High Ambition Pathways for Indonesia's 2035 NDC and Net-zero emissions

SEPTEMBER 2025

Authors:
Ryna Cui*, Jiehong Lou, Maria A. Borrero, Jenna Behrendt, Xinyue Li, Audrey Rader, Molly Schreier, Claire Squire, Tiruwork Berhanu Tibebu, Christoph Bertram, Andy Miller, Dmitry Churlyaev, Mohammed Syed, Nate Hultman
*corresponding author: ycui10@umd.edu

Suggested citation: R. Cui, J. Lou, M. Borrero, J. Behrendt, X. Li, A. Rader, M. Schreier, C. Squire, T. Tibebu, C. Bertram, A. Miller, D. Churlyaev, and N. Hultman. (September 2025). "High Ambition pathways for Indonesia's 2035 NDC and net-zero emissions." Center for Global Sustainability, College Park.

Summary

This report presents plausible, *High Ambition* pathways for Indonesia that achieve a 46%-49% reduction in economy-wide GHG emissions by 2035 and net-zero emissions by 2060. Under these pathways, emissions from all major sources, including energy, land, and non-CO_2 gases have the potential for meaningful reductions and need to be addressed with immediate actions. By contrast, existing policies and targets rely heavily on the land use sector for near-term emissions abatement, while allowing the other sectors to continue emissions growth. In addition, this analysis identifies the policy priorities in each sector and the critical nexus between different policy strategies for energy transition, ending deforestation, and industrial and economic development.

Indonesia is a major emerging economy and a large greenhouse gas (GHG) emitting country in the global context. It is also a major coal producer and the world's largest coal exporter and relies heavily on fossil fuels in its energy system.[1] While the country's leadership has continued to show strong political will for enhanced climate action, progress has been limited due to various institutional and infrastructure barriers. Despite abundant solar resources, Indonesia falls far behind in renewable deployment compared to other Southeast Asian countries.[2] The declining trend of forest loss since 2016 was reversed in 2023 by 58% due to an uptick in land conversion for agriculture, in particular oil palm.[3] Policy attention to methane (CH_4) and other non-CO_2 gases is largely missing, with high data uncertainty and little understanding of the importance, potential opportunities, large co-benefits, and key strategies to reduce non-CO_2 gases. National strategies and policies have pushed strong growth of the nickel mining and processing and palm oil industries, which, however, have large emissions implications domestically through captive coal power and deforestation.

With increasing access to cheap, proven-track-record green technologies, such as renewable electricity and electric vehicles, the potential and opportunities for Indonesia to enhance climate ambition become substantial. As the country is developing its new green growth strategy and the new Nationally

Determined Contribution (NDC) for 2035, Indonesia can benefit from a full integration of its climate and economic goals, leveraging strong synergies between emissions reductions and other national priorities such as green jobs, public health, energy security, and more, while addressing the potential conflicting objectives between the energy, land, and economic systems.

Emissions profile and existing targets

Land Use, Land Use Change and Forestry (LULUCF) is the largest emissions source for Indonesia, accounting for 26% of total GHG emissions in 2022.[4] Methane, from energy, agriculture, and waste sectors, contributed to about 19% of total emissions (GWP100 conversion), and CO_2 emissions from the energy system, including electricity, industry, transport, and others, account for about 40% of the total.[5] Between 2010 and 2023, Indonesia's total GHG emissions increased by 69%, or by 58% excluding LULUCF, largely driven by power sector, LULUCF, and methane emissions.[6,7] Over that period, emissions from power generation increased by 164%, while LULUCF and methane emissions increased by 93% and 61%, respectively.[8,9] Emissions are still growing across all major sources (energy, methane, LULUCF) and have rebounded rapidly after COVID.

Indonesia has committed to reducing 2030 emissions by 31.89% (or 43.20% conditionally) from the business-as-usual (BAU) in its current NDC and to achieving net-zero emissions by 2060.[10] These targets cover CO_2, CH_4 and N_2O emissions from all sectors, leaving out other non-CO_2 gases.[11] The conditional target indicates a 5% reduction in total GHG emissions including LULUCF from 2023, while the unconditional target indicates a 13% growth.

The official NDC document also provides a sectoral breakdown for achieving the 2030 targets compared to a 2010 base year.[12] When comparing these sectoral emissions targets with 2022 emission levels (Table 1), we find that emissions in agriculture (mainly non-CO_2 gases) and forestry and other land use (FOLU) sectors decline by 2030, while emissions in the energy and waste sectors rise rapidly, with smaller increases in Industrial Processes and Product Use (IPPU). For example, the conditional target requires a net-zero land sink before 2030 (-105%), but allows energy emissions to increase by 65% from 2022 to 2030. While the LULUCF target is considered ambitious and presents significant challenges to be delivered in reality, the target for energy emissions appears to lack ambition, which indicates a 6% emission growth rate annually from 2022 to 2030, faster than the 4% per year observed from 2010 to 2022. The unconditional target allows for a larger (77%) increase in energy emissions from 2022 to 2030.

Table 1. Emissions reduction by sector under unconditional and conditional NDC targets compared to 2022. Historical data is from the Indonesia National Inventory; 2030 sectoral breakdown is from Indonesia's NDC.

	2022[13]	2030 NDC (unconditional)[14]		2030 NDC (conditional)[15]	
	$MtCO_2e$	$MtCO_2e$	% change 2022-2030	$MtCO_2e$	% change 2022-2030
Energy	739	1,311	**+77%**	1,223	**+65%**
Waste	139	256	**+84%**	253	**+82%**
IPPU	57	63	**+11%**	61	**+7%**
Agriculture	136	110	**-19%**	108	**-21%**
FOLU	312[16]	214	**-31%**	-15	**-105%**
Total	1,383	1,953	**+41%**	1,632	**+18%**

Additional sectoral targets tend to indicate a similar pattern of unbalanced ambition levels across sectors. Sectoral targets include a net-zero land sink by 2030 (Forest and Land Use Net Sink 2030),[17] power generation emissions peaking by 2037 and reaching net zero by 2060 (regulation No. 10/2025 on Energy Transition Roadmap for the Electricity Sector),[18] reducing the oil share in the primary energy to less than 20% by 2050 (NDC),[19] a sales target of over 2 million of EVs plus 13 million electric motorcycles by 2030 and production target of 600,000,[20,21] reaching a 100% utilization ratio for biodiesel B-40,[22] and 30% methane reductions by 2030 from 2020 levels, consistent with the Global Methane Pledge collective target.[23]

High-ambition economy-wide pathways

Using a field-leading global integrated assessment model (GCAM-CGS), we develop two *High Ambition* pathways for Indonesia that achieve 46%-49% reductions in total GHG emissions (including LULUCF) by 2035 from 2023 levels and net-zero emissions by 2060 (Table 2 and Figure 1a). The two pathways follow the same Shared Socioeconomic Pathways SSP2 (v3.1.0)[24] population trajectories but vary in near-term GDP assumptions, where the High GDP scenario assumes faster GDP growth rates with a 5%-7% five-year average from 2025 to 2035, and the Low GDP scenario follows SSP2 GDP growth rates with a 4%-5% five-year average through 2035 (Table S1 and Figure S2 in Appendix).

In both pathways, total emissions (including LULUCF) peak by 2025, start to decline rapidly afterwards, overachieve the current 2030 NDC targets, and reach net-zero emissions by 2060. Specifically:

- Non-LULUCF emissions also peak by 2025 and decline by 18%-22% between the two alternative GDP scenarios from 2023 and 2035 (Table 2);
- LULUCF emissions achieve the unconditional 2030 NDC target and the net-zero land sink before 2035 (Table 2);
- Moreover, both scenarios include a significant methane reduction of 33% from the modeled 2020 to 2035.

Table 2. Summary of changes in GHG emissions (excluding and including LULUCF) in 2030 and 2035, relative to 2023.[25] Historical data is from PRIMAP-hist, pathways data is from GCAM-CGS.

Year	GHG emissions % change from 2023	
	incl. LULUCF	excl. LULUCF
2030	-29% to -31%	-13% to -16%
2035	-46% to -49%	-18% to -22%

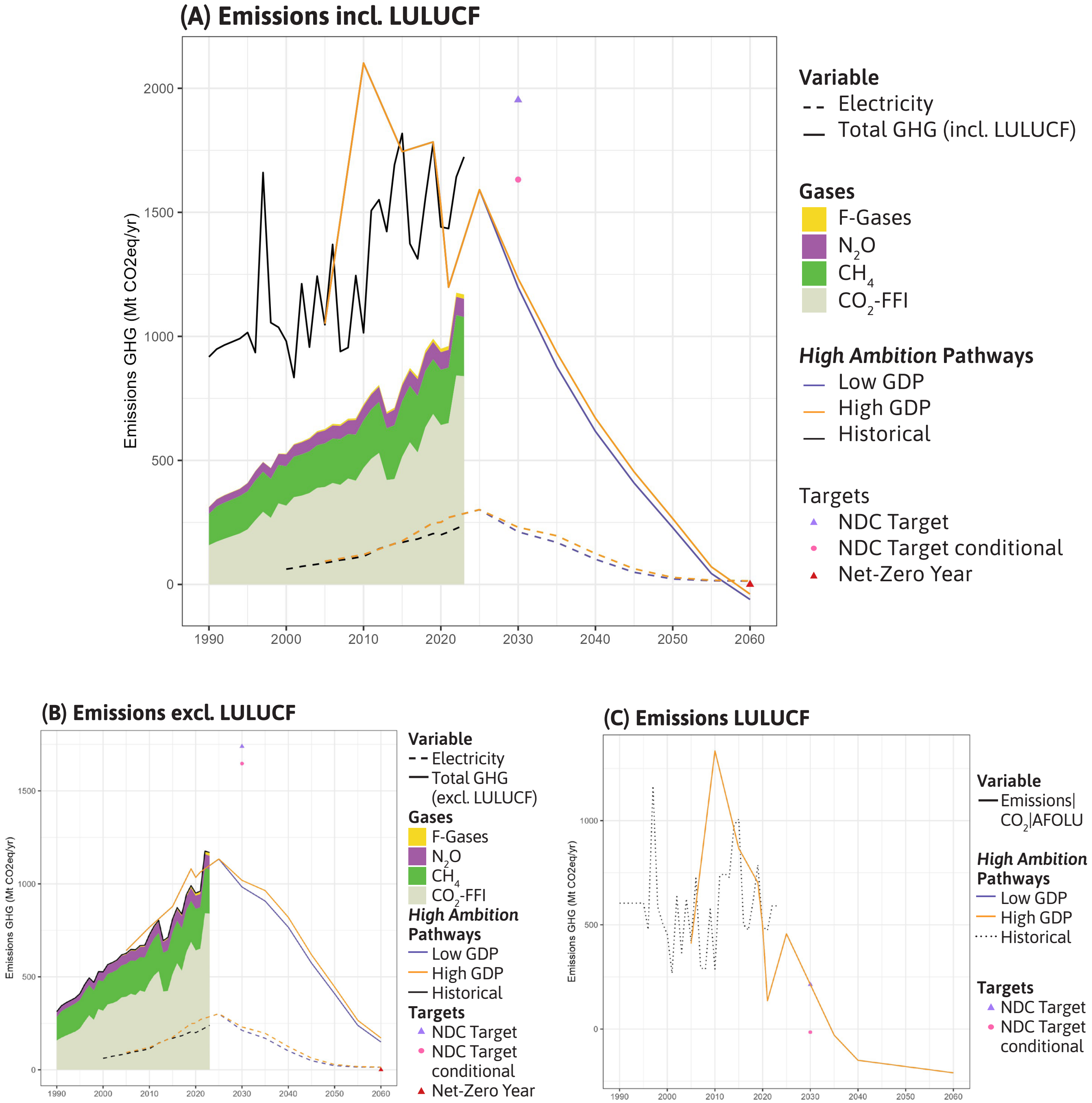

Figure 1. Indonesia's economy-wide emissions pathways under the High GDP and Low GDP scenarios: (A) Total GHG emissions (including LULUCF). Historical data is from PRIMAP-hist (solid black line for total GHG, include LULUCF),[26] Ember (dashed black line for electricity supply GHG emissions),[27] and CEDS (colored breakdown of historic GHG emissions, without F-Gases).[28] Colored triangles and dots mark the official 2030 NDC and net-zero targets.[29] NDC targets are calculated using CGS methodology and may differ from targets in NDC documents. Pathways data includes LULUCF emissions (based on linear pathway from 2023 to the 2030 NDC unconditional target, extended through 2035) and is based on the scenarios developed using the GCAM-CGS IAM for the NGFS Phase V.[30] (B) GHG emissions (excluding LULUCF). (C) LULUCF CO_2 emissions. Historical data is from PRIMAP-hist Third Party.[31]

Sectoral strategies and policy priorities

Under our *High Ambition* pathways, all sectors achieve meaningful and more balanced emissions reductions by 2035. This is a main difference when compared to the sectoral allocation of the current 2030 NDC, where land sectors shoulder a much larger burden of emissions reductions to allow continued rapid growth in the rest of the economy (Table 3).

Specifically, energy emissions decline by 22%-28% from 2022 to 2035 under our *High Ambition* pathways, but grow by 65%-77% by 2030 under the official NDC. Similarly, we show a large potential of emissions reductions in the waste sector (46% by 2035) under the *High Ambition* pathways, which, however, show a substantial growth of 82%-84% under the 2030 NDC. Emissions from industrial processes and products also show different trends between our *High Ambition* pathways and the 2030 NDC. Meanwhile, it is challenging for the agriculture sector, primarily with non-CO_2 emissions, to achieve a 19%-21% reduction from 2022 to 2030 as suggested by the 2030 NDC, where our *High Ambition* pathways show roughly maintained emissions levels with small reductions through 2035. Finally, as discussed earlier, given the recent trends and implementation challenges in the forestry and land use sector, our *High Ambition* pathways follow the unconditional NDC by 2030 and achieve the conditional NDC net-zero land sink five years later.

Table 3. Emissions reduction by sector under unconditional and conditional NDC targets compared to *High Ambition* pathway. Historical data is from the Indonesia National Inventory, 2030 sectoral breakdown is from Indonesia's NDC, 2035 pathways data is from GCAM-CGS compared to CEDS[32] and PRIMAP-hist[33] 2022 historical data.

	2030 NDC % change 2022-2030		CGS *High Ambition* pathways % change 2022-2035
	Unconditional	Conditional	
Energy	+77%	+65%	-22% to -28%
Waste	+84%	+82%	-46%
IPPU	+11%	+7%	-3% to -11%
Agriculture	-19%	-21%	-2% to -4%
FOLU	-31%	-105%	-106%
Total	+41%	+18%	-43% to -47%

In addition, the research further details of the energy sector, including power generation, industry (including IPPU in the national inventory), transportation, and buildings under our *High Ambition* scenarios (Figure 2). Pathways show that near-term reduction of energy and industrial processes CO_2 emissions are largely driven by rapid reductions in the power sector, where emissions decline by 35%-44% from 2025 to 2035. Industry and transportation emissions continue to grow through 2035, especially under the High GDP scenario but decline starting in 2040, with some residual emissions remaining in 2060. Emissions in the buildings sector continue to stay at a low level, declining more rapidly after 2040. These results suggest power sector decarbonization efforts are critical for near-term emissions reductions in the energy sector, while limiting emissions growth to peak earlier at lower levels in the industry and transportation sectors.

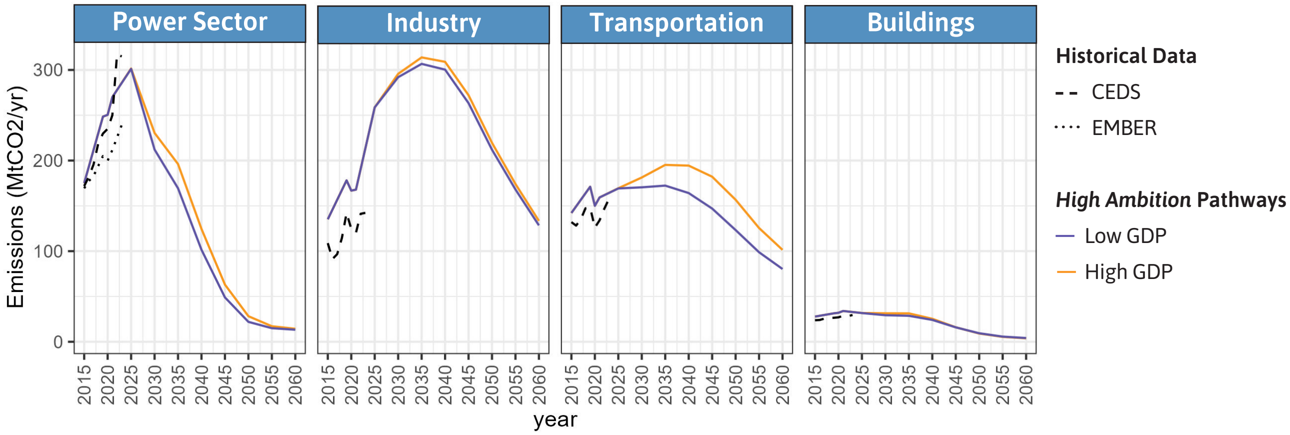

Figure 2. Sectoral *High Ambition* pathways across scenarios. Historical data is from CEDS (dashed black line) and Ember (dotted black line for electricity supply GHG emissions).

The results suggest that to achieve the *High Ambition* pathways, policy actions can be prioritized to deliver meaningful reductions in power generation (on-grid and captive), methane, and land use emissions through 2035. Key mitigation strategies include:

- ***Power:*** Cancel 4.9 GW of pre-construction captive coal power plants; increase renewable power generation share to 74% by 2035; reduce coal power generation by half by 2035 using a diverse set of strategies.

- ***Land and land-energy nexus:*** Extend the moratorium on new oil palm and crop plantation permits in protected forests and peatlands; resolve land use conflicts by enhancing tools of the One Map Policy; expand use rehabilitation and use of degraded lands; and bolster reforestation and rehabilitation targets through various financing mechanisms.

- ***Waste methane:*** Expand waste collection services from major metropolitan areas to all cities and villages; increase waste processing capacity by investing in treatment facilities; and improve and establish a national dataset of MSW and wastewater treatment activities for improved emission estimates.

- ***Coal methane:*** Restrict underground coal mine expansion.

Electricity

Increasing domestic coal consumption in power generation at both on-grid and captive plants has driven rapid growth in Indonesia's energy emissions. Since 2000, power sector emissions have increased significantly, rising by 85% between 2015 and 2022.[34] In 2023, 62% of total generation came from coal and 18% from gas, while renewables accounted for 19% of total generation, with wind and solar contributing less than 1%.[35] Despite abundant renewable resources, solar and wind deployment is lagging far behind other Southeast Asian countries**,** such as Vietnam, the Philippines, and Malaysia.[36] Key barriers include weak policy support, unattractive tariffs and continued fossil fuel subsidies, limited financing mechanisms, poor grid infrastructure, and a powerful state-owned enterprise Perusahaan Listrik Negara — PLN in the power sector.

The rapid growth of captive coal capacity, driven by energy-intensive industry development (particularly nickel mining and processing), has become a major concern. In 2023, captive coal accounted for 22% of the total installed coal capacity.[37] Since the end of 2023, the pre-construction pipeline of captive plants has nearly doubled, with 4.7 GW under construction (of 8.6 GW in total) and 4.9 GW in pre-construction stages.[38] By 2030, once the projects currently under construction come online, captive coal is expected to account for 25% of the country's total installed coal capacity.[39]

Under the *High Ambition* scenarios, 74% of Indonesia's electricity generation mix comes from renewables by 2035, with accelerated solar and wind buildout, adopted bio-mass co-firing, and reduced coal generation by 2035. Specifically, power sector transitions under the *High Ambition* pathways include:

- Increasing the share of wind and solar generation from less than 1% in 2023 to 55%-57% in 2035 by adding 398-490 GW of new capacity (33-40 GW/year), supported by stronger financial incentives and streamlined regulations.
- Reducing coal generation by 28%-33% by 2030 and 48%-54% by 2035 from 2023 levels, lowering its share from 62% in 2023 to below 15% by 2035, through a combination of lower plant utilization, biomass co-firing at eligible plants, and targeted retirement of low-hanging fruit plants.
- Enhancing grid infrastructure to support the replacement of captive plants with on-grid generation amid growing demand.

