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Tracking Progress of Energy Transition in Indonesia: Pursuing Energy Security in the Time of Transition

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Indonesia Energy Transition Outlook 2023

Tracking Progress of Energy Transition in Indonesia: Pursuing Energy Security in the Time of Transition

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Foreword

In 2017, IESR launched a campaign on energy transition in Indonesia in the wake of President Joko Widodo's 35 GW acceleration power supply program. Through the publication of the Indonesia Clean Energy Outlook (ICEO), we have tracked the progress of clean energy deployment in Indonesia since 2017.

Beginning in 2020, ICEO transformed into Indonesia Energy Transition Outlook (IETO), which covers broader issues and deepens the analysis of the dynamics of the entire energy sector, such as evaluating the quality of the enabling environment of the energy transition and the readiness of transition in the power sector. IETO manifests IESR's vision to decarbonize our energy system.

IETO 2023 arrives just as Indonesia embarks on its journey to transform its energy system. After President Jokowi pledged that Indonesia would reach net-zero emissions by 2060 or sooner, the energy policy began to shift away from fossil fuels and toward clean energy last year. The obvious shift occurs in the power sector, where PLN's 10-year RUPTL (2021-2030) for the first time includes more renewable power plants than fossil fuels. The decline in the electricity demand growth, which was exacerbated by the COVID pandemic, compelled PLN to drastically reduce its coal-fired power plants.

The NZE objective also accelerates the power sector's emission peaks relative to the initial plan. A USD 20 billion Just Energy Transition Partnership (JETP), launched during the Indonesia G20 summit, stipulated that emissions from the power sector will peak by 2030 and be capped at 290 MtCO2e. Even though the JETP target is not aligned with the 1.5°C Paris Agreement, it is still a good measure that could allow the rapid deployment of renewable energy, the improvement of energy efficiency measures, and the initiation of the coal phase-down before 2030.

Investment is essential to reach energy transition goal. However, mobilizing investment is a challenge that Indonesia faces. Since 2017, investment in renewable energy generation has been stagnant, and in the last two years, it has fallen short of the government's target. This stagnation is due to a lack of improvement in the enabling environment, inconsistent implementation of policy and regulatory frameworks, delays in PLN's procurement, lengthy PPA negotiation, as well as lingering issues in land acquisition, environmental permits, and licenses.

The results of the Transition Readiness Assessment (TRF) in the power sector illustrate the limited progress made since last year's evaluation. TRF which measures 4 variables and 7 indicators reveal that despite some progress in policy and regulatory framework this year, we are not fully ready to make the transition happens. Investors have not yet determined the effectiveness of new policies because implementation has not occurred.

There is still a great deal of work to be done to make energy transition truly happen and sustainable, i.e. phase out coal and gas subsidies through domestic market cap prices, reform electricity price and subsidy, and address overcapacity as soon as possible by retiring old and inefficient coal plants, as well as tweaking local content regulation for solar, reforming the electricity market, and integrating the transport and industrial decarbonization strategy into the net-zero emission pathway. The government should pursue all these reforms and society should keep pushing for the transition to really occur.

December 15th, 2022

Fabby Tumiwa
Executive Director

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List of Abbreviations

ADB : Asian Development Bank
AIIB : Asian Infrastructure Investment Bank
AMC : Advance Market Commitments
APBD : *Anggaran Pendapatan dan Belanja Daerah* (sub-national government budget)
APROBI : Indonesia Biofuel Producer Association
B2B : Business-to-business
bbl : barrel
BESS : Battery Energy Storage Systems
BEV : Battery Electric Vehicle
BF : Blast furnace
BGH : *Bangunan Gedung Hijau*
BOF : Basic oxygen furnace
BPDPKS : *Badan Pengelola Dana Perkebunan Kelapa Sawit*
BPS : Best policy scenario
BPS : *Badan Pusat Statistik* (Statistics Indonesia)
CAPEX : Capital expenditure
CCS : Carbon Capture and Storage
CCUS : Carbon Capture Utilization and Storage
CCGT : Combined-Cycle Gas Turbine
CFPP : Coal-fired Power Plant
CMEA : Coordinating Ministry For Economic Affairs
CO_2 : Carbon dioxide
CoP : Coefficient of Peformance
COP : Conference of the Parties
COVID-19 : Coronavirus disease
CPO : Crude Palm Oil
CPS : Current policy scenario
CRF : Carbon Reduction Fund
DEN : *Dewan Energi National* (National Energy Council)
Ditjen EBTKE : *Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi*
DMO : Domestic Market Obligation
DRI : Direct reduced iron
E-bus : Electric bus
E-HAPI : Electric and Hybrid Aircraft Platform for Innovation
E2W : Electric 2-wheelers
E3W : Electric 3-wheelers
E4W : Electric 4-wheelers
EAF : Electric Arc Furnace
EMR Office : *Dinas ESDM Provinsi* (Energy and Mineral Resources)
ESS : Energy Storage Systems
EU : European Union
EV : Electric Vehicle
G20 : Group of Twenty
GBIB : Green Building Information Gateway
GBPN : Global Buildings Performance Network
GDP : Gross Domestic Product
GFANZ : Glasgow Financial Alliance for Net Zero
GHG : Greenhouse gas
GJ : Gigajoule
GNI : Gross national income
GT : gross tonnage
GW : Gigawatt
GWh : Gigawatt hour
Ha : Hectare
HBA : *Harga Batubara Acuan* (Coal reference price)
HEESI : Handbook Of Energy & Economic Statistics Of Indonesia
HFO : Heavy fuel oil
ICAO : International Civil Aviation Organization
ICCT : International Council on Clean Transportation
ICE : Internal combustion engine
ICEV : Internal combustion engine vehicles
IDR : Indonesian Rupiah
IEA : Intenational Energy Agency
IESR : Institute for Essential Services Reform
IFC : International Finance Corporation
IIF : Indonesia Infrastructure Finance
INA : Indonesia Investment Authority
IP : Investment Plan
IPP : Independent Power Producer
IRENA : International Renewable Energy Agency

List of Abbreviations

JETP : Just Energy Transition Partnership
KSPN : *Kawasan Strategis Pariwisata Nasional* (National Strategic Tourism Areas)
kW : Kilowatt
LCCP : Low Carbon Scenario Compatible with Paris Agreement
LCOE : Levelized cost of electricity
LCR : Local content requirement (TKDN)
LCY : Local currency
LEED : Leadership in Energy and Environmental Design
LNG : Liquified natural gas
LPG : Liquefied Petroleum Gas
LTS : Long term scenario
LTS-LCCR : Long Term Strategy for Low Carbon and Climate Resilience
MEMR : Ministry of Energy and Mineral Resources
MEPS : Minimum energy performance standard
mmbtu : million british thermal unit
MoF : Ministry of Finance
MoHA : Ministry of Home Affair
MoI : Ministry of Industry
MoT : Ministry of Transportation
MSR : Molten salt reactor
mt : metric ton
$MtCO_2$-eq : Million tonnes of carbon dioxide equivalent
MW : Megawatt
MWh : Megawatt Hour
NDC : Nationally Determined Contribution
NEA : Nuclear Energy Agency
NEPIO : Nuclear Energy Programme Implementing Organization
NTB : Nusa Tenggara Barat (West Nusa Tenggara)
NZE : Net Zero Emission
OJK : *Otoritas Jasa Keuangan* (Financial Services Authority)
PATS : *Pompa Air Tenaga Surya* (solar water pumps)
PBG : *Persetujuan bangunan gedung* (Building permit)
PHS : Pumped Hydropower Storage
PLN : *Perusahaan Listrik Negara* (State Electricity Company)
PPA : Power Purchase Agreement
PPnBM : *Pajak Penjualan atas Barang Mewah* (Tax on Luxury Goods)
PSE : *Pusat Studi Energi* (Center for Energy Studies)
PSN : National Strategic Programs
PV : Photovoltaic
Q1 : Quarter 1
Q3 : Quarter 3
RBDPO : Refined Bleached Deodorized Palm Oil
RE : Renewable energy
RFNBO : Renewable Fuels of Non-Biological Origins
RPJMD : *Rencana Pembangunan Jangka Menengah Daerah* (Local government medium term development plan)
RUED : *Rencana Umum Energi Daerah* (Regional Energy General Plan)
RUEN : *Rencana Umum Energi Nasional* (National Energy General Plan)
RUPTL : *Rencana Umum Penyediaan Tenaga Listrik*
SAF : Sustainable Aviation Fuel
SBH : *Sertifikasi Bangunan Hijau*
SLEB : Super Low Energy Building
SME : Small Medium Enterprises
SMI : *Sarana Multi Infrastruktur*
SMR : Small modular reactor
SMR : Steam methane reforming
TWh : Tera-Watt hour
UK : United Kingdom
UNOPS : United Nations Office for Project Services
US DOE : United States Department of Energy
US : United States
USD : US Dollar
VA : Volt-ampere
VRE : Variable Renewable Energy
WB : World Bank
WHO : World Health Organization
WNA : World Nuclear Association
WWR : Window-to-Wall Ratio
ZEV : Zero emission vehicle

Executive Summary

Executive Summary

- While the global economy recovers from the effects of the COVID-19 pandemic, the world is now dealing with another crisis that has shattered even some of the world's developed economies. The global energy crisis was a ticking time bomb, ready to devastate the global economy. The crisis has been exacerbated by sanctions imposed on Russia as a result of its invasion of Ukraine, causing Russia to contract its gas supplies, resulting in global competition for alternative fossil energy resources. The combination of these factors causes global energy prices to reach a new all-time high, which is expected to be two to four times higher than in 2019.
- Indonesia has not been largely affected in the early days of the crisis due to the country's large allocation on energy subsidies. Nevertheless, such reliances have then heavily burdened the state budget, forcing the government to opt for the unpopular decision by increasing the price of the subsidized fuels just recently. Soaring coal price in the global market has lured coal industries to rather export their products, causing shortage in the domestic supply for power generation in early 2022. Following this event, the government imposes security of coal supply to the state-owned utility PLN by strengthening domestic market obligation (DMO) price cap measure. According to DEN's assessment in 2019, Indonesia scored 6.57 in the Energy Security Index (ESI), placing the country at the 'Secure' level. Clearly, this needs to be updated, weighing in recent events, with refined methodologies to paint an accurate condition of Indonesia's energy security.
- Despite the growing urge, renewable energy (RE) share in Indonesia's primary energy mix has declined from 11.5% in 2021 to 10.4% in 2022. Biodiesel development, which has been touted to be spearheading the renewable increase in the primary energy mix, has stagnated at B30 since 2019. Its volume grew by a mere 1.4% in 2021, mainly due to the pandemic and rising palm oil price. With a few more years left before 2025, the 23% target seems far-fetched if no significant reforms are made. The sluggish adoption of RE is a reflection of low investment realization. By Q3 2022, the investment realized was less than 35% of the target at USD 3.97 billion. The necessary regulatory improvement, for instance the New Energy and Renewable Energy (NERE) bill, has been progressing slowly, preventing increased investment in RE. Nevertheless, the recently enacted Presidential Regulation (PR) 112/2022 should give a head start, particularly in attracting RE investment in the power sector, but the investor's reaction remains to be seen after PLN start procuring.
- Unlike the renewable supply, the demand side has been seeing an encouraging trend. The energy intensity has been declining at a rate of 1.7% per year, matching RUEN target of 1% reduction per year. At the forefront of the trend are household-based SMEs, which contribute to 60% of total GDP, yet have not been recorded as non-residential (working in the economy) in electricity use. Even while residential electricity consumption is high, it could be beneficial to the economy.

Executive Summary

- Hydrogen development, particularly the green one, is currently at the early phase of development. The nearest target set by the government will see a 328 MW green hydrogen production capacity development by 2030. With the estimated price of USD 3-12/kg, USD 2/kg less in the area with best resources, the development plan should be accompanied by policies in favour of lower RE price, which in turn lower the green hydrogen production cost.
- To prevent another shortage of domestic coal supply for the power generation, the government then proposed a scheme that would compensate coal producers for the price difference between the DMO contract and global market prices. The scheme, named BLU *batubara*, will have a similar mechanism used in BPDPKS for the palm oil industry, particularly on the compensation and contribution. To some extent, the scheme is a fair deal between coal producers and the government. Yet, there is an impression that the scheme could prolong coal utilization, for instance in the DME project, to make its price economically-acceptable. The project, intended as a strategy to reduce dependence on LPG import, would woefully produce CO2 emissions five times higher than the LPG.
- Two out of three oil and gas companies have actively involved in RE developments, mainly in utility-scale solar PV and geothermal power generation. Almost half of the coal companies analyzed have done the same, with some expanding to the two-wheelers EV. Yet, only a few fossil fuel companies have actually allocated their CAPEX for these expansions. The allocation is relatively small compared to the one for their current core businesses.
- Power sector transformation has been progressing, albeit rather slowly. Existing net-zero plan by the MEMR is still aiming for 2060 or sooner, in which Coal-fired Power Plant (CFPP) will be retired naturally. Just recently, a legal ground was provided for the CFPP to be retired earlier than its natural lifetime, stipulated in the PR 112/2022. With the early retirement gets a go, the RE must be immediately developed. The current RE share in the generation mix is 12.8%, with 10.8 GW of capacity. To further push the renewable share, PLN decided to rely on hydro, geothermal, and biomass co-firing in its existing coal power plants to achieve the 23% target by 2025. However, the decision has so far full of challenges, particularly on the potential delays of several hydro and geothermal projects and the biomass pricing.
- Solar has finally made its way into a larger part of Indonesia's net-zero emissions pathways this year. According to IEA, IRENA, and IESR net-zero energy sector models, solar will take up at least one-third of total electricity generation by 2060 and from two-third up to 90% in an accelerated 1.5°C-aligned scenario by mid-century. Its deployment today, however, remains slow, stemming from unambitious planning, with respect to grid overcapacity, and poor realization of auctions. Out of the current planned PV capacity addition in RUPTL 2021 (4.7 GWp), only 12% (0.6 GWp) is currently in the pipeline (tendered). In the distributed solar side, the growth of rooftop solar PV and the implementation of MEMR No. 26/2021, which revises the net metering scheme to 1:1, are also hindered by PLN's 15% maximum capacity restriction.

Executive Summary

- Early CFPP retirement is critical in the emission reduction and in further RE adoption in the power sector. The PR is clearly mandating the MEMR to produce an early retirement roadmap, limiting all operating CFPPs up until 2050, whilst also considering the RE to fill in the void. About 11 GW of CFPP has been identified, subjected to further discussion involving other ministries. Moreover, the PR has attracted donor countries to then commit for Just Energy Transition Partnership (JETP), promising to mobilise USD 20 billion to support the retirement of CFPPs and transition of Indonesia's power sector. The partnership includes targets on peak emission at 290 million tonnes CO_2, renewable share at 34% altogether by 2030, and achieving NZE in 2050. Another financing scheme, Energy Transition Mechanism (ETM) country platform, provides the government with another option.
- Future expansion planning should begin to address power system flexibility ahead of high penetration of Variable Renewable Energy (VRE). Enabling factors for such a power system are flexibility in grid operation, supply and demand side management, interconnection (transmission and distribution) assets, and energy storage. In Indonesia, contractual flexibility and system operational practices could be prioritized due to the less-intensive capital requirements. Typically, high-voltage interconnection and energy storage are neglected flexibility options at low VRE penetration levels due to the high required investment. However, due to the geographical condition of Indonesia, which consisting of disconnected power systems with different VRE potentials and levels of penetration, the preparation of regulatory frameworks and development plans should be immediately carried out.
- EVs adoption has been in an uptrend. Most notable increase is observed on the two-wheelers segments, growing almost five times higher than in 2021. Rising gasoline fuels price has been identified as one of the drivers for the switch from ICE-based vehicles. Despite the positive growth, the lack of charging infrastructure slows further EVs adoption by consumers, particularly in meeting even the lowest NDC target at 13 million vehicles. For a heavy-duty transportation, switching towards the clean fuel is more practical than electrifying it. Biodiesel is at the leading edge of clean fuel development in Indonesia. The recent blending ratio for the fuel, 40%, is currently undergoing a road test prior to its implementation, which is still awaiting for its legal ground. The development cost has been shouldered by the revenue of BPDPKS, which was increasing due to rising export levies and closing price gap between biodiesel and diesel.
- Energy use, including direct fuel combustion and electricity consumption, dominated the GHG emissions in industry sector, with over 60% contribution. Fossil fuel combustion, particularly coal and natural gas, is the primary energy source in industries, but the use of electricity has been increasing. Process and energy efficiency improvements and fuel switching have been implemented by some energy-intensive industries to reduce their emissions. Implementation of CCUS could be an important short-term strategy in reducing process emissions in cement, fertilizer, and steel industry, but has not yet started. Development of alternative low-carbon technologies, such as electrolysis-based ammonia for fertilizer and hydrogen-based DRI process for ironmaking, are gaining interests, although most are still in a very early phase of MoU and joint study agreements.

Executive Summary

- Residential and commercial buildings in Indonesia have shown a decreasing trend in their annual energy intensity even before the COVID-19 pandemic hit, each respectively with a rate of 1.38%/year and 2.64%/year. The decrease is largely due to the growing use of electricity in these sectors. It can be expected that more electrical appliances will be employed, but little has awareness on energy-saving measure and the energy labelling efficiency, MEPS.
- As many as 27 out of 38 provinces in Indonesia have already developed regional energy planning (RUED). Each province showcases different approaches to achieving their targets. Central Java, for instance, has committed its public budget for green recovery following the devastated economy caused by the COVID-19 pandemic. Most of the allocated budget goes to biogas digester, followed by rooftop solar PV, to encourage sub-national energy independence. Bali is known for being the first province in Indonesia to issue a regulation on EV, which has seen a 150% increase in EVs adoption in 2020, with a further 250% increase in 2021. Ambitious target is displayed by Nusa Tenggara Barat, targeting to reach NZE by 2050, hence placing it in the front runner of energy transition in Indonesia. Foreign funds are expected to provide the capital for its renewable energy development. Similarly, West Sumatra has set an ambitious target for its RE share of up to 51.7% by 2025. Nevertheless, notable gaps between the 2025 projection and realization should not be swept under the rug. With less than three years left, West Sumatra regional government needs to step up its efforts.
- Alternative funding sources are available to aid Indonesia's energy transition, forged between various parties, including philanthropic donor and Multi Development Bank (MDB), and the government. These sources include: 1) Green Sukuk proceeds and Energy Transition Partnership (ETP), focusing on clean energy deployment; and 2) Clean Investment Fund-Accelerated Coal Transition (CIF-ACT), ETM country platform, and JETP, focusing on early coal retirement and the transition to RE utilization. Bilateral financing remains critical for Indonesia's energy transition, currently amounting up to USD 14 billion, with USD 1 billion under the JETP.
- Local financing used in the renewable energy development in Indonesia has been showing a promising increase. Three of four state-owned banks have been observed mobilizing credits for RE, reaching as high as IDR 9.5 trillion during 2021 financial year alone. Nevertheless, the figure is relatively low, at 0.9%-5.5% from the amount of sustainable portfolios of these banks in 2021, compared to the credit allocation for coal sector. A more robust Green Taxonomy would in fact help tip the balance. Key recommendations for the taxonomy rework are: 1) Incorporate a clear framework for how financial institutions can identify taxonomy classifications on their portfolios and loan books; 2) Create more specific criteria based on climate impact measurement; 3) Evaluate 'transitional activities' under the yellow category, particularly unabated oil, gas, and coal-fired power projects; 4) Align the taxonomy with international acceptable standards to compete with international market.

Executive Summary

- For the most part, the readiness level of energy transition in Indonesia is relatively similar to last year's assessment, apart from the improvement in one indicator. The cost competitiveness of renewable technology is rated 'high' in this year's assessment. This is spearheaded by the price of the latest cheapest solar PV that reaches USD 4 cent/kWh (without battery) and wind power reaches USD 5 cent/kWh, which are comparatively lower than the average coal (USD ~5-8 cent/kWh) and diesel power plants (USD ~13.4 cent/kWh). Surprisingly, the ratification of PR 112/2022 does not really tip the scale of the indicators under the policy and regulatory dimension. Indeed, there are certain improvements required, suggested by RE developers, including: 1) To have one gate system to ease the process, simplification on licensing, and certainty on the process finalization period; 2) The reenactment of FiT and improvement on procurement schemes in order to attract more investors.
- Launched during G20 event, the highly-anticipated partnerships for coal early retirement, ETM country platform and JETP, would need to be strengthened by several derivatives of PR 112/2022. The most to look forward to is the coal early retirement roadmap, showcasing the government's crystalized commitment on the coal phase out. The upcoming RUPTL should also be expected to include alignment of the retirement roadmap with capacity expansion of RE in the system next year to align with 2030's targets. To make 2023 as a successful pivot point for the renewable deployment, the procurements on RE projects must start in 2023 and continue until 2025 in order to be operational before 2030. Grid code must then also be updated to regulate the flexibility of power plants to be able to supply the demand 24/7, especially with an increasing high share of VRE in the system.
- Worth mentioning for next year's renewable energy growth is the increase in the installed capacity of geothermal, hydro, and solar power plants. For instance, the increased capacity of 55 MW in the Patuha Geothermal PP, the Peusangan and Asahan hydropower operations will add 45 MW and 174 MW, respectively, and the Cirata floating PV will add 145 MWac of solar power. Rooftop solar PV will also add to renewables growth, although it will likely still be hampered by the capacity limitation.

1

Energy Security in the Era of Energy Transition

Dr. Handriyanti Diah Puspitarini

- Global energy crisis
- Fossil fuel subsidy in Indonesia
- Renewable energy role in energy crisis mitigation

The occurrence of the global energy crisis is the impact of a series of events in 2020-2022

Global energy crisis occurs due to an unbalance energy supply and demand of fossil fuels affected by abrupt changes in social, politic, economic, and environmental aspects. It causes a soaring energy prices, such as coal, natural gas, crude oil, and electricity which is 2-4 times higher in the mid 2022 than in 2019.

2019

- Global energy demand: 174,285 TWh
- Average of crude oil price: USD 61.41 per bbl
- Average of Europe natural gas price: USD 4.8 per mmbtu
- Average of Australia coal price: USD 61.41 per mt

2020

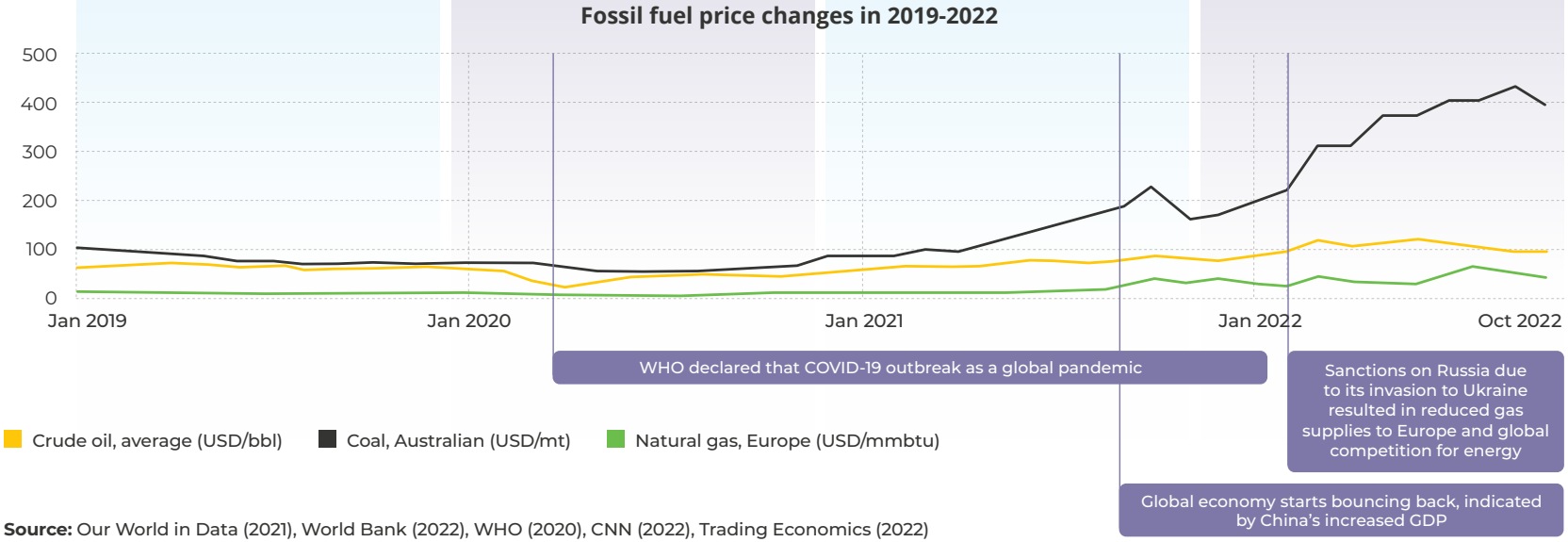
- Global energy demand: 167,781 TWh
- Average of crude oil price: USD 41.26 per bbl
- Average of Europe natural gas price: USD 3.24 per mmbtu
- Average of Australia coal price: USD 60.79 per mt

2021

- Global energy demand: 176,431 TWh
- Average of crude oil price: USD 69.07 per bbl
- