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Navigating Indonesia's Energy Transition at the Crossroads: A Pivotal Moment for Redefining the Future

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Foreword

From perpetual potential to real power: a call to action for accelerating renewables deployment to shift away from fossil fuels.

Indonesia stands at a crossroads as the world accelerates its transition to sustainable energy. Our choices today will determine our energy security, emissions reduction, and green economic growth. The Indonesia Energy Transition Outlook 2025 analyzes our nation's energy transition progress, challenges, and opportunities at this critical juncture.

Indonesia has made limited progress in renewable energy and decarbonization in recent years. Despite the government's pledge to transition away from fossil fuels in 2021 by increasing renewable energy capacity in RUPTL, the country is still far from meeting the 2014 National Energy Policy renewable energy mix target.

To meet the 2060 decarbonization goals, our transition must accelerate. Renewable energy currently makes up only 14% of the national energy mix, far below the 23% target set by 2025. The continued use of coal—a major greenhouse gas emitter—impedes the future of low-carbon energy. Renewables have struggled to grow due to the preference for using coal as an indigenous resource. The electricity sector, which remains under the monopoly of the heavily regulated state-owned PLN, also slowed the transition. Other challenges include financial gaps, regulatory uncertainty, and infrastructure readiness.

Global technological advancements and falling costs have driven unprecedented growth in renewable energy. Solar and wind energy are now cost-competitive with fossil fuels, and innovations in energy storage and smart grids are transforming energy systems. Fossil fuel financing is losing favor among investors and financing institutions. These global trends present an opportunity for Indonesia to leverage its abundant renewable resources and cutting-edge technologies to accelerate its energy transition.

Indonesia has been underutilizing its solar energy potential. With an average solar irradiance of over 4.8 kWh per square meter per day and year-round sunshine, the country has the potential to generate between 7.7 to 20 TW of solar power. Additionally, Indonesia has the world's largest geothermal potential, which could significantly boost renewable energy capacity. The country's diverse agricultural resources could also provide clean fuels from underutilized bioenergy potential. Realizing this potential will require targeted policies, robust investment, innovation, and international collaboration.

We must view the energy transition as an economic opportunity, not merely a technical or environmental necessity or economic burden. Transitioning to green energy can boost industrial growth, create millions of jobs, and drive innovation in clean energy manufacturing and digital technologies. Indonesia could become a regional leader in renewable energy solutions by developing new industries such as solar cell and module manufacturing, energy storage systems, and green hydrogen production.

Still, the road ahead remains challenging. One of the biggest challenges for renewable energy projects is financing. Both local and foreign investment are crucial to finance the transition, especially as global financial markets increasingly align with environmental, social, and governance (ESG) principles. To enable green finance, regulatory reforms, risk-sharing mechanisms, and transparency are essential. Moreover, governance and institutional reform are key to the energy transition. Streamlining permitting process, improving national-local coordination, ensuring at-scale and regular procurement of PLN, and standardizing regulatory frameworks can reduce barriers to renewable energy deployment. Partnerships with the private sector and public-private collaborations can further drive innovation and infrastructure development.

Foreword

Indonesia's future energy transition must prioritize inclusivity and equity. Ensuring access to affordable and reliable energy for all Indonesians, especially in remote and underserved areas, is critical to improving the quality of life. A just transition must also address the socioeconomic impacts of phasing out fossil fuels, providing retraining and alternative livelihoods for affected communities.

Indonesia's energy transition has a bright future, but it requires bold action and persistence. The next five years will be decisive for Indonesia's energy transition. To save the world from global boiling, we must triple our renewable energy capacity to 100 GW and double the rate of energy efficiency by 2030. Technology, international collaboration, and sustainable investment can transform our energy systems to power a greener, more inclusive, and prosperous Indonesia. To protect our environmental, economic, and social well-being, we must achieve the 2050 net-zero emissions target. The recent pledge made by President Prabowo to phase out coal by 2040 must be followed by an ambitious plan and strategies to meet this goal.

This report highlights our progress, addresses challenges, and outlines the transformative pathways needed to achieve our energy transition goals. It emphasizes the need for collaboration among the government, business, civil society, and individuals to create a resilient and sustainable energy future. Let us draw inspiration from global successes in renewable energy and move forward with determination and innovation. Let us leverage our abundant resources, mobilize investments, and encourage innovation to build an energy system that meets both national and global climate goals. The Indonesia Energy Transition Outlook 2025 is both a roadmap and a call to action.

Finally, IESR's team has done excellent work in producing this forward-looking report. Policymakers, businesses, and stakeholders involved in advancing Indonesia's energy transition will find this report valuable in shaping policy, strategy, and planning. Together, we can achieve our goals and turn challenges into opportunities to help Indonesia lead the global energy transition.

Jakarta, November 2024

Fabby Tumiwa
Executive Director

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List of Abbreviations

2W : Two Wheelers
ACCESS : Accelerating Clean Energy Access to Reduce Inequality
APBD : *Anggaran Pendapatan dan Belanja Daerah* (Subnational Government Budget)
AR4 : Assessment Report 4
ARED : Accelerated Renewable Energy Development
BAT : Best Available Technology
BAU : Business-As-Usual
BBN : *Bahan Bakar Nabati* (Biofuel)
BCM : Billion Cubic Meters
BECCS : Bioenergy with Carbon Capture & Storage
BESS : Battery Energy Storage System
BF : Blast Furnace
BGH : *Bangunan Gedung Hijau* (Green Building)
BOE : Billion Oil Equivalent
BOF : Basic Oxygen Furnace
BPK : *Badan Pemeriksa Keuangan* (Audit Board)
BPS : *Badan Pusat Statistik* (Bureau of Statistics Indonesia)
CAGR : Compound Annual Growth Rate
CAT : Climate Action Tracker
CBAM : Carbon Border Adjustment Mechanism
CBU : Completely Built-Up
CCS : Carbon Capture and Storage
CCUS : Carbon Capture, Utilization, and Storage
CFPP : Coal-fired Power Plant
CH_4 : Methane
CIS : Commonwealth of Independent States
CKD : Completely Knocked-Down
CMM : Coal mine methane
CO : Carbon monoxide
CO_2 : Carbon dioxide
CO_2e : Carbon dioxide equivalent
CO_2/boe : Carbon dioxide per barrel of oil equivalent
COD : Commercial Operation Date
COP : Conference of the Parties
CPI : Climate Policy Initiative
CPO : Crude Palm Oil
DAK : *Dana Alokasi Khusus* (Special Allocation Funds)
DBH : *Dana Bagi Hasil* (Revenue Sharing Funds)
DFI : Development Financial Institution
DGE : Directorate General of Electricity
Ditjen EBTKE : *Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi* (Directorate-General of New Renewable Energy and Energy Conservation)
DKI : *Daerah Khusus Ibukota* (Special Capital Region)
DME : Dimethyl ether
DMO : Domestic Market Obligation
DRUKN : *Draf Rencana Umum Ketenagalistrikan Nasional* (Draft of General Plan for National Electricity)
E2W : Electric Two Wheelers
E4W : Electric Four Wheelers
EAF : Electric Arc Furnace
EBT / ET : *Energi Baru Terbarukan / Energi Terbarukan* (New and Renewable Energy / Renewable Energy)
ECA : Electric Cooking Appliances
EDGE : Excellence in Design for Greater Efficiencies
EMDEs : Emerging Market and Developing Economies
EMR : Energy and Mineral Resources (*Dinas ESDM Provinsi*)
ENDC : Enhanced Nationally Determined Contributions
EnMS : Energy Management System
ESCO : Energy Service Companies
ESG : Environmental, Social, and Governance
ESS : Energy Storage Systems
ETS : Emissions Trading System

List of Abbreviations

EU : European Union
EV : Electric Vehicle
FGD : Focus Group Discussion
FOLU : Forrest and Other Land Uses
FPV : Floating Photovoltaics
gCO_2 : Grams of Carbon Dioxide
GDP : Gross Domestic Product
GHG : Greenhouse Gas
GJ : Gigajoule
GR : Government Regulation
GoI : Government of Indonesia
GW : Gigawatt
GWh : Gigawatt hour
GWP : Global Warming Potential
GWP-100yr : The average global warming potential over 100 years
HC : Hydrocarbons
HEESI : Handbook Of Energy & Economic Statistics Of Indonesia
HFC : Hydrofluorocarbon
HGBT : *Harga Gas Bumi Tertentu* (Specific Natural Gas Price)
HPAL : High Pressure Acid Leach, nickel smelter technology
HPP : *Harmonisasi Peraturan Perpajakan* (Harmonization of Tax Regulations)
ICE : Internal Combustion Engines
ICV : Internal Combustion Vehicle
IDR : Indonesian Rupiah
IDX200 : Top 200 Companies listed on Indonesia Stock Exchange
IEA : International Energy Agency
IEEFA : Institute for Energy Economics and Financial Analysis
IMF : International Monetary Fund
IPCC : Intergovernmental Panel on Climate Change
IPG : International Partners Group
IPP : Independent Power Producer
IPPU : Industrial Process And Product Uses
IRID : Indonesia Research Institute for Decarbonization
ISO : International Organization for Standardization
Jargas : *Jaringan gas bumi untuk rumah tangga* (Gas pipeline network)
JETP : Just Energy Transition Partnership
JETP CIPP : Just Energy Transition Partnership - Comprehensive Investment and Policy Plan
kb/day : Thousand barrels per day
KEN : *Kebijakan Energi Nasional* (National Energy Policy)
kg : kilogram
kL : Kilolitre
kt : Kilotonne
kW : Kilowatt
kWh : Kilowatt per hour
kWh/cap. : Kilowatt per hour per capita
LCE : LIfe Cycle Emissions or Lifecycle Assessment (LCA) for Emissions
LCR : Local Content Requirement
LED : Light Emitting Diode
LEED : Leadership in Energy and Environmental Design
LFP : Lithium Iron Phosphate
LKjIP : *Laporan Akuntabilitas Kinerja Instansi Pemerintah* (Government Agency Performance Accountability Report)
LKPD : *Laporan Kinerja Perangkat Daerah* (Regional Apparatus Performance Report)
LME : London Metal Exchange, a global trading body
LNG : Liquefied Natural Gas
LPEM UI : *Lembaga Penyelidikan Ekonomi dan Masyarakat Universitas Indonesia* (Institute for Economic and Social Research, University of Indonesia)
LPG : Liquefied Petroleum Gas
LULUCF : Land use, land-use change, and forestry
m^2 : Square meter
MBOE : Million Barrels of Oil Equivalent

List of Abbreviations

MDF : Medium Distillate Fuel
MEMR : Ministry of Energy and Mineral Resources
MENTARI : *Menuju Transisi Energi Rendah Karbon Indonesia*
MEPS : Minimum Energy Performance Standards
MHP : Mix Hydroxide Precipitate, a type of nickel product
MMBTU : Million British Thermal Unit
MMSCFD : Million Standard Cubic Feet per Day
MoEF : Ministry of Environment and Forestry
MoF : Ministry of Finance
MoHA : Ministry of Home Affairs
MoI : Ministry of Industry
MoT : Ministry of Transportation
MPWH : Ministry of Public Works and Housing
MRT : Mass Rapid Transit
Mt : Million tonne
$MtCO_2$: Million tonnes of carbon dioxide
$MtCO_2e$: Million tonnes of carbon dioxide equivalent
MTOE : Million Tonnes of Oil Equivalent
MW : Megawatt
NDC : Nationally Determined Contributions
NGO : Non Governmental Organization
NH_3 : Ammonia
Ni : Nickel
NP : Nusantara Power
NO_x : Nitrogen Oxides
NPI : Nickel Pig Iron, a type of nickel product
NRE : New and Renewable Energy
NTT : Nusa Tenggara Timur (East Nusa Tenggara)
NZE : Net Zero Emissions
OJK : *Otoritas Jasa Keuangan* (Indonesia Financial Authority)
OKU : Ogan Komering Ulu, a regency in South Sumatera
Otsus : *Otonomi Khusus* (Special Autonomy)
PALI : Penukal Abab Lematang Ilir, a regency in South Sumatera
PBB : *Pajak Bumi dan Bangunan* (Land and Building Tax)
PLN : *Perusahaan Listrik Negara* (State Electricity Company)
PLTA : *Pembangkit Listrik Tenaga Air* (Hydro power plant)
PLTM : *Pembangkit Listrik Tenaga Mikrohidro* (Micro Hydro Power Plant)
PM : Particulate Matter
PMK : Peraturan Menteri Keuangan (Minister of Finance Regulation)
POKJA : *Kelompok Kerja* (Working Group)
PON XXI : *Pekan Olahraga Nasional* 2024 (National Sports Week 2024)
PP : *Peraturan Pemerintah* (Government Regulation)
PPA : Power Purchase Agreement
PR : Presidential Regulation
PTBAE-PU : *Persetujuan Teknis Batas Atas Emisi bagi Pelaku Usaha* (Technical Agreement on Upper Emission Limits-Business Actors)
PV : Photovoltaic
Q2 : Quarter 2
Q3 : Quarter 3
Q4 : Quarter 4
RAPBD : *Rancangan Anggaran Pendapatan dan Belanja Daerah* (Subnational Government Budget Draft)
RDF : Refuse Derived Fuel
RE : Renewable Energy
REC : Renewable Energy Certificate
RKA DESDM : *Rencana Kerja dan Anggaran Dinas Energi dan Sumber Daya Mineral* (Work Plan and Budget of the Energy and Mineral Resources Agency)
RKAB : *Rencana Kerja dan Anggaran Biaya* (Work Plan and Budget)
RKEF : Rotary Kiln Electric Furnace, nickel smelter technology
ROI : Return on Investment
RPJP : *Rencana Pembangunan Jangka Panjang* (Long-Term Development Plan)
RPJM : *Rencana Pembangunan Jangka Menengah* (Medium-Term Development Plan)

List of Abbreviations

RPJPN : *Rencana Pembangunan Jangka Panjang Nasional* (National Government Long Term Development Plan)
RPM : *Rancangan Peraturan Menteri* (Ministerial Regulation Plan)
RPP : *Rencana Peraturan Pemerintah* (Government Regulation Plan)
RUED : *Rencana Umum Energi Daerah* (Regional Energy General Plan)
RUEN : *Rencana Umum Energi Nasional* (National Energy General Plan)
RUKN : *Rencana Umum Ketenagalistrikan Nasional* (National Electricity General Plan)
RUPTL : *Rencana Umum Penyediaan Tenaga Listrik* (National Electricity Supply Business Plan)
Satgas : *Satuan Petugas* (Taskforce)
SCR : Selective Catalytic Reduction
SII : Sumba Iconic Island
SIH : *Sertifikat Industri Hijau* (Green Industry Certificate)
SIINAs : *Sistem Informasi Industri Nasional* (National Industrial Information System)
SNDC : Second Nationally Determined Contribution
SNI : *Standar Nasional Indonesia* (Indonesian National Standard)
SPBKLU : *Stasiun Penukaran Baterai Kendaraan Listrik Umum* (Public Electric Vehicle Battery Swapping Station)
SPE GRK : *Sertifikat Pengurangan Emisi Gas Rumah Kaca* (Greenhouse Gas Emission Reduction Certificate)
SPI : Sustainable Province Initiative
SPKL : *Stasiun Pengisian Kendaraan Listrik* (Electric Vehicle Charging Station)
SPKLU : *Stasiun Pengisian Kendaraan Listrik Umum* (Public Electric Vehicle Charging Station)
STEPS : Stated Policies Scenario
tCO_2 : Tonnes of Carbon Dioxide
TCO : Total Cost of Ownership
TEN : *Transisi Energi Nasional* (National Energy Transition)
TOE : Tonne Oil Equivalent
TSCF : Trillion Standard Cubic Feet
TWh : Terawatt hour
UIP2B : *Unit Induk Pusat Pengaturan Beban* (Central Load Control Unit)
UK : United Kingdom
UMD : University of Maryland
UNFCCC : United Nations Framework Convention on Climate Change
US : United States
USD : United States Dollar
UU : *Undang-undang* (Law)
VA : Volt Ampere
VAT : Value Added Tax
VRE : Variable Renewable Energy
W : Watt
Wh : Watt-hour
y-o-y : year-on-year

Executive Summary

Introduction

- **Geopolitical tensions** in fossil fuel-producing regions like the Middle East and Eurasia/CIS put global fossil fuel supplies at risk, while the production capacity of key energy transition technologies is currently concentrated in only few countries. In 2023, Indonesia's energy supply was **1,843 MBOE**, with **coal being the biggest contributor (736 MBOE)**. **The industrial and transportation sectors are the biggest energy consumer in Indonesia**, accounting for 82% of total final energy consumption.

- Indonesia's renewable energy share in primary supply reached only **13.1% in 2023**, missing the 2025 target set in the previous National Energy Policy (KEN). The new KEN projections **rely heavily on other sectors**, which could **jeopardize Indonesia's commitment to limiting global warming to < 1.5°C**. According to IESR's Transition Readiness Framework (TRF), Indonesia's energy transition is **primarily hindered by low political and regulatory support**, despite advancement in low-carbon technologies.

Industrial Sector

- **Indonesia's industrial energy use** increased by **9%** in 2023, with **coal** remaining dominant, accounting for **56.9%** of the energy use, and **renewables** making up **6.52%**. This led to **460 $MtCO_2e$** in emissions, while ongoing **fossil fuel subsidies** hinder the progress in decarbonization. **Nickel exports** may face up to **USD 341** million in **EU CBAM** charges, underscoring the importance of reducing emissions. The government is investing in **hydrogen, CCS,** and **energy efficiency** to meet emissions targets.

Transportation Sector

- In 2022, Indonesia's **transport sector** included 62 **cars** and 454 **motorcycles** per 1,000 people, with **cars** accounting for **55%** of **transport sector emissions in 2023.** Efforts to promote **EVs** and **public transport** have been insufficient, with **public transport** constituting only **5%** of total transport activity. **Freight decarbonization** is complex, but shifting **freight** from **road** to **rail** could reduce **emissions** by **3.56 $MtCO_2e$** annually by 2030. **EV incentives**, including **VAT reductions** and **tax exemptions**, have contributed to strong **sales growth**, with **80%** of **E4Ws** sold in 2024 benefiting from fiscal incentives.

Commercial and Household Sector

- Despite efforts to transition to modern **energy**, emissions in Indonesia's **commercial and household sectors** have increased due to rising **electricity demand**, **80%** of which is **fossil-fuel dependent**. Nearly 87% of households use **LPG**, with subsidies reaching IDR 83 trillion by Q4 2024. The government targets 1-1.2 million *jargas* **connections** and 700,000 **electric cooking appliances** by 2025, aiming to eliminate **LPG imports** by 2030. However, progress is hampered by **technical** and **economic challenges.**

Executive Summary

- With just 1.45% of **buildings** meeting energy management standards and under 1% obtaining **BGH certification**, Indonesia's **GR No. 33/2023** and **MPWH Regulation No. 21/2021** face low compliance rates. Challenges include **enforcement, awareness,** and **financing**. The government is considering **non-financial incentives** under the **RPM Energy Management**.

Power

- Fossil fuels dominated 81% of Indonesia's electricity generation in 2023, resulting in 287 MtCO_2e emissions. Captive power, with a 21 GW capacity, contributed 27% of these emissions, highlighting **the need for better monitoring and planning of captive sites**. Drafts of the RUKN and KEN emphasize nuclear, CCS, and hydrogen/ammonia fuels post-2040. However, **maximizing renewable energy could cut system costs by 33% by 2060**. Early retirement of the Cirebon-1 CFPP offers a carbon abatement cost of USD 31–40/tCO_2e, lower than CCS (USD 62–324/tCO_2e).

- PLN's new RUPTL plans to add 13.3 GW of renewable projects, with solar (especially FPV) and wind contributing 8.2 GW. However, delays in project delivery could discourage investors. **Bundled procurement can boost pipeline volume and improve economics**, while **cost-effective flexibility and distribution-level operations are key to integrating high penetration of renewables**. Expanding energy storage systems (ESS) requires **supportive regulations and market mechanisms.** With growing investments in solar and battery, **mandated technology transfers in foreign investments are crucial.**

Fuel Production

- Indonesia's **upstream oil and gas revenues** have plummeted from 35% of total revenue (7% of GDP) in 2001 to under **1% of GDP** since 2016, with gas demand projected to rise from 48 to 52 BCM by 2026 and oil production to fall to 400 kb/day by 2030. Over the past decade, Indonesia's gas output dropped by 22%, demand rose by 39%, and **coal output surged** to **687 million tonnes** in 2022, driving 33% of emissions **despite net-zero ambitions for 2060**.

- The push for **net-zero by 2060** includes **biofuel targets**, such as **B50 by 2026** and **E10 by 2029**, which will require **5.7 million hectares of land**. However, this goal faces challenges related to cost, land use, and continued reliance on fossil energy.

Subnational Level

- **Subnational governments** in **33 provinces** have set **RE targets** under **RUEDs**. By **2025, 45%** aim for **23% RE share**, though progress varies. While only seven provinces, like South Sumatera and South Sulawesi, have exceeded their targets, others, such as Aceh and NTT, struggle with mismatches between authority and RUED mandates, as well as limited fiscal capacity to meet their goals.

Executive Summary

- **Aceh** targets 14% RE by 2025 but reached only **11.08% in 2023**, calling for more support on RE infrastructure programs and stronger strategic partnerships. **South Sumatera** exceeded its target with **24% RE mix**, driven largely by private-sector bioenergy, highlighting the potential of collaboration while facing challenges in economic diversification as a coal-producing region. Meanwhile, **NTT** reached **17.68% RE** in 2023 and achieve **95% electrification** by 2023, aided by projects like **Sumba Iconic Island**. However, funding and technical capacity issues remain, despite national and international initiatives providing essential support for **RE development**.

Transition Finance

- Indonesia targets a **29% reduction (358 $MtCO_2e$)** in energy sector emissions by **2030**, but emissions reached **723 $MtCO_2e$** in **2022**, complicating this goal. The total investment required for energy and transportation decarbonization is **USD 246 billion** by **2030**, with **USD 118.5 billion** allocated for renewable energy (RE). However, the public budget allocated for these sectors covers just **23%** of the annual need, creating a **USD 7 billion** funding gap.

- International climate finance, including **USD 2.5 billion** in **2021**, has helped, but RE investments remain insufficient, while fossil fuels receive the bulk of private investment. Although the **JETP** and carbon market are progressing, financing gaps persist. Addressing the **just transition** for workers in coal-dependent areas will be essential for ensuring an equitable transition.

Outlook

- Under a business-as-usual projection, Indonesia's emissions will fall within a >3 °C warming scenario. This calls for a **more ambitious emission reduction target** in the coming years to avoid complacency, especially given that the current NDC 2030 emission target is highly overestimated. A **clear, sector-specific implementation plan could help reduce this overestimation in energy demand projections. Demand-side interventions should also prioritize cost-effective, high-impact measures**, such as road electrification and shifting LPG consumption.

- Short-term recommendations for Indonesia energy transition journey should be focused on **enforcing compliance with monitoring and planning** (e.g. mineral processing, green building, fuel emission standards, RE procurement, captive sites, etc.) and **incentivizing quick-wins** (e.g. road electrifications, carbon trading mechanism, etc.). Long-term recommendations include **building supporting infrastructure** (e.g. hydrogen/ammonia production, strengthening the authority of subnational governments) and **preparing market mechanism** (e.g. ancillary services for power flexibility, ESCOs, etc.).

Ringkasan Eksekutif

Pendahuluan

- ***Ketegangan geopolitik** di kawasan penghasil bahan bakar fosil seperti Timur Tengah dan Eurasia/CIS membahayakan pasokan bahan bakar fosil global, sementara kapasitas produksi teknologi kunci untuk transisi energi saat ini juga **terkonsentrasi di hanya beberapa negara**. Pada tahun 2023, pasokan energi Indonesia mencapai 1.843 MBOE, dengan **batu bara sebagai kontributor terbesar** (736 MBOE). Sektor industri dan transportasi merupakan **konsumen energi terbesar** di Indonesia dengan 82% dari total konsumsi energi final.*

- *Indonesia baru mencapai bauran energi terbarukan dalam pasokan primer sebesar **13,1% pada tahun 2023**, gagal mencapai target tahun 2025 yang ditetapkan dalam Kebijakan Energi Nasional (KEN) sebelumnya. Proyeksi KEN yang baru **terlalu bergantung pada sektor lain dan mengancam komitmen Indonesia untuk membatasi pemanasan global < 1,5°C**. Berdasarkan Kerangka Kesiapan Transisi (TRF) IESR, transisi energi Indonesia terhambat oleh **rendahnya dukungan politik dan regulasi** meskipun ada kemajuan dalam teknologi rendah karbon.*

Sektor Industri

- *Penggunaan energi industri di Indonesia **meningkat sebesar 9% pada tahun 2023**, dengan **batu bara masih dominan sebesar 56,9% dan energi terbarukan sebesar 6,52%.** Hal ini **menyebabkan emisi sebesar 460 MtCO_2e**, sementara subsidi bahan bakar fosil yang sedang berlangsung menghambat kemajuan dekarbonisasi. Ekspor nikel dapat menghadapi **biaya hingga sebesar USD 341 juta akibat CBAM Uni Eropa**, yang menekankan pentingnya pengurangan emisi. Pemerintah berinvestasi dalam hidrogen, CCS, dan efisiensi energi untuk memenuhi target emisi.*

Sektor Transportasi

- *Pada tahun 2022, sektor transportasi di Indonesia **memiliki 62 mobil dan 454 sepeda motor per 1.000 orang**, dengan **mobil menyumbang 55% emisi sektor transportasi pada tahun 2023**. Upaya untuk mempromosikan kendaraan listrik dan angkutan umum masih belum memadai, dengan **jumlah angkutan umum hanya sebesar 5%** dari total aktivitas transportasi. Dekarbonisasi angkutan barang merupakan hal yang kompleks, tetapi mengalihkan angkutan barang dari jalan raya ke kereta api dapat **mengurangi emisi sebesar 3,56 MtCO_2e** per tahun pada tahun 2030. Insentif kendaraan listrik, termasuk pengurangan PPN dan pembebasan pajak, telah berkontribusi pada pertumbuhan penjualan yang kuat, dengan **80% dari E4W yang terjual pada tahun 2024** mendapat manfaat dari insentif fiskal.*

Sektor Komersial dan Rumah Tangga

- *Terlepas dari upaya untuk beralih ke energi modern, emisi di sektor komersial dan rumah tangga di Indonesia telah meningkat karena naiknya permintaan listrik, yang 80% di antaranya bergantung pada bahan bakar fosil. Hampir **87% rumah tangga menggunakan LPG, dengan subsidi mencapai Rp83 triliun** pada kuartal IV tahun 2024. Pemerintah menargetkan **1-1,2 juta sambungan** jargas **dan 700.000 unit kompor listrik** pada tahun 2025, yang bertujuan untuk menghilangkan impor LPG pada tahun 2030, tetapi kemajuannya **terhambat oleh tantangan teknis dan ekonomi.***

Ringkasan Eksekutif

- *Dengan **hanya 1,45% bangunan yang memenuhi standar manajemen energi dan kurang dari 1% yang memperoleh sertifikasi BGH**, PP No. 33/2023 dan Peraturan Menteri PUPR No. 21/2021 di Indonesia masih memiliki **tingkat kepatuhan yang rendah.** Tantangan yang dihadapi antara lain adalah penegakan hukum, kesadaran, dan pembiayaan. Pemerintah sedang **mempertimbangkan insentif non-finansial di bawah RPM Manajemen Energi.***

Sektor Ketenagalistrikan

- *Bahan bakar fosil **mendominasi 81% pembangkit listrik di Indonesia pada tahun 2023**, yang menghasilkan **emisi sebesar 287 MtCO_2e**.* Captive power, *dengan kapasitas 21 GW, **menyumbang 27% emisi**, sehingga menyoroti perlunya **pemantauan dan perencanaan*** **captive power** ***yang lebih baik.** Rancangan RUKN dan KEN menekankan pada bahan bakar nuklir, CCS, dan hidrogen/amonia pasca tahun 2040. Namun, **memaksimalkan energi terbarukan dapat memangkas biaya sistem sebesar 33%** pada tahun 2060. Pengakhiran operasional dini PLTU Cirebon-1 menawarkan **biaya pengurangan karbon sebesar USD 31-40/tCO_2e**, lebih rendah daripada CCS (USD 62-324/tCO_2e).*

- *RUPTL PLN yang baru berencana untuk menambah **13,3 GW proyek-proyek energi terbarukan**, dengan **tenaga surya (terutama FPV) dan angin berkontribusi sebesar 8,2 GW.** Namun, penundaan dalam pelaksanaan proyek berisiko membuat investor enggan. Pengadaan dengan skema* bundling *dapat meningkatkan volume pipa dan meningkatkan keekonomian, sementara **menyediakan opsi fleksibilitas yang hemat biaya** dan **meningkatkan kemampuan operator jaringan distribusi** adalah kunci untuk mengintegrasikan energi terbarukan dengan tingkat penetrasi yang tinggi. Memperluas adopsi sistem penyimpanan energi (ESS) membutuhkan **regulasi dan mekanisme pasar yang mendukung**. Dengan meningkatnya investasi tenaga surya dan baterai, **kewajiban transfer teknologi yang dalam investasi asing** menjadi sangat penting.*

Produksi Bahan Bakar

- *Pendapatan hulu minyak dan gas Indonesia telah anjlok dari 35% dari total pendapatan (7% dari PDB) pada tahun 2001 menjadi **kurang dari 1% dari PDB sejak tahun 2016**, dengan permintaan gas yang diproyeksikan **meningkat dari 48 menjadi 52 BCM pada tahun 2026 dan produksi minyak turun menjadi 400 kb/hari pada tahun 2030**. Produksi gas turun 22% selama satu dekade, permintaan naik 39%, dan produksi batu bara melonjak menjadi 687 juta ton pada tahun 2022, mendorong 33% emisi, meskipun ambisi untuk mencapai nol bersih pada tahun 2060.*

- *Dorongan untuk mencapai emisi nol bersih pada tahun 2060 mencakup **target bahan bakar nabati seperti B50 pada tahun 2026 dan E10 pada tahun 2029,** yang membutuhkan **5,7 juta hektar lahan. Namun, pencapaian target ini harus berhadapan dengan tantangan terkait biaya, penggunaan lahan, dan ketergantungan pada energi fosil.***

Tingkat Daerah

- *Pemerintah daerah di 33 provinsi telah **menetapkan target bauran EBT di dalam RUED**. Pada tahun 2025, **45% provinsi menargetkan paling sedikit 23% bauran EBT**, meskipun kemajuannya bervariasi. Sementara provinsi seperti Sumatera Selatan dan Sulawesi Selatan telah melampaui target, provinsi lain seperti Aceh dan NTT mengalami ketidaksesuaian antara kewenangan dan mandat RUED, serta keterbatasan kapasitas fiskal untuk mencapai tujuan mereka.*

Ringkasan Eksekutif

- ***Aceh** menargetkan 14% EBT pada tahun 2025 namun hanya mencapai **11,08% pada tahun 2023**, sehingga membutuhkan lebih banyak dukungan pada program infrastruktur EBT dan kemitraan strategis yang lebih kuat.. Meskipun potensi EBT (tenaga surya, angin, air) tinggi, **Sumatera Selatan** melampaui **target EBT-nya sebesar 24%**, yang sebagian besar didorong oleh bioenergi sektor swasta, menunjukan potensi kolaborasi, meski masih menghadapi tantangan diversifikasi ekonomi sebagai daerah penghasil batubara. Sementara itu, NTT mencapai 17,68% energi terbarukan pada tahun 2023 dan 95% elektrifikasi pada tahun 2023, dibantu oleh proyek seperti Sumba Iconic Island. Namun permasalahan pendanaan dan kapasitas teknis masih tetap ada, meskipun inisiatif nasional dan internasional telah memberikan dukungan penting bagi pengembangan energi terbarukan.*

Pembiayaan Transisi Energi

- *Indonesia **menargetkan pengurangan emisi sektor energi sebesar 29% (358 MtCO_2e) pada tahun 2030**, namun emisi mencapai 723 MtCO_2e pada tahun 2022, sehingga mempersulit tercapainya tujuan tersebut. Total investasi yang dibutuhkan untuk dekarbonisasi energi dan transportasi adalah USD 246 miliar pada tahun 2030, dengan USD 118,5 miliar untuk energi terbarukan (RE). Namun, anggaran publik yang dialokasikan untuk sektor-sektor ini hanya mencakup 23% dari kebutuhan tahunan, sehingga menimbulkan kesenjangan pendanaan sebesar USD 7 miliar.*

- *Pendanaan iklim internasional, termasuk USD 2,5 miliar pada tahun 2021, telah membantu, namun investasi energi terbarukan masih belum mencukupi, sementara bahan bakar fosil menerima sebagian besar investasi swasta. Meskipun JETP dan pasar karbon bergerak maju, kesenjangan pendanaan masih tetap ada. Mengatasi permasalahan terkait transisi yang adil bagi pekerja di wilayah yang bergantung pada batubara sangatlah penting untuk memastikan tercapainya transisi yang berkeadilan.*

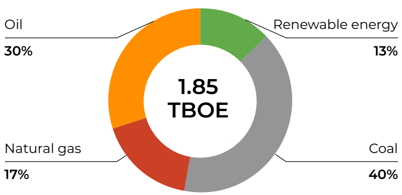
Pandangan

- *Berdasarkan proyeksi* business-as-usual, *emisi Indonesia akan berada dalam skenario pemanasan >3 °C. Hal ini memerlukan target emisi yang lebih ambisius di tahun-tahun mendatang untuk menghindari rasa puas diri, mengingat bahwa target emisi NDC 2030 saat ini ditaksir terlalu tinggi. Rencana penerapan yang jelas pada sektor tertentu dapat mengurangi perkiraan permintaan energi yang berlebihan. Intervensi dari sisi permintaan juga harus memprioritaskan opsi-opsi yang hemat biaya dan berdampak besar, seperti elektrifikasi jalan raya dan peralihan konsumsi LPG.*

- *Rekomendasi jangka pendek untuk perjalanan transisi energi Indonesia harus difokuskan untuk menegakkan kepatuhan terhadap pemantauan dan perencanaan (misalnya pengolahan mineral, bangunan ramah lingkungan, standar emisi bahan bakar, pengadaan energi terbarukan, lokasi yang terikat, dan lainnya.) dan memberikan insentif untuk mencapai hasil yang cepat (misalnya elektrifikasi jalan raya, mekanisme perdagangan karbon, dan lainnya). Rekomendasi jangka panjang mencakup pembangunan infrastruktur pendukung (misalnya produksi hidrogen/amonia, memperkuat kewenangan pemerintah daerah) dan mempersiapkan mekanisme pasar (misalnya layanan tambahan untuk fleksibilitas listrik, ESCO, dan lainnya.)*

Key Highlights

Indonesia energy landscape

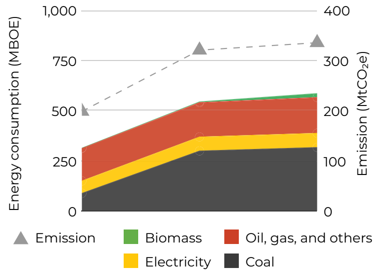


Indonesia's primary energy supply mix in 2023

19-21% (2030)
70-72% (2060)
Indonesia's **renewable energy share target** in primary energy supply, according to the latest National Energy Policy draft.

1,069 - 1,242 $MtCO_2e$
Indonesia's **energy sector peak emissions in 2035**, according to the latest National Energy Policy draft

Industrial sector



Industrial sector energy demand and energy-related emissions

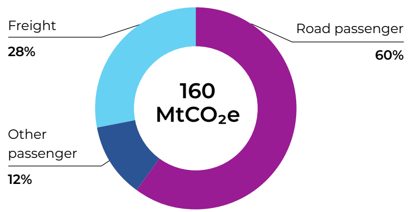
42%
Indonesia's nickel processing **share of global demand** in 2023

8-80 tCO_2e/ton Ni
Indonesia's nickel processing **emission intensity range**

0.07% (2023 y-o-y)
Average industrial sector **energy efficiency improvement**

47% - 90%
Indonesia's key products' **emission intensity difference with EU CBAM threshold**

Transportation sector



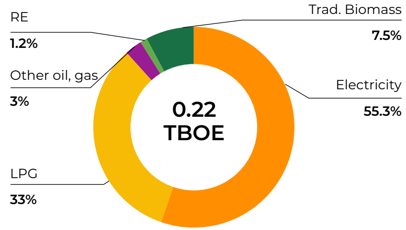
Transportation sector emissions in 2023

130,000 Electric 2W
48,665 Electric 4W
Indonesia's **EV on the road**, as per September 2024

2,205 Swapping station
1,582 Charging station
Indonesia's **EV charging infrastructure**, as per June 2024

64% - 74%
Potential $\mathbf{NO_x}$ **emission reduction** by applying higher emission standards for diesel vehicles (Euro 4-5)

Commercial and household sector



Commercial and household energy demand in 2023

83 IDR trillion
Total **subsidies for LPG** as per Q4 2024

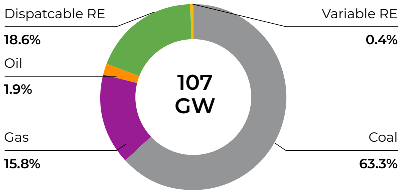
11
Appliances category for MEPS labeling target in 2030

1.45%
Commercial building's **compliance rate towards GR no. 33/2023**, as per October 2024

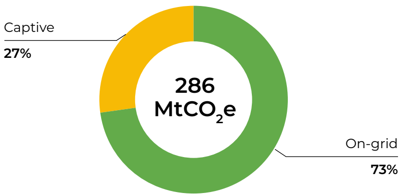
2-10 years
Potential **payback period for energy efficiency projects** for commercial buildings

Key Highlights

Power sector



Installed power capacity and generation mix in 2023



Power sector emissions in 2023

31-40 USD/tCO_2e — Projected **emission abatement costs** of Cirebon-1 CFPP early retirement

13.3 GW — New **renewable energy projects** in the upcoming RUPTL PLN

3% - 12% — **Increase in ramping needs** in Java- Madura-Bali system due to rooftop solar PV

Fuel production

770 Mt — **Indonesia's coal production, 2023**

-16% — **Decline in Indonesia coal exports**, May 2024 (y-o-y)

-3.8% — Indonesia's **total oil production annual decline rate,** 2017-2022

-3.5% — Indonesia's **total gas reserves annual decline rate**, 2013-2023

9.37 USD billion — **Pledged investment on RE projects** from Indonesian fossil fuel companies

6.23 Mha (Palm oil)
1.65 Mha (Sugarcane) — **Land needs for biofuel feedstock production** in 2035

9.98 Mt — **Indonesia's hydrogen demand** in 2060

Subnational

14 — Provinces in Indonesia aim to **achieve at least a 23% renewable energy share by 2025**

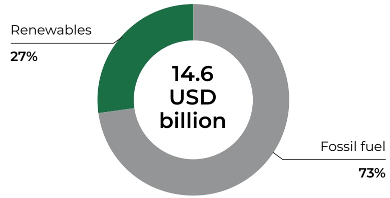
7 — Provinces that already **exceeded their 2025 renewable energy share targets**, as per 2024

5% IDR 1 billion — Median of **provincial budget proportion for renewable energy projects** from total energy sector budget in 2023

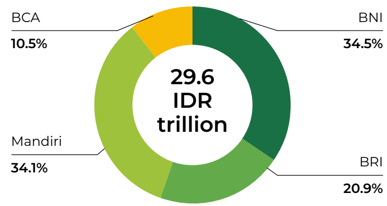
68% IDR 70.7 billion — **Aceh public budget allocation for renewable energy-related projects**

49% IDR 4.46 billion — **South Sumatra government revenue from coal and mineral mining** in 2024 (until November)

Finance



Indonesia's power sector investments, 2019-2021



National banks' credit allocation for RE projects, 2024

19.5 IDR billion — **Total traded value in Indonesia voluntary carbon market** (IDXC) until October 2024

2.34 USD billion — **Financing needs for Indonesian coal workers'** re-training and support until 2050

Chapter 1. Introduction

Contents

- Energy Transition at the Crossroads
- IESR's Energy Transition Readiness Framework

1.1.

Energy Transition at the Crossroads

Alvin Putra Sisdwinugraha

Anindita Hapsari

Contents

- Growing global trends in energy transition
- Review of Indonesia's energy landscape and policy
- New vision of Indonesia's energy policy
- Alignment of Indonesia's new energy vision with climate commitments

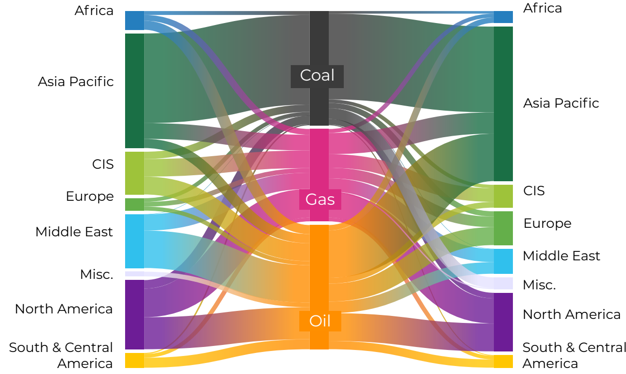
Technology bottleneck concerns due to major producers' rising self-interests require stronger cooperation on energy transition

- Rising geopolitical tensions have threatened the security of the world's fossil fuel supply chain. Ongoing conflicts have increased risks energy security in major fossil fuel-producing and transit regions, most notably in the Middle East (16% of world supply) and the Eurasia/CIS region (13%). Around 20% of global oil and LNG shipping goes through the Hormuz Strait region (IEA, 2024b), adding a potential weak link to the fossil supply chain. With no end in sight for these tensions, the urgency to accelerate RE development has become not only a matter of fulfilling climate commitment but also of ensuring energy security and safeguarding economic growth. This is particularly relevant for emerging market and developing economies (EMDEs) in Asia Pacific, Africa, and Central-South America, many of which are heavily dependent on fossil fuels.

- The production of key technologies for energy transition (such as solar modules, batteries, and electrolyzers) is currently concentrated in only a few countries, most notably China. The dominance of Chinese products in the market has ultimately prompted the US and the EU to adopt protectionist measures in favor of their domestic industries, including high import tariffs on key technologies such as PV modules and EVs (DW, 2024), while ramping up their future production capacity. IEA projection shows that at least 70% of total global clean technology production capacity will remain concentrated in only three countries/regions in 2030 (IEA, 2023). While some emerging economies, such as India and Vietnam, currently already host quite significant production capacity of some key technologies (e.g PV modules, wind turbines), the rising self-interest of major technology producers could present a potential supply chain bottleneck in the near future if other countries do not step up.

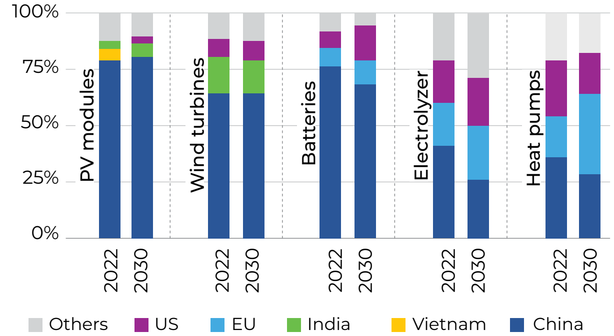
- Countries need to step up their commitment to implementing low-carbon technologies in order to meet global climate goals. The IEA's Stated Policies Scenario (STEPS) shows that global renewable capacity in 2030 will fall short of the COP28's tripling renewable capacity (IEA, 2024b), while global progress on energy efficiency is slow, hindering progress towards the 2030 target (IEA, 2024a). The supply chain vulnerabilities have driven efforts to diversify production, which presents an opportunity for Indonesia's vision of rapid economic growth. This could be supported by strengthening regional cooperation on RE development as well as expanding production capabilities through knowledge and technology transfers.

World fossil fuel production and consumption, 2023



Source: Energy Institute (2024). Production and consumption numbers are converted to energy units.

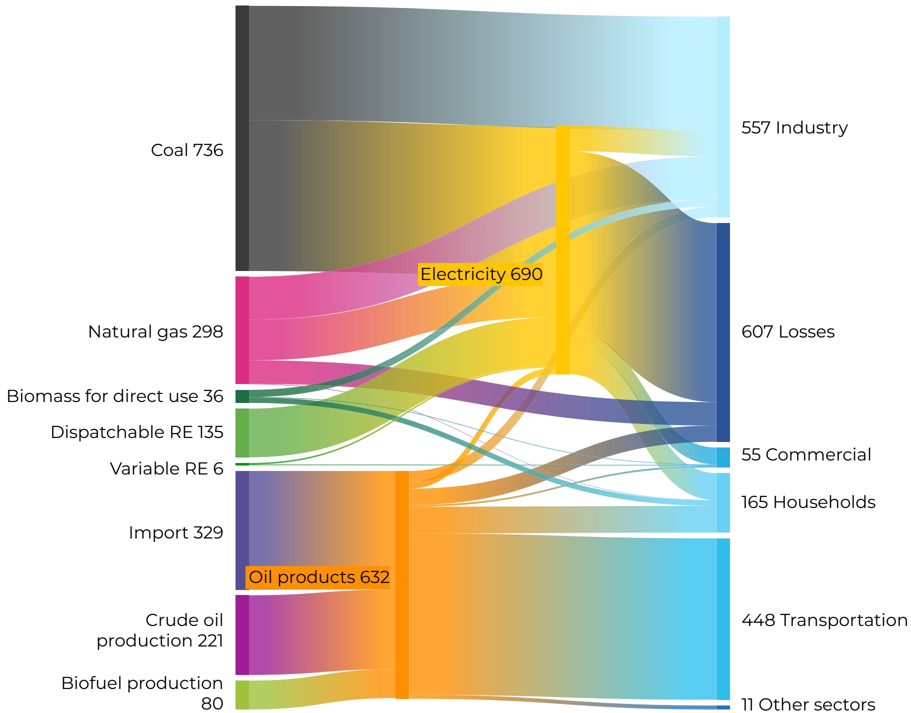
Clean technology production capacity share per country & region, 2022 and 2030



Source: IEA (2023)

Indonesia should prioritize increasing electrification and the use of renewable energy to boost energy efficiency and reduce reliance on fossil fuels

Indonesia domestic primary energy supply, transformation, and final energy demand, 2023 (in million BOE)



Source: MEMR (2024)

Note: Natural Gas losses includes conversion and transportation losses of LNG. Direct use biomass also includes traditional biomass for commercial and residential. Biofuel consists of B100. Variable RE consists of solar and wind (including solar water heater and public lighting), while dispatchable RE consists of hydro, geothermal, and other renewable sources. Oil products also include LPG.

- In 2023, the total primary supply for Indonesia's domestic energy use was 1,843 MBOE. Fossil fuels such as coal, natural gas, and oil products continue to dominate as the primary energy sources in Indonesia, accounting for nearly 90% of the total primary energy supply. Coal (736 MBOE) is the most dominant, with 57% of domestic coal consumption being used for electricity generation.

- The industrial and transportation sectors are major contributors to direct fossil fuel consumption. The industrial sector directly consumes coal (317 MBOE) and natural gas products (119 MBOE), while almost 100% of final energy consumption in the transportation sector (448 MBOE) is supplied by oil fuel products. Together, these two sectors account for 82% of total final energy consumption in Indonesia, making a shift in strategy for these sectors crucial to reducing fossil fuel dependency.

- Most renewable energy sources are converted into electricity generation (139 MBOE), which accounts for around 20% of total electricity generation. However, thermal conversion losses from burning fossil fuels in electricity generation remain significant (497 MBOE), resulting in only 28% overall efficiency in electricity generation. Increasing electrification in end-use sectors while boosting the shares of renewables in electricity generation is a critical strategy for improving energy efficiency and reducing emissions.

- Imported products, including oil fuels and LPG, are primarily used in highly sensitive end-use sectors such as transportation and households. Reducing imports through fuel switching and electrification could help alleviate public budget pressures by insulating the country from global energy price volatility.

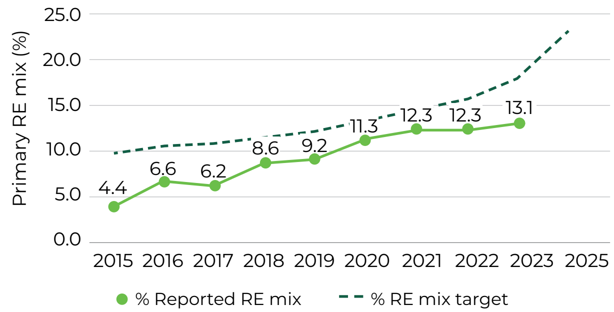
By 2024, Indonesia's National Energy Policy will have been in place for a decade, but the country's progress toward energy independence has been disappointing

- One of the key aspects of the energy resilience objective outlined in the National Energy Policy/KEN (Government Regulation No. 79/2014) is diversifying RE sources. This goal is also reflected in the National General Energy Plan or RUEN (Presidential Regulation No. 22/2017), which sets a target of 23% renewable share in primary supply by 2025. However, nine years after its enactment, only 13.1% has been achieved as of 2023. While the National Energy Council's annual reports claim that the government has relatively succeeded in safeguarding energy supply resilience, this continuous reliance on fossil fuels has certainly contributed to massive energy subsidies and compensation over the years.

- The unmet targets in each sector have contributed to the low share of RE in Indonesia's overall primary energy mix.The fact that targets were not met in each sector has led to a low share of RE in Indonesia's main energy mix. In the power sector, only 18.9% of the country's electricity generation comes from renewables in 2023, a considerable difference compared to the RUEN's projection of 31.8% in 2025. The industrial sector has only 4.5% of its end-use consumption directly supplied by renewable sources, posing a significant gap to the 11.4% projection in 2025. Despite being one of the quick-win targets, commercial and household sector electrification is also progressing slowly, with only 59.8% achieved in 2023, presenting an uphill challenge to achieve the 73.3% target in 2025. Biofuel blending progress is the only initiative that has been able to keep pace with the KEN's goal, with the current B35 program contributing 13.5% of direct RE consumption in the transportation sector by 2023.

- RUEN projections have been severely misaligned by Indonesia's stagnant economic growth over the past decade, resulting in low energy consumption growth. However, KEN implementation's early reluctance to prioritize RE development is making it harder to get back on track. The initial 35,000 MW fast-track program to increase electricity supply prioritized fossil power plants, particularly coal, and slow electricity consumption growth led to power overcapacity and coal asset lock-in from 2019 to 2022. The latest RUPTL PLN 2021-2030 exhibits target misalignment, aiming for a 23% renewable share in power generation by 2025, while the RUEN projection indicates a higher contribution from the electricity sector.

RE realization in Indonesia primary energy supply



Source: MEMR (2024)

Sectoral progress towards National Energy Policy compliance

23% RE share in primary supply

Sectors	Aspects	2025 Projection	2023 Realization
Power	% RE share	31.8%	18.9%
Transportation	% Direct RE	12.8%	13.5%
	% Electrification	0.3%	0.1%
Industry	% Direct RE	11.4%	4.5%
	% Electrification	24.1%	12.7%
Commercial & Households	% Direct RE	1.9%	1.6%
	% Electrification	72.3%	59.8%

Source: IESR analysis (2024), based on Presidential Regulation 22/2017 and MEMR (2024)

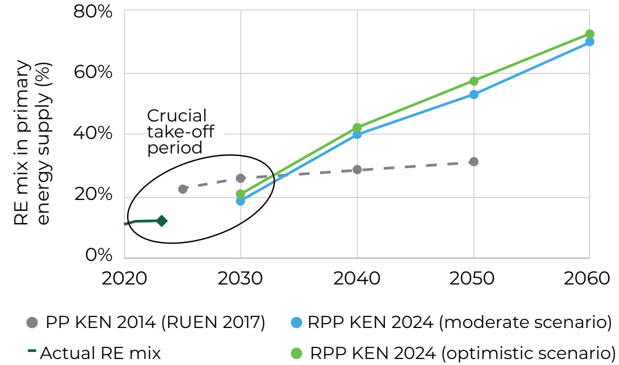
New direction in Indonesia's energy policy means 2025 will be a make-or-break year for the energy transition to take-off

- The year 2024 marks not only a change in Indonesia's presidential term but also a significant shift in policy direction. The Indonesian government has recently enacted the country's long-term national planning document (RPJPN) for 2025-2045 (GoI, 2024), which establishes "the reduction of GHG intensity" through energy transition as one of the plan's key objectives to escape the middle-income trap. The parliament has approved the new National Energy Policy, which outlines "compliance with Indonesia's decarbonization efforts" as a guiding principle, alongside energy security and sovereignty. The new government has acknowledged the importance of this new energy vision, highlighting a focus on energy supply for industrial downstreaming and carbon trading in the first presidential term (Medcom, 2023).

- While this new policy direction seeks to realign with the Paris Agreement and aims to achieve the long-term net-zero emission (NZE) target by 2060 or earlier, the readjustment of certain short-term targets can be counterproductive for Indonesia's energy transition during this crucial takeoff period. This is evident in the decision to lower the RE share in the primary energy supply from 23% in 2025 (based on the Presidential Regulation 22/2017 on the previous National General Energy Plan) to 19-21% in 2030, mainly due to slow progress in RE development (which reached only 13% in 2023). Other notable changes in the new policy include a reduced electricity consumption target and the inclusion of an emission intensity target.

- While adjusting to a more "realistic" target may offer a temporary quick-fix, lessons learned from previous iterations of the National Energy Policy indicate that selecting the right implementation strategy could be a more decisive factor in achieving these targets. For example, the RPJPN short-term (2025–2029) strategy's focus on developing CCS/CCUS needs to be carefully looked over because the technology is still very new compared to technologies like solar and wind power that are already on the market. Another short-term priority to support the new policy is improving the legal basis for energy transition initiatives.The enactment of the Renewable and New Energy Law should better support transition efforts among different implementing bodies. With all these fundamental changes happening in 2024, the year 2025 will serve as the first pit stop for Indonesia energy transition journey, ensuring that the technical planning documents from the relevant ministries /bodies set the appropriate strategy to help realize the new energy vision.

RE mix target in primary energy supply



Source: IESR analysis (2024) based on Presidential Regulation 22/2017, MEMR (2024), and KEN 2024 draft (June 9th 2024 version)

Several target changes in the new National Energy Policy

	National Energy Policy 2014	National Energy Policy 2024*
Primary RE mix	**>23%** (2025), **>31%** (2050)	**19-21%** (2030), **70-72%** (2060)
Electricity consumption	**>2,500** kWh/cap. (2025), **>7,000** kWh/cap. (2050)	**2,346-3,220** kWh/cap. (2025), **5,038-6,526** kWh/cap. (2060)
Emission intensity	Not included	**2.66-2.76** tCO_2/TOE (2030), **0.17-0.19** tCO_2/TOE (2050)

Source: KEN 2024 draft (June 9th 2024 version)

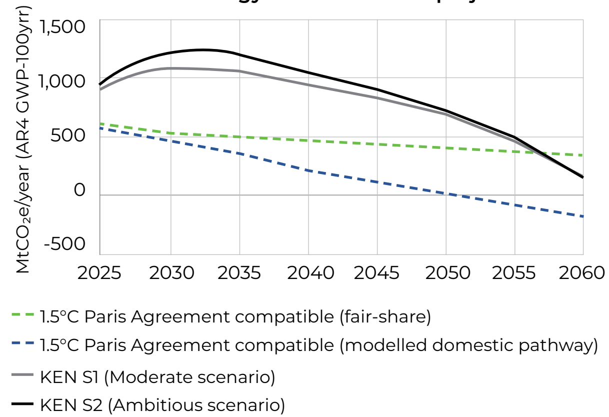
As time runs out for Indonesia to meet climate and energy security, the new decarbonization pathway for energy sector must not rely on other sectors

- Indonesia is in the process of finalizing its SNDC with the expected submission to the UNFCCC by February 2025. It covers updated 2030 to 2035 targets. SNDC included a number of important updates: changing emission reduction baseline from the 2010 BAU to a reference year set to 2019, adding coverage for HFCs gases, and updating the GWP from the IPCC AR2 to AR5. Additionally, the draft SNDC now incorporates a just transition element. According to the CAT's 1.5°C Fair Share, the unconditional ENDC left a gap of around 1000 $MtCO_2e$ to be compatible with 1.5°C target Fair Share, placing it into the "critically insufficient" category (CAT, 2023). This raises expectations for the SNDC to increase Indonesia's climate ambition and reduce the emission gap, including ensuring an emission peak in 2030.

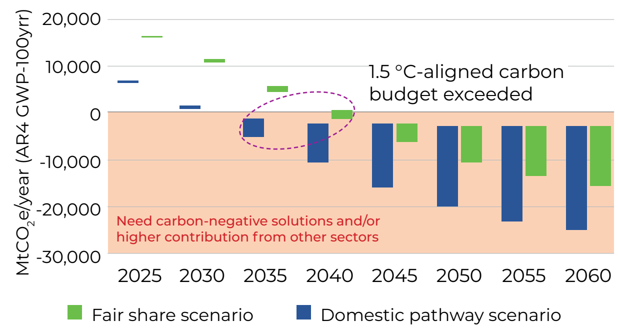
- The process of developing SNDC also aims to align with ongoing national policies of Indonesia, including the National Energy Policy/KEN. However, the KEN pathway for energy sector emissions is far from promising, with emissions peaking in 2035 and almost reaching 1300 $MtCO_2e$ annually. Both the moderate and ambitious scenarios in the KEN draft still project annual emission of 129 $MtCO_2e$ in 2060 (Budiman, 2024), with the net-zero strategy relying on the FOLU sector to double its carbon sequestration capacity from 2030 to 2060.

- The KEN emission projections show that Indonesia may start to run out of its 1.5°C carbon budget for the energy sector between 2035 and 2040, depending on whether the domestic pathway or the fair-share scenario is used (CAT, 2023). This scenario may require the adoption of carbon-negative technologies, which remain largely unproven and costly today, and could significantly increase future mitigation costs. Recent studies also suggest that natural carbon sequestration may soon reach its critical limit due to worsening climate change effects (Ke et al., 2023), putting Indonesia's carbon sink-dependent pathways at high risk of failure. These findings underscore the urgent need to shift the energy sector's peak emissions earlier while reducing total emission level, to avoid cascading catastrophic failure of Indonesia's environmental supporting capacity.

Indonesia energy sector emission projection



Remaining cumulative carbon budget for Indonesia's energy sector based on KEN emission trajectory



Source: KEN draft (June 9th 2024 version) and CAT (2023)

1.2.

IESR's Energy Transition Readiness Framework

Julius Christian Adiatma

Contents

- Political and regulatory
- Investment climate and finance
- Techno-economic
- Social

Summary: Political and regulatory factors remain the main hindrance to the energy transition, despite positive developments in the economic and social aspects

- IESR has been conducting transition readiness framework assessment since the 2021 edition, which tracks the transition readiness in the power sector. This year, the assessment has been expanded to cover the energy transition in non-power sectors, including transportation, industry, and buildings. As a result, new indicators have been introduced, and some indicators have been renamed to better align with the updated purpose. Furthermore, this edition incorporates several new variables to improve the comprehensiveness of the framework. To support this process, we conducted a stakeholders consultation through an FGD to gather perceptions on what is important to measure regarding transition readiness. The FGDs were attended by participants from research institutions, government, and businesses.

- In assessing the framework, in addition to conducting desk studies and examining data points, we also sought to capture the opinions and views of various stakeholders on Indonesia's energy transition readiness through FGD and a survey. The FGD provided an opportunity for each participant to rate the indicators. The survey, which was conducted via an online questionnaire, included 15 respondents, primarily from private companies or associations engaged in energy transition-related activities. These include RE developers, electric vehicle business, battery producers, and general manufacturing companies. The survey aimed to complement the FGD results by gathering perspectives from private actors, especially on indicators that were not sufficiently assessed during the FGDs. The results from both the FGD and the survey form the basis for the ratings presented in this chapter. We decided not to conduct a public survey, as similar surveys were already published this year by other organizations. The detailed description for this assessment methodology is available in Appendix D.

- In summary, despite significant progress in the cost competitiveness of low-carbon technologies and fuels, the energy transition is being hindered primarily by the lack of political commitment, unattractive regulations, and unsupportive governance.

Dimensions	Political and Regulatory			Investment and Finance		Techno-economic			Social	
Variables	Political commitment	Policy and regulations	Institutions and governance	Investment climate	Finance	Ecosystem support	Domestic supply chain	Cost competitive-ness	Public participation	Human resources
Rating	Low	Low	Low	Medium	Low	Medium	Low	High	Medium	Medium

A mounting task for Satgas TEN is to overcome low political commitment, poor governance, and unsupportive regulations, which serve as major barrier to the energy transition

- The absence of a high-level policy document that serves as a legal foundation for the energy transition indicates a lack of political commitment. PR 112/2022 is the only document that explicitly mentions “energy transition," although its definition is unclear, as it still allows the construction of new coal power plants. The proposed draft of the KEN already includes energy transition and decarbonization as a goal, but its pathway remains incompatible with the 1.5°C target, as it is projected to exhaust Indonesia’s entire carbon budget by 2035-2040. Furthermore, the failure to implement planned policies (e.g. carbon tax and electricity price adjustments) and to achieve previous targets (23% renewables by 2025) further highlights the lack of commitment and half-hearted approach of policymakers in enforcing energy transition policies.

- While the energy transition requires coordinated efforts from multiple sectors, the sectoral roadmaps and regulations are not yet ambitious enough to support the 1.5°C target. The industrial sector, in particular, has not yet established its sectoral decarbonization roadmap. Additionally, there are regulations beyond the energy supply and demand sectors that need improvement to support the energy transition. These include environmental and social safeguards for RE and critical minerals, exemption from alcohol tax for bioethanol production, and the modification of building coefficient ratios to accommodate more rooftop solar PV installations. The majority of survey respondents feel that current pricing policies and state loss clause in anti-corruption regulations are hindering the energy transition.

- Poor governance is believed to be impeding progress in the energy transition. Indonesia’s high level of corruption is particularly concerning, as the legal framework and data transparency in the energy transition remain minimal, leaving room for corruption. Limited public involvement in policy making and monitoring implementation only exacerbates this issue. The establishment of Energy Transition Task Force (Satgas TEN) is expected to help bring coordination and oversight of energy transition activities under one institution. However, there is no accountability mechanism, such as performance-based budgeting, to encourage implementation by responsible institutions. Furthermore, the limited capacity of local governments, including budget constraints, manpower shortages, and lack of coordination, further hinders the implementation of energy transition projects.

Political Commitment	High-level policy document on energy transition	Low
	Alignment of climate and energy policies with Paris Agreement	Low
	Implementation of energy transition targets/ plans	Low
Regulatory Framework	Quality of existing regulatory support	Medium
	Alignment of sectoral roadmaps and regulation with decarbonization target	Low
	Supportive non-energy regulations	Low
Institutional & Governance	Corruption level	Low
	Institutional capacity	Low
	Leadership	Medium
	Accountability	Low

Access to credit and financial supports seems to be improving, but varies significantly between subsectors and the scale of business

- Overall, Indonesia maintains a stable investment risk profile, according to several major international credit rating agencies. In particular, the take-or-pay scheme in RE has helped lowering investment risk level by ensuring stable income for project developers. However, uncertainty remains due to challenges in project implementation and complex bureaucracy. Our survey revealed mixed responses from respondents regarding the bureaucracy involved in obtaining business permits, leading to a medium rating. The barriers mentioned include overlapping authorities, procedural uncertainty, and a lack of knowledge among local governments. The increased number of ministries in the upcoming administration may further complicate the bureaucracy.

- Limited access to attractive credit, especially from domestic banks, also hampers investment in the energy transition. Our survey revealed that credits from international banks are considered more accessible and attractive compared to domestic ones. However, most respondents who gave positive responses were from the electric vehicle and manufacturing/processing industries, while RE developers tended to give a lower rating. Many respondents specifically mentioned that the availability of project financing needs improvement. Another concern is that international banks are not interested in small projects, leaving developers with the less attractive loans from domestic banks.

- In regards to public financial support, survey respondents tended to rate international support in the form of aid or grants as inaccessible, while incentives from the Indonesian government are viewed as more accessible. On both issues, respondents from EV and manufacturing industries gave a higher rating than RE developers. The EV industry, in particular, benefits significantly from the E2W incentive, as about 90% of total purchases in 2024 were made under this program. Meanwhile, most RE developers claimed to benefit nothing from government incentives, although some did benefit from import tax exemption for their components.

Stakeholders perceive low-carbon technologies as economically attractive, but more incentives are needed to promote domestic manufacturing

- Low-carbon technologies are becoming cheaper and more competitive with their fossil counterparts, as confirmed by our survey results. The cost of renewable electricity, particularly solar and wind, has been lower than coal power since the 2023 assessment. The low-carbon alternatives in the energy demand subsectors are also cost-competitive. The TCO for EVs is already lower than that of ICE vehicles, both for cars and motorcycles. Energy efficiency measures in commercial buildings, both new and existing, could achieve payback periods of 1.7 to 6.6 years, except for shopping malls, which may take significantly longer. The same applies to residential buildings, where investments could be recovered in less than 4 years, except for 1,300 VA houses (MPWH, 2023). For industrial users, switching to RE sources like biomass is considered cost-effective, although energy efficiency technologies still perform poorly from an economical standpoint.

- Our survey respondents had varying opinions on the availability of domestically sourced components for low-carbon technologies, but most agreed that domestic components are not cost-competitive compared to imported ones. This indicates that the LCR alone might induce increased production costs. Most respondents agreed that LCR is a suitable instrument to encourage investment in domestic manufacturing, but many highlighted the need for complementary incentives. The implementation of a high LCR without sufficient incentive to promote domestic manufacturing could result in non-competitive low-carbon alternatives, ultimately hindering the overall transition progress.

- The existing ecosystem is relatively accommodating to the energy transition. In the power sector, there have been no changes to the grid code and distribution code from the previous edition. The majority of survey respondents agreed that the existing grid is moderately compatible with high RE adoption. They also noted that EV charging and battery swap infrastructure is relatively available in high-population regions and is considered moderately sufficient to support EV growth, although the number of charging stations still falls short of government targets. The presence of green industrial estate is viewed as supportive to tenant's energy transition needs, although standardized requirements and facilities for such estate have yet to be developed. Industry players consider low-carbon energy options, such as rooftop solar PV, RDF, or renewable energy certificate (REC), to be easily accessible, but the quality of RDF and the traceability of REC are not yet standardized.

Ecosystem support	Power system compatibility	Medium
	Green industrial estate	High
	Electrification infrastructure	Medium
Domestic supply chain	Domestic supply chain of low carbon techs	Low
Cost competitiveness	Cost competitiveness of RE power plant	High
	Cost competitiveness of electric vehicle	High
	Cost competitiveness of green appliances	High
	Cost competitiveness of green industry	High

Poor participatory process limits public participation in supporting a just energy transition, despite the high potential of human resources

- Survey conducted by UNDP (2024) found that the majority of Indonesians agree the country should accelerate the shift away from fossil fuels and want the government to take stronger action in mitigating climate change. However, support for the energy transition does not always translate into action, as evidenced by the slow adoption of low-carbon technologies such as rooftop solar PV, electric vehicles, and energy-efficient appliances. This delay is often due to regulatory and financial constraints.

- A lack of awareness and understanding of major initiatives, such as JETP, limits actual public participation in the energy transition. Another survey by the Institute for Policy Development & Yayasan Indonesia Cerah (2024) in three regions with CFPP revealed that over 80% of respondents have no knowledge of JETP, and a similar proportion have not participated in energy transition-related activities. Furthermore, FGD participants mentioned that while public consultation is mandatory for high-level policies, there is limited access to influence policy-making at the more detailed levels, such as the development of RUPTL. On the other hand, our survey revealed that private actors seem to be more involved in the policy process through consultation forums with the government or industry associations and the establishment of working groups. Nevertheless, both civil society and private actors agree that that the aspirations raised during consultation processes are often not adequately addressed.

- Our survey indicates a high potential for human resources, as all respondents believe that it is likely to find qualified workers for their businesses in the market. Bappenas has also developed green jobs occupational mapping that provides guidelines on job specifications, required skills, and certification schemes in sectors related to energy transition, such as RE, construction, and manufacturing. However, there are still limited government programs dedicated to preparing potentially impacted workers in fossil fuel industries for the transition, despite the growing use of “just transition” terminology in policy documents. Furthermore, private actors could contribute more to the just transition and human resources development, for example, by increasing training opportunities. Only half of our survey respondents provide training programs for their employees related to energy transition, and even fewer conduct training for the public.

Human Resource	Capacity of Human Resource	Medium
	Government program for preparing a just energy transition	Medium
Public Participation	General public support for energy transition	Medium
	Participatory process in energy planning	Medium

Chapter 2.

Trends and Transformation on the Demand Side

Contents

- Industry
- Transportation
- Commercial & Household

2.1. Trends and Transformation in the Industrial Sector

Dr. Farid Wijaya

Contents

- Trends in energy consumption and GHG emissions
- Evolving policies regarding emission control
- Growth of the nickel industry and its status
- Energy intensity benchmarking: Indonesia vs. global standards
- Adoption of alternative fuels

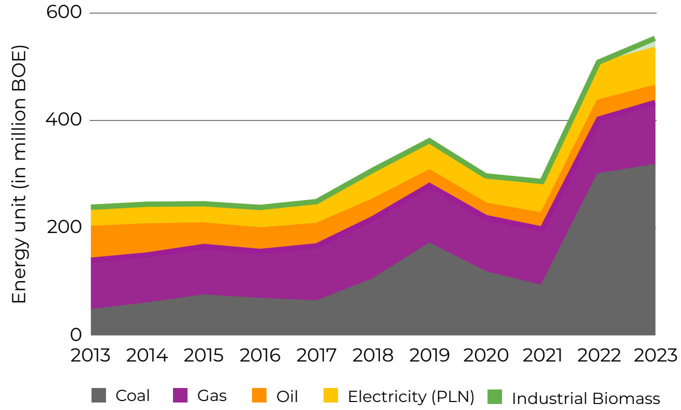
The utilization of coal in the industrial sector augments GHG emissions beyond the global average

- Energy consumption in the industrial sector increased by almost 9%, reaching 556 MBOE in 2023 (MEMR, 2024a). This rise is driven by the y-o-y growth rate of 4.6% (GoI, 2024a). The largest share of energy consumption comes from fossil fuels,with coal accounting for 56.9%, natural gas and LPG for 21.6%, and oil fuel for 5.1%. The utilization of RE increased from 3.82% in 2022 to 6.52% in 2023. Despite a 1.6% increase in the industry's electricity use, electricity now represents only 12.7% of total energy consumption, down from 13.6% in 2022. This trend indicates that industrial electrification remains relatively low compared to overall energy demands in the industrial sector, further increasing reliance on fossils.

- Industrial coal consumption rose by 5% from 2022 to 2023, with a CAGR of 32.4 % since 2017 (MEMR, 2024a). Coal consumption in the iron, steel, and metallurgy subsectors rose by 20%, reaching 60.1 mt in 2023, driven by a y-o-y growth of 14.2%. (MEMR, 2024a; Nurdifa, A. R., 2024). This increase is attributed to the "downstream" program, which has significantly boosted activity in the mining and mineral processing industries, especially in the supply of nickel. In contrast, coal consumption in the cement, textile, and fertilizer subsectors decreased by 25%, while the pulp and paper subsector saw a 16% decline. These reductions are a result of decarbonization efforts, including the use of alternative fuels such as RDF, industrial waste, and biomass, as well as a slowdown in market demand (Ember, 2024; Atmoko, C., 2024; Sayekti, I. M. S., 2024). Nevertheless, the industrial sector remains heavily reliant on coal, with limited transition to RE and sustainable fuels. The mineral processing sectors, in particular, should be prioritized for further decarbonization efforts.

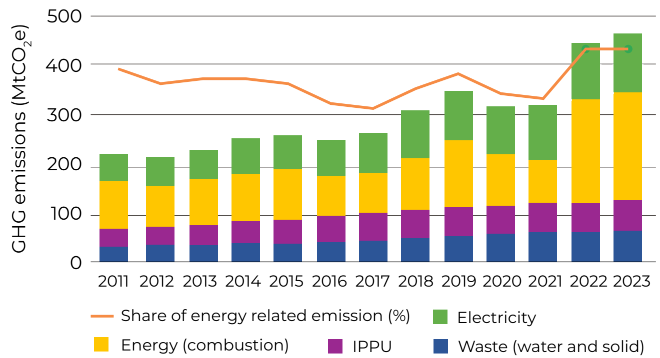
- The industrial sector is expected to contribute at least 460 $MtCO_2e$ in emissions in 2023, marking an increase of nearly 5% compared to 2022. Almost 73% of these emissions are attributed to energy consumption, primarily from combustion of fossil fuels. The high emissions from the industrial sector raise concerns about the effectiveness of emission reduction efforts and their alignment with the NDC and NZE. This includes the extension of fossil fuel subsidies for natural gas under the HGBT policy, as per the MEMR decree 255.K/MG.01/MEM.M/2024, which is set to last at least until 31 December 2024 while the DMO coal market cap remains in effect indefinitely.

Energy utilization by sources in the industrial sector



Note: There are changes in the energy landscape in the industrial sector including update to biomass, gas, and oil data and the elimination of the use of "traditional biomass" in the HEESI published by MEMR in 2024 (MEMR, 2024a).

Historical GHG emissions from industrial activities



Source: MoEF, (2023); MEMR, (2024a)

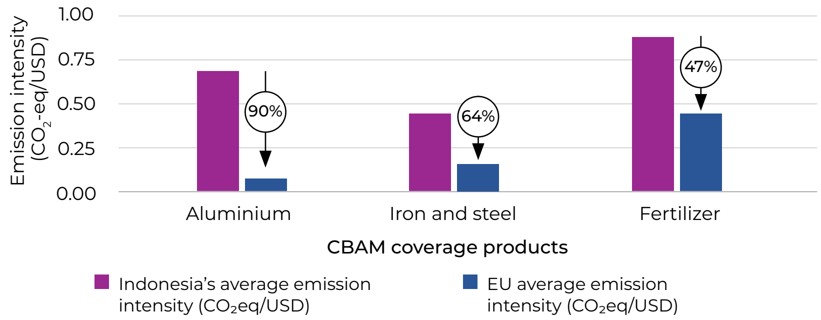
Driving low-carbon policies to maximize decarbonization efforts and enhance domestic competitiveness in the global market

- Indonesia's carbon pricing system, introduced at the end of 2023, has yet to be incorporated into industrial policy to fully accommodate the industrial sector (Agustiyanti, 2024). Under the Green Industry Centre, MoI is developing decarbonization and carbon pricing roadmaps, which are expected to be completed by early 2025. As of mid-2024, there were 103 certified green industries and 37 recognized standards, illustrating the landscape of the green industrial ecosystem (MoI, 2024; Simanjuntak, A. K. M., 2024). These developments highlight the long road ahead, which include shaping the GoI's policy direction for achieving NZE in the industrial sector by 2060 or sooner.

- Indonesia enacted its carbon tax policy through Law No. 7/2021 on Harmonization of Tax Regulations (*UU HPP*) (DML, 2024; HSI consulting, 2024). However, the policy was not implemented until the time of writing, despite being initially scheduled for April 2022 (Anggela L., N., 2024). This delay raises concerns about whether Indonesia will have enough time to meet the EU CBAM carbon emissions footprint requirements. The EU CBAM transition began in the fourth quarter of 2023 and will continue through 2025, with carbon tariffs set to take effect in 2026. The EU CBAM policy imposes carbon tariffs on imported commodities to protect local industries that have reduced their carbon footprints. Turkey, Australia, and the UK have started developing their CBAM policies (GMK, 2024; EY, 2024), and more are expected to follow suit.

- The relative emission intensity of three key commodities—aluminum, fertilizer, and iron and steel—produced in Indonesia is 45.5% to 89.9% higher than the EU CBAM's threshold. In 2023, the total export value of these commodities amounted to USD 757.7 million, representing 4.54% of Indonesia's total export to the EU (Ministry of Trade, 2024). Given the relative excess emission intensity and export value, it is estimated that if the EU CBAM is fully implemented, Indonesia could face charges of at least USD 341 million—nearly half the total export value in 2023. This underscores the significant challenge posed by Indonesia's high pollution level and highlights the need for urgent action to remain competitive in the global market for low-carbon commodities.

Comparison of average emissions of 3 key commodities in Indonesia with CBAM



Source: Adapted from Ministry of Trade (2024)

- It is crucial for Indonesia to adopt a CBAM-like system for imported goods to protect its domestic sector and achieve its NZE goals. The accelerated implementation of the Technical Agreement on Upper Emission Limits-Business Actors (PTBAE-PU) and the certification of green industry standards in the industrial sector can enhance the sector's competitiveness, particularly in response to the impact of CBAM's growing market.

- Another critical concern is that industrial activities reported to SIINAs are not being conducted optimally as required under MoI Regulation No.2/2019. In practice, these activities are not carried out effectively and fall short of expectations. According to the MoI, in mid-2024, only two sub-sectors have completed data in SIINAs, making it difficult to establish carbon pricing and a decarbonization roadmap for the industrial sector due to the lack of comprehensive data. SIINAs are crucial for monitoring industry's compliance with energy conservation under GR No.33/2023, as well as for tracking GHG emissions, waste management, and environmental conservation, ultimately providing reliable annual statistics on Indonesia's industrial landscape.

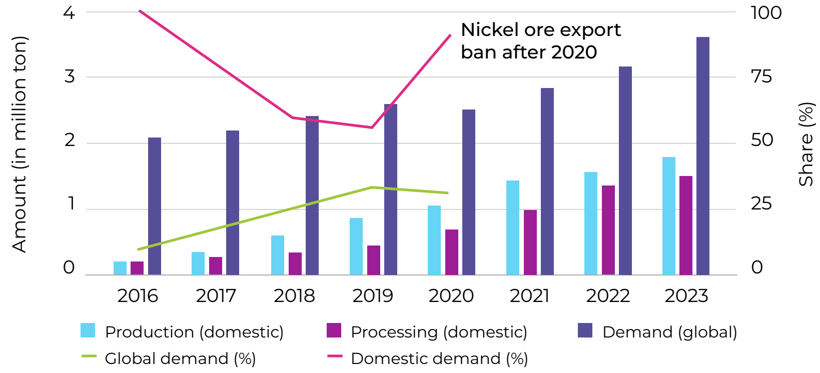
For nickel to remain competitive, its carbon footprint and ESG-related issues must be minimized

- The nickel processing industry has grown rapidly since the implementation of the downstream program and the prohibition of nickel ore exports. In 2023, there were 54 nickel processing smelters, 91% of which produce NPI, ferronickel, and nickel matte for the iron and steel sector. The remaining 9% produce MHP and nickel sulfate from HPAL for the battery sector (Paskalis, Y., 2024; KISI, 2022). In 2024, at least 147 nickel smelters were registered, with 66% using RKEF, 13% using HPAL, and 21% unidentified, and at least 248 furnaces have been in operation (Sultranesia, 2024; Jelita, I. N., 2024; Lestari, A., 2024). Energy efficiency and decarbonization should be prioritized, given Indonesia's nickel still has high energy intensity and emissions. Without strong legislative oversight, ensuring environmental and ESG compliance in nickel exploitation will be challenging, particularly for nickel smelters classified as national strategic projects.

- The coal-fired captive capacity of nickel smelters has increased significantly—by nearly 8 times—from 1.4 GW in 2013 to 10.8 GW in 2023 (KADIN, 2024). This high coal usage produces 58.6 tCO_2e per tonne of domestically-produced nickel, which is 22%-40% higher than the global average (Sani, A. D., 2024; Bloomberg, 2024). According to the LME and Metals Hub, low-carbon nickel has a carbon footprint of less than 20 tCO_2e per tonne of nickel equivalent across all emission scopes (1-3) (IEA, 2024a; Metal-hubs, 2024). As a result, it will be challenging for domestic nickel to compete in the global market, which is moving toward low-carbon alternatives.

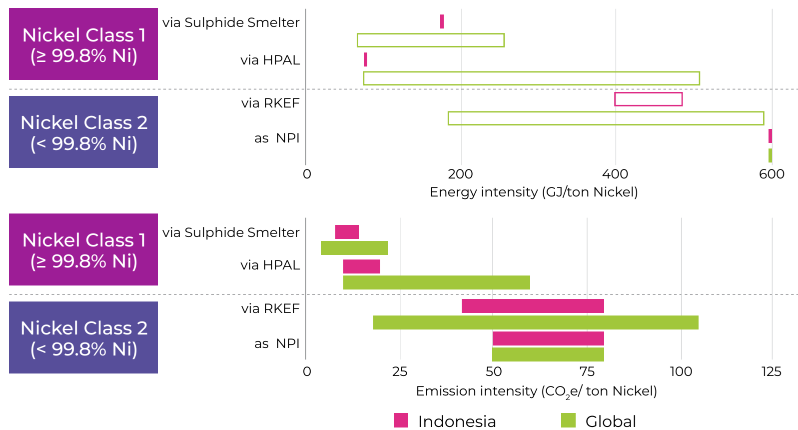
- Environmental issues arising from “dirty” nickel mining and processing include air and water pollution (such as Cr6 contamination), deforestation, and harm to local communities (Jong, H. N., 2024; Firdaus, F., 2022; AEER, 2023). Leaving air pollution unchecked would cost USD 6 billion and result in over 8,000 deaths by 2060 (CELIOS, 2024). Recent effects include the cancellation of a USD 2.6 billion nickel-cobalt refinery venture in mid-2024 due to investor concerns about Indonesia's environmental policies (CRI, 2024a).

Domestic and global nickel status



Source: Adapted from CREA-CELIOS, 2024; Kompas, 2023; USGS, 2023

Nickel processing energy and emission intensity per technology



Source: IESR analysis. Full detail on Appendix E

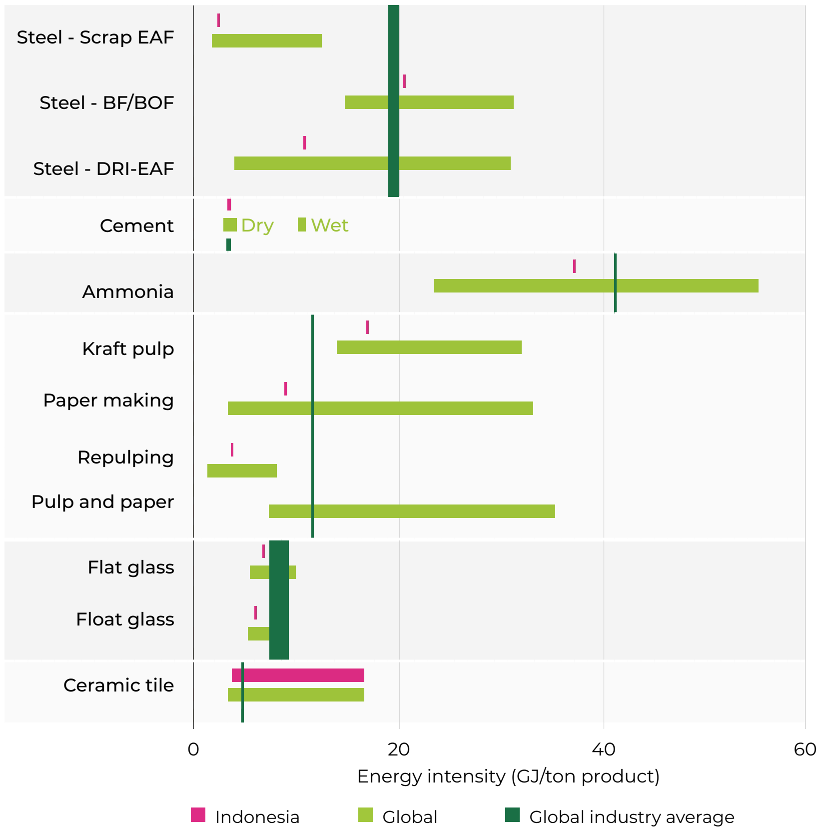
Energy efficiency benchmark to facilitate sustainable industrial decarbonization

- Energy efficiency is an integral part of energy conservation efforts and a key pillar of industrial decarbonization, a process that will continue to be implemented. According to GR 33/2023 on energy conservation, which applies to industries consuming more than 4,000 TOE/year, the industry is expected to save 5.28 MTOE by 2030 (MEMR, 2024b). As of 2023, only 217 out of 450 industries have reported its energy management efforts (Yuliastuti, N., 2024; ESDM, 2024c). This data indicates that energy management is still in its early phases and, to achieve a greater impact, it must be expedited, which includes expanding its coverage across industries.

- Based on data from the MEMR, the progress in energy efficiency across seven industrial sub-sectors in 2023 ranged from 0.01% to 0.27% on a y-o-y basis, with an average of 0.07% (MEMR, 2024c). According to the IEA, energy efficiency and energy intensity must double this decade from 2% in 2022 to over 4% annually until 2030 (Danastri, 2024, IEA, 2023). This target is higher than the NZE scenario, which calls for a 1.8% annual reduction in energy intensity (MEMR, 2024). Furthermore, it does not align with Indonesia's 2014 KEN and 2017 RUEN, which aim to reduce energy intensity by 1% per year until 2025. To reduce future burdens, the industrial sector should be encouraged to meet the IEA's energy efficiency and intensity targets.

- MoI supports energy efficiency practices in the industrial sector in collaboration with development partners, aiming to improve energy efficiency across the sector (MoI, 2024a). One key objective is to elevate 25 industries to a higher level of energy management knowledge and to establish an Energy Management System (EnMS) for five exemplary industries to achieve SNI ISO 50001 certification (Sayekti, I. M. S., 2024). Based on the lower limit (BAT) of global energy intensity, Indonesia's manufacturing industry has room to improve its energy efficiency. Raising awareness and expediting the implementation of energy audits are essential, particularly in light of GR 33/2023, green industrial standards, and the PTBAE-PU implementation.

Industry energy intensity comparison between Indonesia and global



Source: IESR analysis. Full detail on Appendix F.

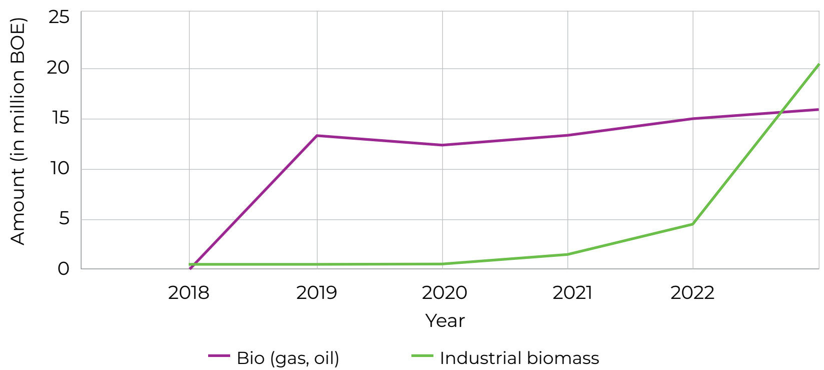
Despite unstandardized carbon footprints, the industrial sector eagerly awaits the adoption of bioenergy as an alternative fuel

- The adoption of alternative fuels, such as bioenergy, low-carbon hydrogen, and ammonia, remains far below expectations. The industry faces several challenges in adopting these fuels, including limited availability, export preferences, low domestic selling prices, quality issues, and associated risks (Zahira, N., 2023; FWI, 2024). Specifically, hydrogen and ammonia—currently being assessed for their practicality, affordability, and availability—are not expected to see widespread use until after 2030.

- The industrial sector still relies heavily on fossil fuels but is beginning to explore the use of biomass and biofuels. According to the HEESI report issued by the MEMR, the industrial sector consumes 6.9% of the nation's biofuels, excluding those used for transportation and logistics. However, the sector has not yet received a reliable biogas supply. Biomass and biofuels account for approximately 6.5% of the industrial sector's total energy consumption (MEMR, 2024a). One key barrier to adoption is pricing, as the export market for coal—offering two to six times the price of the domestic market for coal with the same calorific content—is far more lucrative (IESR, 2024; Trend Asia, 2024). As a result, domestic biomass sales are less attractive to business actors.

- The push for bioenergy adoption is not as effective as often discussed, as the carbon footprint of biomass burning to generate heat or electricity is 150% that of coal and 300–400% that of natural gas (PFPI, 2024). Meanwhile, biodiesel B100 has a carbon footprint up to seven times higher than that of conventional diesel (IESR, 2023a). The chemical composition of these fuels, which includes carbon, may contribute to GHG emissions that are similar to or even greater than those from fossil fuels. A key consideration is LCE, including emissions from LULUCF, which are often overlooked. Therefore, developing a certification and standardization framework for bioenergy, based on LCE assessment inventories, is crucial.

Biomass and biofuel consumption in the industrial sector 2018-2023



Source: MEMR (2024a)

- The Industrial sector consumes around 85 Mt/year of coal, which is equivalent to approximately 500 Mt of biomass. This amount is difficult to achieve, given the country's limited biomass production capabilities, and might lead to deforestation and habitat loss (Heatech, 2024). Thus, it is crucial to prioritize electrification, renewable electricity, alternative fuels such as sustainable hydrogen and ammonia, and the use of CCS/CCUS technology to minimize industrial sector GHG emissions.

- In 2023, the industrial sector utilized 1.8 Mt/year of high-carbon footprint, or "grey," hydrogen to generate ammonia, fertilizer, and petrochemicals (Perdana, A., P. 2024). According to the National Hydrogen & Ammonia Roadmap draft, low-carbon hydrogen will start replacing "grey" hydrogen in the industrial sector by 2025 and is expected to reach up to 3.9 Mt/year by 2060 (MEMR, 2023a; MEMR, 2024b). This shift could make hydrogen a game-changer with the potential to transform the energy landscape of the industrial sector.

2.2. Trends and Transformation in the Transportation Sector

Faris Adnan Padhilah

Rahmi Puspita Sari

Contents

- Transportation sector overview
- Road electrification adoption and infrastructure
- Biofuel and air pollution

Private vehicles continue to dominate GHG emissions, reflecting the immovable status quo of the transport sector

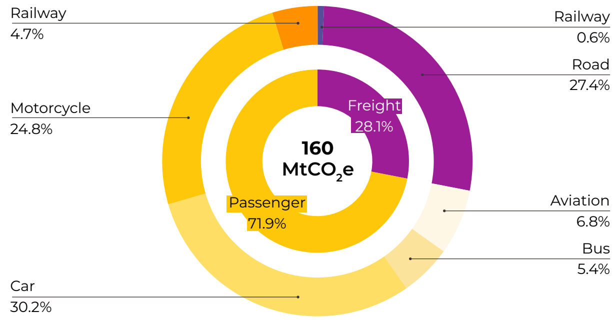
- In Indonesia, car ownership remains relatively low, with 62 cars per 1,000 people in 2022 (BPS, 2024), far from the saturation level (Dargay et al, 2007). Meanwhile, motorcycle ownership is much higher, with 454 motorcycles per 1,000 people. Despite the low number of cars, their contribution to the sector's total GHG emissions is greater than that of motorcycles, making cars the highest contributor among all passenger vehicle modes. Together, cars and motorcycles—classified as private passenger vehicles— are contributing to 55% of the sector's total GHG emissions in 2023. Indonesia has been working on decarbonizing its private vehicle sector since 2019, following the enactment of President Regulation 55/2019, which supports of EV usage by promoting the EV industry and developing charging infrastructure.

- While efforts have been made to promote a 'shift' toward public transport, these efforts remain insufficient to meet decarbonization goals, with the public transport modal share only around 5% of total transport activity (JUTPI, 2019). Several rail network expansions are currently under construction, such as MRT Phase 2A, which is expected to be completed around 2028-2029 (PwC, 2022). The development of urban mass transportation is one of the key concerns outlined in the long-term development plan 2025-2045 (RPJPN), including the development of mass public transportation in the Medan metropolitan area, which remains underdeveloped, and in other large cities such as Palembang, Pekanbaru, and Padang, which are not yet adequately prepared for the increasing urbanization (GoI, 2024).

- Freight accounts for 28.1% of total transport sector emissions, the majority of which are generated by road transport, making it one of the most challenging sub sectors to decarbonize (IEA, 2023). The transition to heavy-duty EVs requires significantly higher costs compared to their internal combustion vehicle (ICV) counterparts, while alternative solutions, such as hydrogen, are still under development (IEA, 2023). Currently, the biodiesel mandate is the primary strategy within the current policy framework for decarbonizing the road freight sector.

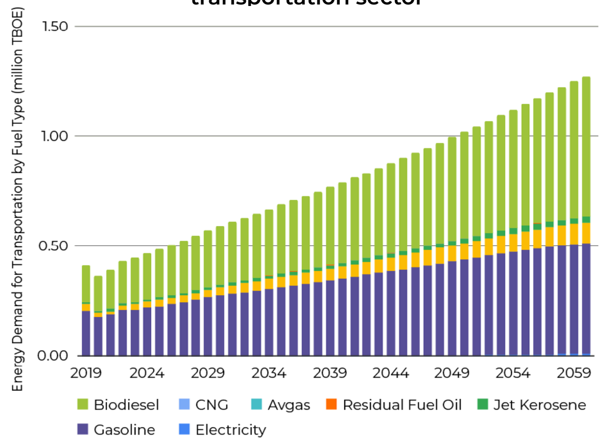
- Another alternative for decarbonizing the freight subsector is through modal "shift" to lower-emission options, such as railways. Shifting freight transport from road to rail is considered highly effective in reducing externalities, including CO2 and other emissions, accidents, and congestion (GIZ, 2021). Under a strong ambition scenario, achieving a 19.59% modal share for rail could lead to an annual reduction of 3.56 $MtCO_2e$ by 2030, assuming a 26% reduction in rail transport costs and a 29% reduction in transit times (GIZ, 2021).

Indonesia's greenhouse gas emission shares in the transportation sector in 2023



Source: IESR Analysis (2024)

Projection of energy demand by fuel type in the transportation sector



Source: IESR Analysis (2024)

EV incentives should be continued due to the significant stimulus they provided to new EV sales

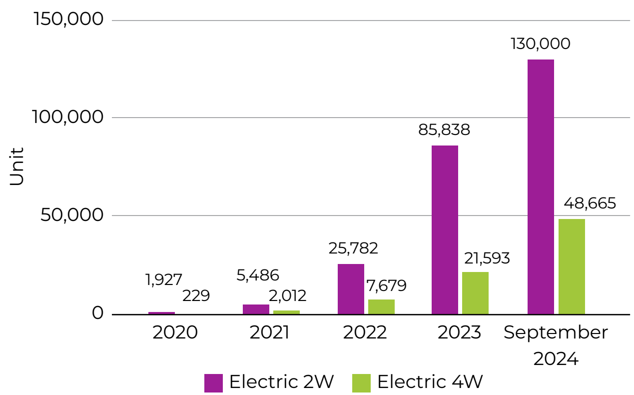
- Indonesia's EV ambition began with the release of Presidential Regulation 55/2019, which supports the goal of making Indonesia a regional EV hub. This regulation laid the foundation for subsequent policies aimed at supporting EV sales. The government also has introduced several incentives to boost EV sales. For example, the vehicle ownership tax and title transfer fees are exempted through MoHA Regulation No. 6/2023. Additionally, the government introduced more incentives, such as MoF Regulation No. 38/2023, which reduces 10% VAT for E4Ws that meet a minimum 40% LCR, and offers 5% and 10% VAT reduction for e-buses with at least 20% and 40% LCR. The government also attracted E4W brands to enter the Indonesian market by offering a luxury and import taxes exemption for both CBU and CKD E4Ws through MoF Regulation No. 9/2024 and Ministry of Investment Regulation No. 6/2023.

- The incentive packages have shown positive results in E4W sales. In 2023, around 70% of E4Ws sold were from ten types of E4W from five brands that received VAT reductions. In 2024, the number of E4Ws sold with VAT reductions reached around 15,000 units, which is 2,000 more than the previous year. Additionally, around 7,500 units of E4Ws sold in 2024 benefited from the luxury and import taxes exemption. In total, more than 80% of E4Ws sold in 2024 received fiscal incentives that lowered their selling prices.

- The government also released MoI Regulation No. 21/2023, which offers a discount of IDR 7 million for the first purchase of an E2W with at least 40% LCR and over 72,000 E2Ws were sold under this scheme in one year. Unfortunately, there are no signs that this scheme will continue, which could slow down E2W sales in the future. The push for E2Ws also comes from the conversion program, where the government provides an incentive to reduce conversion costs by 10 million IDR through MEMR Reg. No. 13/2023. Currently, there are 1,239 converted E2Ws on the road (MoT, 2024).

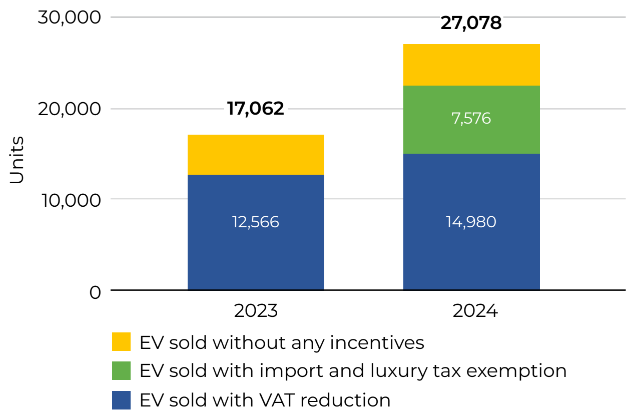
- Given the positive results from the incentives for EVs sales, the government should continue these incentive schemes. It is also important for the government to introduce more criteria for incentives eligibility, especially for E2Ws. The criteria can be related to specification or performance of EVs, which have been applied in several countries that have successfully developed EV markets, such as China (Lam et al., 2018) and India (Autocar pro news desk, 2019). Introducing additional criteria will enhance competitiveness, especially within the E2W segment and between E2Ws and traditional 2Ws in the market.

Status of EVs on the road



Source: IESR Analysis from various sources

Incentives effect on E4W sales in 2023 and 2024



Source: Gaikindo data (2023- Sept 2024)

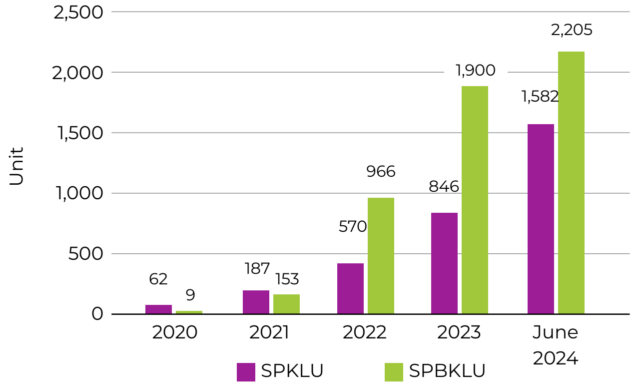
Electricity demand from charging E4Ws is rising, yet its impact on the grid remains insignificant

- Charging infrastructure remains the main barrier to EV sales in Indonesia, according to an IESR survey conducted in October 2023 (IESR, 2023). To address this challenge, the government, through the MEMR and PLN, has introduced several measures to increase the number of EV charging stations. One key initiative is MEMR Regulation No. 1/2023, which removes the requirement for public charging stations (SPKLU) to have three ports, significantly reducing upfront costs. Additionally, PLN offers a 50% discount for new installations or power upgrades for business entities, public transport private charging stations (SPKL), and SPKLU and battery-swapping station (SPBKLU) owners in partnership with PLN. SPKLU and SPBKLU operators also benefit from lower electricity tariffs under MEMR Regulation No. 7/2024. To further support infrastructure growth, PLN has introduced four franchising partnership schemes and implemented service fees for fast and ultra-fast charging to enhance profitability through MEMR Ministerial Decree No. 182.K/2023.

- Diversifying the types of charging stations is another crucial consideration to optimize investments in SPKLU construction. For instance, slow-to-medium chargers, with power outputs ranging from 7 kW to 22 kW, are suitable for locations such as offices, shopping malls, and apartment buildings, where users tend to stay for extended periods. In contrast, fast and ultra-fast chargers, ranging from 25 kW to over 200 kW, are better suited for highways and inter-regional routes, where minimizing charging time is essential. Developing a mix of charging options is vital, as slow and medium chargers are significantly cheaper—costing up to IDR 50 million—compared to the IDR 500 million to IDR 1 billion required for fast and ultra-fast chargers (GridOto, 2022)

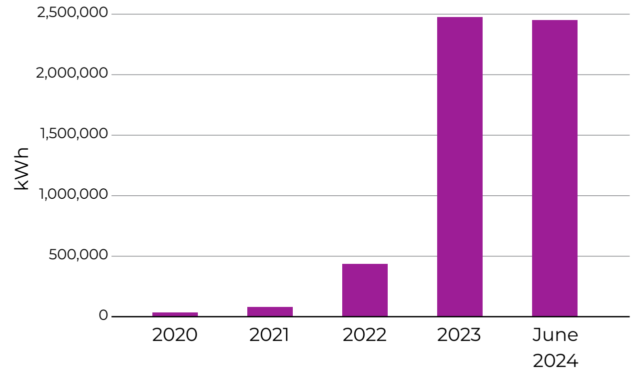
- In the first half of 2024, approximately 700 SPKLU and 300 SPBKLU units were constructed, bringing the total number to 1,582 and 2,205 units, respectively. Electricity consumption from these stations reached 2.4 GWh during this period, nearly matching the total for the previous year. However, despite this growth, EV charging remains a small fraction of Indonesia's total electricity usage, which was 288 TWh in 2023. The government must also address peak load concerns as EV adoption increases. Without proper charging management, the addition of approximately 938,000 E4Ws could raise the Jamali grid's peak load by around 5.9 GW (Ihsan et al., 2020).

Charging infrastructure status



Source: IESR Analysis based on different sources of ministries and news

SPKLU electricity consumption by year



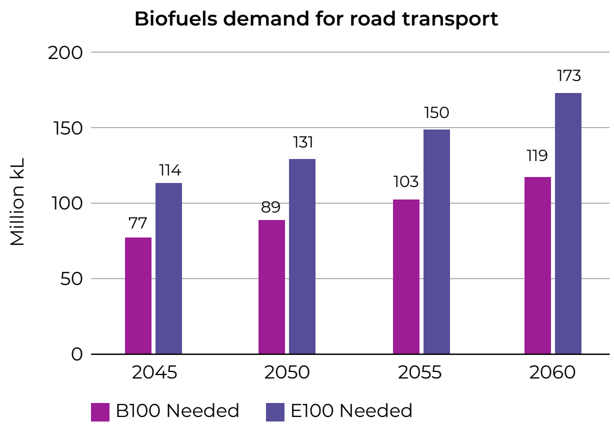
Source: IESR Analysis from PLN data

Higher Euro emissions standards for vehicles and fuels are crucial for the large-scale implementation of high-blend biofuels

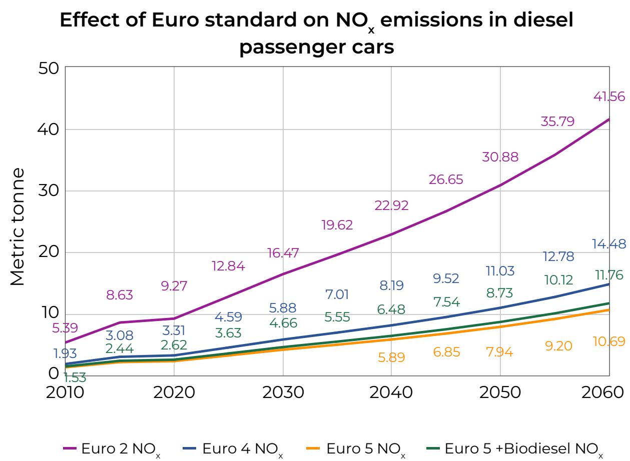
- The EU's palm oil import bans have prompted Indonesia to reduce its reliance on fossil fuel imports and strive for energy self-sufficiency. As a significant first step, the government plans to implement the B50 biodiesel policy by 2025, aiming to eliminate diesel imports and potentially saving up to USD 20 billion annually (Reccessary, 2024). Additionally, the government intends to introduce a 5% bioethanol blend (E5) nationwide by 2028, followed by a 10% blend (E10) starting in 2029, with full implementation expected by 2035 (Kompas Cyber Media, 2024).

- Biofuels play a crucial role in Indonesia's energy transition, particularly in sectors where battery technology remains impractical or cost-prohibitive, such as long-haul heavy-duty transport, shipping, and aviation. However, biofuels have lower energy density compared to fossil fuels. For instance, biodiesel with a 20% blend (B20) has about 1% lower energy density than conventional diesel, while E85 bioethanol has 17-27% lower energy density than gasoline. As the blending percentage increases, the energy density decreases further. If B100 and E100 blends were fully adopted for road transport, fuel demand would rise by approximately 49% for diesel and 8% for gasoline. By 2060, with 100% blending, Indonesia's biodiesel and bioethanol needs could reach 119 million kL and 173 million kL, respectively.

- Despite their environmental benefits, high biofuel blends can present challenges. While biodiesel reduces pollutants such as PM, CO, HC, and CO_2, it tends to increase NO_x emissions. To mitigate this, stricter emissions standards are essential. Implementing Euro 4 and Euro 5 standards in passenger diesel vehicles can reduce NO_x emissions by 64% and 74%, respectively. Euro 5 is particularly effective, as it incorporates Selective Catalytic Reduction (SCR) technology, which can cut NO_x emissions by up to 90%. Compared to the current Euro 2 standards, adopting Euro 5 could reduce the NO_x increase from high biofuel blends by about 70%. This reduction is crucial, especially since road transport was the largest contributor to Jakarta's NO_x emissions in 2020 (CREA, 2023).



Source: IESR Analysis, derived from various sources



Source: IESR analysis from different sources

2.3. Trends and Transformation in the Commercial & Household Sector

Muhammad Dhifan Nabighdazweda

Contents

- Energy consumption and emissions profile
- Progress in shifting the cooking fuel mix
- Progress in sustainable buildings mandate
- Opportunities in green building ecosystem

Electricity and LPG continue to be the main sources of Indonesia's rising household and commercial sector emissions and energy consumption

Energy consumption and emissions from Indonesia's household and commercial sector

Source: IESR analysis from HEESI (2024)

Notes: Biogas, biogas oil, and solar heater assumed to have zero emission factor

- Over the past two decades, Indonesia's household and commercial sectors have been transitioning toward modern energy sources, with some changes accelerated by government policies. However, emissions have risen, primarily driven by increasing electricity demand, which still relies on a fossil-fuel mix of 80%. Driven by population growth and the increasing adoption of electrical appliances, electricity demand in the household and commercial sectors increased by 62.56% from 2013 to 2023, with a CAGR of 4.75%. Under Indonesia's ENDC 2022, several policies have been rolled out to mitigate the emissions from this growth, such as mandatory energy management for certain buildings (2023) and Minimum Energy Performance Standards (MEPS) for appliances (2017).

- Another significant source of emissions, especially in the household sector, is LPG. Since 2007, Indonesia has promoted the shift from kerosene and biomass to LPG for cooking, including through LPG stove distribution programs. As a result, emissions from household cooking have decreased by 23.72% from 2013 to 2023. Under the ENDC 2022, additional policies have been introduced, such as the gas pipeline network expansion (*jargas*) and induction electric stoves (although the project is currently on hold for further study).

- Despite these efforts, overall emissions from energy use in the household and commercial sectors per capita continue to outpace these efforts, rising by 12.2% with a CAGR of 1.14% over the past decade. Renewable solutions, such as biogas and solar heaters, have yet to be implemented on a national scale. However, these solutions are beginning to gain traction on smaller and more scattered scales, with notable initiatives from pilot governments, NGOs, and community programs deployed in recent years.

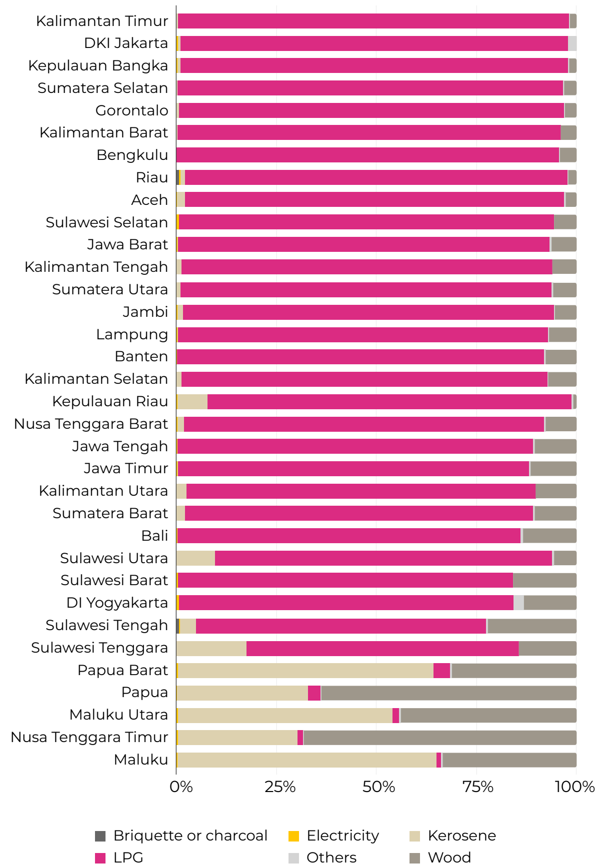
LPG must be shifted gradually due to import and fiscal strain, but overlapping programs have not been successful in achieving targets or promoting equity

- As of 2023, almost 87% of Indonesian households rely on LPG for cooking. While the transition from kerosene and wood to LPG since 2007 has improved health and reduced emissions, it has also strained public finances and jeopardized energy security. The 3 kg LPG subsidy reached IDR 83 trillion by Q4 2024 (MEMR, 2024), and imports totaled 6.95 Mt in 2023 (HEESI, 2024). To address these issues, the 2024 National Energy Policy Draft (RPP KEN) outlines two key strategies aimed at making imports on LPG zero by 2030: expanding the natural gas pipeline network (*jargas*) and promoting electric cooking appliances (ECA), such as rice cookers and induction stoves. By 2025, the government aims to connect 1–1.2 million households to *jargas* and promote ECAs in 700,000 households. The long-term goals include 5.7–7.3 million *jargas* connections and 52 million ECA adopters by 2050.

- Despite these efforts, the implementation has not been successful to reduce LPG. Although *jargas* has expanded to 900,000 households in 2023, the program is likely to miss its intended target of 2.4 million households in 2024 (MEMR, 2024). Similarly, the 2022 electric stove pilot projects in Denpasar and Semarang were halted due to difficulties scaling up, as many households have low electrical capacities (900 VA or less), making it impractical to use high-wattage stoves (1,000–1,500 W). The technical feasibility of a separate metering scheme for electric stoves also remains questionable for nationwide implementation. Other efforts to explore alternative fuels have also stalled. Dimethyl ether (DME) plants have proven economically unviable (IEEFA, 2023), and while biogas could provide 13.3% of cooking fuel, especially in remote areas with high agriculture activities (WRI, 2024), high costs, maintenance concerns, and fragmented initiatives have limited its expansion.

- In addition to technical and economic challenges, the current programs have not adequately addressed equity in cooking. About 12.27% of households still use traditional biomass (9.82%) and kerosene (2.45%) in regions such as NTT, Maluku, and Papua, which pose health and environmental risks. Furthermore, *jargas* expansion is only limited to Java, Sumatra, and Kalimantan, potentially leading to stranded assets due to reserves lasting less than 20 years (MEMR, 2021). Similarly, ECA adoption is limited in areas with higher electrical capacities and more reliable grids, mainly in these islands. This underscores the need for government initiatives across all cooking fuel programs to be harmonized to avoid overlaps and inefficiencies. Moreover, the current LPG subsidy should be reallocated to the eastern regions and to low-income households in the western regions.

Indonesia cooking fuel mix in 2023



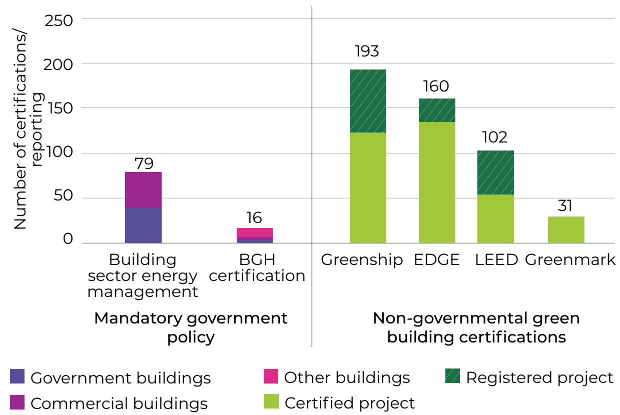
Mandates for sustainable buildings are still in the early stages and require stronger government action to enhance compliance and incentivize adoption

- There are two main mandates regarding sustainable buildings: GR No. 33/2023 on energy management and MPWH Regulation No. 21/2021 on green building (BGH) certification. The former requires buildings that consume over 500 TOE or have annual energy bills exceeding IDR 500 million to implement energy management. The latter mandates that certain new and existing public and commercial buildings, ranging from 5,000 to 50,000 m², must obtain BGH certification. However, adherence to these regulations remains low, with only 1.45% of buildings complying with GR No. 33/2023 and less than 1% obtaining BGH certification.

- A key challenge is the lack of a robust regulatory framework and enforcement mechanisms. Building owners are awaiting a derivative regulation from the MEMR, which is expected to clarify implementation procedures, such as reporting, monitoring and evaluation, and disincentives. However, the proposed penalties for non-compliance are limited to social sanctions, such as public disclosure, and there is no dedicated body to enforce compliance. While a monitoring POKJA, which includes non-governmental members, is planned to conduct random inspections, concerns remain regarding the effectiveness of these measures. In addition to weak enforcement, awareness of energy management and BGH certification remains low, particularly among targeted building owners and local governments (CEDSGreeB UGM, 2024). The lack of international recognition and branding incentives may also explain the higher success rate of non-governmental building certifications, which have issued 391 certifications compared to just 16 BGH certifications.

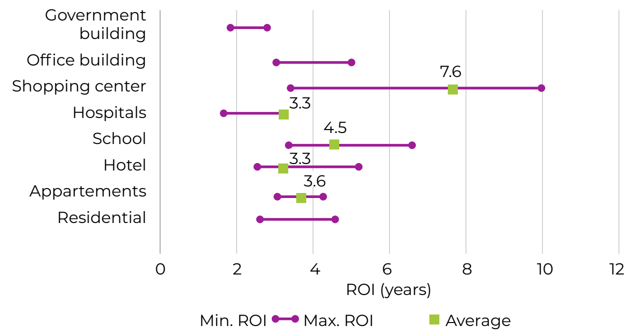
- Another significant barrier is limited access to affordable financing for energy efficiency projects, particularly for smaller buildings (CPI, 2024), despite the potential for a 2- to 10-year ROI (MPWH, 2024). This issue may become more pronounced if future regulations expand beyond the current target of buildings consuming 500 TOE, in line with Indonesia's emissions reduction targets under its future NDCs. To address these challenges, the government is currently exploring potential incentives under the upcoming RPM Energy Management policy. These may include rebates on land and building taxes (PBB), fiscal incentives from the fiscal policy agency, and carbon economic values from energy conservation (currently applied only to the industrial sector). However, in the near term, the government has stated that it will prioritize non-financial incentives to raise awareness and encourage habit formation among building owners.

Mandate and compliance of energy management and green building



Source: MEMR (2024); MPWH (2024); SLEB (2024); GBIG (2024); SBH (2024)

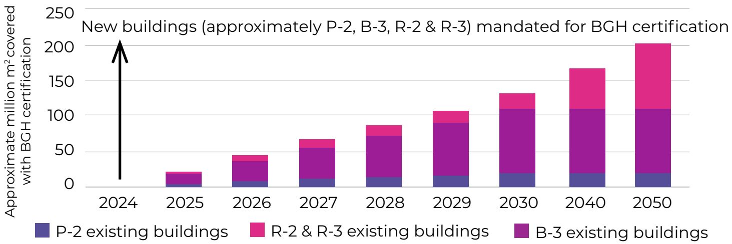
ROI of several energy efficiency initiatives for building types



Source: MEMR (2024); MPWH (2024)

Green buildings targets could spark demand for local green builders, services, and materials but require regulatory harmonization, compliance, and a supporting framework

Roadmap for the implementation & development of BGH



Source: IESR Analysis from MPWH, 2024

	Green Materials
Cement	**8** Cement Producers certified by GPCI (GPCI, 2024) SIH certified industries available (MoI, 2024)
Paint	**8** Paint Producers certified by GPCI (GPCI, 2024)

	Short-term	Middle-term	Long-term
Appliances (MEMR, 2024)	**[7 in 2024]** AC, rice cooker, fan, refrigerator, LED, refrigerated display case, TV	**[11 by 2030]** electric motor, boiler, induction stove, chiller, iron, water pump	**[19 beyond 2030]**

	Human Resources
Green Building (BGH) (MPWH, 2024)	**34** BGH performance assessors **268** professional experts in green buildings
Energy Management (MEMR, 2024)	**2,374** energy auditors (thermal, electricity, and buildings auditors

	Services
Energy Service Companies (ESCO)	**25 ESCOs** approximately (OECD, 2021) **6 ESCOs** partnership with MEMR (MEMR, 2024)

- If fully implemented, the green building (BGH) mandates could stimulate growth in related services and industries. However, current BGH standards are not well aligned with other ministerial programs, leading to fragmentation across sectors. For example, the standards for environmentally friendly materials—such as local sourcing within 1,000 km, cement and paint from ISO 14001-certified factories, 50% recycled content for wall/roof materials, and a minimum of 40% domestic content—are not integrated with other ministerial programs.

- Aligning these standards with the Ministry of Industry's Green Industry Certificate (SIH), which covers high embodied-carbon materials like cement, steel, ceramics, and glass, could create a more cohesive approach. This alignment would increase demand for SIH certification, establish clear criteria for the government's green procurement list, and facilitate industry-wide adoption of sustainable materials. Similarly, incorporating the MEMR energy management and energy-saving labels into BGH standards would encourage appliance manufacturers to comply and motivate the building sector to adopt energy management practices as a condition for certification.

- Moreover, compliance with mandates remains a significant challenge for the success of the green building ecosystem. This could be one reason why the demand for non-governmental BGH assessors and building energy auditors is currently limited. Ensuring consistent compliance across regions would expand the pool of assessors, encouraging local professionals and vocational schools to pursue certification and serve local markets.

- A robust regulatory framework is also critical for supporting green building initiatives and related services. For example, the repeal of MEMR Regulation No. 14/2016 in 2018 reduced the attractiveness of ESCO projects to the insurance and finance sectors. Currently, ESCOs are gaining momentum with government support for carbon value projects, thanks to their integrated financial and technical backing. Reintroducing an updated ESCO regulation could boost confidence in the sector by offering clear protections and guarantees around energy savings, reducing risks, and making these projects more appealing to investors.

Chapter 3.

Trends and Transformation on the Supply Side

Contents

- Power sector
- Resource and reserve (non-power sector)

3.1. Trends and Transformation in the Power Sector

Alvin Putra Sisdwinugraha

His Muhammad Bintang

Dr. Raditya Yudha Wiranegara

Contents

- Power sector overview and planning
- Coal phase-down and phase-out strategy
- RE progress and outlook
- Power system flexibility
- Renewable and storage technology supply chain

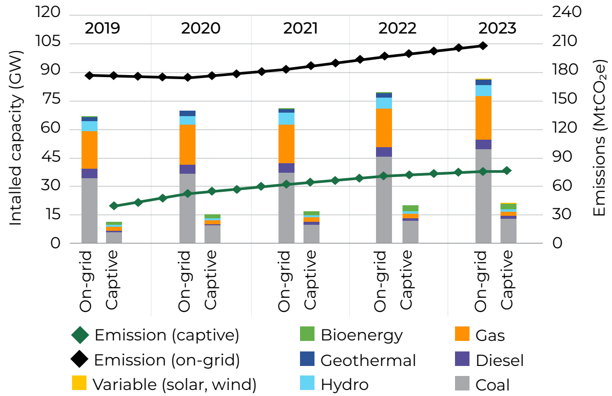
Although overcapacity no longer hinders on-grid RE development, power system decarbonization requires greater compliance and accountability from captive power sites

- Indonesia's installed power plant capacity stood at 107 GW in 2023, with fossil fuels still dominating electricity generation, accounting for approximately 81% of the total generation. Baseload RE sources such as hydropower, geothermal, and various bioenergy contribute 18.6% of the total electricity generation, while the share of VRE is below 0.4%. PLN's annual statistics show that only 9.4 GW out of 16.9 GW planned in PLN's electricity provision plan (RUPTL) was added during 2021-2023, despite annual electricity consumption growth of 5.83%, which matches RUPTL projections. As of late 2023, only 0.95 GW (27%) of the 3.5 GW renewable power plants planned for completion between 2021 and 2023 has been operational, while the buildout of fossil power plants continues to soar, with 8.7 GW (64%) out of the planned 13.5 GW completed in the same period. This has led to the ever-rising emission levels from the PLN electricity grid, which reached approximately 210 $MtCO_2e$ annually in 2023.

- Captive power capacity has been poorly documented, leading to inconsistent figures across ministerial reports. The latest official data from MEMR shows that power generation for captive usage has surged in recent years, reaching an installed capacity of 21 GW in 2023. CFPP lead this captive expansion, with their installed capacity having doubled in the last 5 years, driving annual emissions to approximately 77 $MtCO_2e$ in 2023. As captive power capacity is expected to continue rising in the coming years (ADB, 2023), MEMR should demand their electricity provision plan compliance to the national energy and electricity planning, including RE share and a more robust captive site monitoring and reporting.

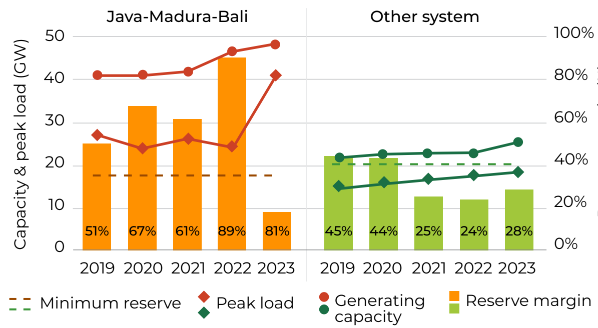
- The overcapacity issue looming over the Java-Madura-Bali system is often cited as the main hindrance to expanding renewable capacity, with the calculated historical reserve margin consistently greater than 50%. However, PLN's 2023 statistics show that the reserve margin in Java-Madura-Bali has plummeted to below 35%, a sudden surge in peak demand—attributed to "Java-Madura-Bali dispatch centre" (UIP2B) in the statistics—drove the system peak demand to above 40 GW level, a 39% increase from the previous year. If similar growth persists in the coming years, this presents an opportunity to aggressively expand RE capacity to meet rising demand, as well as in other systems that are already facing power reserve shortages.

Indonesia power plant installed capacity and CO_2 emissions from 2019 to 2023



Source: MEMR (2024a) and publicly available data on captive sites

Grid peak load and installed power plant capacity



Source: PLN Statistics (2019-2023)

Setting feasible strategies through consistent planning is essential for driving Indonesia's power system to net-zero

- As the National Energy Policy 2024 (KEN draft) nears finalization, both DGE of MEMR and PLN are preparing the latest updates to the National General Electricity Plan (RUKN) and Electricity Provision Business Plan (RUPTL), respectively. The RUPTL 2024-2033 draft has been harmonized with the RUKN draft, at least for the on-grid expansion planning, through the 2040 Accelerated Renewable Energy Development (ARED) scenario (Setiawan, 2024a). Both the KEN and RUKN drafts share common macroeconomic assumptions aligned with Indonesia's Vision 2045, as outlined in the national long-term development plan (RPJPN 2025-2045) and population growth projections (DEN, 2024; MEMR, 2024b).

- Inconsistencies can still be observed between these documents, as highlighted in the comparison table. The KEN draft shows 15 GW more coal power plant retired capacity by 2040, while the RUKN draft prioritizes phase down strategies for CFPPs by converting most existing plants to biomass co-firing with CCS/CCUS and ammonia-fueled power generation (DEN, 2024; MEMR, 2024b). This results in an emissions discrepancy between the KEN and RUKN drafts, ranging from 142 to 253 $MtCO_2e$. These profound discrepancies among government planning documents should not be overlooked, as they could send mixed signals and potentially disrupt planning and budgeting efforts (Halimatussadiah et al., 2024). Breaking down the siloed culture between ministries and agencies responsible for these documents is essential for ensuring an effective and transparent planning process.

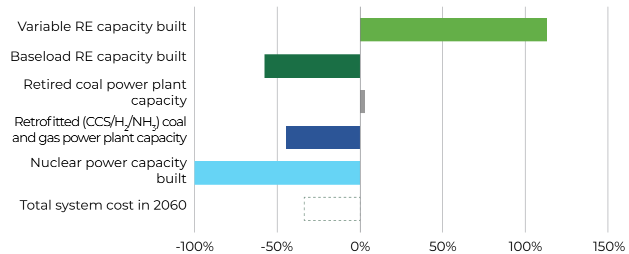
- Despite the inconsistencies, both documents present similar RE capacity targets for 2040 and 2060, alongside aligned decarbonization strategies, such as CCS/CCUS and nuclear power. However, the financial feasibility of these strategies remains uncertain, as neither document includes a comprehensive analysis of total system costs for 2060. This omission makes it difficult to assess whether the proposed pathways represent the least-cost options for decarbonizing the power sector. Using IESR's PLEXOS model, a capacity expansion analysis of the RUKN projections suggests that Indonesia's power sector should place less emphasis on nuclear power and retrofitting fossil power plants. Instead, a more ambitious expansion of RE and accelerated coal retirement offers a more cost-effective approach (up to 33% total system cost reduction) for achieving power system decarbonization.

Comparison between National Energy Policy (KEN) and National General Electricity Plan (RUKN) drafts

Aspects	KEN draft	RUKN draft
Electricity demand projection (TWh)	1,064-1,510 TWh (2040), 1,813-2,349 TWh (2060)	1,078-1,127 TWh (2040) 1,813-2,169 TWh (2060)
RE power plant capacity (GW)	112-159 GW (2040), 252-318 GW (2060)	117 GW (2040), 281 GW (2060)
RE generation share (%)	34-36% (2040) 43-47% (2060)	47% (2040) 49% (2060)
Nuclear Power Plant Buildout	7-10 GW (2040), 45-54 GW (2060)	7 GW (2040), 35 GW (2060)
Coal phase-out/ down strategies	Coal retirement in two phases (2030-2035 and 2035-2040). CCS implementation starts 2035.	No early retirement. Fossil power plant retrofit to using CCS/ H2/NH3, biomass co-firing for PLN's assets. Implementation of BECCS starts 2035.
Emissions from electricity generation	283-394 $MtCO_2e$ (2040), 0 $MtCO_2e$ (2060)	536 $MtCO_2e$ (2040), 0 $MtCO_2e$ (2060)

Source: DEN (2024), RUKN 2024-2060 draft (November 2024 version)

Optimized least-cost Indonesia's power system planning comparison with RUKN 2024-2060 draft



Source: IESR analysis (2024) using IESR's PLEXOS® model

Note: The optimized least-cost scenario uses the same electricity demand growth assumption and emission pathway with the RUKN 2024-2060 draft as the baseline scenario. Full detail of the power system model can be found in Appendix A.

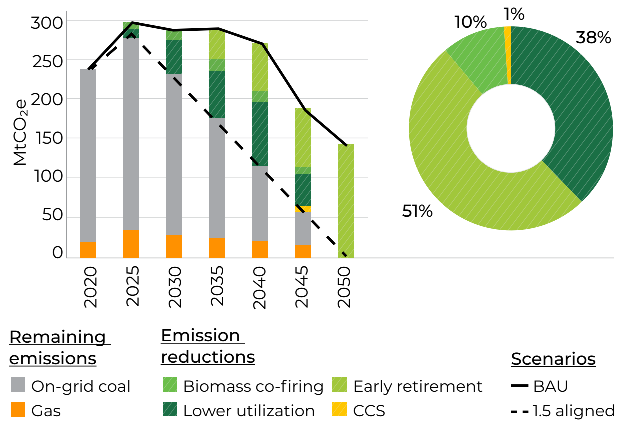
Indonesia's commitment to coal phase-out hangs in the balance due to legal and cost challenges

- Reducing emissions from CFPPs is essential for Indonesia to keep power sector emissions from peaking by 2030. This requires keeping the coal phase-out discussion on the table, particularly for pilot projects like Cirebon-1 and Pelabuhan Ratu. A study by IESR and the University of Maryland (UMD) suggests that early coal retirement should begin in 2035 and gradually become the primary decarbonization strategy by 2050, in alignment with the Paris Agreement goals (IESR & UMD, 2024). Early retirement is projected to account for 51% of the total emission reductions required. The recommended pathway coincidentally aligns with the Indonesian government's recent pledge to retire all CFPPs within 15 years and achieve NZE by 2050 (Riyandanu, 2024).

- Although Presidential Regulation 112/2022 has been enacted, the MEMR, MoF, and MSoE have yet to finalize the early coal retirement roadmap. The roadmap is currently under review by the Office of the Attorney General for its legal implications (Savitri, 2024a). This hesitation and slow progress are driven by several concerns. One significant challenge for PLN is the potential for legal action related to possible state losses (IESR, 2023a). This risk is associated with substantial costs, including potential compensation payments to lenders, which could draw scrutiny from the Audit Board (BPK). Careful cost management, a robust legal framework, and direct government appointment are crucial to minimizing the risk of PLN facing legal challenges when implementing the early retirement plan.

- Another concern is the impact of early retirement on system costs. In the case of Cirebon-1, IESR conducted an assessment using two approaches to fill the generation gap: the system-level approach and the asset-by-asset approach. The system-level approach resulted in fewer emissions reductions due to increased generation from existing fossil plants within the Java-Madura-Bali system. Both approaches inevitably lead to higher system costs, with the asset-by-asset approach being the most expensive. However, the abatement cost of replacements in the asset-by-asset approach is lower than that of replacements handled at the system level. Despite these variations, early retirement of CFPPs remains a relatively cost-effective emissions reduction strategy compared to alternatives. For instance, the lowest abatement cost for CCS/CCUS is USD 62/tCO_2 (ERIA, 2022), making early retirement a more economical option within the broader mitigation framework.

On-grid CFPP decarbonization pathway



Source: IESR & UMD (2024)

Cirebon-1 power plant early retirement assessment exercise

Approach	Abated emission ($MtCO_2$)	Increased system cost (mill$)	Retirement cost (mill$)	Abatement cost ($/t$CO_2$)
System	9.9	96.4	250 - 300 (Fair Finance Japan, 2023)	34.99 - 40.04
Asset-by-asset	54.7	1,435.9		30.81 - 31.72

Source: IESR analysis using PLEXOS®

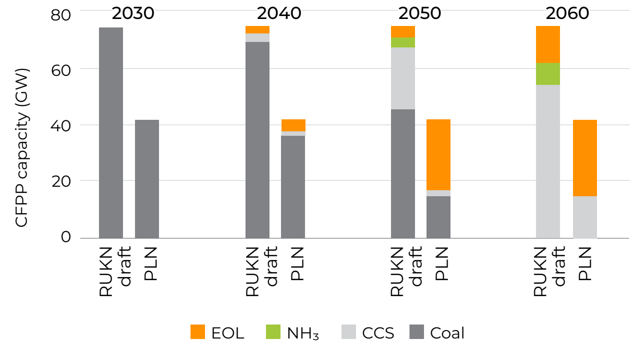
Note: Abatement cost is calculated from summing the increased system cost with retirement cost divided by the abatement emission.

Indonesia's coal phase-down strategy, which includes ammonia co-firing and CCS, raises concerns about its cost and effectiveness, jeopardizing the emissions reduction target

- Coal phase-down has the potential to serve as a temporary emissions reduction strategy before extensive early coal retirements take effect (IESR & UMD, 2024). Key measures include reducing the utilization of on-grid CFPPs by gradually lowering their CF to 30% by 2045, increasing the biomass co-firing rate to 57% by 2030, and incorporating CCS technologies. The study estimated that these measures would respectively contributed to 38%, 10%, and 1% of the total emissions reductions required by 2050. Rather than pursuing both coal phase-out and phase-down, the government has chosen the latter as its primary strategy to decarbonize the CFPP fleet (Karyza, 2023). In addition to biomass co-firing, the government has further emphasized the use of ammonia (NH_3) co-firing and CCS.

- Three coal plants have been tested with ammonia co-firing: Gresik power plant, Suralaya units 9 and 10, and Labuan 2 power plant (Azaria, 2023, Simanjuntak, 2023). At Labuan 2 power plant, the ammonia is reported to be sourced from green ammonia supplied by PT Pupuk Kujang and transported by truck from its Haber-Bosch plant in Cikampek (Jhanesta, 2024). Unlike ammonia co-firing, the application of CCS for emissions reduction in the CFPP is still in its early stages. The first 1 GW pilot project is expected to come online in 2030 (PLN, 2024b). As part of its plans, PLN intends to reserve 15 GW of CFPP capacity, with cumulative emissions of 2.4 $GtCO_2$ annually, for future retrofitting with CCS technology.

Coal phase-down in the planning of the RUKN draft 2024-2060 and PLN from 2030 to 2060



Source: MEMR (2024b), PLN (2024b)

Note:

1. *EOL: End Of Lifetime*
2. *CCS in the case of the DRUKN is retrofitted to co-firing CFPP*
3. *Captive CFPP fleet is included in the DRUKN, which explains the discrepancy with the PLN, as it only covers the on-grid CFPP fleet*

- Despite the potential benefits of both ammonia co-firing and CCS, there are a number of caveats concerning their effectiveness in emissions reduction and cost. For a 20% co-firing rate, ammonia co-firing reduces emissions by 15.5% compared to Indonesia's current grid emissions of 958.4 gCO_2/kWh (Kennedy et al., 2023). Moreover, its abatement cost is three times higher than that of solar and onshore wind in Indonesia. It should be noted that these calculations do not yet include losses from the upstream supply chain. Regarding CCS, the only commercially operating power plant using this technology has consistently failed to meet its target of a 90% capture rate over the past nine years (Schlissel & Kalegha, 2024). The cost of abatement ranges from USD 62/tCO_2 to USD 324.1/tCO_2, depending on various conditional factors (ERIA, 2022; CASE Indonesia, 2024). Given these limitations, leaning toward such technologies would not only increase the cost of generation and hamper the progress in decarbonizing the electricity sector but also prolong the lifespan of fossil fuel assets and conventional grid operations.

Incautiously allowing the build-up of captive coal-fired power plants would lead to economic losses

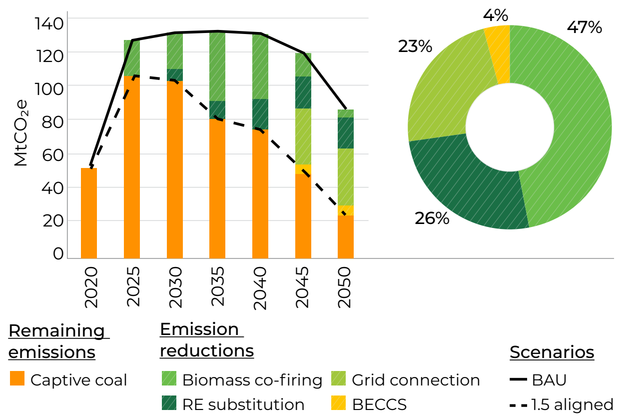
- Reducing emissions from captive power is imperative, given its potential contribution to power sector emissions, which could range from 135 to 197 $MtCO_2$ by 2030, primarily due to the massive utilization of CFPPs (IESR, 2023b; IESR & UMD, 2024). IESR and UMD have suggested measures that could be considered (IESR & UMD, 2024). The cancellation of announced and pre-permitted CFPP projects, with a total capacity of 2.6 GW, could save roughly 18 $MtCO_2$. Other measures targeting existing assets include operating 13 GW with biomass co-firing, substituting 2.5 GW with renewables, connecting 4.8 GW to PLN's grid, and retrofitting 1.1 GW to incorporate BECCS.

- In addition to potential emissions reduction, cancelling captive CFPP projects could help companies avoid significant economic losses. For instance, the government's expansion plan for nickel production outlined in MEMR's Minerals and Coals Grand Strategy (MEMR, 2022), could drastically shorten the estimated lifetime of nickel reserves from 30 years to 12 years for high-Ni ores and from 107 years to 29 years for low-Ni ores. When contrasted with the expansion of captive CFPPs, especially for nickel smelters, this reveals a mismatch between CFPP capacity build-up and depleting reserves, which could lead to underutilization and the risk of stranded assets.

- One of the efforts to switch to renewables identified from captive CFPP beneficiaries in Indonesia is the adoption of solar power. Nickel and EV battery-related industries are spearheading these efforts, with up to 3.3 GWp planned at various locations (IESR, 2024a). One nickel mining company, in particular, has even utilized hydropower to cater the energy needs of its two RKEF plants, resulting in a carbon intensity range of 28-38 tCO_2/tNi (Vale, 2024). This is lower than other companies still supplied by CFPPs, which have a carbon intensity of 57-70 tCO_2/tNi (Peh, 2024).

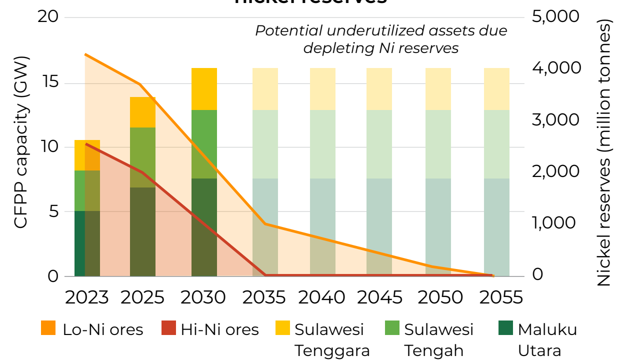
- Reforming existing policies could discourage further utilization of captive CFPPs. Strengthening the 35% emissions reduction commitment in PR 112/2022 is one potential measure. This should be made mandatory, rather than voluntary, to have a meaningful impact. The combined effects of this reform, along with the high cost of emissions abatement technology discussed earlier, should deter the continued use of CFPPs. The power wheeling mechanism could offer an opportunity for captive sites to purchase and even trade green electricity (including solar energy) without negatively impacting PLN's grid and financial stability, provided the appropriate wheeling tariff is set (IESR, 2024).

Off-grid CFPP decarbonization pathway



Source: IESR & UMD (2024)

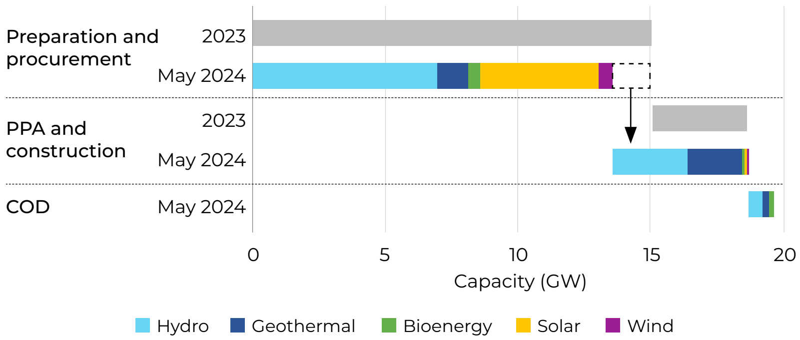
Captive CFPP development against projected nickel reserves



Source: IESR analysis with nickel reserve data and projected production capacity available in MEMR (2020) & MEMR (2022)

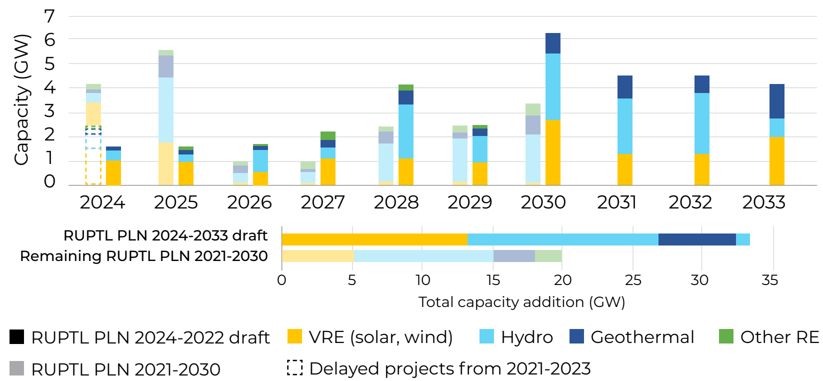
Despite PLN's rising ambition, delays in current projects and a lack of tender volume threaten to push RE development backward

RUPTL 2021-2030 RE development progress per May 2024



Source: PLN DIV MEB (May 2024)

Comparison of RE buildout between RUPTL PLN 2021-2030 and RUPTL PLN 2024-2033 draft



Source: PLN (2021), PLN DIV RSL (May 2024)

- There has been no significant progress of Indonesia's RE development over the past year, apart from the 1.5 GW that has progressed toward the PPA and construction phases. However, many hydropower and geothermal projects have been stalled at the PPA and construction stages, worsening their already long lead time. The Batang Toru hydropower project, which signed its PPA in 2015, will take 11 years to develop, with the power plant expected to reach its COD in 2026 (Perdana et al., 2024). Despite frequent government offers for geothermal projects, PPA amendments have delayed the progress of existing projects such as the Muara Laboh unit 2 and Rajabasa projects, which are still in the exploration phase, with expected CODs in 2025 (and 2029 for Rajabasa unit 2) (Wahyudi, 2024a; Wahyudi, 2024b). Delays in solar and wind projects are mainly due to a lack of project volume, with only approximately 542 MW of solar and wind project tendered between 2021 and 2023. In total, there are almost 2.5 GW of delayed RE projects from the 2021-2023 period, according to the original RUPTL PLN 2021-2030 timeline.

- On the other hand, PLN is attempting to improve its ambition for RE development, with its ARED plan announced at the COP 29 by the Indonesian special envoy for energy and climate (Setiawan, 2024b). The plan aims to add 100 GW of new and RE power plants by 2040. In line with this target, 33.3 GW of RE projects are being prepared for the upcoming RUPTL 2024-2033 draft, which includes an additional 13.3 GW of projects beyond those already in the pipeline. VRE sources, such as solar (including rooftop solar quota) and wind, lead this addition with an extra 8.2 GW, while new hydro and geothermal projects contribute 3.6 GW and 2.4 GW, respectively. However, the draft has revealed PLN's efforts to push these RE projects to later years, with 66% (approximately 22 GW) of these projects set to be completed after 2028. This constant postponement in delivery timelines could generate negative perceptions of Indonesia's RE development, as the system planning and procurement process might be seen as unstable.

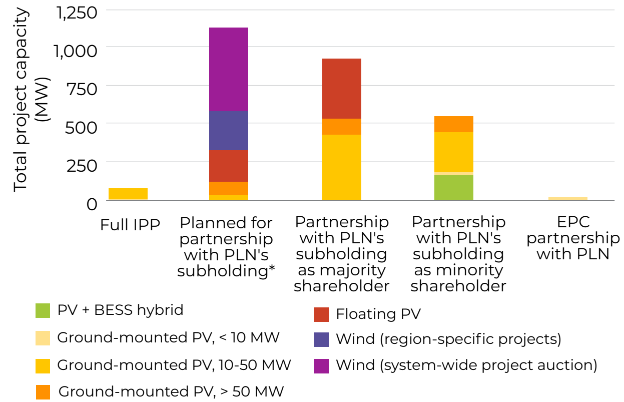
Floating PV and wind power are gaining traction in the upcoming RUPTL PLN 2024-2033, while bundled RE procurement could improve project economics and market signaling

- Floating PV (FPV) has emerged as a promising solution to the utility-scale solar power land acquisition problem in Indonesia. Provided that the planning and procurement processes are executed correctly and according to schedule, the lead time could be less than three years from the signing of the PPA, as demonstrated in the Cirata FPV project (IESR, 2023; IESR, 2024a). With this advantage, upcoming FPV projects could potentially lead the way in expanding utility-scale solar power capacity in the country. As of September 2024, 41.6% of the 1.89 GW of solar projects in the pipeline are ground-mounted PV systems with capacities of 10-50 MW, followed by FPV at 31.3% (IESR, 2024a). These projects will primarily be executed by PLN's subholdings (Indonesia and Nusantara Power), under both majority and minority shareholder schemes.

- Wind power development is relatively lagging behind solar power, as reflected in the previous planning document. Tanah Laut in South Kalimantan is the only on-grid project currently in the PPA and construction phase, with its COD anticipated in 2025 (Savitri, 2024b). The PPA has been signed at a power price of USD 0.055/kWh, making it the lowest historical price to date for wind power. The recent RUPTL 2024-2033 draft indicates greater interest from PLN to develop more wind power projects, with a total of 5.3 GW of projects in preparation. The recent EOI announcement for Project X from Nusantara Power also includes around 805 MW of wind projects, although the majority are still listed as system-based auctions rather than specific sites. This situation has attracted interest from IPPs, and as of Q3 2024, 20 wind power projects have been announced, with a total capacity of 4.5 GW and an estimated investment of USD 9 billion (Petromindo, 2024).

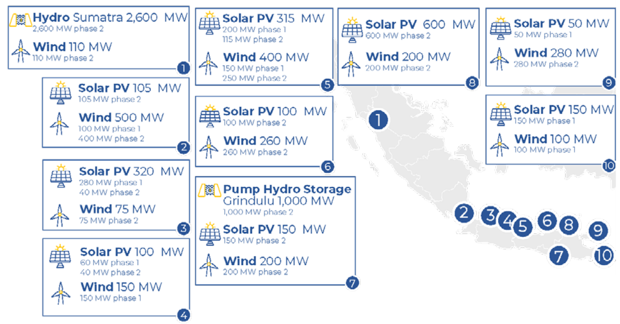
- To improve market signaling and project economics, PLN has initiated a discussion on implementing a bundling procurement scheme for multiple RE projects. This includes a potential 1.9 GW of solar projects, 2.3 GW of wind projects, and 3.6 GW of hydro and pumped-storage projects scattered across Sumatra and Java-Madura-Bali systems. While integrating multiple technology types may increase complexity, such combinations could enable substitution between individual projects, potentially enhancing overall economic competitiveness with an appropriately designed procurement process (Ehrhart et al., 2024).

Solar and wind power project pipeline breakdown, as of September 2024



Source: Interview with PLN's DIV MEB, PLN NP (2023)
**Partnership PLN's subholding, but no specific scheme (majority/minority) mentioned.*

RE project with bundling tender scheme plan by PLN



Source: PLN presentation (May 2024)

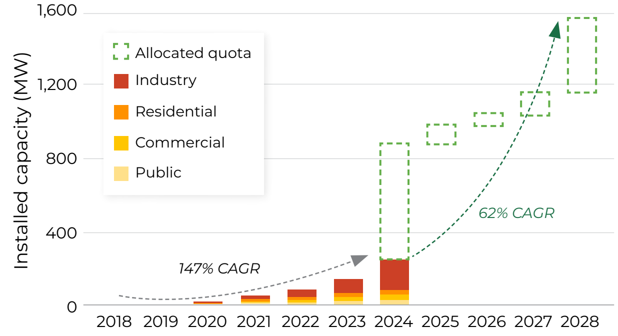
The new quota system has improved market certainty for rooftop solar PV, although higher penetration is still technically and economically viable

- Rooftop solar PV in Indonesia has seen significant growth over the years, despite the PLN's capacity limitation policy introduced in 2022. The CAGR during the 2018-2023 period was 147.5%, resulting in 245 MW of rooftop solar PV capacity installed by June 2024. The latest quota system stipulated by the MEMR Regulation 2/2024 has introduced a certain level of market certainty for rooftop solar PV in Indonesia, with a total rooftop solar PV quota of 1.59 GW set until 2028. MEMR claimed that the new quota system has generated significant interest from developers and consumers, with only 60-90 MW remaining from the allocated 901 MW after the first application period in July 2024 (Anggela, 2024). However, the removal of the net-metering policy in the new regulation is expected to reduce electricity saving benefits for customers, especially in the residential sector (IESR, 2023). This could create a business opportunity for behind-the-meter storage in the coming years (IESR, 2024a), given that battery costs have consistently dropped over the last few years.

- To ensure the successful implementation of rooftop solar PV quota system, greater transparency is needed from PLN and other private utilities, particularly in the quota determination and reallocation process. Improving the efficiency of the permitting process across different PLN distribution and customer service units is crucial to streamline the business processes of rooftop solar PV developers. Additionally, establishing a carbon economic value or Renewable Energy Certification (REC) guideline for rooftop solar PV installation will provide another revenue stream for developers and customers, further accelerating adoption rate.

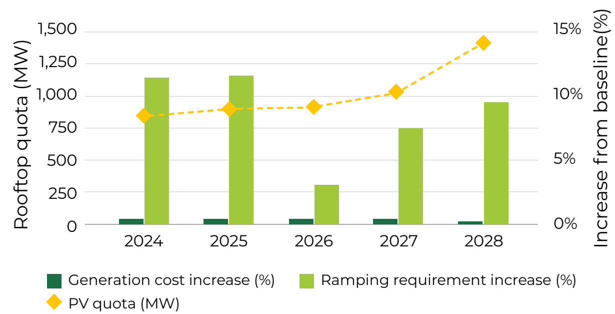
- An analysis using IESR's PLEXOS model shows that rooftop solar PV penetration based on the stipulated quota is projected to result in only a miniscule increase (<0.5%) in electricity generation costs for the Java-Madura-Bali system. The rise in costs is mostly due to an increase (3-12%) in ramping requirements of the system, which are currently met by expensive sources such as gas power plants. This minimal impact on the system suggests that a more aggressive rooftop solar PV quota is both technically and economically viable, especially for a mature system such as Java-Madura-Bali system. Attention should also be focused on improving the distribution code and infrastructure, as well as enhancing the role and capabilities of distribution system operators in managing variability at the distribution level.

Installed capacity and allocated quota for rooftop solar PV in Indonesia



Source: MEMR. Installed capacity update as per June 2024, before the quota application period in July 2024.

Projected generation cost and ramping requirement increase due to rooftop solar PV penetration in Java-Madura-Bali system



Source: IESR analysis using PLEXOS ®. Full model description can be found in Appendix A.

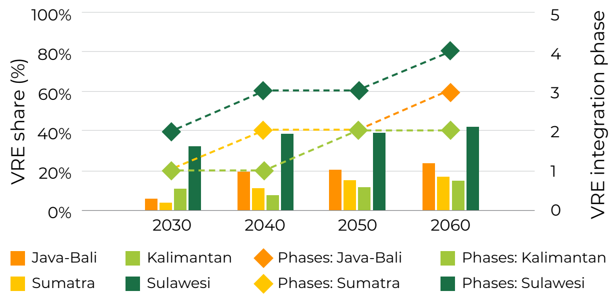
PLN should prioritize cost-effective flexibility options over costly gas and unproven hydrogen, while well-defined grid codes are essential for ancillary flexibility services

- Variable renewable energy (VRE) sources such as solar and wind will play a crucial role in Indonesia's power generation in the coming years, as indicated in the latest RUKN draft. The Sulawesi system is set to emerge as Indonesia's frontrunner in VRE development, with its current 6% share expected to jump to 33% by 2030, entering phase 2 of the IEA's VRE integration phases. This shift is minor but would pose substantial impact on the grid, requiring grid operators to adopt enhanced balancing strategies and improve real-time grid operations and forecasting. Pilot projects in smaller yet scalable systems, such as Nusa Penida, (IESR, 2024b) will help enhance grid operator's capability in managing highly variable systems.

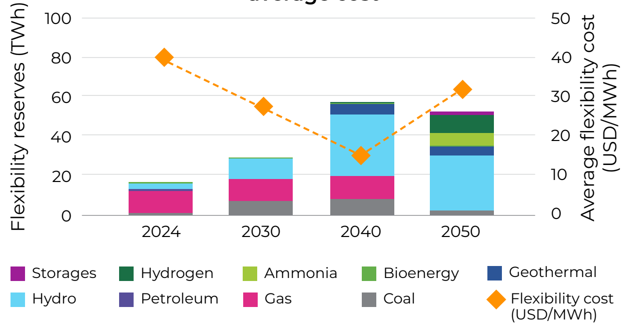
- Adequate flexibility reserves are essential for grid operators to maintain system stability in high VRE penetration. To demonstrate this, IESR conducted such an analysis for the Sulawesi system using PLEXOS. In the early stages of the VRE integration in the system, gas power plants are expected to provide most (66%) of the flexibility reserves, with minor contribution from existing hydro, diesel and coal power plants. However, this dependence on gas to provide flexibility reserves could impose high flexibility costs on the system, making gas power plant a less economical option for the long run. The strategy of using gas as a "transition" fuel to integrate more VRE into the system should be reviewed carefully by PLN, as cheaper flexibility options need to be prioritized in system planning. Ultimately, defining ancillary services for flexibility provision in the grid code will be crucial for effectively utilizing available flexibility reserves.

- As other energy sources are built in the Sulawesi system, flexibility provision will shift to lower marginal cost options such as baseload RE, as shown by the decrease in average flexibility costs between 2024 and 2040. The abundance of large hydropower in Sulawesi plays an important role in integrating more solar and wind into the system, as it is projected to provide 51% of flexibility reserves by 2040. However, projections based on the RUKN draft show that the system's average flexibility costs will rise by 2050, with the majority (95%) of these costs coming from hydrogen and ammonia power plants. Other energy storage options, such as BESS and pumped hydro, need to be considered first, since the fuel production costs of green hydrogen and ammonia remain uncertain, making their economic case for providing system flexibility questionable.

Projected VRE share and integration phase in major Indonesia power systems



Projected Sulawesi system yearly flexibility reserves and average cost



Source: IESR analysis using PLEXOS® based on RUKN 2024-2060 draft.

Note: VRE integration phases refers to IEA (2024a), while average flexibility costs are calculated from total marginal costs of the flexibility reserves (VOM + fuel costs) divided by total flexibility reserves. Full model description can be found in Appendix A.

Improving the regulatory framework and establishing legal certainty are key actions to accelerate energy storage adoption, reducing development risks, and increasing investor confidence

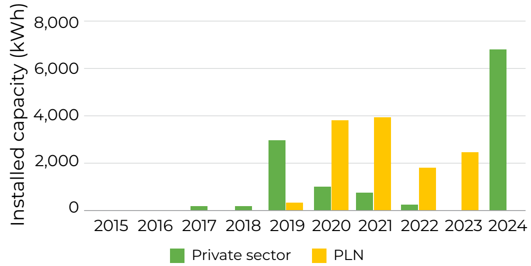
- PLN has increased its installation of medium-scale BESS capacity, particularly following the commissioning of a lithium-ion battery storage system at the Selayar PV system in 2021, which spurred further project development. Previously, the private sector, mostly users of costly diesel generators, led the way in storage installation, implementing medium-scale BESS as early as 2015. PLN has recently integrated at least 2 MW of new BESS capacity annually, with its cumulative capacity now exceeding 12 MW. However, large-scale energy storage is still in the early stages. The Upper Cisokan pilot pumped hydropower storage project, expected to enhance grid stability by 2027, has recently made progress in land acquisition and infrastructure improvements for construction logistics.

- The government's roadmap anticipates a significant increase in energy storage adoption after 2034, as VRE penetration grows and battery prices decline. However, the 29 GWh of storage capacity planned for electricity export projects and utility-led initiatives in the RUPTL could increase installed capacity a thousand-fold over the next decade. Meanwhile, on the consumer side, particularly in the residential sector, BESS installations have yet to yield satisfactory returns under current market regulations. This limits the development of a robust supply chain ecosystem and the growth of domestic expertise in storage technology, which would also help address maintenance challenges for storage assets.

- Although the current technical setup of the power system is not fully favorable to a nationwide energy storage systems (ESS) rollout, there are important deployment opportunities, particularly in improving electrification levels and addressing low reliability and efficiency in small grids. Leveraging these opportunities as a foundation can help expand the role of energy storage in the future grid. IESR's analysis identified key limitations, including the slow pace of VRE capacity growth, the low priority given to energy storage as a peaker asset, and the focus on other grid-enhancing assets with similar functions in current plans.

- Moreover, regulatory frameworks still need improvement to generate demand and establish the economic viability of ESS projects. Currently, planning documents do not fully address the diverse roles and benefits of ESS, and existing regulations have yet to create a strong environment for ESS growth. In addition to improving the regulatory framework and legal certainty, implementing pilot projects to test various ESS technology options and building a storage technology ecosystem, along with a research and development roadmap, should be prioritized in the government's agenda.

Annual capacity addition of medium-scale (>100 kWh) BESS in Indonesia



Source: IESR analysis

Existing characteristics of the power system and their influence on energy storage deployment

Characteristics	Influence on ESS Adoption
Low VRE penetration level and slow growth	Demote
Low electricity load and peak load growth	Demote
High capacity of fast response generators in the pipeline	Demote/ Neutral
Several isolated systems with limited energy sources	Promote
Inferior power system reliability and efficiency in smaller systems	Promote
Low flexibility in current generation mix to accommodate rapid VRE integration	Promote/ Neutral

Source: IESR analysis

As investment in renewable and storage technology supplies pours in, creating an enabling environment to foster domestic demand and technology transfers is essential to attaining industrial competitiveness

- Foreign solar manufacturers are significantly increasing their investments in Indonesia, with potential annual production additions of 200,000 tonnes of polysilicon, 11 GW of wafers, 17 GW of cells, and 19 GW of modules. This includes TMAI, which will be the first Tier-1 solar manufacturer to operate in Indonesia (Hariyanto, 2024). This surge in investment is driven by strategic initiatives, such as the Indonesia-Singapore Green Corridor project, which emphasizes the expansion of domestic manufacturing capacity (Keppel, 2023). Additionally, access to export markets is a key incentive, particularly given the trade tensions between China and Western countries (Chen & Hanyan, 2024). The latest revision of the local content requirement (LCR) regulation (MEMR Regulation 11/2024) also mandates a commitment declaration from solar manufacturers, granting them import relaxation until June 2025. This could potentially increase domestic solar energy manufacturing capacity in the near future, but it needs to be supported by firm domestic demand for solar energy.

- Substantial reserves of critical minerals, such as nickel (ranked 1st globally) and cobalt (3rd), have strategically positioned Indonesia to enter the global clean technology market. Since the banning of raw nickel exports in 2020, nickel production has surged from 35.5 million tonnes per year to over 175 million tonnes in 2023 (MEMR, 2024c), accompanied by significant investments in domestic smelters. However, only about a quarter of this has been converted into battery-grade nickel (MHP type), as only 5 of the 54 operational smelters currently use HPAL technology. With 22 additional HPAL smelters under construction or in planning, smelter capacity is expected to triple (Hasiana, 2024) and could potentially meet half of the global nickel demand for clean energy, which is projected to reach 2.8 million tonnes by 2030 (IEA, 2024b).

Indonesia critical mineral and clean technology production capacity, June 2024

	Existing	Under construction	Planned/ agreed
Polysilicon	-	-	200,000 MT
Silicon wafer	-	5 GW	6 GW
Solar cell	-	3.5 GW	13.5 GW
Solar module	2.3 GW	3.5 GW	15.5 GW
Nickel	175 MT	-	-
Copper	0.84 MT	-	-
Battery cathode	270 ktpa	60 ktpa	-
Battery cell	10.1 GWh	-	25 GWh

Source: IESR analysis from various sources

- GoI is expanding its ambition to become a major player in the global battery supply chain by supporting the development of large-scale manufacturing facilities, or gigafactories. In addition to new battery assembly companies, HLI Green Power has reportedly begun producing battery cells with an annual capacity of approximately 10 GWh, aiming to double this capacity by next year. Factories for anode (graphite) and cathode (LFP) components in Kendal were also inaugurated this year. These facilities are currently in their first phase, targeting production capacities of 120 kt and 160 kt, respectively, by 2025 (KEK, 2024a; KEK, 2024b) . However, domestic cell production capacity is still far from globally competitive. China, which currently produces over 2 TWh annually, is expected to more than double its capacity and dominate the projected 7 TWh demand by 2030 (IEA, 2024c). In comparison, Indonesia's planned production capacity remains modest, at just 25–35 GWh. Increasing global competitiveness to scale up domestic battery production capacity can be achieved through investment incentives, while also mandating technology transfers in strategic partnerships with leading global companies.

3.2. Trends and Transformation in Fuel Production

Ilham R. F. Surya

Shahnaz Nur Firdausi

Contents

- Fossil fuels production
  - Coal
  - Oil
  - Gas
- Alternative fuels
  - Biomass
  - Hydrogen

Oil and gas sectors continue to be unattractive to investors, resulting in a declining supply amid rising demand

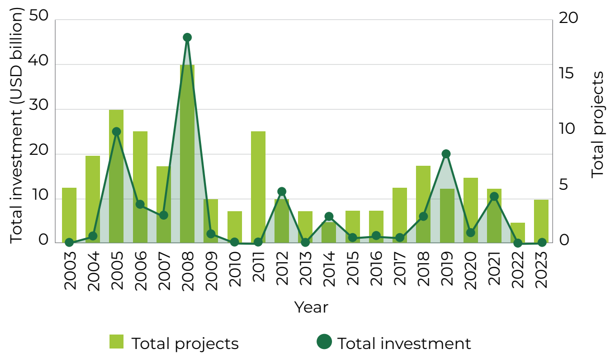
- Indonesia's government revenues from upstream oil and gas have significantly decreased, dropping from 35% of total revenue (7% of GDP) in 2001 to only 6% of total revenue (less than 1% of GDP) by 2016, and remaining below 1% of GDP through 2023 (IMF 2004; IMF 2017; IMF, 2023). This reduction in government revenue from the oil and gas sector corresponds to a similar decline in both the number of investments and the total investment in the industry over the past 20 years.

- In the last few years, the Indonesian government has offered flexible contract options for gas contractors, such as cost-recovery or gross-split arrangements. However, this flexibility has been insufficient to lift production. Additionally, the government's decision to cap gas prices for certain industrial sectors at USD 6/MMBTU—significantly lower than the market price of USD 13/MMBTU as of November 2024—has been perceived as unattractive to potential investors. Furthermore, the government is considering to require gas producers to allocate a portion of their production for domestic use (DMO), which further diminishes the sector's appeal to investors.

- The Indonesian government's intention to increase gas utilization in the power sector has intensified in recent years. As a result, Indonesia's gas demand is projected to increase in the short term, from 48 BCM in 2024 to 52 BCM in 2026 (IEA, 2023b). Demand from electricity generation and the industrial sector is projected to be the strongest driver of overall gas consumption.

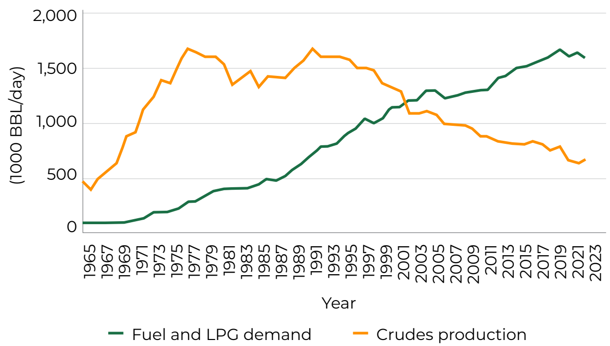
- Indonesia's oil production continues to decline steadily, with no major projects in the pipeline to reverse the downward trend. Currently, oil production in Indonesia is at 630 kb/day and has been declining since early 1990s. It is projected to decrease by 36.5% from 2016 levels, falling to 400 kb/day by 2030 (IEA, 2024b). The largest demand for crude oil is driven by rising fuel consumption in the transportation sector. Several efforts have been made to reduce oil consumption in the transportation sector, including blending biofuels with diesel and ethanol with gasoline, with gradual increases in blending levels. Additionally, vehicle electrification is viewed as a crucial strategy for reducing oil consumption. The MEMR roadmap projects that it could save over 29 MBOE by 2030, assuming electric vehicle adoption meets the NDC targets (MEMR, 2023b).

Total disclosed oil & gas investment in the last 20 years



Source: IESR analysis (2024)

Daily mean of national crude production vs fuel demand



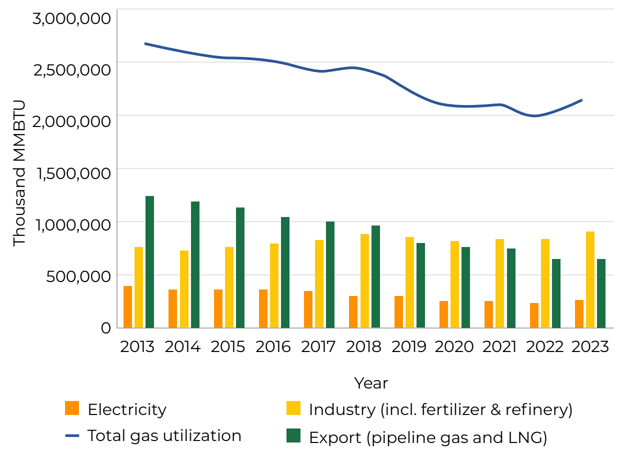
Source: KPBB (2024)

Climate warming risks, potential competition with the industrial sector, and an unbankable forecast make natural gas an uncertain choice as a transition fuel

- The Indonesian government has labelled natural gas as "transition fuel"[1], replacing coal for electricity generation. While burning natural gas emits less CO_2 per unit of energy than coal, the downstream gas industry in Indonesia still leaks significant amounts of fugitive methane (CH_4). In fact, fugitive methane from the downstream gas sector alone accounts for 21% of all methane emissions across the entire gas supply chain (IEA, 2021b). Methane is a potent greenhouse gas, trapping heat in the atmosphere much more effectively than CO_2 (Howarth, 2014). Over a 100-year period, the impact of one tonne of methane is equivalent to 28-36 tonnes of CO2 (IEA, 2021a).

- Designating gas as a transition fuel for power generation also means that the already-shrinking national production of gas will compete with the growing demand from the industrial sector. Over the last 10 years, industrial demand for gas has increased by nearly 20%, compared to relatively stagnant gas utilization for power generation. Industrial demand for gas is expected to continue rising following the stipulation of Ministerial Decree of Energy and Mineral Resources 255/2024 on the Specific Natural Gas Price (HGBT), which revises the eligible industries for the HGBT scheme. The new sub-sectors included in the scheme are fertilizer, petrochemical, oleochemical, steel, ceramics, glass, and rubber glove industries.

Gas utilization trend in the last 10 years



Source: MEMR (2024)

- With the growing demand from industry and, potentially, the power sector, Indonesia is projected to become a net gas importer by the 2030s (IEA, 2022a). Indonesia's gas reserves are shrinking rapidly, dropping by 33% from 150.39 TSCF in 2013 to 99.5 (reserves and contingent resources) in 2023 (MEMR, 2023c; 2024). At the current lifting rate, gas reserves (and contingent resources) have been declining at an average rate of 3.5% annually over the last decade.

- Indonesia's archipelagic geography and dispersed natural gas reserves necessitate the liquefaction of gas into LNG for distribution. This is especially critical given that gas supplies are concentrated in eastern Indonesia, while demand is predominantly in the western regions. To support the growing need for gas distribution, Indonesia must invest in additional LNG terminals and regasification facilities. However, increased investment in LNG facilities could potentially hinder, rather than facilitate, the transition to RE (Nikkei Asia, 2022). Furthermore, gas infrastructure projects, which are long-term investments requiring 30 years to become profitable, are projected to become unbankable in the coming years. Given this timeframe, such projects are unlikely to serve as effective "medium-term" solutions.

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[1] CNBC Indonesia, 4 July 2024, Sumber Energi Ini Jadi Andalan RI untuk Percepatan Transisi Energi.

Coal production shortfalls amid ambitious production plans could risk coal companies' finance, even as demand from captive CFPPs rises

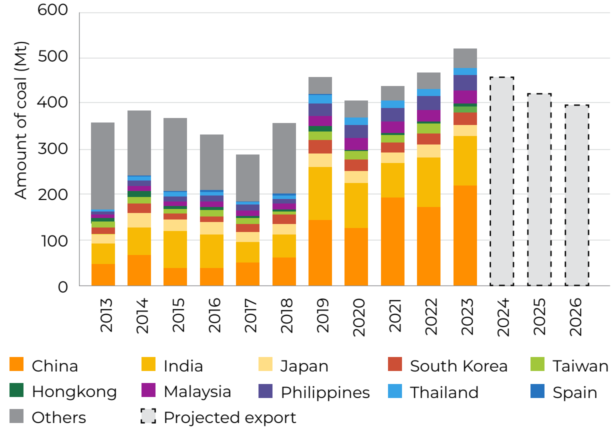
- In 2023, Indonesia's coal production reached an all-time high of 770 Mt. For 2024, the official target set by the MEMR is 710 Mt, while the Indonesian Coal Annual Budget and Cost Work Plan (RKAB) states that the allowed quota of coal production will reach an unprecedented 900 Mt between 2024 and 2026. In this context, export sales will likely determine how much coal Indonesia will produce. IEA also projects that global coal exports peaked in 2023 and are expected to decline over the next two years, driven by an abundant supply of domestically produced coal in China and India (IEA, 2023a).