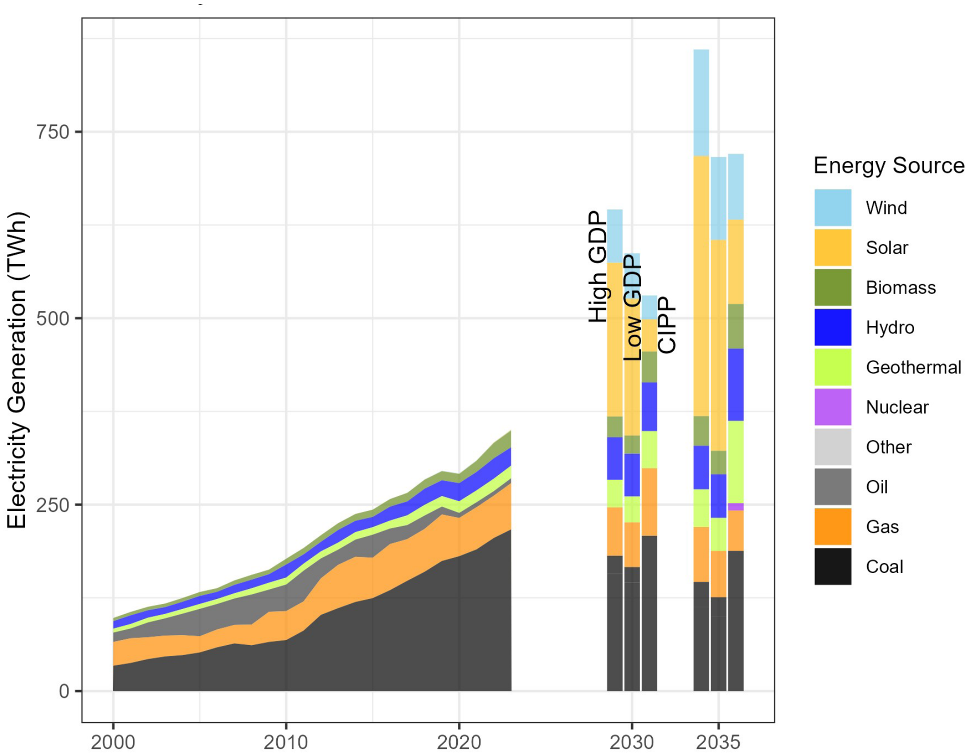

Figure 3. Electricity generation in Indonesia by technology in historical years and modeled projections for 2030 and 2035 under the *High Ambition* scenarios. Historical data is from Ember[40] and 2030 and 2035 data is from GCAM-CGS and the CIPP.[41]

The *High Ambition* scenarios are more stringent than Indonesia's Just Energy Transition Partnership (JETP) Comprehensive Investment and Policy Plan (CIPP),[6] as the latter maintains a higher share of fossil fuel generation through 2035 (34% in CIPP vs. ~26% in both *High Ambition* scenarios). On-grid electricity demand projections are similar in the CIPP and Low GDP scenario, with average annual growth of 6% from 2023 to 2035, up from 2% per year in recent years. However, the CIPP projects a higher share of coal generation (26% by 2035) compared to 14% in the Low GDP *High Ambition* pathway, while the share of gas remains similar (8%-9%). The CIPP includes greater deployment of geothermal, hydro, and biomass, whereas the Low GDP *High Ambition* scenario emphasizes solar and wind. Combined, solar and wind reach 55% of total generation by 2035, compared to 28% under the CIPP. Additionally, the CIPP introduces nuclear power starting in 2035 which is not included in either of the *High Ambition* scenarios.

Even when compared to the High GDP scenario, the CIPP remains less ambitious. In the High GDP scenario, electricity demand grows at an average of 8% per year, with the additional demand supplied by renewables rather than fossil fuels. In contrast, under the CIPP, both coal and gas generation fall by only 13% from 2023 to 2035, while in the High GDP scenario, coal and gas generation decline 48% and 19%, respectively, over the same period.

Industry and economic development

Indonesia's decarbonization strategies have a strong link to its industry and economic development. Indonesia is a major coal producer and the world's largest coal exporter.[42] More than two-thirds of its total coal production is for export. Large increases in both production and exports were observed in 2023, hitting a record high in history.[43] However, this dependence on foreign exports has left Indonesia vulnerable to external market forces; Indonesian coal exports dropped in the summer of 2025 as China and India sought higher-quality coal from other sources.[44]

To prepare for the global low-carbon transition away from coal, Indonesia has actively promoted the development of "green industries", particularly nickel and palm oil, backed by strong policy support. However, both sectors have large domestic emissions implications. While some nickel mining and processing contribute to the global supply chain for batteries (15% of local production by 2030),[45] most routes to the stainless steel industry and relies on energy intensive pyrometallurgical smelters largely powered by captive coal plants. Thus, nickel smelting operations have caused rapid growth in Indonesia's captive coal fleet and emissions.[46] While nickel industrial parks account for only 9.9% of industrial parks, they make up almost half (10.9 GW) of the documented electricity capacity for all industrial parks in Indonesia.[47] Both the overcapacity of the nickel industry and repeated crises over environmental damages and human rights violations point to the need for stronger governmental monitoring and regulation, as well as the development of other domestic industries tied to global energy transition, such as solar panel manufacturing.

Under the *High Ambition* pathways, industry sector emissions continue to increase through 2025, driven by coal consumption in nickel processing. They peak by 2035, then decline and return to 2015 levels by 2060 (see Figure 2). Key mitigation strategies to decarbonize Indonesia's industry sector include:

- Improving circularity to reduce product demand and enhancing energy efficiency.
- Electrifying low- and mid- temperature processes.
- Switching fossil fuels for biomass and hydrogen in high-temperature processes.

- Deploying Carbon Capture Utilization and Storage (CCUS) in hard-to-abate sectors and industrial process emissions.
- Improving emissions monitoring of energy-intensive industries such as nickel processing.
- Substituting coal in captive power plants with solar power plants and connecting industrial power demand to the grid.
- Limiting new nickel mining concessions and Rotary Kiln-Electric Furnace (RKEF) smelter development in favor of more downstream manufacturing.
- Designing and implementing higher GHG emission standards for mining and metal processing companies.

Transportation

With a growing population and rising affluence, low-carbon transportation options are key to mitigating emissions in Indonesia. EV sales grew from just 10 units in 2021 to more than 15,000 in 2022, and then doubled in 2024. Based on the sales trends in the first half of 2025, EVs are projected to double once more and reach 11% of the total wholesale market by the end of 2025 compared to 1.5% in 2023.[48] While this represents a significant improvement, sales must continue to grow for the government to achieve its current target of 2 million EVs and 13 million motorcycles on the road by 2030.[49]

Indonesia's first major legislation addressing transportation sector emissions and EV deployment was Presidential Regulation No. 55/2019, which focused on domestic EV manufacturing and charging infrastructure. This was followed by Presidential Regulation No. 79/2023,[50] along with Ministry of Finance Regulation No. 38/2023[51] and No. 10/2024,[52] which expanded domestic production benefits, lowered EV purchase price by reducing value-added tax from 11% to 1%, encouraged EV imports through a 0% import duty, amongst other strategies to increase EV uptake. These policies have contributed to a significant rise in new EV sales, spanning both domestically manufactured and imported brands, while also supporting the steady growth of Indonesia's domestic EV manufacturing industry. Other efforts to decarbonize the transportation sector include promoting biofuel and biodiesel blending targets, including reaching a 100% utilization of B40 by 2030.[53]

However, palm oil estate expansion, the main feedstock for biodiesel, remains one of Indonesia's largest drivers of deforestation.[54,55] New biofuel and biomass co-firing targets aimed at supporting transportation sector needs would lead to greater land use change and competition with food estate planning, highlighting the urgent need to integrate these activities into broader land management strategies.[56]

Under the *High Ambition* pathways, transportation emissions peak by 2035 in both the High GDP and Low GDP scenarios, with limited growth in the latter (Figure 2). Transportation demand is dependent on GDP assumptions, as total energy consumption increases through 2035 under Low GDP pathway, but through 2045 under High GDP assumptions. Strategies for reducing emissions in the transportation sector include:

- Increasing the share of LDV electric vehicles: under our *High Ambition* pathways, by 2035, 14-15% of passenger final energy comes from EVs.

- Expanding HDV EV deployment, as EVs are also critical for freight transportation over the long run.
- Increasing hydrogen fuel-switching, for both LDV and HDV.
- Addressing uncertainties around potential LULUCF emissions of biofuels and concerns about over-reliance on bioenergy is needed to ensure policy actions contribute toward economy-wide climate goals.
- Advancing both electrification, hydrogen and biofuel use can help to reduce Indonesia's oil import dependency and strengthen energy security.

Land and land-energy nexus

LULUCF has long been the country's largest emissions source, accounting for over 26% of total GHG emissions in 2022.[57,58] While forest loss has been decreasing since 2016, it rebounded by 58% in 2023 before dropping slightly in 2024, largely driven by expansion of permanent agriculture alongside fires, shifting cultivation, logging, and mining.[59] Future pathways for LULUCF emissions remain unclear, as a range of ongoing and emerging activities may drive deforestation and forest degradation. Investment in nationalized food estates and energy security initiatives aimed at achieving food and energy self-sufficiency may become an important driver of large-scale land clearing in the coming years,[60] while expansion of mining activities, though a smaller driver, continues to grow, threatening previously unimpacted regions.[61] Attaining a biodiesel blending ratio of 50% (B50), as proposed earlier this year,[62] will require expanded oil palm production; though current upticks in blending have been attained through pauses in exports, reaching B50 will require increased supply.[63] Expansion of biofuel ambition to include molasses-based bioethanol poses a new threat to Indonesia's carbon sink. Mass land clearing for sugarcane at the National Strategic Project in Merauke has already caused 10,000 hectares of forest loss[64] and could result in up to two million hectares of overall land conversion for this initiative.[65] Forest fires continue to worsen under climate change, peaking cyclically during El Niño years.[66]

The recently announced target of achieving net-zero land sink by 2030 is highly ambitious, but feasibility is uncertain, even under new enhanced measures. The impacts of energy policy on land use change, particularly with regard to bioenergy expansion, requires further assessment, and the NDC planning process is looking for additional expertise and capacity in these areas.

Under the *High Ambition* pathways, LULUCF emissions reach the 2030 NDC unconditional target for this sector (214 $MtCO_2e$) and continue to decrease at the same rate until 2035, achieving a net sink before that year (see Figure 4). Strategies to mitigate emissions from land use include:

- Extending the moratorium on new oil palm and crop plantation permits in protected forests and peatlands.
- Resolving land use conflicts by enhancing tools of the One Map Policy.
- Expanding the rehabilitation and use of degraded lands.
- Bolstering reforestation and rehabilitation targets through various financing mechanisms.

- Using waste residue for biomass co-firing over the long run.
- Avoiding peatlands and forest for biodiesel production, intensifying existing palm oil production, and implementing integrated land use planning.
- Improving sugarcane production and processing efficiency.
- Avoiding peatlands and forest for rice cultivation and intensifying existing paddies.

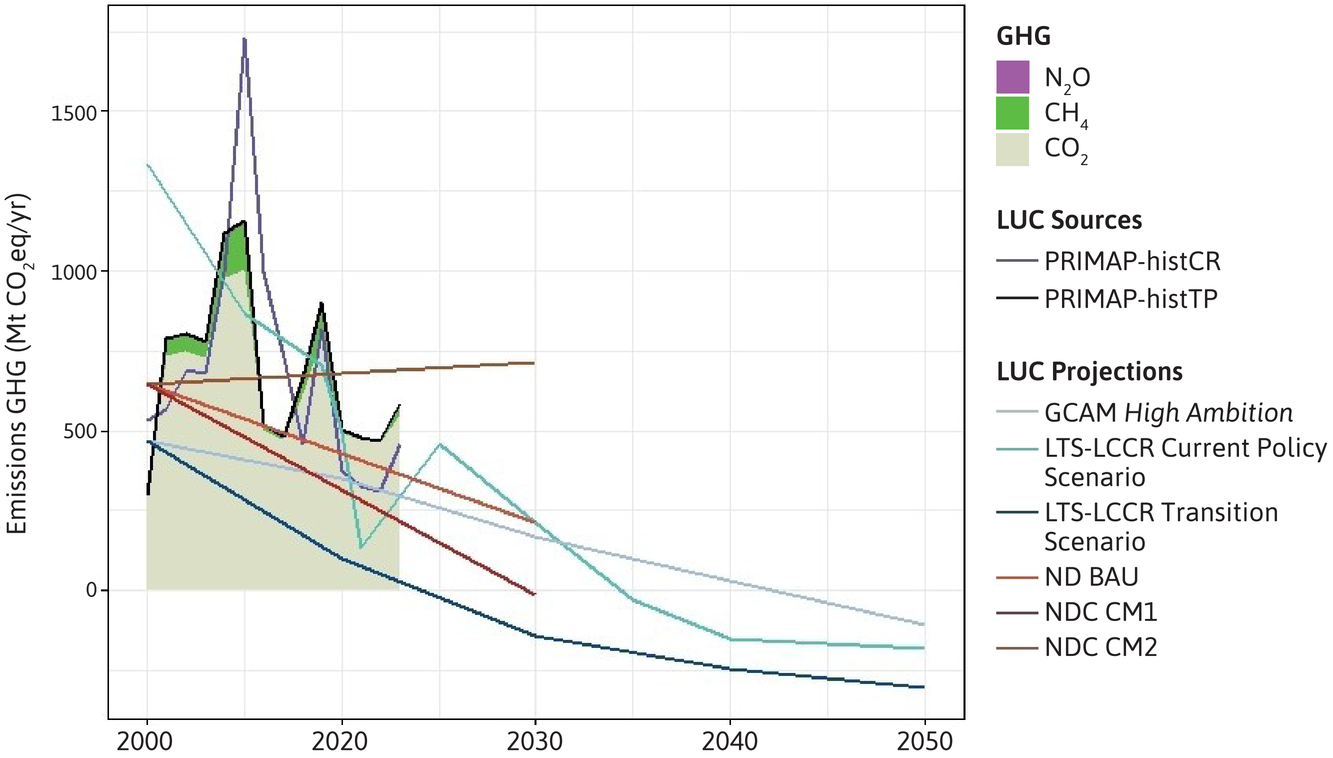

Figure 4. Historical and Projected LULUCF Emissions. Historical data is from PRIMAP-hist (Country Reports (CR) - solid blue line; Third Party (TP)-solid black line, with breakdown by gas).[67] LTS current policy and LTS transition are from Indonesia's Long-term Strategy for Low Carbon and Climate Resilence,[68] while NDC CM1, NDC CM2, and NDC BAU correspond to the unconditional target, the conditional target, and the Business as Usual scenario from Indonesia's 2030 NDC,[69] GCAM High Ambition is based on the scenarios developed using the GCAM-CGS model.[70]

Methane

According to a global inventory, CEDS, methane was the country's second-largest emissions source in 2022.[71] While methane is covered by the existing NDC, specific policy and mitigation opportunities are largely missing from the current NDC planning process. Data uncertainty is high, and officially reported data may underestimate Indonesia's methane emissions.[72]

Under the *High Ambition* pathways, methane emissions decline, reversing the historical increasing trend (25% growth from 2015 to 2022), achieving a 30% reduction by 2030 from 2020 levels and a 33% reduction by 2035 (Figure 5). To achieve meaningful reductions, key policy priorities include:

- Establishing robust MRV capacity and updating reporting, particularly for the waste and coal mining sectors.

- Restricting underground coal mine expansion.

- Reducing methane emissions from the waste sector, through comprehensive improvement in municipal solid waste (MSW) management.

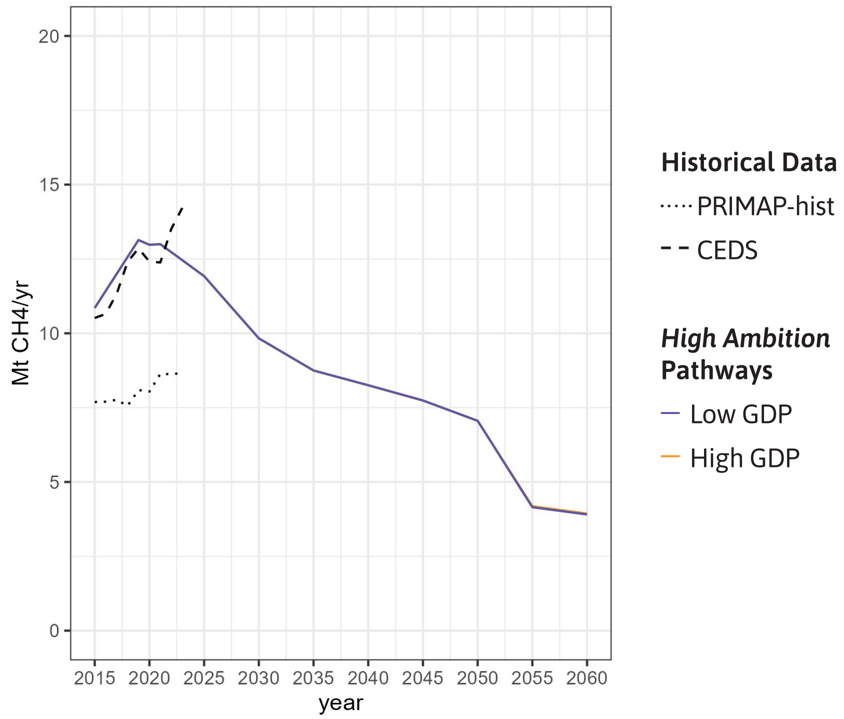

Figure 5. Methane emissions pathways across *High Ambition* scenarios. Historical data are from PRIMAP-hist[73] (dotted black line), and CEDS (dashed black line).[74] High GDP and Low GDP scenarios are based on the scenarios developed using the GCAM-CGS model, and have the same projections for methane emissions.

Waste methane mitigation strategies include expanding waste collection services from major metropolitan areas to all cities and villages, increasing waste processing capacity by investing in treatment facilities, and improving and establishing a national dataset of MSW and water treatment to enhance emission estimates. Indonesia has one of the highest per capita methane emissions from the waste sector,[75] largely due to unmanaged waste in landfills, open dumping practices, and poor waste management implementation. Tackling these emissions from this sector would not only deliver significant short-term climate gains but also long-term economic and social benefits. Improved waste management also has strong co-benefits on poverty reduction, public health, and rural development. Expanding and improving waste-to-energy systems can both supply electricity and significantly reduce landfill waste, supporting both sustainable energy goals and waste management. Local governments and actors can be engaged and mobilized to support some of these actions in targeted geographies. To mitigate waste emissions, local authorities in Indonesia need better information on waste quantities, categories, flows, and treatment potentials. Technical capacities must be strengthened to use existing technologies effectively. Additionally, waste financing systems require more funding and innovation, as local facilities often struggle with operation costs.

Appendix

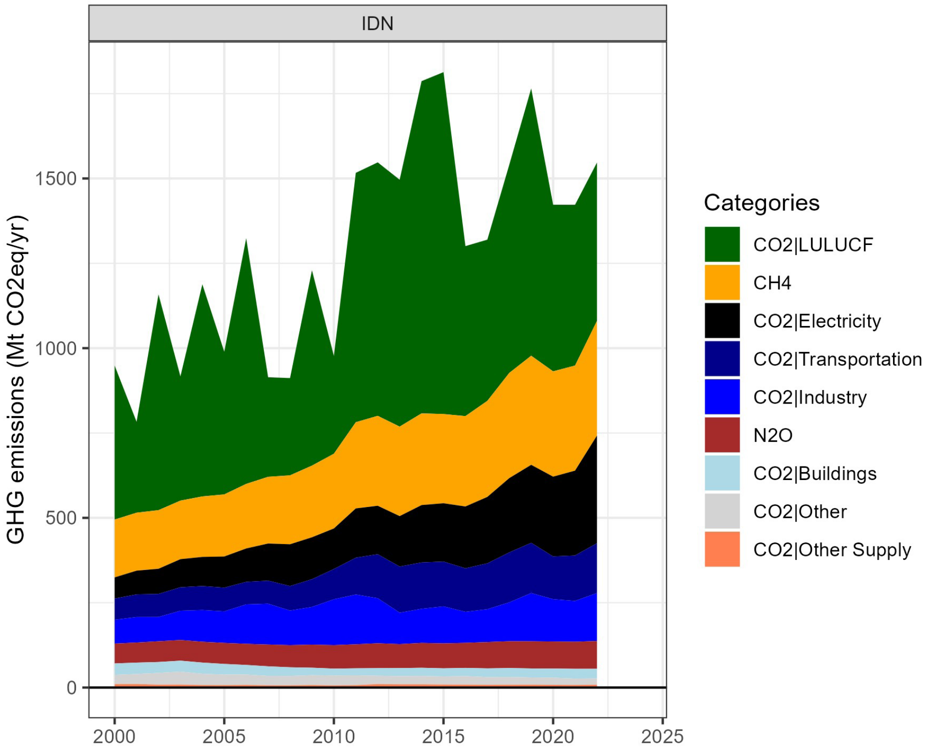

Figure S1. Historical GHG (incl. LULUCF) emissions by sector, sorted from largest to smallest in 2022. Source: Community Emissions Database (CEDS), PRIMAP-hist for CO2|LULUCF data.[76]

Scenarios

Table S1. Historical and Projected GDP across High and Low GDP scenarios.

	2010-13	*2014-19*	*2020*	*2021*	*2022-23*	2025	2030	2035	2040	2045	2050	2060	2100
High GDP	*6%*	*5%*	*-2%*	*4%*	*5%*	5%	7%	6%	5%	4%	3%	2%	1%
Low GDP (SSP2 default)	*6%*	*5%*	*-2%*	*4%*	*5%*	5%	4%	4%	3%	3%	2%	2%	1%

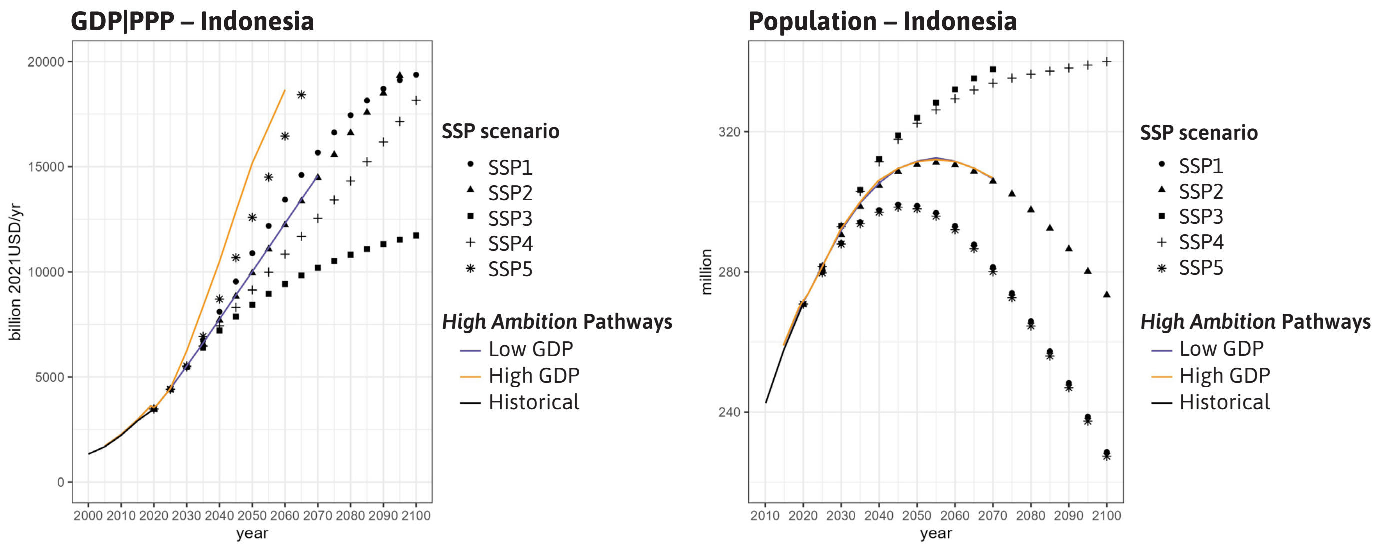

Figure S2. Historical and Projected Population and GDP. Sources: IIASA SSP Database.[77]

Emissions accounting

PRIMAP-CR is used for total GHG emissions (excl LULUCF), and PRIMAP-TP is used for LULUCF emissions for historical years. For projected years, we assume LULUCF emissions reach the 2030 NDC unconditional target for this sector (214 $MtCO_2e$) and continue decreasing at the same rate until 2035. Our analysis uses 100 year global warming potentials (GWP) from IPCC's fourth assessment report (AR4).

Endnotes

1. IEA, "Indonesia - Countries & Regions," IEA, 2024, https://www.iea.org/countries/indonesia/energy-mix.

2. Ember, "Electricity Data Explorer - Open Source Global Electricity Data," Ember, 2025, https://ember-climate.org/data/data-tools/data-explorer/.

3. GFW, "Indonesia Deforestation Rates & Statistics," Global Forest Watch (GFW), 2025, https://www.globalforestwatch.org/dashboards/country/IDN?category=forest-change.

4. Rachel Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree," version v_2025_03_18, Zenodo, March 18, 2025, https://doi.org/10.5281/zenodo.15001544.

5. Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree."

6. Johannes Gütschow and Mika Pflüger, "The PRIMAP-Hist National Historical Emissions Time Series (1750-2022) v2.5," version 2.5, Zenodo, 2023, https://doi.org/10.5281/zenodo.10006301.

7. Pierre Friedlingstein et al., "Global Carbon Budget 2023," *Earth System Science Data* 15, no. 12 (2023): 5301–69.

8. Gütschow and Pflüger, "The PRIMAP-Hist National Historical Emissions Time Series (1750-2022) v2.5."

9. Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree."

10. Republic of Indonesia., "Enhanced Nationally Determined Contribution," UNFCCC, 2022, https://unfccc.int/sites/default/files/NDC/2022-09/23.09.2022_Enhanced%20NDC%20Indonesia.pdf.

11. Republic of Indonesia., "Enhanced Nationally Determined Contribution."

12. Republic of Indonesia., "Enhanced Nationally Determined Contribution."

13. Republic of Indonesia, "Indonesia. 2024 National Inventory Document (NID)," UNFCCC, December 24, 2024, https://unfccc.int/documents/645083.

14. Republic of Indonesia., "Enhanced Nationally Determined Contribution."

15. Republic of Indonesia., "Enhanced Nationally Determined Contribution."

16. Gütschow and Pflüger, "The PRIMAP-Hist National Historical Emissions Time Series (1750-2022) v2.5."

17. Indonesia's Ministry of Environment and Forestry, "FOLU Net Sink: Indonesia's Climate Actions Towards 2030," 2023, https://phl.menlhk.go.id/media/publikasi/publikasi_file_1687146739.pdf.

18. Ministry of Energy and Mineral Resources, "Regulation of the Minister of Energy and Mineral Resources Number 10 of 2025 Concerning the Road Map for the Energy Transition in the Electricity Sector," 2025, https://jdih.esdm.go.id/dokumen/view?id=2567.

19. Republic of Indonesia, "Press Release Number 286.Pers/04/SJI/2024 'Government's Target for Electric Vehicles by 2030,'" Ministry of Energy and mineral Resources, May 22, 2024, https://www.esdm.go.id/id/media-center/arsip-berita/ini-target-pemerintah-untuk-populasi-kendaraan-listrik-di-tahun-2030.

20. Republic of Indonesia, "Press Release Number 286.Pers/04/SJI/2024 'Government's Target for Electric Vehicles by 2030.'"

21. Office Assistant to Deputy Cabinet Secretary for State Documents and Translation, "Indonesia Ready to Welcome EV Era, Minister Says," *Cabinet Secretary of the Repubic of Indonesia*, February 23, 2022, https://setkab.go.id/en/indonesia-ready-to-welcome-ev-era-minister-says/.

22. Ministry of Energy and Mineral Resources, "To Achieve Energy Security and Reduce Imports, the Minister of Energy and Mineral Resources: Mandatory B40 Will Take Effect January 1, 2025," Ministry of Energy and mineral Resources, 2025, https://desdm.kalteng.go.id/berita/wujudkan-ketahanan-energi-dan-kurangi-impor-menteri-esdm-mandatori-b40-berlaku-1-januari-2025/.

23. Climate & Clean Air Coalition Secretariat, "About the Global Methane Pledge," Global Methane Pledge, https://www.ccacoalition.org/content/global-methane-pledge.

24. IIASA, "SSP Scenario Explorer 3.1.0. Release July 2024," International Institute for Applied Systems Analysis (IIASA), July 2024, https://data.ece.iiasa.ac.at/ssp/#/login?redirect=%2Fworkspaces.

25. Gütschow and Pflüger, "The PRIMAP-Hist National Historical Emissions Time Series (1750-2022) v2.5."

26. Gütschow and Pflüger, "The PRIMAP-Hist National Historical Emissions Time Series (1750-2022) v2.5."

27. Ember, "Electricity Data Explorer - Open Source Global Electricity Data."

28. Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree."

29. Republic of Indonesia., "Enhanced Nationally Determined Contribution."

30. NGFS, "NGFS Scenarios Portal," Network for Greening the Financial System (NGFS), 2024, https://www.ngfs.net/ngfs-scenarios-portal/.

31. Friedlingstein et al., Global Carbon Budget 2023, ESSD, 2023.

32. Arif Wijaya et al., "How Can Indonesia Achieve Its Climate Change Mitigation Goal? An Analysis of Potential Emissions Reductions from Energy and Land-Use Policies," 2017, https://doi.org/10.1163/9789004322714_cclc_2017-0020-001.

33. Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree."

34. Gütschow and Pflüger, "The PRIMAP-Hist National Historical Emissions Time Series (1750-2022) v2.5."

35. Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree."

36. Ember, "Electricity Data Explorer - Open Source Global Electricity Data."

37. Ember, "Electricity Data Explorer - Open Source Global Electricity Data."

38. GEM, "Global Coal Plant Tracker (GCPT)," Global Energy Monitor (GEM), January 2025, https://globalenergymonitor.org/projects/global-coal-plant-tracker/.

