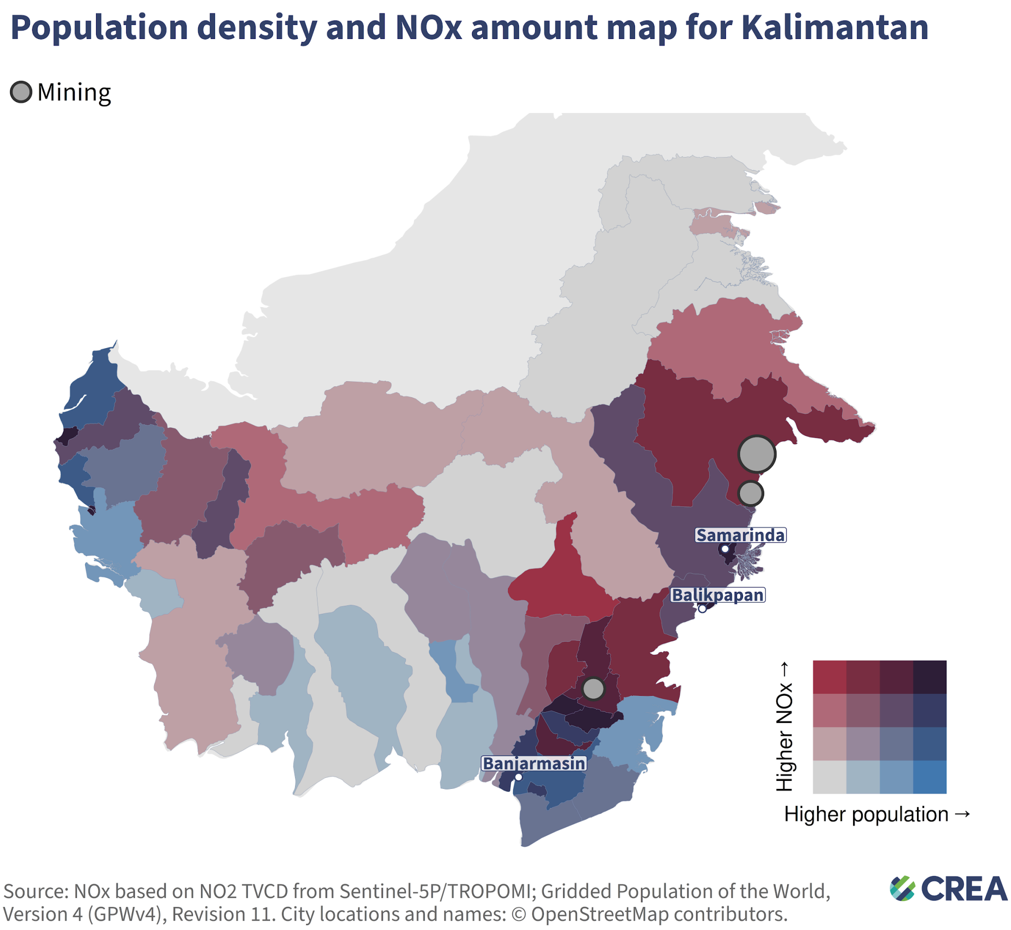


Figure 12 — Three "Mining" hotspots identified in the island of Kalimantan

These extraction complexes are increasingly co-located with dedicated mine-mouth power infrastructure — such as the 200 MW Kaltim FTP2 power station in East Kalimantan, alongside South Kalimantan's 200 MW Tabalong power station and the 60 MW Tabalong Wisesa power station. This dense industrial integration creates concentrated emission hotspots, releasing substantial volumes of NO_x, SO2, CO2, and particulate matter into the local atmosphere through combined mobile-fleet and stationary combustion sources (Chu et al., 2023).

Compounding this extraction and power emissions profile is East Kalimantan's heavy industrial manufacturing zone in Bontang. Here, high-capacity chemical synthesis facilities — such as the PT Kaltim Methanol Industri Bontang Methanol Plant operated by PT Kaltim Methanol Industri (KMI) and the PT Pupuk Kalimantan Timur Bontang Ammonia Complex (Pupuk Kaltim) — utilize natural gas feedstocks paired with continuous industrial steam boilers and utility generation units. The spatial overlay of open-pit mining, coal combustion, as well as fertilizer and methanol refining produces prominent, multi-sector air pollution plumes across East Kalimantan.

From a governance perspective, a critical regulatory mismatch persists between power generation and mineral extraction. While thermal power plants are legally bound to point-source emission thresholds and real-time Continuous Emission Monitoring Systems (CEMS) monitored by the Ministry of Environment, regulatory oversight across remote mining sites remains fragmented.

Crucially, open-pit mining operations are managed through broad, landscape-level environmental frameworks — such as Government Regulation No. 22 Year 2021 on the Implementation of Environmental Protection and Management — rather than standardized, enforceable stack-emission caps or non-road diesel fleet standards (Nexus3 Foundation, 2022).

Nickel processing – 6 hotspots

Satellite observations reveal that the rapid expansion of captive coal power and heavy smelting infrastructure in remote regions has fundamentally altered Indonesia's emissions profile. While non-urban, the scale of these localised industrial columns is immense.

Figure 13 provides a visual representation of this dynamic, mapping the intensity and spatial concentration of the emerging average NO_x emission hotspots generated exclusively by nickel processing hubs across the Sulawesi and Maluku archipelagos.

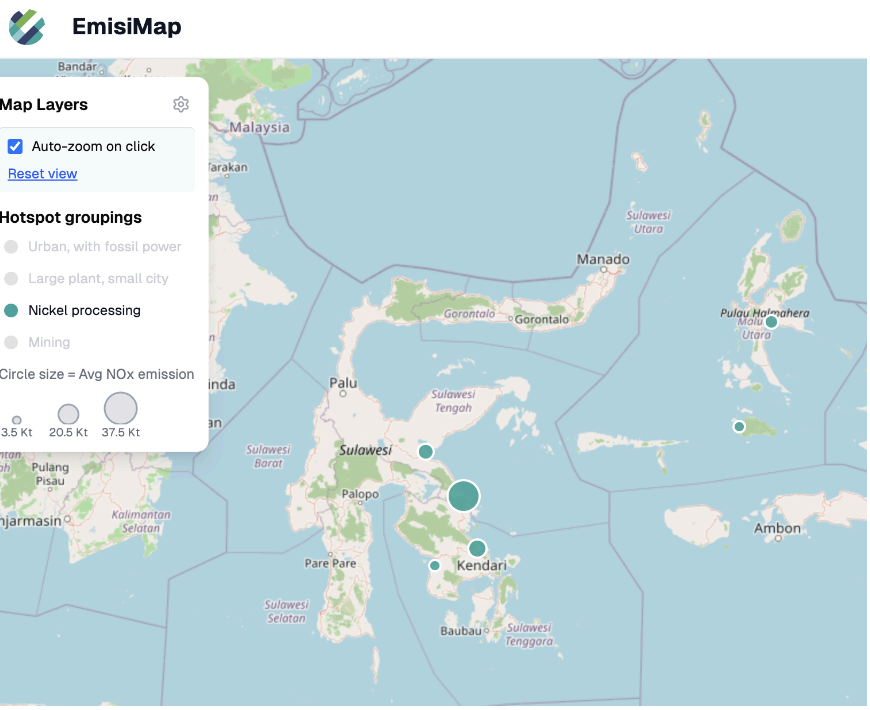


Figure 13 — EmisiMap "Nickel processing" hotspots identified across Sulawesi and North Maluku islands

Driven by the global demand for critical minerals supporting the green energy transition, Indonesia has aggressively leveraged its status as the holder of the world's largest nickel reserves, accounting for 50% of the global refined nickel supply and 51% of global mine production (Kompas, 2025; IEEFA, 2024).

Following the 2020 raw nickel ore export ban introduced to mandate domestic downstreaming, foreign capital inflows rapidly reshaped the country's industrial landscape. By 2024, 54 nickel smelters were operational, with 120 under construction and 16 in the planning phases (Indonesia Business Post, 2025). This rapid industrialisation transformed the Maluku and Sulawesi regions into massive critical mineral hubs.

However, this rapid downstreaming has relied heavily on unmitigated coal power. Laterite nickel ore processing, predominantly utilising Rotary Kiln Electric Furnace (RKEF) technology to produce ferronickel and nickel pig iron, is an exceptionally energy-intensive process requiring vast volumes of thermal energy and electricity. In Indonesia, this baseload demand is met almost exclusively by dedicated off-grid captive power plants.

The year-by-year distribution of captive coal power expansion directly linked to Indonesia's nickel industry, detailed in Figure 14, illustrates the stark growth. The combined captive coal power capacity in these nickel-producing provinces has grown massively in a decade. **This growth rapidly accelerated in the recent five years as capacity has grown by more than six-fold, from 3 GW in 2019 to 16 GW in 2025.**

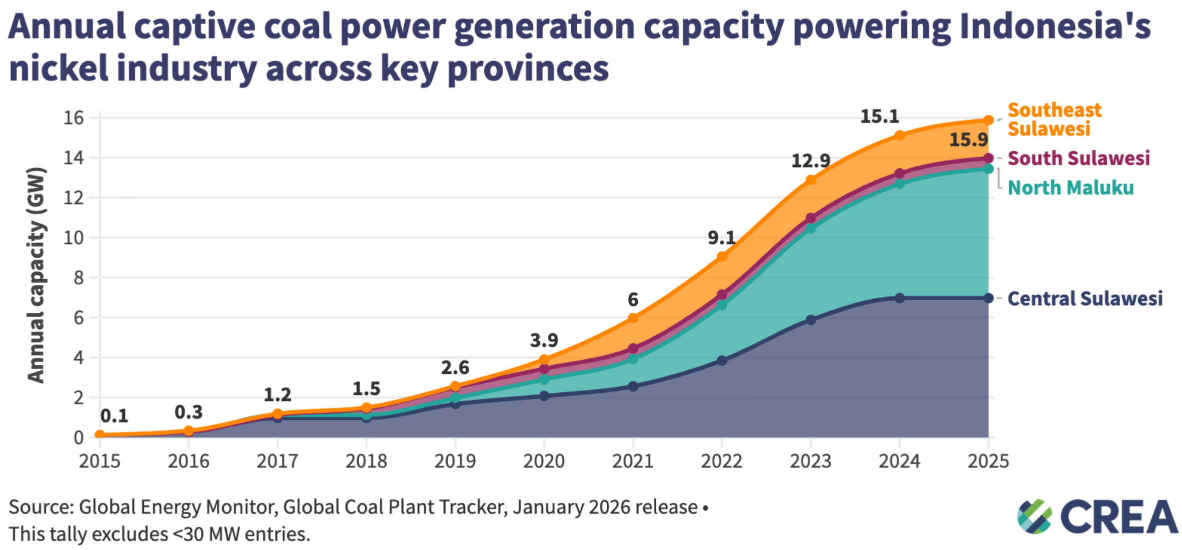


Figure 14 — Nickel-linked captive coal power capacity growth across key provinces where major nickel ore reserves are located (2019-2025)

This structural reliance on captive coal has created the fastest-growing and most environmentally volatile source of industrial air pollution in the archipelago. Six distinct NO_x emission hotspots have emerged directly over these isolated processing zones. Despite being remote, the scale of emissions from these clusters is unprecedented.

Figure 15 visualises the spatial dispersion of NO_x emissions across Indonesia's primary nickel processing hubs, and the changes in NO_x amount from 2018 to 2025. Driven by the 2020 raw ore export ban and a six-fold increase in off-grid captive coal power capacity, six localized emission hotspots (A–F) have emerged across the remote landscapes of Sulawesi and North Maluku.

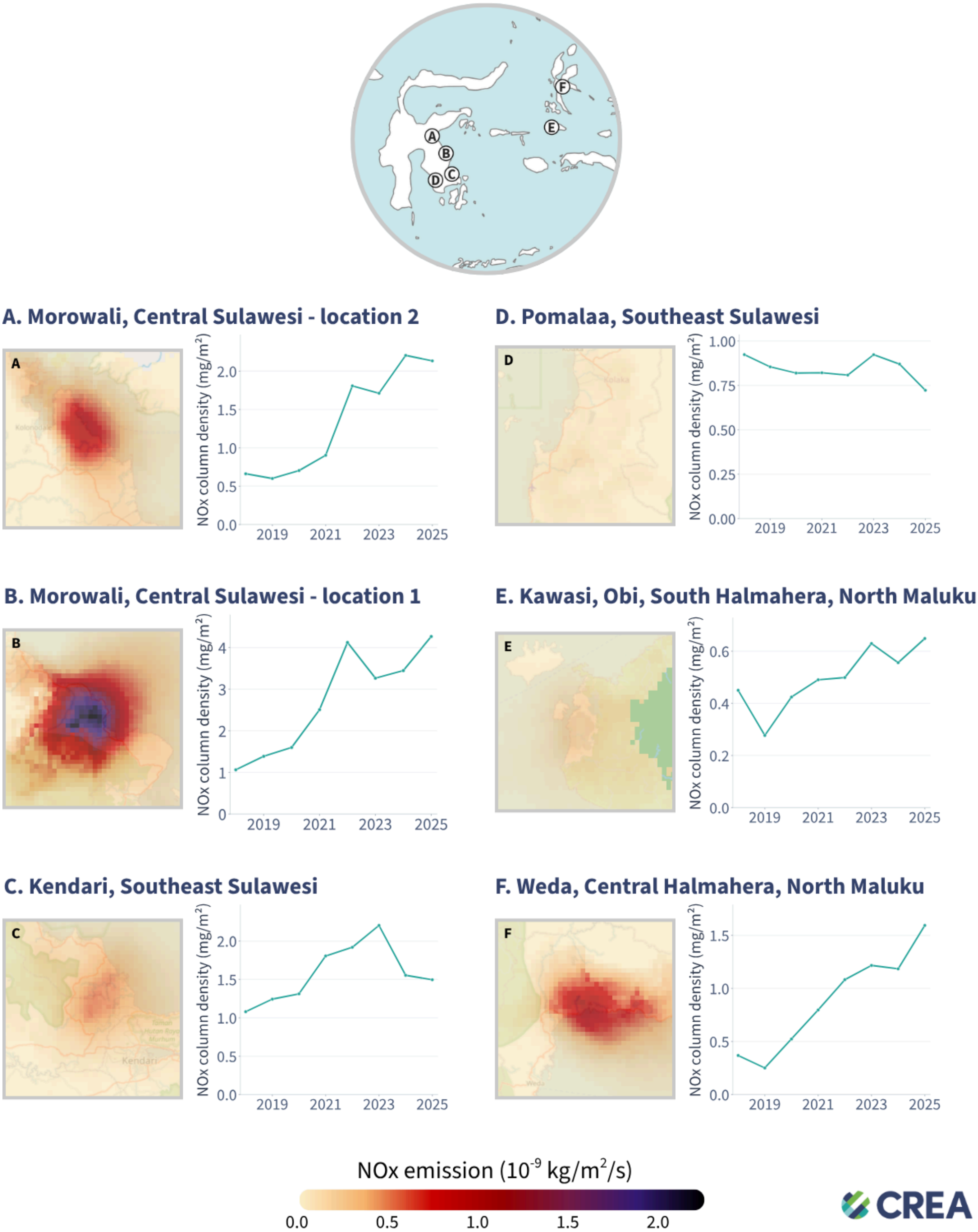


Figure 15 — Average NO_x emission and change in NO_x amount from 2018 to 2025 for six "Nickel processing" hotspots in Sulawesi and North Maluku

Hotspots A, B, and F display the most severe concentration spikes and expansion trajectories, confirming that energy-intensive nickel processing technologies have transformed previously low-baseline, remote coastal regions into major industrial emission plumes.