- In May 2024, BPS reported a 16% year-on-year decline in coal exports (BPS, 2024). This significant drop is likely due to China's domestic policy changes and actions. Between 2013 and 2023, China was the largest destination for Indonesian coal, accounting for an average of 25% of Indonesia's coal exports during that period (MEMR, 2024a). However, China's renewable growth is expected to reduce its demand for Indonesia's coal. In 2023, China installed as much solar PV as the rest of the world combined and increased its wind capacity by 66% y-o-y (IEA, 2024a).

- Assuming a 5-7% annual decrease in exports starting in 2024,[2] and with domestic demand projected to reach 284 Mt in 2026 (IEA, 2023a), demand for Indonesia's coal is estimated to be less than 650 Mt in 2026. Against this backdrop, the RKAB production plan for 2024 - 2026 is already set at 900 Mt. If actual production falls short of the RKAB target, resulting in lower revenue, coal companies may struggle to repay bank loans because their income is less than initially anticipated. This could harm their financial standing, and financial institutions may apply stricter lending criteria. Subsequently, restricted access to capital could hinder companies' ability to raise funds for future production (IEA, 2023c).

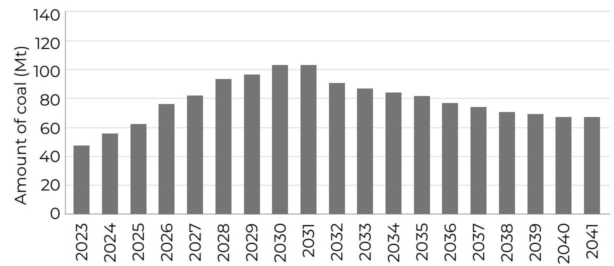
- The reduction in exports could be offset by demand from domestic captive CFPPs. In 2023, demands from captive CFPPs surged, driven by the critical minerals supply chain for smelting and the development of regionally-dispersed industrial parks. According to our calculations, 1 GWh of CFPPs in Indonesia consume approximately 507 tonnes of coal. Therefore, 30 GW of captive CFPPs in 2030 would consume approximately 102 Mt of coal or around 11% of coal production at that time.

Historical and projected Indonesian coal export by destination



Source: MEMR (2024); IESR analysis based on IEA report (2023a)

Estimated coal demands from captive CFPP



Source: IESR analysis (2023)

[2] S&P Global, 8 February 2024, THERMAL COAL SERIES: Indonesia unlikely to relinquish top exporter position in foreseeable future.

Accurate methane monitoring is the primary step to materialize Indonesia's commitment to Global Methane Pledge 2030

- In 2021, the Indonesian government joined the Global Methane Pledge, committing to reduce global methane emissions by at least 30% by 2030, compared to 2020 levels. However, several challenges threaten to undermine these efforts. A significant issue is the underreporting of coal mine methane (CMM) emissions in official data, which are at least five times lower than independent estimates. This discrepancy likely stems from factors such as outdated emission factors, reliance on an obsolete global warming potential (GWP) metric, and the exclusion of emissions from underground coal mines (Ember, 2024b).

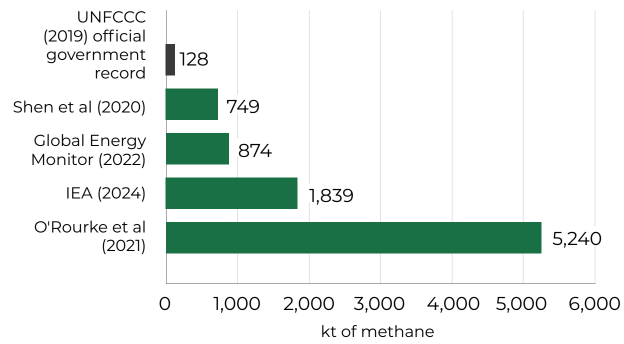
- Indonesian coal producers primarily focus on reducing CO_2 emissions, often overlooking CMM in their decarbonization strategies. Only four of the ten largest coal companies include CMM emissions in their reports (Ember, 2024a). Moreover, CMM emissions from some companies could be twice as high as those from fuel combustion and purchased electricity combined.

- Indonesia ranks as the fourth-highest global emitter in terms of emission intensity among gas producers (IEA, 2023c). Over half of these emissions stem from methane, flaring, and venting activities. To minimize flaring, the government, through MEMR Regulation 17/2021, has imposed a cap on flaring for upstream oil fields, reducing the daily average from 5 MMSCFD to 2 MMSCFD. However, this effort has not been enough to curb flaring emissions, as the volume of upstream gas flaring utilization increased by 65% between 2018 and 2023, including a more than 100% jump from 2021 to 2022 (MEMR, 2023a).

- Effective regulation on flaring must be paired with methane oversight, as setting a flaring cap alone could inadvertently lead to increased venting. The IEA estimates that vented methane accounts for approximately 11% of Indonesia's total methane emissions from the energy sector (IEA, 2021b). Company-level monitoring and reporting of gas venting should be mandatory since this process directly releases harmful methane into the atmosphere.

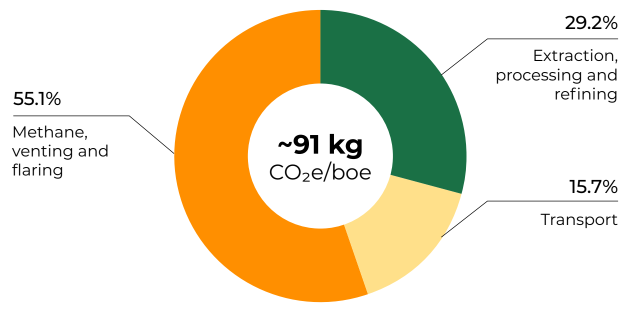
- Inaccurate and unreported emissions can lead to underinvestment in decarbonization projects, resulting in ineffective mitigation efforts. To improve domestic methane tracking, the OJK, which oversees publicly listed companies and has the authority to regulate their activities—including emission reporting—should play a central role. However, OJK Regulation 51/POJK.03/2017 only mentions "emission" without specifying the type. To strengthen monitoring, the OJK could mandate that fossil fuel producers report both carbon dioxide and methane emissions.

Coal mine methane emission estimates in Indonesia



Source: Ember (2024b), IEA (2022b); O'Rourke et al. (2021)

Emission intensity from Indonesia's gas production activities (2022)



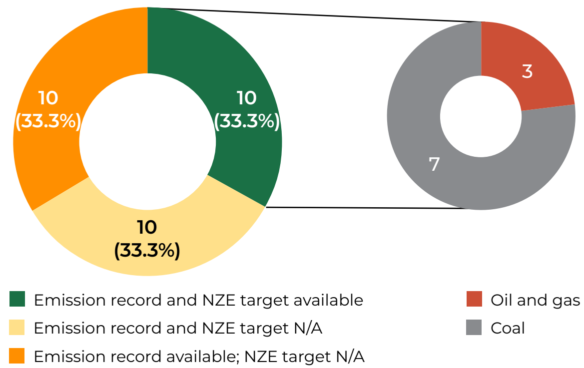
Source: IEA (2023c)

Fossil fuel companies are adopting decarbonization strategies and setting net-zero goals, but questions persist about the consistency and transparency of their measurement practices

- Fossil fuel producers are increasingly recognizing the importance of addressing their carbon emissions and committing to net-zero goals. Among the 30 fossil fuel producers listed in the IDX 200 in 2023, 10 (33.3%) have set net-zero or carbon neutrality targets, with timelines generally extending between 2050 and 2060. This represents an increase from the previous year, when only 6 out of 28 companies (21%) had made NZE commitments. Additionally, there has been a notable increase in the number of companies tracking their Scope 1 and Scope 2 emissions, with 66% now actively monitoring these metrics.

- Generally, these companies are targeting reductions in absolute emissions from their operations. Activities include solar panel installation, biofuel use, transport optimization and the installation of LED lamps. Carbon offsetting through natural carbon sinks is also being relied upon, while the feasibility of CCS is being thoroughly assessed by several companies. In 2030, Pertamina alone expects to build storage capacity for 7.3 Gt of CO_2 (Pertamina, 2024).

Availability of scope 1 & scope 2, emission record and stated net zero targets (2023)



Source: IESR analysis based on company sustainability reports (2024)

- Although several companies have pledged to achieve net zero emissions by 2050 or 2060, the specific strategies for reaching these goals remain largely undefined. While some companies have established timelines for certain emission reduction targets, the details on how these targets will be met are still unclear. Additionally, questions persist regarding the accuracy and reliability of the self-reported measurements used by companies to track their emissions. Some companies omit a breakdown of the components within scope 1 and scope 2 emissions, raising concerns about what is actually included in these reports. Reliable and proven measurement methods are critical for assessing emission reduction progress.

- Long-term goals, such as achieving net-zero emissions, are often set without specific short-term and medium-term goals that could help track companies' progress in decarbonization and hold them more accountable. Assessing companies' decarbonization progress is difficult due to the varying depths of information disclosed by each company, leading to gaps in the information available to the public. Without standardized reporting, accountability remains limited, with only companies able to fully monitor their own actions.

- Some companies are less committed to transitioning and remain focused on the fossil fuel business, either by acquiring other fossil fuel companies or increasing production. For instance, 8 out of 12 tracked fossil fuel companies, despite having diversified into greener business, are still planning to increase their coal production in 2024, with several companies referring to the target production plan of 922 Mt.

Fossil fuel giants have begun to dip into government-backed green businesses, further highlighting the importance of consistent government policies for businesses

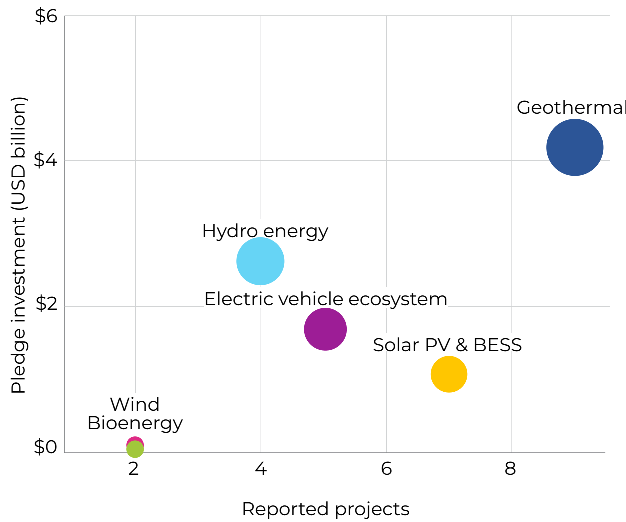
- Around 40% of fossil fuel companies tracked in the IDX 200 in 2023 have begun diversifying their businesses into new and RE sectors. Notably, these companies are venturing into RE power plants and developing ecosystems around electric vehicles. Many of these companies are large, with significant production capacity, allowing them to allocate more capital toward these initiatives.

- Greater capital expenditure enables companies to diversify their green assets. Among the initiatives undertaken by the tracked fossil fuel companies, they have pledged approximately USD 9.37 billion to RE projects, including geothermal (42.5%), hydro energy (26.7%), solar (11%), and green technologies such as electric vehicles (EVs), charging infrastructure, and EV batteries (15%).

- Some companies are driven to diversify by the appeal of stable, predictable revenue streams, seeking to mitigate the risks of fossil fuel price volatility. A popular avenue for green diversification is the electric vehicle ecosystem. Though still relatively new, this sector has gained significant traction, largely due to strong government support. Since 2019, there has been a steady flow of incentives for EVs, underscoring how clear and consistent government policies can significantly shape market dynamics.

- Among the relatively small group of diversified fossil fuel companies, a few have set ambitious goals, aiming to derive 50% of their revenue from non-fossil sources by 2025 or 2030 through the divestment of fossil assets. However, divestment merely shifts the investment to another party, meaning the overall level of fossil fuel production remains largely unchanged.

Business diversification strategy and pledged investment of Indonesian fossil fuel companies (per July 2024)



Source: IESR analysis based on company sustainability reports (2024)

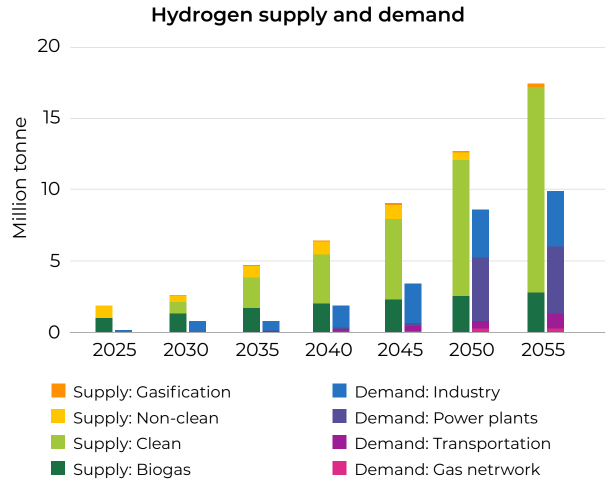
- In their efforts to diversify into RE, fossil fuel producers encounter several challenges, primarily because the investment and operational dynamics of renewables differ significantly from those of coal, oil, and gas projects. A key limiting factor is the lack of access to fully developed technologies, as many of these technologies are either inaccessible to these companies or still in the early stages of development. To mitigate these risks, companies can focus on their core competencies. For example, oil companies can continue to operate in liquid fuel production, refinery and transportation by leveraging existing assets, while gradually developing new capabilities to produce low-emission fuels, such as liquid bioenergy and hydrogen-based fuels (IEA, 2023c).

Despite robust strategies, reduced green hydrogen costs still struggle to compete with incentivized gas prices

- Indonesia launched its National Hydrogen Strategy in December 2023 and is currently developing a roadmap for clean hydrogen and ammonia production (MEMR, 2023d). Currently, most of the hydrogen used in Indonesia is derived from natural gas and primarily consumed in the industrial sector, particularly as a raw material for fertilizer production.

- To date, Indonesia's hydrogen consumption is approximately 1.75 million tonnes per year, with urea production accounting for 88%, ammonia production for 4%, and oil refineries for 2% of total consumption. By 2025, the domestic hydrogen supply is projected to be primarily sourced from biogas and natural gas, and by 2060, over 75% of hydrogen is expected to come from renewables (MEMR, 2024b).

- Electricity demand projections in the RUKN, aligned with the final KEN draft, vary depending on the inclusion of green hydrogen production. Without green hydrogen, electricity demand grows at an annual rate of 3.8%, reaching 1,813 TWh and a per capita consumption of 5,038 kWh by 2060. With green hydrogen, electricity demand increases by 4.3% annually, reaching 2,169 TWh and 6,026 kWh per capita. Green hydrogen and ammonia production are expected to be generated using hydropower in Papua, nuclear energy in West Kalimantan, and solar power in NTT (DEN, 2024).



Source: MEMR (2024b)

- There are 17 potential locations for green hydrogen production, with projected costs ranging from USD 1.9 to 3.9 per kg (or USD 14 to 28.9 per MMBTU) by 2040 (MEMR, 2023d). These costs are relatively low compared to the current global cost for green hydrogen production, which ranges from USD 2.7 to 12.8 per kg. However, Indonesia's incentivized gas price for seven industrial sectors is currently set at USD 6 per MMBTU (GoI, 2024a), which creates a challenge for cost competitiveness. To address this, reducing gas price incentives and implementing carbon pricing could enhance the competitiveness of green hydrogen in domestic industrial applications.

- Coal gasification for hydrogen production is expected to commence in 2030, starting with an estimated 20,000 tonnes per year and increasing to around 150,000 tonnes per year by 2060. Hydrogen production from natural gas is expected to continue until 2055 (MEMR, 2024b). Reliance on fossil fuels for hydrogen production poses a risk of higher emissions, and continued dependence on gas threatens energy security as domestic gas reserves are dwindling.

The shortfall in biomass targets calls for sustainable practices and a clarified roadmap

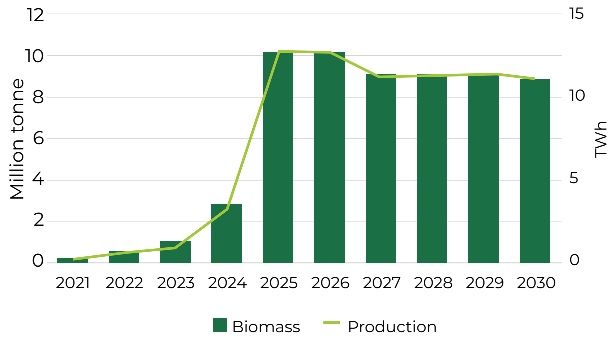
- Through its regulation, MR 12/2023, the MEMR has increased the biomass fuel pricing coefficient to 1.2 times the Free on Board (FoB) coal price to make biomass more economically attractive. While this pricing is considered attractive for certain types of biomass, higher-cost fuels, such as wood pellets, remain a challenge. PLN targets 10.2 million tonnes of biomass use by 2025, up from 1.08 million tonnes in 2023, but current domestic production and investment are insufficient (MEBI, 2024).

- The majority of the 10.2 million tonnes of biomass targeted for 2025 is expected to come from community plantation residues, palm plantation residues, and other agricultural or plantation residues (MEMR, 2024c). Strict sustainability standards are essential for biomass sourcing to avoid carbon stock loss from land-use changes associated with energy plantation forests. The projected conversion of 420,000 hectares of natural forest into energy plantations (FWI, 2024) poses a serious threat to ecosystem services and undermines sustainability goals.

- Touted as a middle ground between emissions reduction and potential cost increase, biomass co-firing has been chosen by PLN to decarbonize its coal fleet. As of December 2023, 44 CFPPs, all of which are owned by PLN subsidiaries, have implemented biomass co-firing, consuming 991,000 tonnes of biomass and generating 1.04 TWh of 'green' energy. So far, this has contributed to a reduction of 1.05 $MtCO_2$ in national emissions (MEMR, 2024d).

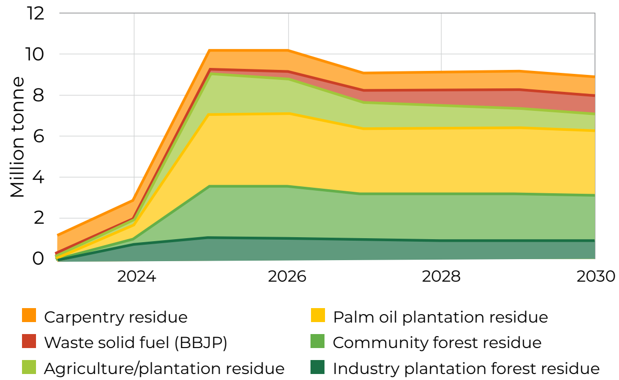
- Drawing from the experience of PLN NP's asset, Tanjung Awar-awar power plant, the main issues with biomass co-firing, aside from supply, are handling and mixing. Additional investment may be required should the co-firing is to be scaled-up, as indicated in the current draft of the RUKN. Given the operational difficulties, the implementation of biomass co-firing should be carefully considered. Rather than simply increasing the co-firing percentage, the focus could shift to converting these plants entirely to biomass power generation.

Biomass co-firing roadmap for on-grid power plants



Source: MEMR (2024c)

Biomass co-firing sourcing roadmap for on-grid power



Source: MEMR (2024c)

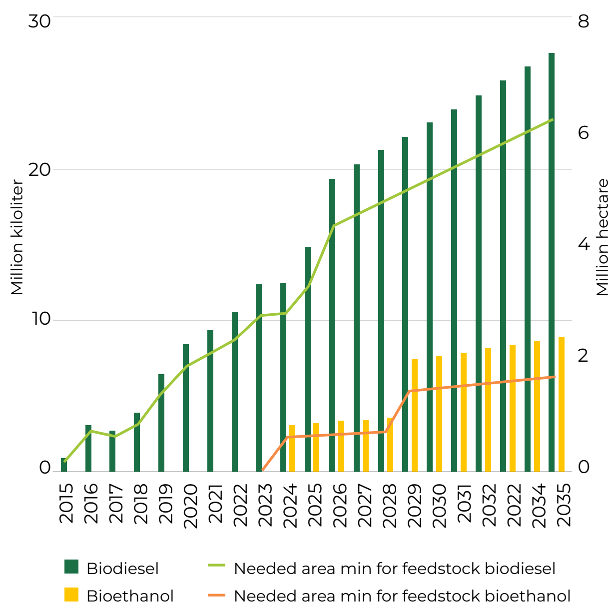
Expanding domestic biofuel production requires sustainable land use strategies

- In line with President Prabowo Subianto's directive, achieving energy self-sufficiency (*Swasembada Energi*) has become the primary policy focus of the MEMR, including efforts to reduce fuel consumption through the optimization of the Biofuel (BBN) program (MEMR, 2024e). In 2023, renewables contributed 13.1% to the primary energy mix, with 31% of that share coming from biodiesel (B35). A total of 12.28 million kL of biodiesel was distributed domestically in 2023, continuing an upward trend since 2017. The government aims to implement B40 by 2025 (MEMR, 2024f) and B50 by 2026 (Bloomberg Technoz, 2024). The increase in blending mandates drives higher demand for CPO production to support both biodiesel consumption and exports, as biodiesel subsidies are funded through CPO export levies.

- Meeting the 2023 biodiesel domestic distribution target of 12.28 million kL requires at least 2.76 million hectares of land. If Indonesia adopts B40 in 2025, the biodiesel requirement will rise to approximately 14.8 million kL, necessitating at least 3.3 million hectares. Transitioning to B50 in 2026 would require 19.4 million kL of biodiesel, demanding at least 4.35 million hectares solely for biodiesel production. This expansion is challenging, as it competes with the growing demand for CPO in food production. In addition, expansion efforts must prioritize degraded lands and avoid the conversion of natural forests to prevent the loss of ecosystem services.

- Indonesia has initiated bioethanol blending through Pertamax Green 95, a fuel containing 5% bioethanol mix (E5), which is currently available at 75 gas stations in Jakarta and Surabaya. There are plans to increase the blend to 10% (E10) by 2029 (GoI, 2024b). However, achieving a 10% blend is challenging, as the domestic industry currently produces only 40,000 kL of bioethanol annually. To implement E5 nationwide, an annual supply of 3–3.5 million kL of bioethanol will be required from 2024 to 2028. Scaling up to a 10% blending target in 2029 will require approximately 7.3 million kL of bioethanol, which will necessitate at least 1.37 million hectares of sugarcane plantations. In June 2024, the former President announced that Pertamina would acquire a Brazilian company, subject to due diligence, to ensure a stable supply of sugar and ethanol for the initiative. However, the plan was canceled a month later, with the government shifting its focus to strengthening domestic feedstock production for bioethanol (Kompas, 2024).

Biodiesel and bioethanol demand projections and land use requirement



Source: IESR Analysis (2024)

Chapter 4.

Energy Transition at the Subnational Level

Martha Jesica Solomasi Mendrofa

Contents

- Subnational authorities in energy transition
- Subnational fiscal capacity for energy transition
- Status and trends of subnational energy transition (case studies: Aceh, South Sumatera, and NTT)

RUED is a key tool for the subnational energy transition, but its impact is hindered by the absence of a dedicated, energy-specific budget plan

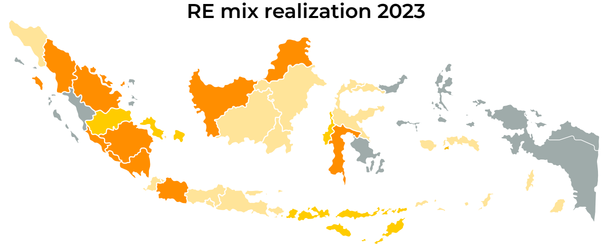
- Subnational (provincial) government initiatives play a crucial role in Indonesia's energy transition due to their authority over RE and the need for multi-level adaptation to local contexts. Law 23/2014 outlines the division of authority between national, subnational, and municipal/regency governments, including in the RE sector. Subnational authority over RE is limited to issuing permits for direct geothermal energy use and overseeing biofuel businesses with an annual supply capacity of up to 10,000 tonnes. Moreover, subnational authority in energy-related sectors, such as industry and transportation, does not include specific energy transition initiatives (see Appendix G). Most authority over RE development and energy transition initiatives lies with the national government.

- Despite their limited authority, subnational governments are mandated to develop a comprehensive energy plan (RUED), aligned with the RUEN. This planning document sets RE mix targets for each province and outlines mandates to support the broader energy transition agenda. As of this year, 33 provinces in Indonesia have set RE mix target through their RUEDs. Of these, 45% aim to achieve at least a 23% RE share in their primary energy use by 2025, while the rest fall below the national target.

- Progress towards these RE mix targets presents a mixed picture (see figure beside). By 2024, seven provinces—North Sumatera, South Sulawesi, Bengkulu, West Java, DKI Jakarta, South Sumatera, and Bangka Belitung—exceeded their 2025 targets, primarily due to national-level projects and biomass use. However, with just one year remaining until 2025, the rest of the provinces remain below their targets, with eight achieving less than half of their RE mix targets. This highlights the challenge of achieving RUED targets.

- RUED is not directly integrated with the subnational government budget (APBD) (see figure beside), despite most of the planned agendas relying on it. Moreover, as elaborated, there are mismatches between RUED mandates and subnational government authority, compounded by limited support from the national government. As a result, RUED alone does not ensure the realization of planned activities due to its indirect link to APBD and authority mismatches. To enhance the impact of RUED on subnational energy transition, it is important to strengthen its role as the basis for the energy agency's annual work plan (RKA DESDM), integrate energy transition initiatives aligned with subnational authorities into RUED, and develop an energy-specific budget plan with diverse funding sources.

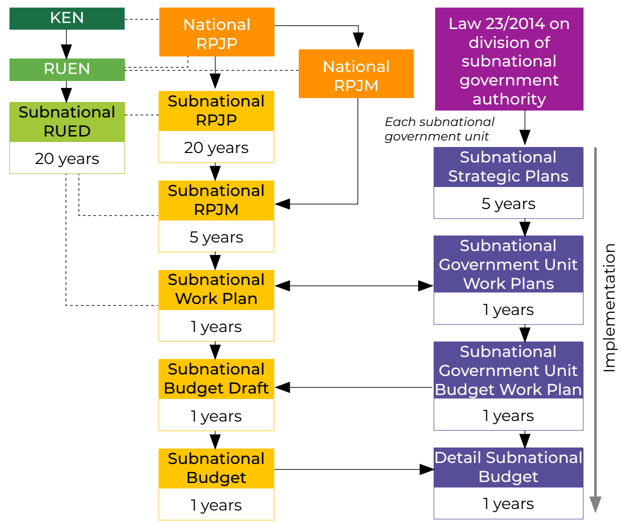
RE mix realization 2023



2-17% (below the national target)
17-23% (align with the national target)
23-42% (above the national target)
No data (until Dec 2024)

Source: IESR analysis from DEN data (2024)

Position of energy planning and budgeting at the subnational



Source: IESR analysis

The limited fiscal capacity and additional authorities are making energy transition efforts more complex at the subnational level

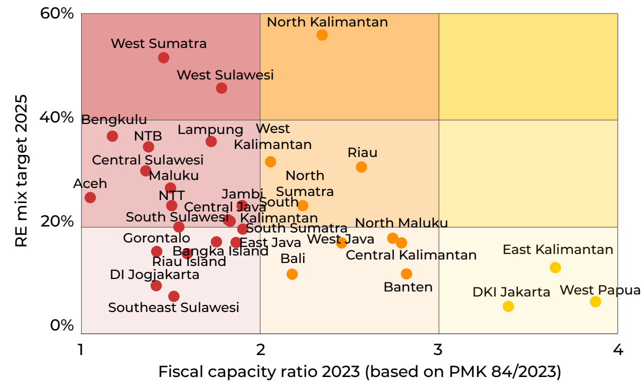
- Subnational fiscal capacity reflects a government's ability to deliver public services, including RE initiatives. According to the MoF, 39% of Indonesia's provinces have low (31%) or very low (8%) fiscal capacity, while 34% are moderate, and 26% have high or very high capacity (PMK 84/2023). Fiscal capacity is calculated by subtracting designated and routine expenditures from total income, leaving most provinces struggling to independently fund public services, including RE initiatives. Provinces with high RE mix targets often lack the fiscal capacity to meet these goals (see figure beside). This highlights the limitations subnational governments face in achieving energy transition targets on their own, underscoring the need for stronger national support.

- In 2023, the median provincial budget earmarked for NRE was around IDR 1 billion (USD 0.063 million), just 5% of the total energy sector budget (see figure beside). This allocation is insufficient to fund major RE projects. In fact, most of it was allocated for technical assistance on energy conservation and the management of biofuel trading businesses, rather than RE infrastructure development. The limited RE implementation budget stems from the restricted authority of subnational governments over RE matters, which discourage independent efforts. Additionally, subnational governments struggle to initiate energy transition projects due to gaps in governance capacity, including deficiencies in knowledge, level of participation, and the availability of supporting instruments (IESR, 2024).

- Subnational authorities were recently added under PR 11/2023, which expands their business permits to include biomass and biogas utilization, various RE management activities, and energy conservation. While this regulation holds promise for greater subnational involvement, its full implementation depends on the upcoming MoHA Decree for RE budget tagging, which is expected in fiscal year 2025. This shows the complexity of implementing the energy transition at the subnational level, which could be navigated more effectively with enhanced financial mechanisms, such as matching grants.

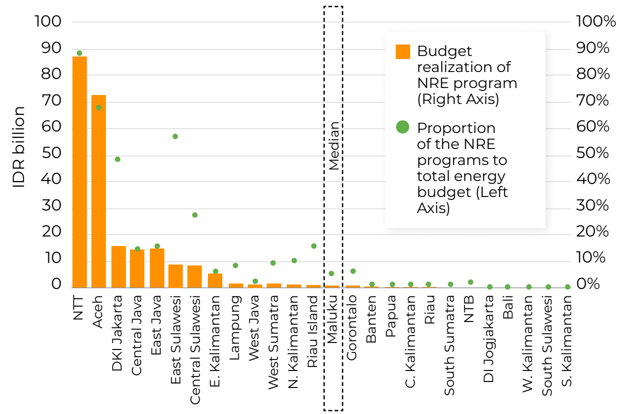
- The reintroduction of specific physical transfer funds (DAK) from the state budget for RE infrastructure in 2023 (PR 15/2023) and 2024 (PR 57/2024) is a positive step toward enhancing financial mechanisms to fund RE projects in underdeveloped areas. These funds had been frozen from 2019 to 2022. These measures signal that stronger national support may be forthcoming. Moving forward, stronger collaboration between national and subnational governments and careful monitoring of the continuity of these funds will be critical in 2025 and beyond.

RE mix target 2025 vs. fiscal capacity ratio 2023



Source: IESR analysis from MoF PMK 84 (2023) and DEN (2024)
Note: The MoF categorizes fiscal capacity into five levels, but this graph simplifies them into three broader categories: ratios 1–2, 2–3, and 3–4.

Budget realization for NRE 2023



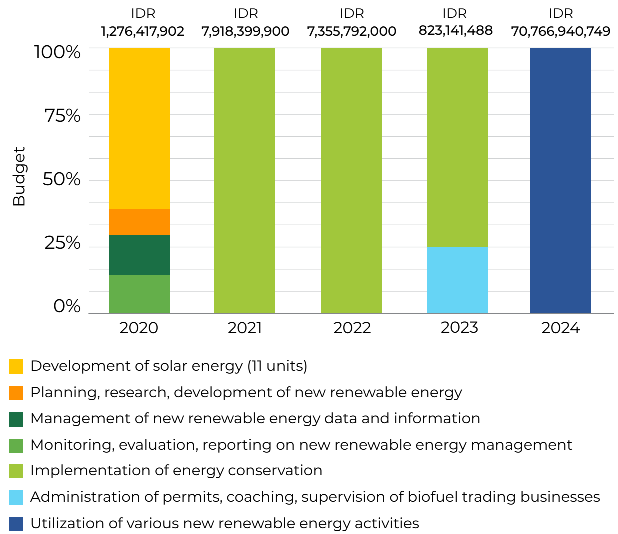
Source: IESR analysis from Detailed Government Budget Documents. Full detail available on Appendix H

Aceh should enhance strategic partnerships and allocate greater resources for RE infrastructure projects to achieve its energy transition goals

- Aceh targets a 14% RE mix by 2025 but achieved only 11.08% in 2023, indicating the challenges that lie ahead in achieving this target. Aceh has significant RE potential, including 99.2 GWp of solar, 2.4 GW of wind, 1.5 GW of hydro, 1.2 GW of bioenergy, and 1.09 GW of geothermal (DEN, 2024). Hydro and geothermal dominate RE utilization, including the upcoming 88 MW PLTA Peusangan, which is set to begin operation in May 2025 (MEMR, 2024). Moving forward, several RE initiative are planned in Aceh, including the Hijaunesia program by PLN, launched in 2023, which aims to develop wind power plants and is currently seeking investment partners. Similarly, PLN is committed to ensuring a reliable electricity supply for PON XXI in Aceh, with 15% of the supply sourced from RE, such as solar and hydro (Aceh Government, 2024). The ongoing RE initiatives in Aceh are mostly driven by the national government and PLN.

- As a subnational government, Aceh has relatively high fiscal capacity in the energy sector but low initiative in RE development. Aceh has allocated 68% of its 2024 public budget for NRE programs, approximately IDR 70.7 billion (USD 4.4 million), mainly sourced from special autonomy and revenue-sharing funds (Otsus and DBH). This year's budget was allocated for various RE programs, such as solar and hydro power inventories, as well as energy conservation initiatives. This marks a shift from previous years, when the budget was mostly spent on energy conservation socialization for government officials. Similarly, a study ranks Aceh with a medium energy transition readiness index, reflecting high governance capacity, moderate economic (and fiscal) resilience, and low clean energy initiatives (CELIOS, 2024).

Aceh's public budget for energy in 2020-2024



Source: IESR analysis from Aceh Detailed APBD (2020-2024)

- Private sector initiatives and international collaboration also provide additional momentum for Aceh's energy transition. Aceh is one of the locations for Pertamina's *Desa Energi Berdikari* Program, which aims to promote rural energy independence. For example, a 4.91 Wp solar power plant has been installed in Lampuyangan, Pulo Aceh (CNBC, 2023). While the electricity generated—around 17 Wh per household per day—still falls short of standard daily household consumption, this programs marks a significant step forward and holds great potential for further RE development in Aceh. Additionally, under the Indonesia-Denmark partnership, Aceh has collaborated with the Danish Energy Agency through the Sustainable Province Initiative (SPI), receiving technical support and exposure to research facilities and a large wind power plant in Copenhagen.

- In conclusion, while Aceh is making progress in its energy transition efforts, significant challenges remain in reaching its 2025 target. By focusing subnational government budgets on RE infrastructure and strengthening strategic partnerships, Aceh can build on its current momentum and advance its energy transition initiatives.

As a coal-producing region, South Sumatera must focus on collaborative RE efforts and economic empowerment programs to ensure a just energy transition

- South Sumatera, one of Indonesia's largest coal-producing regions, achieved a 1.1 ratio of actual RE mix realization to its target in 2023. The 2023 RE mix realization (24%) exceeded the 2025 target (21%). By 2023, South Sumatra had 989 MW of installed RE capacity, consisting of 7.7 MW solar, 21.9 MW hydro, 146 MW geothermal, and 813.4 MW bioenergy (EMR Agency of South Sumatera, 2024). Bioenergy is the largest contributor to South Sumatera's RE mix, particularly in meeting electricity demand from private sector activities, such as agro-industry and pulp and paper production. However, despite this progress, the budget for NRE program in 2023-2024 remains low, accounting for only 0.5% of the total energy budget, or IDR 150 million. A study also ranks South Sumatra's energy transition readiness as moderate, with high governance capacity but low economic (and fiscal) resilience and low clean energy initiatives (CELIOS, 2024). This landscape shows the potential for increasing RE mix not only through government efforts but also private sector involvement.

- According to South Sumatera EMR Department, ongoing RE initiatives include bioenergy potential studies (in Musi Banyuasin, Muara Enim, OKU Timur, and PALI), a solar potential study in OKU, and the government procurement of two units of E4W and six units of E2W for EMR Agency officials. Over the next five years, in alignment with the medium-term development plan, South Sumatera aims to implement several RE initiatives, for instance, increasing the capacity of geothermal power plants (55 MW PLTP Lumut Balai and 20 MW PLTP Danau Ranau) and mini-hydro power plant (3.6 MW PLTM Kenali). In addition, international and private sector collaborations will be explored. Moving forward, these initiatives will require more detailed technical planning and stronger national government support.

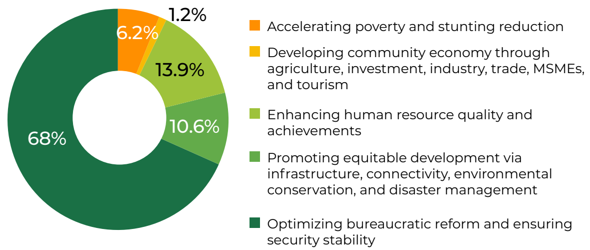
- As the region heavily relies on coal, subnational revenues are significantly generated from the coal mining sector. By November 2024, South Sumatera government revenue from mineral and coal mining amounts to IDR 26.8 billion from fixed fees and IDR 4,466 billion from royalties, accounting for 49% of its subnational DBH revenue (MoF, 2024). As a coal-producing region, South Sumatera must prepare for a just transition from fossil fuels to RE without disrupting to the socioeconomic conditions (IESR, 2023). Preparation could begin with subnational efforts, requiring greater fiscal resources for economic empowerment programs. Currently, South Sumatera has earmarked only 1.2% of its total 2024 budget for such programs. These programs should include microfinance and entrepreneurship support and agro-industrial research.

RE power plants share in 2023

Source	Type	Capacity
Solar (7.75 MW)	IPP Solar Power Plant	2 MWp
	Rooftop Solar Power Plant	2.8 MWp
	Centralized Solar Power Plant	2.91 MWp
	Solar Power Plant for Irrigation	0.04 MWp
Hydro (21.96 MW)	IPP Mini Hydro Power Plant	21.1 MW
	Mini Hydro Power Plant (Excess Power)	0.22 MW
	Distributed Mini Hydro Power Plant	0.64 MW
Geothermal (146 MW)	Geothermal Power Plant (PLTP - Rantau Dedap and Lumut Balai)	146 MW
Bioenergy (813.41)	Biomass Power Plant (Captive Power)	802.59 MW
	Biogas Power Plant (Captive Power)	6.22 MW
	Biogas Power Plant (Excess Power)	4.1 MW
	Waste-to-Energy Power Plant	0.5 MW

Source: South Sumatera EMR department presentation (2024)

Recapitulation of the 2024 South Sumatera Work Plan (RKPD) based on its priority programs



Source: IESR analysis from South Sumatera RKPD (2024)

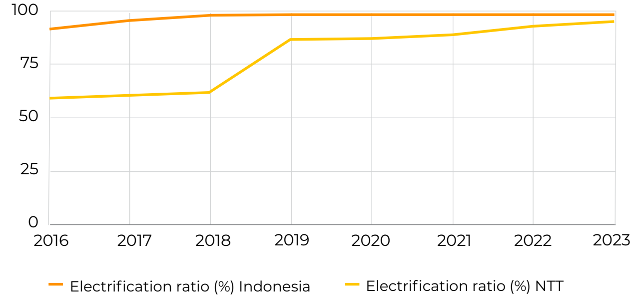
To bolster localized RE solution, the NTT government should continue fostering strategic partnerships and strengthening community involvement

- NTT is known for its abundant RE potential, including solar and wind power, but it has also been one of least-electrified provinces in Indonesia. By 2023, NTT had utilized 17.68% RE on its energy mix (DEN, 2024). With over 1,200 islands, many of which are remote, localized RE solutions are crucial for providing reliable power across the province. Government initiatives, such as pre-electrification efforts and the national government's 100% electrification campaign, have significantly raised the electrification ratio in NTT, from 59.85% in 2017 to over 95% by 2023. Nearly 88% of the population are connected to PLN, while 7% rely on non-PLN electricity sources (BPS, 2024). Isolated electricity systems in NTT are powered by various resources, including diesel, geothermal, mini-hydro, and solar energy (IRID, 2024; PLN 2024). These efforts reflect the opportunity and need to bridge the energy access gap in remote areas through off-grid RE technologies.

- Since 2010, the Sumba Iconic Island (SII)[1] program has been a cornerstone project in promoting RE in NTT, aiming to provide reliable RE access and achieve 100% RE for Sumba. This program has increased the electrification ratio to 75% and has also brought socioeconomic benefits to local communities, including improvement in learning quality, social activities, and health due to increased access to electricity (Energi Hijau, 2021). However, the program has also faced challenges, including limited funding and the need for extensive community engagement and technical capacity-building to ensure its sustainability. In response, the MENTARI initiative, a partnership between Indonesia and the UK, began in 2020 to provide technical support for local communities and foster collaboration among stakeholders. A key lesson learned from the SII program is that tailored technical solutions and transparent business practices are critical for the success of subnational RE initiatives.

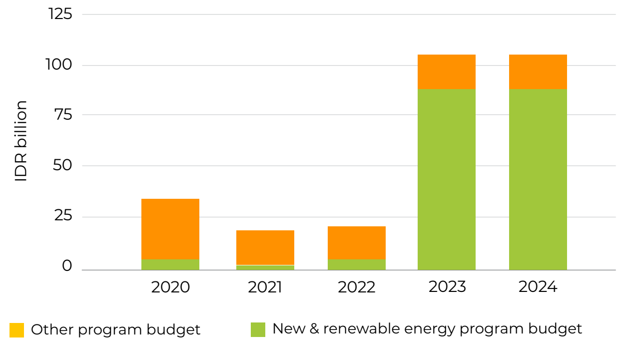
- Currently, many RE programs in NTT are being initiated by the national government, international partners, and privates sector companies through commercial projects; for example, the revitalization of the Sumba Iconic Island, the ACCESS[2] project, which aims to instal solar power plant in remote areas like Sumba, and geothermal power plant projects in Flores led by private energy companies. The national government's focus on RE sector in NTT is significant, as reflected in increased funding over the last two years, primarily sourced from state budget-specific transfer (physical DAK). This funding is essential for improving the capacity of subnational governments to implement RE initiatives. To further bolster localized RE solution, the NTT government should continue fostering strategic partnerships with various stakeholders and strengthening community involvement in the planning and execution of these initiatives.

Electrification ratio (%) in NTT and Indonesia



Source: IESR analysis from MEMR Statistik Ketenagalistrikan (2017-2024)

NTT EMR agency spending budget on renewables



Source: IESR analysis from NTT Detailed APBD (2019-2023)

[1] Sumba Iconic Island (SII) is initiated by MEMR, Bappenas, and Hivos

[2] ACCESS (Accelerating Clean Energy Access to Reduce Inequality) is a collaboration between GoI and UNDP

Chapter 5.

Energy Transition Financing Trend

Putra Maswan

Contents

- Public finance allocation
- International financing support
- Private finance mobilization
- Carbon market progress
- Financing a just transition

The state budget covers only a small portion of the investment required for the energy sector under the unconditional NDC scenario, leaving a significant gap in achieving the target

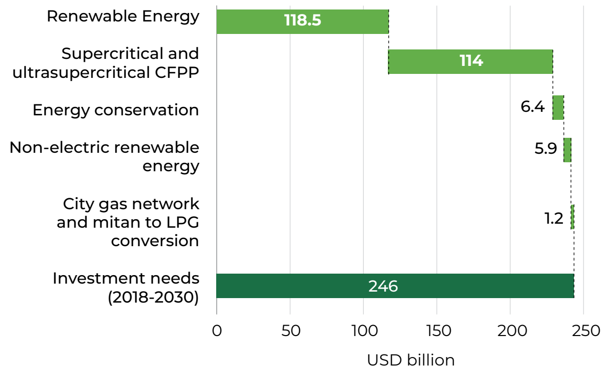
- Indonesia has pledged to reduce emissions from the energy sector by 29%, or 358 $MtCO_2e$, by 2030—unconditionally, without international assistance (UNFCCC, 2021). However, the energy sector has been the largest contributor to national emissions since 2020 and continues to rise, reaching 723 $MtCO_2e$ in 2022 (MoEF, 2024). This trend could hinder the country's ability to meet its decarbonization targets and increase future financing needs.

- To decarbonize its energy and transportation sectors, Indonesia requires a total investment of USD 246 billion from 2018 to 2030, or approximately USD 18 billion annually through its own efforts. Of this amount, USD 118.5 billion, or USD 9.1 billion annually, is needed specifically for RE development. However, the public budget allocated to the energy and transportation sectors through climate budget tagging in the national plan (RPJMN 2020-2024) covers only 23% of the required annual funding, highlighting a significant investment gap.

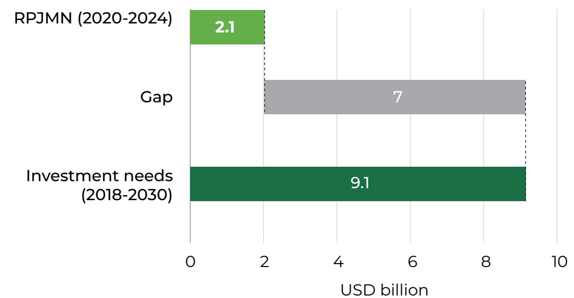
- The government allocates 4.3% of the total state fiscal budget to climate action, with 82% directed toward mitigation efforts and 13% toward adaptation (MoF, 2022). Under the national plan, the energy and transport sectors are allocated USD 10.4 billion from 2020 to 2024, averaging USD 2.1 billion annually. However, this leaves a significant annual funding gap of USD 7 billion, highlighting the limitations of public financing for climate action. Furthermore, RE development received an average of only USD 62.8 million annually during the 2018-2020 period under Ditjen EBTKE (BKF, 2020), underscoring the need for greater investment in the energy transition.

- Given the constraints of the public fiscal budget, these funds should be used strategically to reduce risks associated with the RE subsector and enhance the attractiveness of clean energy investments to other financing sources. Additionally, strengthening the regulatory framework and fostering collaboration with potential financing sources, both domestic and international, are critical steps to bridging the investment gap.

Investment needs for energy and transportation sectors (2018-2030)



Comparison of public budget allocation and financing needs (annual average)



Source: UNFCCC (2021); BKF (2020)

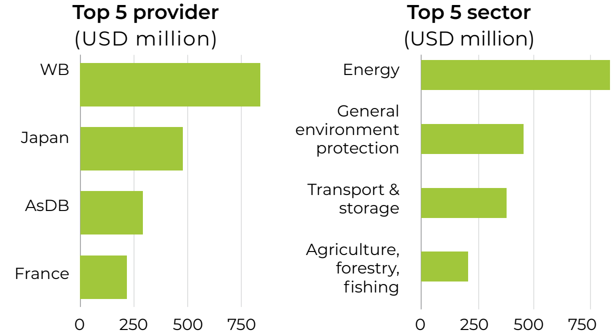
Increase mobilization of international funds to support Indonesia's energy transition commitment, with grants extending beyond technical assistance

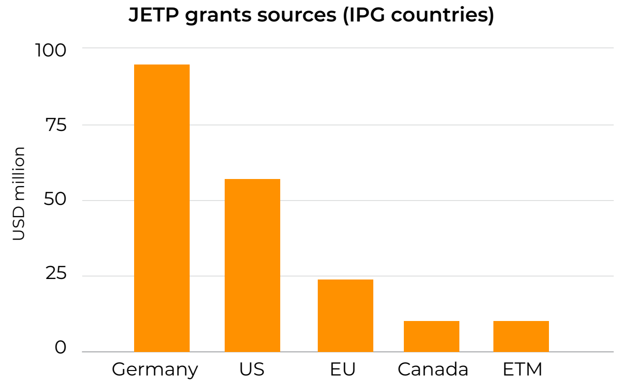
- Global climate finance reached its target of mobilizing USD 100 billion annually in 2022. However, only 5% of these funds were allocated to Southeast Asia, highlighting a significant financing gap in one of the regions most vulnerable to climate change impacts (ADB, 2023). This disparity underscores the need for a more focused effort to direct climate finance to the region, ensuring equitable access to resources for both mitigation and adaptation efforts.

- Indonesia received USD 2.5 billion in international climate finance in 2021, with mitigation efforts accounting for more than half of the total (OECD, 2023). The World Bank emerged as the top contributor, reflecting robust multilateral support. Notably, the energy sector secured USD 0.8 billion, the largest allocation, emphasizing its critical role in advancing Indonesia's energy transition. Despite this support, Indonesia's substantial climate finance needs call for increased fund mobilization. Enhanced financial flows are essential to expedite clean energy development and address broader climate-related challenges, ensuring the country meets its ambitious climate goals.

- The JETP has made progress toward its 2024 financing goal, securing its first equity investment of USD 30 million from IPG countries for RE development and obtaining a loan commitment of over USD 500 million from development finance institutions (DFIs) for sustainable development projects, including RE initiatives under the JETP plan (JETP, 2024). However, these amounts are relatively small compared to the USD 21.6 billion commitment, with the program set to begin in 2025.

- In 2024, the JETP reported USD 204.3 million in grants signed and launched by IPG countries, covering 70% of the USD 284.4 million outlined in the JETP CIPP. These grants support 32 of the 40 planned technical assistance (TA) programs, nearly half of which contributed by Germany. The funding includes USD 59.7 million for 13 new programs, USD 144.6 million for 19 ongoing initiatives, and USD 77.3 million for six programs under discussion, showcasing progress in mobilizing grants for Indonesia's energy transition. Additionally, grants should extend beyond TA to support just transition efforts and small-scale RE projects that are challenging to finance through conventional means.





Source: OECD (2023); JETP (2024)

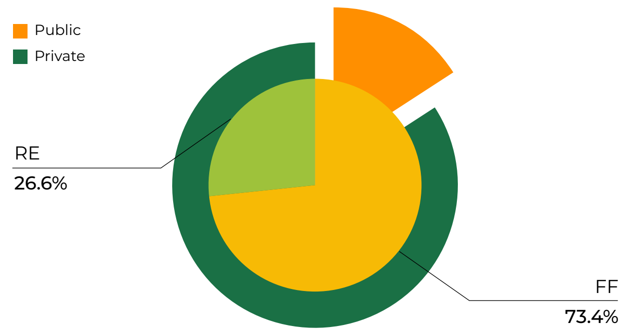
Private financing has substantial resources, but policy uncertainty and project bankability issues hinder investments in renewable energy

- Fossil fuels continue to receive the largest share of private investment in Indonesia's energy sector, accounting for 73.4% of the total portfolio (USD 10.8 billion) compared to RE, which received only 26.6% (USD 3.8 billion) during the 2019-2020 period. This disparity highlights the significant potential of private investment in the RE sector, emphasizing the need to reduce reliance on limited public financing sources. However, perceived risks and concerns about project bankability remain key challenges for private financial institutions, including national banks, which tend to favor the well-established fossil fuel market over the emerging RE market.

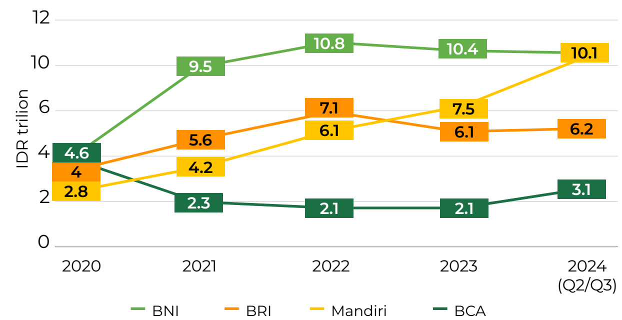
- Unlocking the investment potential of national banks in the RE sector is crucial to increasing private sector financing flows. Total investment in RE development showed a positive trend over the given period, mobilizing IDR 29.6 trillion (USD 1.9 billion) in 2024. Despite this increase and growing interest from the banking sector, RE project developers still face challenges in accessing financing due to the risks associated with these projects, which are often linked to higher credit rates. Additionally, banks operate under a prudent banking model, financing projects based on the profile and credibility of the project sponsor rather than the "green" project category itself, such as for RE projects.

- In practice, banks tend to direct their green investments toward RE projects owned by developers with large amounts of capital and assets, leaving small-scale developers struggling to secure financing for projects that are often classified as unbankable. Moreover, banks view the long tenures of RE projects and regulatory uncertainty as additional risks, making them reluctant to invest, as they typically manage third-party funds with short-term periods. Therefore, the government should provide guarantees and support facilities for small-scale developers while ensuring policy and regulatory certainty to reduce risks. These measures can enhance the attractiveness of clean energy projects, encouraging greater participation from the private sector and national banks.

Power sector investment, 2019-2021



National banks credit allocation for RE



Source: CPI (2024); IESR analysis

The Indonesia Carbon Market has shown slow progress in the voluntary market, with no transactions recorded in the compliance market during its early phase of development

- Indonesia fulfilled its carbon pricing commitment by launching a national carbon market in 2023 with IDX Carbon as the trading platform. The carbon market is designed to help the country reduce its national emissions and support RE development. However, one year after official trading began, the carbon market shows slow progress in both voluntary and compliance segments due to the lack of an enabling environment, including supportive policies and incentives. As of October 2024, the total trading value has only reached IDR 19.5 billion, despite the claim of 557 $MtCO_2e$ of verified carbon credit announced at COP 29 (Setiawan, 2024).

- In the voluntary carbon market, which trades carbon credits or SPE-GRK for offsetting purposes, only three projects from SOEs have been listed to date. The carbon price is IDR 69,600 (USD 4.45) per tCO_2e, with a total of 1.4 million tCO_2e available for trading and a total value of IDR 19.5 billion (year-to-date). This price is relatively low compared to the price of carbon credits in international market, reflecting the quality of the carbon credits. Additionally, the low price may incentivize emitters to continue purchasing carbon credits rather than investing in clean energy, potentially leading to counterproductive practices.

- Indonesia's Emissions Trading System (ETS) is a compliance-based market for carbon allowances, known as PTBAE-PU, using a cap-and-trade system regulated by MEMR Regulation No.16/2022. This regulation serves as the basis for setting an emissions cap for the electricity subsector, specifically for CFPPs, which are the pilot subsector in the first phase of ETS development. However, no trading activity has occurred in Indonesia's ETS to date, largely due to the high emissions limit set for CFPPs. Lowering the emissions limit is necessary to make the market functional and to help meet emission reduction targets.

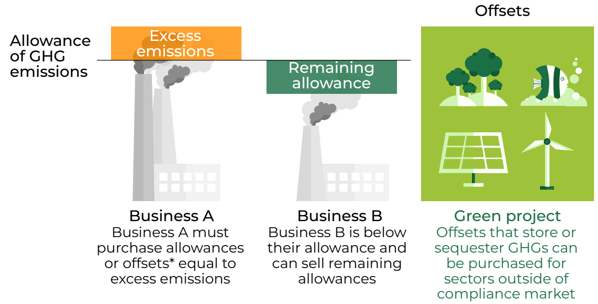
- A carbon tax, as an additional carbon pricing mechanism, is expected to be implemented in 2025, following the ongoing development of a national carbon roadmap. This comes despite the tax rate already set at IDR 30 per kg CO_2e in Law No.7/2021, one of the lowest globally (GoI, 2021). However, if effectively imposed, the carbon tax could serve as a tool to boost the attractiveness of clean energy investments. It could also generate additional fiscal revenue, estimated at up to IDR 23.7 trillion in 2025 (Pratama et al., 2022), enabling further investment in green energy development.

Indonesia carbon market

Indonesia carbon market	Emission Trading System (ETS)	Carbon offsets market
Status	Compliance	Voluntary
Product	Carbon allowances (PTBAE PU)	Carbon credits (SPE GRK)
System	Cap-and-trade	Carbon Economic Value (*Nilai Ekonomi Karbon*)
Listed projects	146 coal-fired power plants (CFPP) on-grid with capacity ≥ 100 MW	3 clean power plants
Trading volume	n/a	1.4 million tCO_2e*
Trading value	n/a	IDR 19.5 billion*

**as per October 2024*

ETS and offsetting activities



**Purchase of offsets to meet emissions allowance is often limited to a ercentage or overair emissions reductions*

Source: IDXCarbon (2024)

Indonesia should establish a comprehensive framework for a just transition while securing alternative sources of financing

- Indonesia is preparing to incorporate a just transition into its climate pledge, as outlined in the draft of its second NDC. However, the country currently lacks an official framework to define and estimate the costs of just transition activities. While a framework exists within the JETP CIPP, it remains underdeveloped and insufficient for accurately assessing financial needs. A comprehensive framework must address the full range of the transition's impacts—on people, the economy, and the environment. This includes ensuring inclusivity by accounting for affected groups and addressing the economic impacts on direct activities like coal mining, indirect activities such as supply chains, and induced activities like local businesses that rely on worker spending. It should also mitigate losses, such as decreased local revenues in coal-dependent areas, and address environmental costs, including land rehabilitation in coal mining regions.

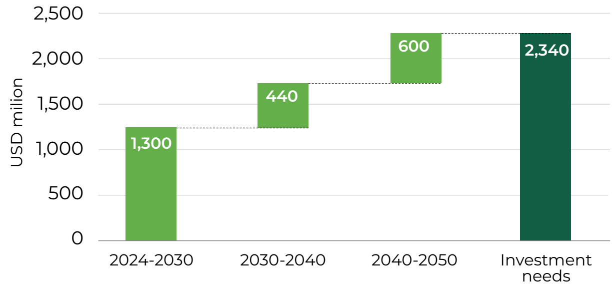
- Regarding the people aspect, we estimate that the investment required for retraining and support for direct jobs affected by the coal phase-out, as outlined in the JETP plan, will total USD 2.34 billion by 2050 (NCI and IESR, 2024). The phase-out will affect various groups of workers in the sector over time, with impacts unfolding in three distinct phases. During the first phase (2024-2030), a significant portion of the costs will be incurred, with up to 200,000 workers needing support for job losses, amounting to USD 1.30 billion. The remaining costs will be distributed over the subsequent phases (2030-2050), with USD 1.04 billion allocated for early retirement compensation and retraining initiatives. This progressive financial commitment is crucial to ensuring a smooth and equitable transition for workers in coal-dependent regions.

- The JETP has identified a USD 353 million investment need for a just transition, primarily allocated to capacity building and project priority assessments. However, only USD 29 million (0.25%) is expected to come from grants, with the remaining funding sources still undetermined (JETP, 2024). Grants and low-interest debt are suitable financial instruments for supporting just transition activities, as they do not increase the country's fiscal burden, unlike traditional loans. Therefore, it is essential to explore alternative financing options, such as green bonds and social bonds, which can provide additional funding for just transition efforts.

Direct jobs affected by coal phase-out

Category	Year	Affected workers	Financial needs
Coal plant construction	2024-2030	Up to **200,000** affected workers due to the decline in new CFFP construction	**USD 1.3 billion** required for workers' retraining and job relocation
Coal plant operation & maintenance	2030-2040	**60,000** workers affected by early retirement of CFFP from 2030 to 2040	Total of **USD 440 million** needed: USD 170 million for early retirement support for older workers and USD 270 million for retraining for workers of productive age
Coal mining	2040-2050	**70,000** workers potentially affected by the decline in the coal mining sector	Total of **USD 600 million** required: USD 240 million for early retirement and USD 360 million for retraining support

Financing needs for workers retraining and support until 2050



Source: NCI and IESR (2024)

Chapter 6.

Outlook and Key Recommendations

Alvin Putra Sisdwinugraha

Pintoko Aji

Contents

- Indonesia's energy sector emission projections
- Primary energy supply and final consumption projections
- Marginal abatement cost curve
- Key recommendations

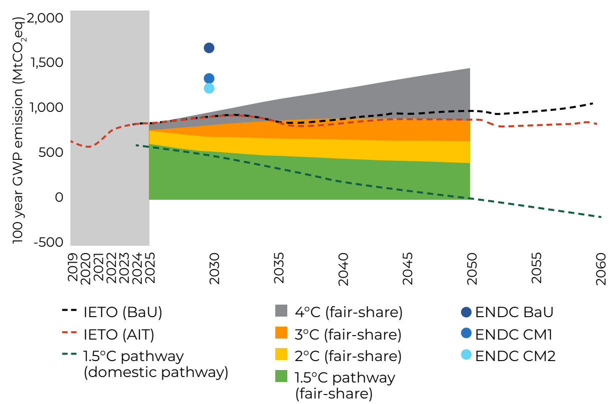
Without more ambitious targets and policies, Indonesia risks contributing to over +3°C warming

- IESR's IETO model projects that Indonesia's energy-sector emission trajectory—whether in the business-as-usual (BaU) or the announced intervention target (AIT) scenario—still falls within a >3°C warming scenario, which is categorized as Critically Insufficient (CAT). Meanwhile, the Enhanced NDC's emissions targets of 1,223 or 1,311 $MtCO_2e$ for 2030 are already outdated and incompatible with current socio-economic realities. With just five years remaining until 2030, these emission reduction targets may be achieved or even exceeded without any additional effort. This emphasizes the critical need to evaluate and update these pledges, especially as work on the Second NDC progresses concurrently with the formulation of the Government Regulation Plan for the National Energy Policy. This creates a crucial momentum for reforming the energy sector in alignment with the Paris Agreement, aiming for emissions of 523.8 $MtCO_2e$ (-42.8%) or below by 2030 and 487.4 $MtCO_2e$ (-43.2%) by 2035, compared to the BaU scenario estimates of 915 $MtCO_2e$ in 2030 and 858 $MtCO_2e$ in 2035.

- Under the IETO model projection (BaU), Indonesia's energy sector was expected to emit 796 $MtCO2_2e$ in 2023, and 831 $MtCO2_2eq$ in 2024, with emissions likely continue to rise until 2032, peaking at 931 $MtCO2_2e$ in next decade. However, without further intervention emissions could begin to rise again starting from 2038, with CAGR of almost 1% per year until 2060. This projection results from the increase in mitigation activities being limited to the on-grid power sector, which is expected to peak in 2031. However, there is insufficient focus on the "New Monster" sectors—transportation and industry—which will continue to expand uncontrolled without additional measures.

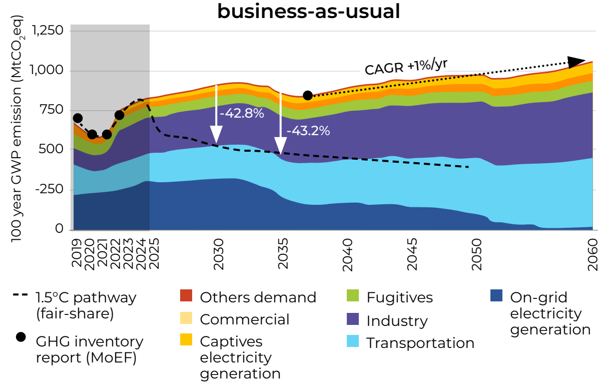
- It is understandable that the decarbonization agenda often places the most focus on the (on-grid) power sector, as it is the largest sector emitter, contributing 275.9 $MtCO_2e$ (34.6%) of emissions in 2023. This focus is evident in Indonesia's extensive discussions on the upcoming RUPTL, DRUKN, and JETP, which aim to cap emissions and reach a peak in 2030 with 250 $MtCO_2e$ (for on-grid generation) (p). Although this is a crucial part of the emissions pathway, and unlocking demand-side decarbonization through sector coupling (electrification) action is essential, additional attention must be given to creating a "call to action" roadmap, particularly for the industrial and transport sectors.

Energy sector emission projections



Source: IESR analysis using IESR IETO Model, Climate Action Tracker, ENDC 2020-2030 (MoEF)

Energy-related emissions and 1.5°C budget, business-as-usual



Source: IESR Analysis using IESR IETO Model, GHG Inventory and MRV (MoEF), Climate Action Tracker

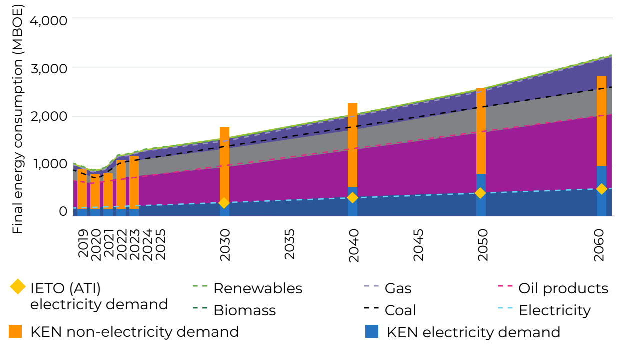
A new realistic target lacks ambition and risks failing to achieve Indonesia's 2045 Vision for "Indonesia Emas"

- IESR's IETO model projects Indonesia's final energy consumption to increase from 1,246 MBOE in 2023 to 1,564 MBOE in 2030, with a CAGR of 3.3%. By 2030, electricity demand is predicted to increase from 313 TWh in 2023 to 415 TWh. Driven by population growth and economic development, energy consumption will continue to rise, reaching 2,304 MBOE and 695 TWh by 2045 and 3,209 MBOE and 887 TWh by 2060.

- In comparison to the national energy plan (KEN) draft, KEN's energy and electricity estimates are higher than the IETO model. Energy demand is expected to reach 2,262 MBOE (+15.7% higher than the IETO model) and electricity consumption is expected to be 548.67 TWh (+30.2% higher than the IETO model) by 2030. However, KEN will only begin decarbonizing the demand side in 2035, primarily through electrification, direct use of renewables, and the adoption of "new" energy. By that point, the increase in energy demand can be curbed through fuel shifting and electrification, which will reduce energy intensity. As a result, energy consumption is expected to be 2,614 MBOE in 2050 (+1.48% compared to IETO) and and 2,857 MBOE in 2060 (-10.98% compared to IETO). Meanwhile, under KEN's plan, electricity demand will reach approximately 1,410 TWh in 2050 (+82.36% compared to IETO) and 1,712 TWh in 2060 (+91.33% compared to IETO). It is hoped that the electrification agenda will be implemented with a clear plan, reducing the risk of overestimating electricity demand, avoiding construction delays, and preventing oversupply.

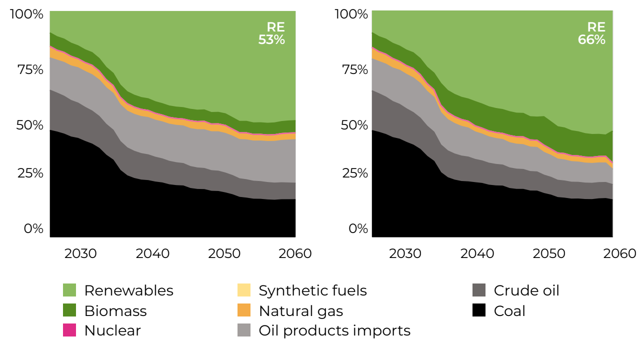
- In the primary energy mix, the IETO (BaU) projection estimates that RE will account for 16% of the energy mix in 2025, rising to 23% in 2030, and 45% in 2040, surpassing the KEN's new targets of 19% by 2030 and 40% by 2040. This growth is largely driven by the expansion of RE capacity in the power sector. In addition, in the IETO (AIT) scenario, which relies heavily on the extensive implementation of biofuel blends (including biodiesel, bioethanol, and bioavtur/SAF), these measures only contribute marginally to the renewable energy mix. Biofuels adds just +1.5% and +5.7% to the mix through biomass, bringing the total share of RE to 24.3% in 2030 and 50.8% in 2040. Looking beyond KEN, Indonesia Emas 2045 Vision aims for a 70% renewable energy mix by 2045 (RPJPN 2025-2045 draft). However, under the IETO model projections, this target is unlikely to be achieved without more ambitious actions and a more robust implementation plan.