39. GEM, "Global Coal Plant Tracker (GCPT)."

40. GEM, "Global Coal Plant Tracker (GCPT)."

41. Ember, "Electricity Data Explorer - Open Source Global Electricity Data."

42. JETP Indonesia, "The Comprehensive Investment and Policy Plan (CIPP) for Indonesia's Just Energy Transition Partnership (JETP)," JETP Indonesia, 2023, https://jetp-id.org/cipp.

43. IEA, "Indonesia - Countries & Regions."

44. IEA, "Indonesia - Countries & Regions."

45. Sudarshan Varadhan et al., "Indonesia Nickel Slump Piles Pressure on Coal Miners Hit by Falling Exports," Asian Markets, *Reuters*, July 29, 2025, https://www.reuters.com/markets/asia/indonesia-nickel-slump-piles-pressure-coal-miners-hit-by-falling-exports-2025-07-29/.

46. IEA, *Global Critical Minerals Outlook 2024* (International Energy Agency (IEA), 2024), https://iea.blob.core.windows.net/assets/ee01701d-1d5c-4ba8-9df6-abeeac9de99a/GlobalCriticalMineralsOutlook2024.pdf.

47. Mengye Zhu et al., *Decarbonizing Captive Coal Power Plants in Indonesia and Implications for Chinese Stakeholders: Trends, Challenges And Opportunities*, 2023.

48. Molly Schreier et al., *Industrial Parks in Indonesia: Challenges and Opportunities for Sustainable Industrial Development* (Center for Global Sustainability, University of Maryland, 2024), https://cgs.umd.edu/sites/default/files/2024-06/file_Indonesia%20industrial%20parks%20policy%20brief_6.4.pdf.

49. GAIKINDO, "Indonesian Automobile Industry Data," The Association of Indonesia Automotive Industries (GAIKINDO), 2025, https://www.gaikindo.or.id/en/indonesian-automobile-industry-data/.

50. Republic of Indonesia, "Press Release Number 286.Pers/04/SJI/2024 'Government's Target for Electric Vehicles by 2030.'"

51. Republic of Indonesia, "Regulation of the Minister of Finance (PMK) Number 38 of 2023 'Value Added Tax on the Delivery of Certain Four-Wheel Battery-Based Electric Motor Vehicles and Certain Bus Battery-Based Electric Motor Vehicles to Be Borne by the Government in Budget Year 2023,'" Database Peraturan | JDIH BPK, 2023, 38, http://peraturan.bpk.go.id/Details/246542/pmk-no-38-tahun-2023.

52. Republic of Indonesia, "Regulation of the Minister of Finance (PMK) Number 38 of 2023 'Value Added Tax on the Delivery of Certain Four-Wheel Battery-Based Electric Motor Vehicles and Certain Bus Battery-Based Electric Motor Vehicles to Be Borne by the Government in Budget Year 2023.'"

53. Republic of Indonesia, "Regulation of the Minister of Finance Number 10 of 2024 'Amendment to the Regulation of the Minister of Finance Number 26/PMK.010/2022 Concerning the Determination of the Goods Classification System and the Imposition of Import Duty Tariffs on Imported Goods,'" Database Peraturan | JDIH BPK, February 2024, http://peraturan.bpk.go.id/Details/279874/pmk-no-10-tahun-2024.

54. Ministry of Energy and Mineral Resources, "To Achieve Energy Security and Reduce Imports, the Minister of Energy and Mineral Resources: Mandatory B40 Will Take Effect January 1, 2025."

55. Kemen G Austin et al., "What Causes Deforestation in Indonesia?," *Environmental Research Letters* 14, no. 2 (2019): 2, https://doi.org/10.1088/1748-9326/aaf6db.

56. Diana Parker et al., "Land in Limbo: Nearly One Third of Indonesia's Cleared Old-Growth Forests Left Idle," *Proceedings of the National Academy of Sciences* 121, no. 28 (2024): e2318029121, https://doi.org/10.1073/pnas.2318029121.

57. Jiehong Lou et al., "Indonesia's Land Use Dilemma: Balancing Food Security, Bioenergy Expansion, and Deforestation Risks," preprint, Research Square, May 6, 2025, https://doi.org/10.21203/rs.3.rs-6378393/v1.

58. Gütschow and Pflüger, "The PRIMAP-Hist National Historical Emissions Time Series (1750-2022) v2.5."

59. Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree."

60. GFW, "Indonesia Deforestation Rates & Statistics."

61. Lou et al., "Indonesia's Land Use Dilemma."

62. Michaela G. Y. Lo et al., "Nickel Mining Reduced Forest Cover in Indonesia but Had Mixed Outcomes for Well-Being," *One Earth* 7, no. 11 (2024): 2019–33, https://doi.org/10.1016/j.oneear.2024.10.010.

63. Shofa Jayanty Nada, "Indonesia to Implement B50 Palm Oil Biodiesel Mandate Next Year," *Jakarta Globe* (Jakarta, Indonesia), February 4, 2025, https://jakartaglobe.id/business/indonesia-to-implement-b50-palm-oil-biodiesel-mandate-next-year.

64. Arif Rahmanulloh and Lisa Ahramjian, *Biofuels Annual*, nos. ID2025-0029, Biofuels (United States Department of Agriculture Foreign Agricultural Service, 2025), https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_Jakarta_Indonesia_ID2025-0029.pdf.

65. David Gaveau, "Land Clearing in Papua: 2024–2025 Trends and Drivers," *Nusantara Atlas*, July 28, 2025, https://nusantara-atlas.org/farming-the-unfarmable-the-high-stakes-gamble-in-papuas-wetlands/.

66. Hans Nicholas Jong and Sarjan Lahay, "Sugarcane Megaproject Poses Latest Threat to Papua's Forests, Communities," Environmental News, *Mongabay Environmental News*, June 19, 2024, https://news.mongabay.com/2024/06/sugarcane-megaproject-poses-latest-threat-to-papuas-forests-communities/.

67. Ryan B. Edwards et al., "Causes of Indonesia's Forest Fires," *World Development* 127 (March 2020): 104717, https://doi.org/10.1016/j.worlddev.2019.104717.

68. Gütschow and Pflüger, "The PRIMAP-Hist National Historical Emissions Time Series (1750-2022) v2.5."

69. Republic of Indonesia, "Indonesia. Long-Term Strategy for Low Carbon and Climate Resilience 2050," UNFCCC, 2021, https://unfccc.int/sites/default/files/resource/Indonesia_LTS-LCCR_2021.pdf.

70. Republic of Indonesia., "Enhanced Nationally Determined Contribution."

71. Katherine Calvin et al., "GCAM v7.1 Documentation: Common Assumptions," GitHub, 2024, https://jgcri.github.io/gcam-doc/toc.html.

72. Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree."

73. Dody Setiawan and Chris Wright, "Uncovering Indonesia's Hidden Methane Problem," Ember, March 12, 2024, https://ember-climate.org/insights/research/uncovering-indonesias-hidden-methane-problem/.

74. Gütschow and Pflüger, "The PRIMAP-Hist National Historical Emissions Time Series (1750-2022) v2.5."

75. Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree."

76. IEA, "Methane Tracker – Data Tools," International Energy Agency, 2024, https://www.iea.org/data-and-statistics/data-tools/methane-tracker.

77. Hoesly et al., "CEDS V_2025_03_18 Gridded Data 0.5 Degree."

78. IIASA, "SSP Scenario Explorer 3.1.0. Release July 2024."