In Central Sulawesi, hotspots A and B center on the immense industrial complexes of North Morowali and the Indonesia Morowali Industrial Park (IMIP). Hotspot A (-2.01461°, 121.43200°), covering Delong Nickel Phase III (945 MW) and Phase IV (660 MW) captive coal power stations alongside PT Gunbuster Nickel Industry operations, exhibits intense NO_x accumulation. The area has faced regulatory scrutiny for wastewater violations and unmitigated air emissions, accompanied by severe operational safety hazards (CRI, 2024).

Immediately to the south, Hotspot B (-2.88620°, 122.16446°) encompasses IMIP's central infrastructure, powered by the massive Sulawesi Mining (2,080 MW) and Sulawesi Labota (3,360 MW) captive coal power complexes. Thermal discharge and particulate fallout here have severely degraded surrounding marine ecosystems, forcing local fishers further offshore and driving sharp increases in acute respiratory infections among the regency's 203,000 residents.

Moving into Southeast Sulawesi, Hotspots C and D illustrate the expanding geographical footprint of captive coal-powered smelting. Hotspot C (-3.89291°, 122.43082°), situated near Kendari and Konawe, is anchored by the Delong Nickel Phase I (530 MW) and Delong Nickel Phase II (1,840 MW) captive coal power stations, linked to major ferronickel producers such as PT Virtue Dragon Nickel Industry and PT Obsidian Stainless Steel. The resulting air and water pollution has triggered widespread respiratory issues among Kendari's 375,000 residents, damaged local shrimp aquaculture, and prompted legal challenges over unfulfilled community commitments.

Further south, Hotspot D (-4.20693°, 121.61804°) in Pomalaa reflects PT Aneka Tambang Tbk (Antam) ferronickel production, served by a 60 MW captive coal power plant. While smaller in immediate intensity, ongoing High-Pressure Acid Leaching (HPAL) expansion by PT Vale Indonesia Tbk highlights a persistent trade-off between local economic development and coastal ecosystem degradation, particularly concerning coral reef siltation (Purnama et al., 2025; Petromindo, 2026).

In North Maluku, Hotspots E and F represent two of the most environmentally volatile clusters mapped in Figure 15. Hotspot E (-1.53193°, 127.44299°), located on Obi Island, hosts major metals processing complexes, supported by nearly 2 GW of operational captive coal capacity combined linked to PT Halmahera Persada Lygend Nickel Smelter (2,390 MW — 1,630 MW operational, 780 MW in construction), Xinxing Ductile Iron Pipes (152 MW), and

Jinchuan Group WP&RKA (150 MW). Industrial run-off on the island has led to severe hexavalent chromium (Cr VI) contamination in local water supplies — testing up to 19 times above legal limits — and driven spikes in respiratory illness across South Halmahera.

Finally, Hotspot F (0.49310°, 128.04688°) over the Indonesia Weda Bay Industrial Park (IWIP) in Central Halmahera demonstrates the most dramatic surge in NO_x levels. Powered by a massive 4,540 MW captive coal power complex, IWIP has replaced more than 5,300 hectares of tropical forest with industrial infrastructure (IWGIA, 2026). This environmental conversion has contaminated local rivers, elevated heavy metal levels (mercury and arsenic) in nearby residents, and triggered a surge in respiratory illnesses from 434 cases in 2020 to over 10,500 in 2023 (Mongabay, 2025a; Mongabay, 2025c).

Aggressive nickel industry expansion results in severely disproportionate burden

NO_x emissions from coal combustion in power generation and smelting operations, as well as other related nickel processing activities, pose growing health and environmental risks, especially for communities located within or adjacent to these zones. The concentration of hotspots in Sulawesi and Maluku highlights a disproportionate emissions burden relative to their population size.

Combined, NO_x emissions from hotspots across Sulawesi and Maluku total 43.5 kilotonnes — exceeding the total emissions from the point sources in the Greater Jakarta Metropolitan Area, which stand at 37.7 kilotonnes.

This comparison underscores the severity of industrial emissions in these regions, despite their remoteness and significantly smaller populations. Beyond air quality degradation, the rapid physical footprint of the nickel industry has extracted a severe human and environmental toll.

Open-cast mining to access shallow laterite deposits has driven **extensive deforestation**, destroying 5,331 hectares of tropical forest, directly releasing 2 million metric tons of carbon emissions (IWGIA, 2026). Coastal communities face downstream flash flooding, heavy metal bioaccumulation, and total disruption of traditional fishing and agricultural livelihoods — implying severe **disruption to local hydrology** (CRI, 2024).

Public health records within communities adjacent to major processing zones show that **respiratory illnesses surged exponentially from 434 cases in 2020 to 10,579 cases in 2023**, while clinical pathology tests have revealed **highly unsafe concentrations of arsenic and mercury in residents' blood** (Mongabay, 2025c).

Furthermore, weak occupational oversight has repeatedly resulted in **systemic safety failures**. Documented incidents include a major March 2025 landslide at IMIP that buried four workers under unstable nickel waste, part of a broader industrial pattern accounting for at least 40 fatalities at the complex since 2015 (Mongabay, 2025b; TuK Indonesia, 2025).

Addressing the blind spot in Indonesia's energy transition

Indonesia's international climate commitments—most notably the Just Energy Transition Partnership (JETP) investment plan—have focused primarily on grid-tied power generation managed by state utility *Perusahaan Listrik Negara* (PLN). However, the explosive growth of off-grid, industrial captive coal infrastructure creates a major policy contradiction.

While grid-tied coal expansion has slowed under public decarbonisation pledges, off-grid captive coal capacity powering industrial processing parks grew by nearly two-fold in merely two years, climbing from 10.4 GW in 2023 to 19.3 GW in 2025. Driven primarily by nickel processing expansion in Sulawesi and North Maluku, captive coal accounted for roughly 80% of all new coal additions nationwide, pushing the total operating, under-construction, and planned captive capacity pipeline to a staggering 31 GW (CREA & GEM, 2026).

This explosive growth is sheltered by regulatory loopholes in Presidential Regulation No. 112/2022 on Renewable Energy Acceleration (Perpres 112/2022), which explicitly exempts industrial captive power plants supporting National Strategic Projects or *Proyek Strategis Nasional* (PSN) from early retirement mandates and coal construction bans. Rather than closing these exemptions, proposed revisions to Perpres 112/2022 threaten to further weaken decarbonisation commitments by expanding legal pathways for new captive coal construction (The Jakarta Post, 2025).

By insulating industrial captive power from decarbonisation timelines and carbon pricing mechanisms, national policy has incentivised off-grid fossil reliance. CREA's modeling projects that excluding captive units from national retirement targets will cause 27,000 additional air pollution-related deaths and USD 20 billion cumulative economic burden (CREA & IESR, 2023).

Crucially, this figure represents a conservative lower bound. The actual health and financial toll is expected to climb significantly higher as industrial expansion under PSN proceeds without clear asset-level implementation roadmaps, compounded by the National Electricity Plan 2024–2060 (*Rencana Umum Ketenagalistrikan Nasional*, RUKN), which projects over 20 GW of additional off-grid captive coal capacity through 2031 (Ember, 2025).

This governance blind spot allows heavy industrial facilities to operate continuous, unmitigated coal combustion networks under the umbrella of economic growth and critical minerals demand, effectively canceling out urban grid decarbonisation gains and shifting national industrial emissions into unmonitored remote areas and coastal ecosystems.

Bridging the air quality monitoring transparency gap for accountability and governance

From a governance standpoint, industrial nickel facilities are legally mandated to maintain stringent compliance structures. Operators must report emissions data directly to the National Industrial Information System (SIINas) and deploy CEMS on all smelting and power stacks. Under the Ministry of Environment's mandates, these continuous streams must feed directly into the national SISPEK digital compliance platform (Nexus3 Foundation, 2022). Additionally, large-scale industrial projects are required to complete formal Environmental Impact Assessments (AMDAL).

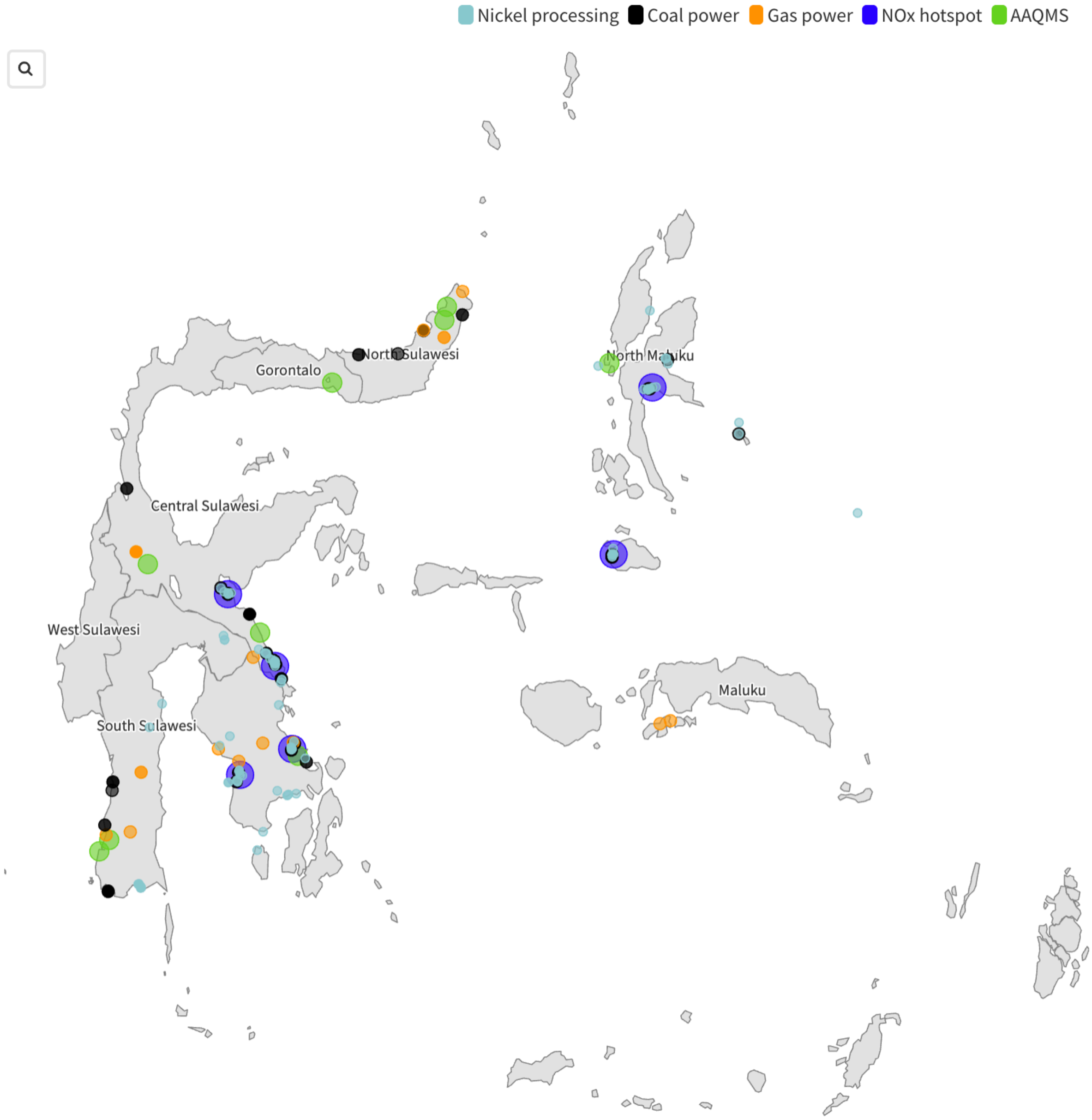
However, a profound enforcement and transparency gap persists. Public access to both raw AMDAL filings and real-time CEMS telemetry remains strictly restricted, heavily limiting independent civic accountability. This regulatory insulation is compounded by a near-total absence of independent validation infrastructure on the ground.

Illustrated in Figure 16, the official ambient ground-monitoring network is critically sparse across Sulawesi and North Maluku, leaving massive, multi-gigawatt industrial processing hubs entirely unmonitored by public ground stations, and tracking ambient environmental degradation perhaps could only be done through top-down satellite verification. Across Sulawesi and North Maluku, the current network of nine AAQMS creates a critical governance gap. While prioritising major urban population centers — such as Makassar, Manado, Gorontalo, and Ternate — is justifiable and essential for urban public health protection, it leaves the primary source of environmental risk completely unmonitored.

The map clearly illustrates that the highest concentration of heavy industrial infrastructure, including extensive nickel processing hubs and captive fossil-based power generation, is **densely clustered outside these provincial cities**.

Despite their smaller population sizes, the coastal communities living in proximity to these heavy industrial parks face severe, cumulative exposure to toxic emissions. These local populations deserve equal national protection, which mandates extending continuous ambient air quality monitoring to industrial zones, enforcing strict compliance with ambient air quality standards, and requiring rigorous, ongoing Environmental Impact Assessments for all industrial expansion.

Distribution of nickel processing hubs and fossil-based power infrastructure across Sulawesi and North Maluku, against the identified NOx hotspots and existing ambient air quality monitoring stations



Source: Collation of nickel industrial sites, as published in CREA & CELIOS 2024 study , Earthwise Institute Indonesia Power Summary datasets, Global Energy Monitor, Global Coal Plant Tracker & Global Oil and Gas Plant Tracker Jan 2026 release

Figure 16 — Spatial disparity between nickel processing hubs and ambient air quality monitoring stations in Sulawesi and North Maluku

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Policy recommendations

Comprehensive mapping of NO_x hotspots across the Indonesian archipelago reveals a rapidly evolving air quality crisis, showing that industrial emissions are no longer just an urban issue. From massive coal power complexes and heavy thermal cement kilns of Java, to captive biomass and pulp and paper facilities of Sumatra, and vast coal-dependent nickel smelting hubs of Sulawesi and North Maluku, a pattern of localised pollution has emerged. Hotspots in remote areas frequently rival or even exceed emissions of the nation's largest urban areas, shifting an unprecedented environmental and public health burden onto local communities with limited to no access to ambient air quality monitoring.

Indonesia's air quality governance must transition from passive compliance tracking to assertive intervention.

- **Set and enforce stringent ambient air quality standards and emission limits.** Enforcing these foundational pillars must take precedence over secondary measures. The 2023 Jakarta pollution crisis has shown the limits of reactive fixes, such as shutting down Suralaya coal power units 1–4, running random factory spot-checks, or mandating work-from-home policies (Kontan.co.id, 2023; Kompas, 2023; CREA, 2023). Growing air pollution across identified hotspots exposes clear gaps in regulation that can only be addressed by mandating effective air pollution control technologies and enforcing robust compliance across all sectors.
- **Institutionalise health impact valuation in energy and industrial planning.** Regulatory bodies must integrate the true societal externalities of air pollution — including healthcare expenditures, lost labor productivity, and environmental degradation — into national energy and macroeconomic models. Factoring in these impacts would clearly demonstrate that ambitious, climate- and health-aligned targets deliver far greater economic value for Indonesia.
- **Use CEMS stack data, ground-level air quality monitoring and satellite-based insights to enforce compliance and exercise proper air quality planning.** CEMS continuous stack-level monitoring data managed by the Ministry of Environment should automatically flag non-compliance, triggering automatic fines and notices, or site inspections. The framework recently established under the Ministerial Regulation of Environment No. 5 Year 2026 on provincial emission inventories and air quality management plans, can complement enforcement and inform policy

interventions, bringing to light major contributing point sources and sectors that still lack oversight.

- **Establish a real-time, publicly accessible emissions dashboard.** Make public stack monitoring data and ambient air quality information available on an accessible platform to eliminate reliance on corporate self-reporting. Providing radical data transparency would affirm active regulatory enforcement, not only in major cities but also in remote areas near major industrial hubs that would foster public trust, and empower civil society to act as an independent oversight.
- **Connect real-time monitoring to the recently enforced early warning response.** When forecast air pollution levels reach the emergency thresholds, relevant agencies could enforce safeguards until air quality returns to safe levels. This connected system would allow them to quickly adjust emergency responses while giving the public timely alerts to take protective measures.

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References

Asia Pacific Resources International Holdings Ltd (APRIL). (2026, June). *2025 Sustainability report*. https://www.aprilasia.com/en/sustainability/sustainability-report

Asia Pulp & Paper (APP). (2025, August 1). *Sustainability report PT APP Purinusa Ekapersada 2024*. APP Group Bio Link. https://link.app.co.id/app-sr-2024/

Aulia, S. A. (2024). Air pollution threatens health and climate change in Jakarta. *Human Error and Safety*, 1(1), 36–46. https://doi.org/10.61511/hes.v1i1.2024.648

Barrios, N., Gonzalez, M. E., Zabib, N., Marquez, R., & Pal, L. (2026). Achieving net-zero carbon in the pulp and paper industry: Tackling scope 1, 2, and 3 emission hotspots. *Resources, Conservation & Recycling Advances*, 29, 200318. https://doi.org/10.1016/j.rcradv.2026.200318

Beirle, S., Borger, C., Jost, A., & Wagner, T. (2023). *Improved catalog of NOx point source emissions (Version 2)*. Earth System Science Data, 15(7), 3051–3073. https://doi.org/10.5194/essd-15-3051-2023

Center of Economic and Law Studies (CELIOS), Centre for Research on Energy and Clean Air (CREA), & Trend Asia. (2025, November 5). *Press release toxic 20: Unmasking Indonesia's most toxic coal fired power plants*. Toxic20. https://toxic20.org/press-release-toxic-20-unmasking-indonesias-most-toxic-coal-fired-power-plants/

Center of Economic and Law Studies (CELIOS), Centre for Research on Energy and Clean Air (CREA), & Trend Asia. (2026, July 6). *Toxic 20*. Toxic20. https://toxic20.org/

Centre for Research on Energy and Clean Air (CREA). (2020, August 11). *Transboundary air pollution in the Jakarta, Banten, and West Java provinces*. https://energyandcleanair.org/wp/wp-content/uploads/2020/08/Jakarta-Transboundary-Pollution_FINALEnglish.pdf

Centre for Research on Energy and Clean Air (CREA) & Institute for Essential Services Reform (IESR). (2023, July 18). *Health benefits of just energy transition and coal phase-out in Indonesia.* https://energyandcleanair.org/publication/health-benefits-of-just-energy-transition-and-coal-phase-out-in-indonesia/

Centre for Research on Energy and Clean Air (CREA). (2023a, August 25). *Work from home (WFH) and other gimmicks cannot clear Jakarta's air.* https://energyandcleanair.org/work-from-home-wfh-and-other-gimmicks-cannot-clear-jakartas-air/

Centre for Research on Energy and Clean Air (CREA). (2023b, September 12). *Air quality impacts of the Banten-Suralaya complex*. https://energyandcleanair.org/publication/air-quality-impacts-of-the-banten-suralaya-complex/

Centre for Research on Energy and Clean Air (CREA) & Global Energy Monitor (GEM). (2026, February 10). Out of sight, out of control: 31 GW of captive coal is jeopardizing Indonesia's economic and emissions goals – Centre for research on energy and clean air. https://energyandcleanair.org/publication/31-gw-of-captive-coal-is-jeopardizing-indonesias-economic-and-emissions-goals/

Chu, Y., Holladay, J. S., Qiu, Y., Tian, X., & Zhou, M. (2023). Air pollution and mortality impacts of coal mining: Evidence from coalmine accidents in China. *Journal of Environmental Economics and Management*, 121, 102846. https://doi.org/10.1016/j.jeem.2023.102846

Climate Rights International (CRI). (2024, January). *Nickel unearthed: The human and climate costs of Indonesia's nickel industry*. https://cri.org/reports/nickel-unearthed/

Climate TRACE. (n.d.). *Indonesia greenhouse gas emissions inventory*. Retrieved July 2026, from https://climatetrace.org/explore#admin=Indonesia%20(IDN):126:IDN:country&gas=co2e&year=2025&timeframe=100&sector=&asset=

Climateworks Centre. (2025, December 4). *Decarbonising Indonesia's high-value industrial sites through place-based action*. https://climateworkscentre.org/resource/decarbonising-indonesias-high-value-industrial-sites-through-place-based-action/

CNN Indonesia. (2025, October 9). *PLTU Jawa unit 9 dan 10 Suralaya resmi beroperasi*. https://www.cnnindonesia.com/ekonomi/20251009012508-85-1282525/pltu-jawa-unit-9-dan-10-suralaya-resmi-beroperasi

De Vries, W. (2021). *Impacts of nitrogen emissions on ecosystems and human health: A mini review*. Current Opinion in Environmental Science & Health, 21, 100249. https://doi.org/10.1016/j.coesh.2021.100249

Dialogue Earth. (2021, April 14). *Pollution and foreign debt: Indonesia's unhealthy addiction to coal*. https://dialogue.earth/en/energy/pollution-and-foreign-debt-indonesias-unhealthy-addiction-to-coal/

Ember. (2025, March 13). *Captive coal expansion plan could undermine Indonesia's climate goals.* https://ember-energy.org/latest-insights/captive-coal-expansion-plan-could-undermine-indonesias-climate-goals/

European Union Joint Research Centre (EU JRC). (n.d.). *EDGAR - The Emissions Database for Global Atmospheric Research*. Retrieved July 2026, from https://edgar.jrc.ec.europa.eu/

Global Energy Monitor (GEM). (n.d.-a). *Global bioenergy power tracker*. Retrieved July 2026, from https://globalenergymonitor.org/projects/global-bioenergy-power-tracker

Global Energy Monitor (GEM). (n.d.-b). *Global cement and concrete tracker*. Retrieved July 2026, from https://globalenergymonitor.org/projects/global-cement-concrete-tracker

Global Energy Monitor (GEM). (n.d.-c). *Global chemicals inventory*. Retrieved July 2026, from https://globalenergymonitor.org/projects/global-chemicals-inventory

Global Energy Monitor (GEM). (n.d.-d). *Global coal mine tracker*. Retrieved July 2026, from https://globalenergymonitor.org/projects/global-coal-mine-tracker

Global Energy Monitor (GEM). (n.d.-e). *Global coal plant tracker*. Retrieved July 2026, from https://globalenergymonitor.org/projects/global-coal-plant-tracker/

Global Energy Monitor (GEM). (n.d.-f). *Global coal terminals tracker*. Retrieved July 2026, from https://globalenergymonitor.org/projects/global-coal-terminals-tracker

Global Energy Monitor (GEM). (n.d.-g). *Global gas infrastructure tracker*. Retrieved July 2026, from https://globalenergymonitor.org/projects/global-gas-infrastructure-tracker

Global Energy Monitor (GEM). (n.d.-h). *Global iron and steel tracker*. Retrieved July 2026, from https://globalenergymonitor.org/projects/global-iron-steel-tracker

Global Energy Monitor (GEM). (n.d.-i). *Global oil and gas plant tracker*. Retrieved July 2026, from https://globalenergymonitor.org/projects/global-oil-gas-plant-tracker/

Global Energy Monitor (GEM). (2025a, October 21). *PT Halmahera Persada Lygend nickel smelter power station*. https://www.gem.wiki/PT_Halmahera_Persada_Lygend_Nickel_Smelter_power_station

Global Energy Monitor (GEM). (2025b, October 21). *Sulawesi Labota power station*. https://www.gem.wiki/Sulawesi_Labota_power_station

Global Energy Monitor (GEM). (2025c, November 14). *Banten Suralaya power station*. https://www.gem.wiki/Banten_Suralaya_power_station

Global Energy Monitor (GEM). (2025d, December 11). *Delong nickel phase III power station*. https://www.gem.wiki/Delong_Nickel_Phase_III_power_station

Global Energy Monitor (GEM). (2025e, December 11). *Delong nickel phase IV power station*. https://www.gem.wiki/Delong_Nickel_Phase_IV_power_station

Global Energy Monitor (GEM). (2026a, January 7). *Weda Bay power station*. https://www.gem.wiki/Weda_Bay_power_station

Global Energy Monitor (GEM). (2026b, February 12). *Banten Serang power station*. https://www.gem.wiki/Banten_Serang_power_station

Global Energy Monitor (GEM). (2026c, July 24). *Bekasi power station*. https://www.gem.wiki/Bekasi_power_station

Global Energy Monitor (GEM). (2026d, July 24). *Cilegon KDL power station*. https://www.gem.wiki/Cilegon_KDL_power_station

Global Energy Monitor (GEM). (2026e, July 24). *Cilegon power station*. https://www.gem.wiki/Cilegon_power_station

Global Energy Monitor (GEM). (2026f, July 24). *Krakatau power station*. https://www.gem.wiki/Krakatau_power_station

Global Energy Monitor (GEM). (2026g, July 24). *Muara Karang power station*. https://www.gem.wiki/Muara_Karang_power_station

Global Energy Monitor (GEM). (2026h, July 24). *Tanjung Priok power station*. https://www.gem.wiki/Tanjung_Priok_power_station

Global Energy Monitor (GEM). (2026i, July 25). *Jababeka industrial estate power station*. https://www.gem.wiki/Jababeka_Industrial_Estate_power_station

Global Energy Monitor (GEM). (2026j, July 25). *Merak power station*. https://www.gem.wiki/Merak_power_station

Global Energy Monitor (GEM). (2026k, July 27). *KPC operation coal mine*. https://www.gem.wiki/KPC_Operation_Coal_Mine

Global Energy Monitor (GEM). (2026l, July 27). *Krakatau Steel Cilegon plant*. https://www.gem.wiki/Krakatau_Steel_Cilegon_plant

Global Energy Monitor (GEM). (2026m, July 27). *KS Posco Cilegon steel plant*. https://www.gem.wiki/KS_Posco_Cilegon_steel_plant

Global Energy Monitor (GEM). (2026n, July 27). *Perawang mill power station*. https://www.gem.wiki/Perawang_Mill_power_station

Global Energy Monitor (GEM). (2026o, July 27). *Pomalaa nickel power station*. https://www.gem.wiki/Pomalaa_Nickel_power_station

Global Energy Monitor (GEM). (2026p, July 27). *PT Conch Cement Indonesia Serang cement plant*. https://www.gem.wiki/PT_Conch_Cement_Indonesia_Serang_Cement_Plant

Global Energy Monitor (GEM). (2026q, July 27). *PT Semen Indonesia (Persero) Kabupaten Tuban cement plant*. https://www.gem.wiki/PT_Semen_Indonesia_(Persero)_Kabupaten_Tuban_Cement_Plant

Global Energy Monitor (GEM). (2026r, July 27). *Sulawesi mining power station*. https://www.gem.wiki/Sulawesi_Mining_power_station

Global Energy Monitor (GEM). (2026s, July 27). *Tabalong Wisesa power station*. https://www.gem.wiki/Tabalong_Wisesa_power_station

Global Energy Monitor (GEM). (2026t, July 27). *Tanjung Awar-Awar power station*. https://www.gem.wiki/Tanjung_Awar-Awar_power_station

Global Energy Monitor (GEM). (2026u, July 27). *Tanjung Jati B power station*. https://www.gem.wiki/Tanjung_Jati_B_power_station

Global Energy Monitor (GEM). (2026v, July 27). *Tutupan coal mine*. https://www.gem.wiki/Tutupan_Coal_Mine

Global Energy Monitor (GEM). (2026w, July 28). *Delong nickel phase I power station*. https://www.gem.wiki/Delong_Nickel_Phase_I_power_station

Global Energy Monitor (GEM). (2026x, July 28). *Delong nickel phase II power station*. https://www.gem.wiki/Delong_Nickel_Phase_II_power_station

Global Energy Monitor (GEM). (2026y, July 28). *Elynda Jaya coal mine*. https://www.gem.wiki/Elynda_Jaya_Coal_Mine

Global Energy Monitor (GEM). (2026z, July 28). *Indramayu power station*. https://www.gem.wiki/Indramayu_power_station

Global Energy Monitor (GEM). (2026aa, July 28). *INEOS Cilegon chemical plant*. https://www.gem.wiki/INEOS_Cilegon_Chemical_Plant

Global Energy Monitor (GEM). (2026ab, July 28). *Jinchuan Group WP&RKA power station*. https://www.gem.wiki/Jinchuan_Group_WP%26RKA_power_station

Global Energy Monitor (GEM). (2026ac, July 28). *Kaltim FTP2 power station*. https://www.gem.wiki/Kaltim_FTP2_power_station

Global Energy Monitor (GEM). (2026ad, July 28). *Kerinci mill power station*. https://www.gem.wiki/Kerinci_Mill_power_station

Global Energy Monitor (GEM). (2026ae, July 28). *LOTTE Chemical Cilegon chemical plant*. https://www.gem.wiki/LOTTE_Chemical_Cilegon_Chemical_Plant

Global Energy Monitor (GEM). (2026af, July 28). *PT Kaltim Methanol Industri Bontang methanol plant*. https://www.gem.wiki/PT_Kaltim_Methanol_Industri_Bontang_Methanol_Plant

Global Energy Monitor (GEM). (2026ag, July 28). *PT Pupuk Kalimantan Timur Bontang ammonia complex*. https://www.gem.wiki/PT_Pupuk_Kaltimantan_Timur_Bontang_Ammonia_Complex

Global Energy Monitor (GEM). (2026ah, July 28). *PT Semen Indonesia (Persero) Kabupaten Rembang cement plant*. https://www.gem.wiki/PT_Semen_Indonesia_(Persero)_Kabupaten_Rembang_Cement_Plant

Global Energy Monitor (GEM). (2026ai, July 28). *PT Sun Fook Industries Serang cement plant*. https://www.gem.wiki/PT_Sun_Fook_Industries_Serang_Cement_Plant

Global Energy Monitor (GEM). (2026aj, July 28). *Rembang power station*. https://www.gem.wiki/Rembang_power_station

Global Energy Monitor (GEM). (2026ak, July 28). *Sinar Mas OKI paper mill power station*. https://www.gem.wiki/Sinar_Mas_OKI_Paper_Mill_power_station

Global Energy Monitor (GEM). (2026al, July 28). *Tabalong power station*. https://www.gem.wiki/Tabalong_power_station

Global Energy Monitor (GEM). (2026am, July 28). *TMR coal mine*. https://www.gem.wiki/TMR_Coal_Mine

Global Energy Monitor (GEM). (2026an, July 28). *Wara coal mine*. https://www.gem.wiki/Wara_Coal_Mine

Global Energy Monitor (GEM). (2026ao, July 28). *Xinxing ductile iron pipes power station*. https://www.gem.wiki/Xinxing_Ductile_Iron_Pipes_power_station

Indonesia Business Post. (2025, March 10). *54 smelters in operation, 60 in the process of securing permits: BKPM*. https://indonesiabusinesspost.com/3878/policy/54-smelters-in-operation-60-in-the-process-of-securing-permits-bkpm

Institute for Energy Economics & Financial Analysis (IEEFA). (2024, October 24). *Indonesia's nickel companies: The need for renewable energy amid increasing production*. https://ieefa.org/resources/indonesias-nickel-companies-need-renewable-energy-amid-increasing-production

International Work Group for Indigenous Affairs (IWGIA). (2026, February 9). *Nickel for electric vehicles threatens key forests and the last nomadic tribes in Indonesia*. https://www.iwgia.org/en/news/debates-2025-nickel-for-electric-vehicles-in-indonesia

Jaringan Dokumentasi dan Informasi Hukum Badan Pemeriksa Keuangan (JDIH BPK). (2021, February 2). *Peraturan Pemerintah (PP) No. 22 Tahun 2021 tentang Penyelenggaraan Perlindungan dan Pengelolaan Lingkungan Hidup*. Database Peraturan. https://peraturan.bpk.go.id/Details/161852/pp-no-22-tahun-2021

Kompas. (2023, September 11). *Cari Sumber Polusi Udara Jakarta, Polisi Sidak 12 Pabrik.* https://www.kompas.id/artikel/cari-sumber-polusi-udara-jakarta-polisi-sidak-12-pabrik

Kompas. (2025, June 8). *Indonesian nickel under pressure from global trade and environmental pollution*. https://www.kompas.id/artikel/en-nikel-indonesia-dalam-tekanan-perdagangan-global-dan-isu-lingkungan

Kontan.co.id. (2023, September 4). *Sebagian Unit PLTU Suralaya Dipadamkan, Begini Respon Pengusaha.* https://industri.kontan.co.id/news/sebagian-unit-pltu-suralaya-dipadamkan-begini-respon-pengusaha

Lawrence Berkeley National Laboratory (LBNL). (2024, February). *Industry decarbonization roadmaps for Indonesia: Opportunities and challenges to net-zero emissions*. https://eta.lbl.gov/publications/industry-decarbonization-roadmaps

Ministry of Environment (MOE) - Kementerian Lingkungan Hidup (KLH). (2026, June 4). *Permen LH No. 5 tentang Perencanaan Perlindungan Dan Pengelolaan Mutu Udara*. PPEPD. https://ppepd.kemenlh.go.id/publikasi/permen-lh-no-5-tentang-perencanaan-perlindungan-dan-pengelolaan-mutu-udara

Mongabay. (2025a, February 6). *Disease surges in Indonesia community on frontline of world energy transition*.

https://news.mongabay.com/2025/02/disease-surges-in-indonesia-community-on-frontline-of-world-energy-transition/

Mongabay. (2025b, May 1). *Landslide deaths again highlight safety failures in Indonesia's nickel industry*. https://news.mongabay.com/2025/05/landslide-deaths-again-highlight-safety-failures-in-indonesias-nickel-industry/

Mongabay. (2025c, July 9). *Indonesia tests shows blood mercury rising at ground zero of world energy transition*. https://news.mongabay.com/2025/07/indonesia-tests-shows-blood-mercury-rising-at-ground-zero-of-world-energy-transition/

Mongabay. (2025d, December 10). *Boom in burning waste for fuel could put human health and environment at risk*. https://news.mongabay.com/2025/12/boom-in-burning-waste-for-fuel-puts-human-health-and-environment-at-risk/

Nexus3 Foundation. (2022, December). *Deskstudy assessment: Pollutants release and transfer register (PRTR) implementations potential in Indonesia*. https://www.nexus3foundation.org/publikasi/deskstudy-assessment-prtr-implementations-potential-in-indonesia/?nocache=1777361162

Pacific Northwest National Laboratory (PNNL). (n.d.). *Community Earth-atmosphere Data System (CEDS) for historical surface fluxes*. Retrieved July 2026, from https://www.pnnl.gov/projects/ceds

Petromindo. (2026, January 20). *Vale Indonesia updates on progress of Sulawesi HPAL projects*. https://www.petromindo.com/news/article/vale-indonesia-updates-on-progress-of-sulawesi-hpal-projects

Purnama, M., Prayitno, S. B., Muskananfola, M. R., & Suryanti, S. (2025). Existing condition of gastropods community in coastal areas affected by nickel overburden in Pomalaa district, Southeast Sulawesi province, Indonesia. *BIOTROPIA*, 32(1), 69–86. https://doi.org/10.11598/btb.2025.32.1.2416

Soomro, M., Tam, V. W., & Jorge Evangelista, A. C. (2023). Production of cement and its environmental impact. In V. W. Tam & A. C. Jorge Evangelista (Eds.), *Recycled Concrete* (pp. 11–46). Elsevier. https://doi.org/10.1016/b978-0-323-85210-4.00010-2

Syuhada, G., Akbar, A., Hardiawan, D., Pun, V., Darmawan, A., Heryati, S. H., Siregar, A. Y., Kusuma, R. R., Driejana, R., Ingole, V., Kass, D., & Mehta, S. (2023). Impacts of air pollution on health and cost of illness in Jakarta, Indonesia. *International Journal of Environmental Research and Public Health*, 20(4), 2916. https://doi.org/10.3390/ijerph20042916

Tempo. (2025, July 8). *Pramono targetkan RDF Rorotan mulai beroperasi bulan depan*. https://www.tempo.co/politik/pramono-targetkan-rdf-rorotan-mulai-beroperasi-bulan-depan-1935477

The Jakarta Post. (2025, December 13). *Analysis: Proposed renewable rule change spark concerns of coal expansion - Academia - The Jakarta post.* https://www.thejakartapost.com/opinion/2025/12/13/analysis-proposed-renewable-rule-change-spark-concerns-of-coal-expansion

TuK Indonesia. (2025, April 17). *IMIP workers buried in nickel tailing: NGOs, trade unions demand legal accountability*. https://www.tuk.or.id/en/2025/04/imip-workers-buried-in-nickel-tailing-ngos-trade-unions-demand-legal-accountability/

Udara Jakarta. (n.d.). *Lokasi SPKU*. Retrieved July 2026, from https://udara.jakarta.go.id/lokasi-spku

World Health Organization (WHO). (2021a, September 22). *WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. https://www.who.int/publications/i/item/9789240034228

World Health Organization (WHO). (2021b, September 22). *What are the WHO air quality guidelines?* https://www.who.int/news-room/feature-stories/detail/what-are-the-who-air-quality-guidelines

World Population Review. (2026, July 24). *Jakarta population 2026*. https://worldpopulationreview.com/cities/indonesia/jakarta

Yang, S., Li, M., Guo, C., Requia, W. J., Sakhvidi, M. J., Lin, K., Zhu, Q., Chen, Z., Cao, P., Yang, L., Luo, D., & Yang, J. (2025). Associations of long-term exposure to nitrogen oxides with all-cause and cause-specific mortality. *Nature Communications*, 16(1), 1–11. https://doi.org/10.1038/s41467-025-56963-y

Zhang, R., Wang, G., Guo, S., Zamora, M. L., Ying, Q., Lin, Y., Wang, Y., & Hu, M. (2015). Formation of urban fine particulate matter. *Chemical Reviews*, *115*(10), 3803–3855. https://doi.org/10.1021/acs.chemrev.5b00067

Appendix

Table A1. The identified 29 NO_x hotspots across Indonesia

#	Location	Coordinates	Key emitters	Avg NOx emission (kt/yr)
1	Suralaya / Cilegon, Banten	-5.8885°, 106.0318°	Banten Suralaya Complex (6.8 GW Coal + 1.4 GW Gas), Steel & Cement Kilns	37.5
2	Tanjung Jati B (Jepara), Central Java	-6.4421°, 110.7410°	PLTU Tanjung Jati B Coal Complex (4.64 GW)	28.4
3	Pelalawan & Siak, Riau	0.4406°, 101.8883°	RAPP Kerinci (535 MW Bio/Coal) & IKPP Perawang (755 MW Coal) Pulp Mills	22.1
4	North Jakarta, DKI Jakarta	-6.1215°, 106.8402°	Tanjung Priok (2.8 GW) & Muara Karang (2.1 GW) Gas Plants	20.5
5	Outer Bekasi, West Java	-6.2841°, 107.1705°	Jababeka (864 MW) & Bekasi (130 MW) Gas Plants, Industrial Boilers	18.2
6	Tuban, East Java	-6.7820°, 111.8901°	Tanjung Awar-Awar (700 MW) & Semen Indonesia Tuban (11.9 Mtpa)	16.5
7	Cilacap, Central Java	-7.6833°, 109.0333°	Karangkandri Coal Complex & Pertamina RU IV Refinery	15.2
8	Morowali (IMIP), Central Sulawesi	-2.8862°, 122.1645°	IMIP Complex (Sulawesi Mining & Labota Captive Coal: 5.44 GW)	14.9
9	Surabaya Core & Port, East Java	-7.2575°, 112.7521°	Gresik & Sidoarjo Power/Industrial Complexes, Port Shipping Fleets	14.8
10	Bontang, East Kalimantan	0.1333°, 117.5000°	PT Pupuk Kaltim Ammonia Complex & PT Kaltim Methanol Industri	13.7
11	West Karawang & Cikampek, West Java	-6.3612°, 107.4102°	Industrial Estate Boilers, Chemical Synthesis, Heavy Automotive	12.4
12	Sangatta & Bengalon, East Kalimantan	0.8841°, 117.5512°	KPC Open-Pit Coal Mine Fleets & Kaltim FTP2 Power Station (200 MW)	11.5
13	Indramayu, West Java	-6.2680°, 107.9621°	Indramayu (990 MW)	11.1
14	OKI (Air Sugihan), South Sumatra	-2.8510°, 105.1205°	APP OKI Pulp Mill Bioenergy Gasifiers & Auxiliary Power Complex	10.4

#	Location	Coordinates	Key emitters	Avg NOx emission (kt/yr)
15	Rembang, Central Java	-6.6432°, 111.4720°	Rembang (630 MW) & Semen Indonesia Cement Kiln (3 Mtpa)	9.8
16	Palembang, South Sumatra	-2.9909°, 104.7565°	Gas Power Generation, Oil Refineries, Riverine Coal Terminals	9.6
17	Greater Medan, North Sumatra	3.5952°, 98.6722°	Peri-urban Bioenergy Plants, Steel Rolling Mills, Heavy Transport	8.9
18	Muara Enim Mining Basin, South Sumatra	-3.6521°, 103.7802°	Bukit Asam Open-Pit Mines, Mine-Mouth Coal Plants (Bukit Asam/Sumsel 8)	8.4
19	North Morowali, Central Sulawesi	-2.0146°, 121.4320°	Delong Phase III/IV & GNI Operations (1.6 GW Captive Coal)	8.1
20	Konawe, Southeast Sulawesi	-3.8929°, 122.4308°	Virtue Dragon & Delong Phase I/II Captive Coal Plants (2.37 GW)	7.8
21	Tabalong, South Kalimantan	-2.1804°, 115.3812°	Adaro Tutupan/Wara Mines, Tabalong (200 MW) & Tabalong Wisesa (60 MW)	7.2
22	Semarang Coast, Central Java	-6.9667°, 110.4167°	Tambak Lorok Power Station (Gas/Oil), Industrial Estates	6.5
23	East Kutai, East Kalimantan	0.5120°, 117.2104°	TMR & Elynda Jaya Coal Mining Concessions, Diesel Haul Fleets	5.6
24	Weda Bay, North Maluku	0.4931°, 128.0469°	IWIP Complex (Captive Coal Power Stations: 4.54 GW)	5.4
25	Pasir Mining Corridor, East Kalimantan	-1.8210°, 116.1205°	Kideco Jaya Pasir Coal Concession, Non-Road Heavy Diesel Fleets	4.9
26	Denpasar, Bali	-8.6705°, 115.2126°	Pesanggaran Gas/Diesel Power Plant, Urban Transit Corridor	4.2
27	Obi Island, North Maluku	-1.5319°, 127.4430°	Harita/HP Lygend, Xinxing & Jinchuan Captive Coal Plants (~2.0 GW)	4.2
28	West Sumbawa, West Nusa Tenggara	-8.7612°, 116.7801°	Batu Hijau Mine Captive Power Station (156 MW Coal/Diesel)	3.8
29	Pomalaa, Southeast Sulawesi	-4.2069°, 121.6180°	Antam Ferronickel (60 MW Coal) & Vale HPAL Expansion Project	3.1