Final energy consumption projection, business-as-usual



Source: IESR analysis using IESR IETO Model, KEN Draft (DEN) for projection comparison, HEESI (ESDM) for historical

IETO (BaU) primary energy mix | **IETO (AIT) primary energy mix**



Source: IESR analysis using IESR IETO Model. Note: The energy mix calculation was based on partial substitution method with the efficiency for non-combustible power plant assumption in Appendix B. Using primary energy content method (as used by IEA & DNV), IETO (BaU) shows the renewable energy mix of 10.5% in 2025, 12% in 2030, and 30% in 2040.

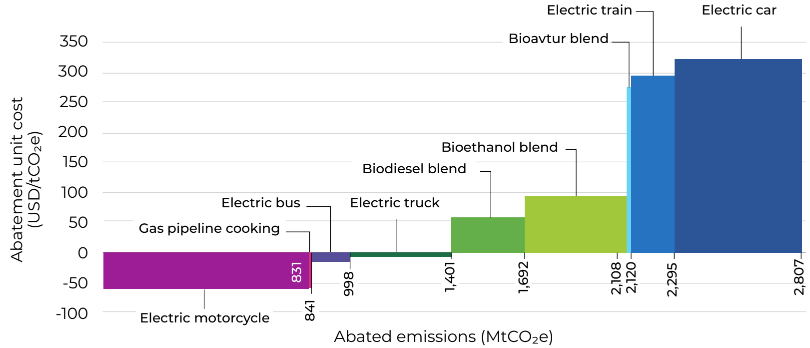
Demand-side interventions should prioritize least-cost options and expand implementation targets to other end-use sectors

Demand-side intervention strategies and targets in NZE roadmap draft

Sector	Intervention strategy	2060 implementation target
Transportation	Electric train	13.7-14.8 TWh annual consumption
	Electric motorcycle	165.6-170.8 million units
	Electric car	23.7-25.6 million units
	Electric bus	252-273 thousand units
	Electric truck	4.4-4.9 million units
	Bioethanol blending	20-30% blending (E20-E30)
	Biodiesel blending	50% blending (B50)
	Bioavtur blending	30-40% blending (A30-A40)
Residential	Gas pipeline cooking	5.6-7.6 million households

Source: NZE 2060 roadmap draft

Marginal abatement cost curve (MACC) of demand-side intervention targets, 2025-2060



Source: IESR analysis using IESR IETO Model

Note: Emissions from land-use changes for biofuels are not included, electric trucks are for light logistics

- The business-as-usual projection shows that direct emissions from demand-side sectors will contribute to 54% (469 $MtCO_2e$) of total emissions from Indonesia's energy sector in 2030. This requires significant shifts in strategies for direct emission abatement. The ongoing update of the net-zero emissions (NZE) roadmap for Indonesia's energy sector has set several demand-side implementation strategies, which are also aligned with the energy sector goals stated in the latest KEN draft. Most of these strategies focus on transport electrification and biofuel blending, while gas pipeline cooking has also been introduced to reduce dependency on LPG consumption by residential customers.

- The marginal abatement cost curve (MACC) for the 2025-2060 timeframe shows that two-wheelers electrification and the gas pipeline network for residential cooking are the most cost-effective measures, with the potential to abate 841 $MtCO_2e$ of emissions and generate around USD 51 billion in economic benefits due to reduced oil product imports. These low-cost, high-impact measures should be prioritized and scaled up in the short term. While the emission abatement potential is high, biofuel (biodiesel, bioethanol, bioavtur) blending may be less beneficial due to uncertain production costs that could outweigh the benefits of reduced oil imports, indicating the need to review its economic feasibility. Electric vehicle and railway electrification should be paired with effective regulatory support and subsidies for the long-term strategy to reduce the high upfront costs. Additionally, expanding specific implementation strategies for other end-use sectors, such as industry and commercial sectors, should also be encouraged, particularly for emission-intensive activities.

Taking bold steps for Indonesia's energy transition: key recommendations

	Short-term recommendations (before 2030)	Long-term recommendations (after 2030)
Industry	• Improve SIINAs data integration and compliance • Strengthen industries' energy audits and monitoring enforcement • Expand carbon trading and tax mechanism for industry sector • Establish robust ESG standards for mineral processing industries (e.g. nickel)	• Energy efficiency/energy intensity standards roadmap and strategy for emission-intensive industries • Emission-intensity standards for emission-intensive products • Support and incentivize industrial electrification
Transportation	• Meticulous targeted incentive to boost EV and supporting ecosystem (e.g. charging/swapping station) adoption • Emissions standard for oil fuels	• Improve financing access and options for public transport infrastructure • Biofuel/alternative fuels roadmap for hard-to-abate modes
Commercial & Household	• Targeted gas pipeline and electric cooking programs to reduce LPG consumption • Strengthen enforcement and awareness on green building standards	• Incentive mechanism for energy-efficient appliances, green building initiatives, and green material production • Promote and support energy-as-service companies (ESCOs) ecosystem
Power	• Effective and scaled-up renewable energy procurement • Investment incentives and technology transfer mandate for solar and battery manufacturers • Robust captive monitoring and planning • Regulatory framework to support coal retirement financing mechanism • Improve bulk access to renewable energy sources by establishing a power wheeling mechanism	• Market mechanism for ancillary services and flexibility provision in high VRE and distributed generation penetration • New energy (e.g. nuclear, hydrogen, ammonia) and carbon storage technologies as last option for limited location
Fuel production	• Establish methane emissions monitoring mechanism and standards for fossil fuel producers • Sustainability reporting standards and enforcement of net-zero strategy for fossil fuel-producing companies • Sustainability and ESG safeguards for plantation-based fuels	• Limit gas field expansions to avoid stranded asset risks • Incentivize green alternative fuels (hydrogen/ammonia) production and supporting infrastructure
Subnational governance	• Promote alternative financing mechanisms for energy access, renewable energy and energy efficiency projects in underdeveloped areas (e.g. physical transfer funds for RE projects, private-public partnership)	• Strengthen regional energy planning role for annual workplan and budget tagging • Expand regional government's authority on renewable energy affairs
Finance and Investment	• Provide guarantees and support facilities for strategic renewable energy and energy efficiency projects and small-scale developers • More aggressive emissions limit and carbon tax to kickstart carbon market activities • Mobilize international funds beyond technical assistance	• Long-term regulatory stability to reduce perceived risks • Explore alternative financing options (e.g. green/social bonds) to fund just transition efforts

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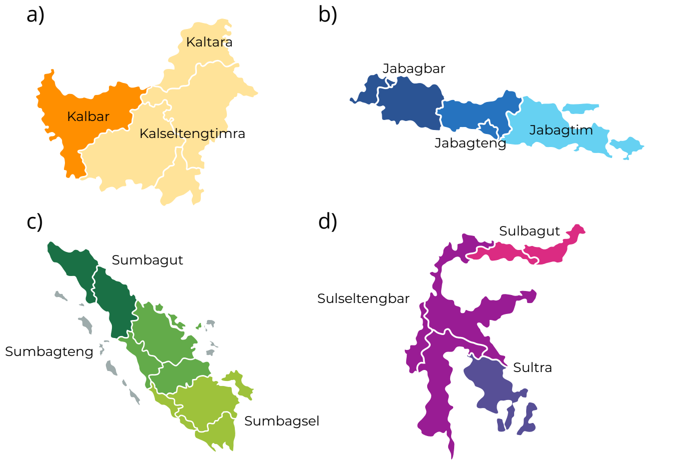
Appendix A - IESR's PLEXOS® Power System Model



Maluku, Papua, and Nusa Tenggara (MPNT) region are modelled as a single node per island system, with a total of 17 nodes.

Power plant fuel prices

Fuel	Price
Coal	70 USD/tonne
Gas Pipeline	6 USD/MMBTU
LNG	12 USD/MMBTU
Diesel Oil	81 USD/barrel
Biomass	70 USD/tonne
Biogas	4 USD/MMBTU
Ammonia	200 USD/tonne
Hydrogen	15 USD/MMBTU

Power plant technical parameters

Technology	Build cost (USD/ kW)	Mini-mum Stable Level (%)	Efficien-cy (%)	Capacity Factor (%)	Variable O&M (USD/ MWh)	Fixed O&M (USD/ kW/ Year)	Start Up Time (Hour)	Ramp-ing Rate (%)
CFPP	1,600	40	35	N/A	1.5	51.6	1.5	4
Diesel	867.06	6	46	N/A	7.3	9.12	0.01	25
OCGT	1,288.2	40	38	N/A	3.6	26.5	0.1	20
CCGT	1,311	45	57	N/A	2.6	26.8	1	20
Geothermal		80	N/A	85	0.27	110	N/A	3
Hydro Large		0	N/A	50	0.74	43	N/A	50
Hydro Medium		0	N/A	50	0.57	47	N/A	50
Hydro Mini		0	N/A	60	0.57	60.4	N/A	50
PV		N/A	N/A	20	N/A	7.5	N/A	N/A
Wind		N/A	N/A	30	N/A	40	N/A	N/A
Nuclear (SMR)	4,600	25	30	N/A	2.2	102	1.5	1.2
CCGT + CCS	930	45	48	N/A	4.96	37.8	2	20
CFPP + CCS	3,590	30	26	N/A	12	97	4	4
BECCS	2,000	50	23	N/A	92	92.1	6	3
CFPP NH3	1,930	40	44	N/A	1.65	56.76	1.5	4
CCGT H2	1,578	40	57	N/A	2.73	28.14	1	20

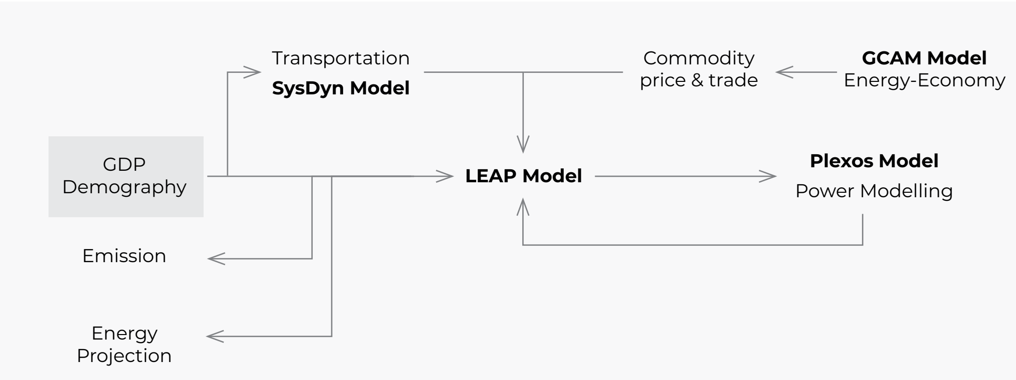
Source: MEMR-DEA Technology Catalogue for Indonesia Power Sector, 2024. (URL)

PLEXOS® simulation parameters

Simulation parameter	Value
Horizon	2024 - 2030
Optimization step	1 year
Load chronology	Sampled
Load details	Hourly (8760 data points)
Sampled days	365
VRE profile details	Hourly (8760 data points), sampled per node

Appendix B - IESR IETO Model key assumptions

IESR IETO model structure



Non-Combustible Power Plant Efficiency Assumption

Types of Power Plant	Efficiency
Hydro power (PLTA)	33%
Micro- Mini- Hydro (PLTMH, PLTM)	25%
Geothermal (PLTP)	33%
Solar PV (PLTS, PLTS Atap)	13%
Wind (PLTB)	25%
Solar Powered Public Street Lighting & Energy Saving Lamp (PJU TS & LTSHE)	100%
Bioenergy (PLTBm, PLTBg, PLTSa)	25%
Hybrid (PLTHybrid)	13%
Tidal (PLTAl)	25%
Nuclear (PLTN)	27%

Note: These assumptions were used to convert the non-combustible power generation to primary energy

- LEAP Cloud Data Server: Population and Urbanization projections are based on the World Population Prospects 2019 (UN, 2019) & Population Pyramid.
- LEAP Cloud Data Server: GDP PPP (constant 2017 international dollars) incorporates both short-term projections (accounting for COVID-19 impacts) and long-term projections based on Shared Socioeconomic Pathway 4 (Publisher: World Bank, IMF and OECD with additional analysis by SEI, 2021); BPS Gross Regional Domestic Product 2019-2023
- The demand-side model was developed using a bottom-up approach, drawing on data from the Residential End-Use Survey, Appliance Market Study (Fan, Lighting, Refrigerator, Rice Cooker) & MEPS Regulations, National Socio-Economic Survey 2011-2023, Benchmarking of Specific Energy Consumption in Commercial Buildings, Green Building Cost, IESR's commercial building floor area projection, IESR's transport system dynamics model, and IESR's mixed-method model for industry. The industrial model uses a bottom-up approach for key sectors (basic metals, ammonia, fertilizer, cement, textiles, pulp and paper, ceramics, glass) and top down by statistics of manufacture 2011-2022 for others industries.
- The framework involves multi-model interaction, with LEAP (Low Emissions Analysis Platform) serving as an integrator. This includes:
  - A CGE-based (GCAM) model to generate commodity prices and trade,
  - A system dynamics (Vensim) model to capture behavioral patterns, and
  - PLEXOS® for capacity expansion and detailed power system analysis

Appendix C - Progress in solar and battery supply chain production capacity in Indonesia (1)

Location	Companies	Product Type	Status	Source(s)
Central Java, Batang	SEG Solar, ATW Investasi Selaras	Phase 1: + 5 GW cell and 3 GW module (start production in Q2 2024) Phase 2: + 5 GW wafer and 2 GW module (start production in Q2 2025)	Agreement signing with Kawasan Industri Terpadu Batang (Grand Batang City) for 40 hectares for the USD 500 million project	UMBRA (2024), Publicover (2024), MENTARI (2024)
Central Java, Demak	LESSO New Energy	Current capacity at 2 x 1.2 GW module, future plan to add 2 GW	Inaugurated in September 2023	Setda Demak (2024), Lesso Solar (2024)
Central Java, Kendal	Trina Mas Agra Indonesia (Trinasolar, PT DSS, PLN IP)	1 GWp cell + module in Q2/Q3 2024, 3 GWp cell + module in 2025/2026	Groundbreaking in August 2023, under construction	Kontan (2024), MENTARI (2024)
Riau Islands, Batam	INSPIRA (Medco, Adaro, TBS) and Utomo SolarUV	No specific information	MoU signing, possible partnership with Longi Solar and Sungrow	Bloomberg (2024), Handayani (2023)
Riau Islands, Batam	Vena Energy, Suntech, Powin, REPT Battero	No specific information	MoU signing (March 2023)	Wahyudi (2023), Carroll (2023)
Riau Islands, Batam	IDN Solar Tech	Current capacity at 1 GW module, future plan to add integrated wafer + module production	No specific information	MENTARI (2024)
Riau islands, Batam	New East Solar	2.5 GW cell and module in 2023, + 5.5 GW cell and module by 2024	Under construction	NE Solar (2024)
Rempang Eco City (Batam) and North Kalimantan	Xinyi Glass Holdings	200,000 million tonnes polysilicon	Under discussion: integrated Industrial estate of glass, polysilicon, cell, and module plants	Rahman (2023) Wahyudi (2024a) FDD Global (2024)
Riau Islands, Batam (Wiraraja)	Mirah Green through PT Tynergy Technology Group	Silica processing for semiconductor and solar PV use	Declared a commitment to invest	Puspadini (2023)
Greenland International Industrial Center, West Java	GStar	3 GW silicon rod and 3 GW silicon wafer production by the end of 2024	No specific information	PV Magazine (2024), MENTARI (2024)

Appendix C - Progress in solar and battery supply chain production capacity in Indonesia (2)

Location	Companies	Product Type	Status	Source(s)
Indonesia Morowali Industrial Estate, Central Sulawesi	PT Huayue Nickel Cobalt, PT QMB New Energy Material, PT Fajar Metal Industry, PT Teluk Metal Industry	Ni-Co and Ni sulfide battery cathode, total production of 240 ktpa	Operational	Muliawati (2022)
Central Java Industrial Park	PT LBM Energi Baru Indonesia	LFP battery cathode, phase 1 production capacity 30 ktpa, phase 2 production capacity 60 ktpa	Phase 1 operational, phase 2 under construction (COD 2025)	CJIP (2024)
Karawang, West Java	Indonesia Battery Cooperation (IBC), CBL International Development Pte Ltd. (CATL subsidiaries)	Battery cell production of 15 GWh	Joint venture agreement signed, COD 2027	Rajendra (2024), Binekasri (2024)
Batang Integrated Industrial Area, Central Java	Indonesia Battery Cooperation (IBC), LG Energy Solution	Battery cell production of 10 GWh	Interest shown to expand current capacity production	Wahyudi (2023)

Appendix D - IESR Transition Readiness Framework Assessment Methodology

- The first FGD was conducted on 28 August 2024 with participants from 12 organizations. The aim of the FGD was to consult on the proposed variables and indicators with the relevant stakeholders. The authors then processed the input and finalized the variables and indicators to be used.

- The second FGD was conducted on 14 October 2024, with participants from 16 organizations. During this session, we presented facts that have been collected from a desk study and asked participants to rate each indicator into low, medium, or high, and provide their reasoning. Each participant was involved in assessing two dimensions, depending on their expertise. However, for some indicators, only a few participants submitted their ratings.

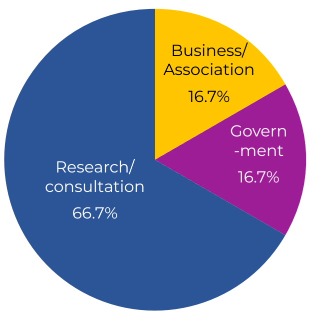
- In the end, the authors decided on the final ratings based on the data gathered from the desk study, the assessment ratings by FGD participants, and the survey results. The data obtained from the FGDs and surveys might be made available upon request.

- The survey was conducted using Google Forms and distributed manually to personal contacts.The survey consisted of 25 Likert scale questions (5-point), 2 yes-or-no questions, 1 checkbox question, and 10 open questions. It was completed by 15 respondents from 11 companies and 3 business associations within the period of 6-19 November 2024. Two respondents were from the same company, for which we take the average value from both and consider it as one response.

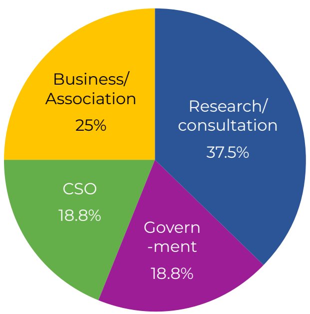
- The results from the 5-point likert scale questions were used to rate the indicators. Questions with an average rating under 2.75 is translated as "low", those between 2.75 and 3.25 as "medium", and those above 3.25 as "high".

- Below is the core business profile of the companies/associations participated in the survey. One respondent could engage in more than one business area. Battery industry is categorized under both manufacturing and electric vehicle.

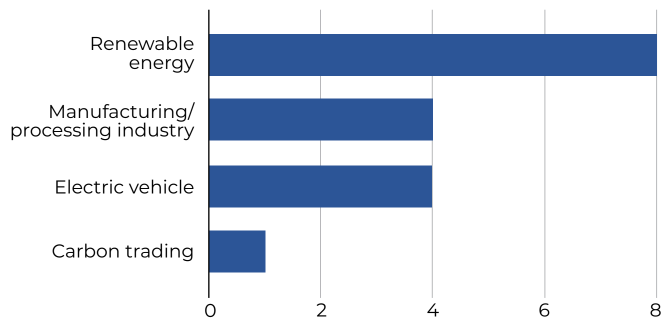
Profile of participants in the first FGD



Profile of participants in the second FGD



Business area of survey respondents



Appendix D - IESR Transition Readiness Framework Assessment Methodology (2)

Below is the list of questions asked in the survey questionnaire (1):

Dimension	Question	Type
Political & Regulatory	In your experience, how accessible are Indonesia's regulations related to energy transition?	5 point likert scale
	In your experience, how understandable are Indonesia's regulations related to energy transition?	5 point likert scale
	In your opinion, how stable is Indonesia's regulatory framework for energy transition?	5 point likert scale
	In your opinion, how attractive is the current regulatory framework for supporting an investment-friendly climate in the energy transition within your sector?	5 point likert scale
	Please elaborate which regulation/policy that you think needs improvement to attract more investment in energy transition in your sector.	Open question
	Which of these regulations/policies beyond the energy sector that hinders progress in energy transition?	Checkbox
	In your experience, to what extent that private sector are consulted in the energy planning and policy-making processes?	5 point likert scale
	Could you provide example of how are you typically involved in energy planning and policy-making processes?	Open question
	Within the sector of your business, in your opinion, how likely firms and public officials engage in bribery and/or other corruption practices?	5 point likert scale
Investment and Finance	In your experience, how streamlined is the bureaucracy process in getting permits for doing business in energy transition?	5 point likert scale
	Please elaborate more on your organization's experience on the permitting process for energy transition projects	Open question
	In your experience, how accessible is credit from domestic banks for energy transition investment?	5 point likert scale
	In your opinion, how attractive are the credit terms (e.g. interest rate, loan tenor, etc.) from domestic banks for energy transition investment?	5 point likert scale
	In your experience, how accessible is credit from international financiers for energy transition investment?	5 point likert scale
	In your opinion, how attractive are the credit terms (e.g. interest rate, loan tenor, etc.) from international financiers for energy transition investment?	5 point likert scale
	Please elaborate on what needs improvements in terms of accessibility and attractiveness of credit from local and international banks, if any	Open question
	In your experience, how accessible is international grants/aids for developing energy transition projects?	5 point likert scale
	In your experience, how accessible is government's fiscal incentives for energy transition investments?	5 point likert scale
	In your experience, has your company's project benefited from government fiscal incentives? If so, in what way? Please explain your answer.	5 point likert scale

Appendix D - IESR Transition Readiness Framework Assessment Methodology (3)

<table>
<tr><th>Dimension</th><th>Question</th><th>Type</th></tr>
<tr><td rowspan="13">Techno-economic</td><td>In your experience, how cost-competitive is the low carbon technologies compared to conventional technologies in your business sector?</td><td>5 point likert scale</td></tr>
<tr><td>In your experience, how cost-competitive is the renewable energy sources compared to fossil fuels in your business sector?</td><td>5 point likert scale</td></tr>
<tr><td>Please describe what kind of low-carbon technologies and renewable energy sources do you consider for the two questions above.</td><td>Open question</td></tr>
<tr><td>In your experience, how widespread is domestic suppliers for main components in your technology?</td><td>5 point likert scale</td></tr>
<tr><td>In your experience, how cost-competitive is domestically sourced components compared to imported components?</td><td>5 point likert scale</td></tr>
<tr><td>In your opinion, how suitable is the local content requirement (TKDN) in encouraging investment in domestic component manufacturers?</td><td>5 point likert scale</td></tr>
<tr><td>Do you have any suggestion to improve domestic manufacturing capabilities of energy transition technologies?</td><td>Open question</td></tr>
<tr><td>(For businesses in renewable energy and power sector)
In your understanding, how compatible is the existing grid to accommodate high renewable energy penetration?</td><td>5 point likert scale</td></tr>
<tr><td>(For businesses in manufacturing or processing industries)
In your experience, how easy it is to obtain renewable energy for your operation?</td><td>5 point likert scale</td></tr>
<tr><td>(For businesses in manufacturing or processing industries)
In your experience, how cost-attractive it is to switch from fossil fuels to renewable energy sources for your operation?</td><td>5 point likert scale</td></tr>
<tr><td>(For businesses in manufacturing or processing industries)
What kind of renewable energy sources do you think is the most accessible and cost-effective for your operation?</td><td>Open question</td></tr>
<tr><td>(For businesses in manufacturing or processing industries)
In you opinion, how supportive is the presence of green industrial estates (Kawasan Industri Hijau) in accommodating the tenants' needs for energy transition?</td><td>5 point likert scale</td></tr>
<tr><td>(For businesses in electric vehicles or transportation industries)
In your opinion, how sufficient is the amount of public charging and battery swap infrastructure to support the growth of electric vehicles?</td><td>5 point likert scale</td></tr>
<tr><td rowspan="5">Social</td><td>Has your company participated in or supported any government programs that aimed to support just energy transition in Indonesia?</td><td>Yes/no</td></tr>
<tr><td>If yes, what programs have you participated in and what is the role of your company in the program?</td><td>Open question</td></tr>
<tr><td>In your experience, how likely you can find qualified local workforce for energy transition projects?</td><td>5 point likert scale</td></tr>
<tr><td>Does your company provide any training, upskilling, or reskilling program to improve your employees capability in energy transition related work?</td><td>Yes/no</td></tr>
<tr><td>If yes, please provide examples of trainings, upskilling, or reskilling programs your company provide related to energy transition.</td><td>Open question</td></tr>
</table>

Appendix E - Energy and emission intensity of nickel processing by technology

Nickel type	Technology	Indonesia range	Global range
Energy Intensity (GJ/tonne Nickel)			
Nickel Class 1 (≥ 99.8% Ni)	via Sulphide Smelter	174 [(a)]	68 - 256 [(b, c)]
	via HPAL	75 [(g)]	74 - 508 [(b)]
NIckel Class 2 (< 99.8% Ni)	via RKEF	397 - 486 [(b, e, g)]	180 - 592 [(b, d)]
	as NPI	598 [(a)]	598 [(d)]
Emission Intensity (tCO_2e/tonne Nickel)			
Nickel Class 1 (≥ 99.8% Ni)	via Sulphide Smelter	8 - 14 [(1, 2)]	4 - 22 [(6, 8, 9)]
	via HPAL	10 - 20 [(1, 3)]	10 - 60 [(5, 6, 7,8)]
NIckel Class 2 (< 99.8% Ni)	via RKEF	42 - 80 [(1, 3, 5)]	18 - 105 [(5, 10)]
	as NPI	50 - 80 [(1, 2 ,4)]	50 - 80 [(1, 6, 7, 8, 10)]

Source: IESR analysis adapted from [a]Systemiq (2023); [b]Nickel Institute (2020, 2021, 2023; 2024); [c]Ali, A.-R. (2023); [d]Wei, W., et. al. (2020); [e]MBM (2024); [f]Fukuzawa, R. (2012); [g]DNV (2024)
[1]CRI (2024b); [2]Systemiq (2023); [3]Anderson, J. (2023); [4]Jain, R. (2022); [5]IEA (2024a); [6]Wyloo (2024);[7]fpxnickel (2021); [8]CCSI (2023); [9] Minviro (2023); [10] Wei, W., et. al. (2020); [11]IEEFA (2024).

Appendix F - Comparison of industry energy intensity between Indonesia and the global average

Sector of Industry	Indonesia average (GJ/tonne)	Global range (GJ/tonne)	Global Average in general (GJ/ton)
Steel - Scrap EAF Steel - BF/BOF Steel - DRI-EAF	2.3 - 2.52 [1, 9] 20.4 [1] 10.7 [1]	1.8 - 12.5 [2, 3, 9, 24] 14.8 - 31.2 [2, 3,4] 4 - 30.9 [2, 3, 4, 21]	19-20 [19, 25]
Cement	3.3 - 3.6 [1, 9]	2.9 - 4.2 (Dry) [5, 22, 23] 6 - 6.7 (Wet) [5, 22, 23]	3.22-3.6 [13, 17, 19, 20, 23]
Ammonia	37 [1]	23.5 - 51.9 (NG) [18] 46.2 -55 (Coal) [1, 19, 26]	41 [1, 18]
Kraft pulp Paper making Repulping Pulp and Paper	16.8 [1] 8 9 [1] 3.7 [1] -	14 - 32 [1, 7] 3.3 - 33 [7,8] 1.4 - 8.11 [1, 7] 7.3 - 35.2 [7]	11.5 [7]
Flat Glass Float glass	6.7 [16] 5.95 [16]	5.5 - 10 [13,14, 15] 5.3 - 8.3 [15]	7.5 -9.2 [14, 15, 16]
Ceramic tile	3.81 [11] 16.6 [9, 10]	3.31 - 16.6 [10, 12]	4.6 [24]

Source: IESR analysis adapted from [1]IESR-LBNL (2024); [2]UNIDO (2014a); [3]Pardo, N. (2012); [4]Shahabuddin, M., et. al. (2023); [5]Turkalov, Z. et. al. (2024); [6]Juntueng S. et al. (2012); [7]Moya, J.A., et. al. (2018); [8] Jacobs (2006); [9]Nugroho, F. (2017); [10]MEMR (2018); [11]Arwana (2023); [12]Osama, A., et. al. (2017); [13]Obrist.. M. D., et. al. (2021); [14]Westbroek, C.D., et. al. (2021); [15]CEPS (2014); [16]Revitasri, R., et. al. (2018); [17]IEA (2024b); [18]UNIDO (2014b); [19]IEA (2021); [20]IEA (2024b); [21]Julian, S., et. al. (2022); [22]Ohnakin, O. S. (2013); [23]Ecofys (2009); [24]Mezquita, A., et. al. (2014); [25]WEF (2023); [26]IIP (2024)

Appendix G - Energy transition-related authorities for subnational governments

Energy Transition-Related Sector	Type of Authority	Energy Transition-Related Authorities for subnational governments
Energy and mineral resources	Optional matter	1. Renewable Energy (RE): a. Issuing permits for direct geothermal utilization b. Issuing registration certificates for supporting service businesses operating within the province c. Issuing permits, supervision, and oversight of biofuel trade as an alternative fuel with a supply capacity up to 10,000 (ten thousand) tonnes per year 2. Electricity: a. Issuing licenses for non-state-owned electricity supplies and sales of electricity and network leasing to electricity providers within the province b. Issuing operational permits for installations within the province c. Setting electricity tariffs for consumers and issuing permits for network utilization for telecommunications, multimedia, and information technology by license holders designated by the provincial government d. Approving electricity sale prices and network leasing, electricity supply business plans, and surplus electricity sales from license holders e. Issuing licenses for electricity support service businesses for companies with majority domestic ownership f. Providing funds for underserved communities, underdeveloped electricity supply infrastructure, remote, and rural areas
Industry	Optional matter	1. Determining industrial development plans 2. Issuing licenses for large and small industries across regencies/municipalities (note: small- and medium- business licenses are under the authority of municipalities/regencies; licenses for industries with significant environmental impact are under the national government).
Transportation	Mandatory, non-basic service	1. Road traffic and transport: Various authorities are related to planning, provision, and management within the province and across regencies/municipalities, but none are specific to supporting energy transition 2. Shipping: Various authorities, such as issuing sea transportation licenses, planning the master development, and building port and infrastructure, but none specifically support energy transition 3. Railways: Various authorities such as planning the master development and issuing business licenses, but none specifically support energy transition
Environment	Mandatory, non-basic service	None
Public works and spatial planning	Mandatory, basic service	None
Employment	Mandatory, non-basic service	None

Source: IESR analysis from GoI. (2014). Undang-undang (UU) Nomor 23 Tahun 2014 tentang Pemerintahan Daerah. URL.

Appendix H - Data for subnational energy sector budget realization in 2023 (1)

Province	Realization of Energy Budget	Realization of NRE Program Budget	Source	Type of document
NTT	IDR98,660,648,111	IDR87,476,631,585	URL	LKjIP DESDM 2023
Aceh	IDR107,070,024,432	IDR73,290,594,721	URL	LKjIP DESDM 2023
DKI Jakarta	IDR32,132,609,833	IDR15,856,683,078	URL	LKPD Provinsi 2023
Central Java	IDR98,259,476,000	IDR14,727,518,000	URL	LKjIP DESDM 2023
East Java	IDR94,828,888,755	IDR14,575,997,864	URL	LKjIP DESDM 2023
Southeast Sulawesi	IDR16,314,841,679	IDR9,429,741,420	URL	Penjabaran Perubahan APBD 2023
Central Sulawesi	IDR33,074,793,262	IDR9,181,970,403	URL	LKjIP DESDM 2023
East Kalimantan	IDR91,202,578,982	IDR5,581,072,328	URL	LKjIP DESDM 2023
Lampung	IDR20,719,348,632	IDR1,758,027,012	URL	Penjabaran Perubahan APBD 2023
West Java	IDR109,300,080,344	IDR1,501,103,574	URL	LKjIP DESDM 2023
West Sumatra	IDR15,134,655,484	IDR1,454,910,983	URL	LKjIP DESDM 2023
North Kalimantan	IDR13,346,862,227	IDR1,355,140,000	URL	LKjIP DESDM 2023
Riau Islands	IDR6,560,354,584	IDR1,038,102,478	URL	LKjIP DESDM 2023
Maluku	IDR18,659,783,889	IDR1,000,000,000	URL	Penjabaran Perubahan APBD 2023
Gorontalo	IDR16,007,309,391	IDR933,895,535	URL	LKIP Dinas Tenaga Kerja, ESDM, dan Transmigrasi 2023
Banten	IDR41,622,799,799	IDR515,452,000	URL	LKjIP DESDM 2023
Papua	IDR39,901,832,925	IDR300,000,000	URL	RKPD Perubahan 2023
Central Kalimantan	IDR28,047,908,424	IDR278,029,047	URL	LKjIP DESDM 2023
Riau	IDR62,744,730,047	IDR239,999,600	URL	LKjIP DESDM 2023
South Sumatra	IDR26,614,776,975	IDR150,000,000	URL	Penjabaran Perubahan APBD 2023

Appendix H - Data for subnational energy sector budget realization in 2023 (2)

Province	Realization of Energy Budget	Realization of NRE Program Budget	Source	Type of document
NTB	IDR9,240,453,300	IDR145,714,620	URL	LKjIP DESDM 2023
DI Yogyakarta	IDR552,139,114,376	IDR118,050,000	URL	LKjIP PUPESDM 2023
Bali	IDR28,841,611,047	IDR43,131,394	URL	LKjIP Dinas Tenaga Kejra dan rESDM 2023
West Kalimantan	IDR14,265,314,611	IDR34,862,633	URL	LKjIP Dinas Perindustrian, Perdagangan, dan ESDM 2023
South Sulawesi	IDR20,854,211,066	IDR9,540,000	URL	LKPD 2023
South Kalimantan	IDR24,602,840,095	IDR0	URL	LKjIP DESDM 2023

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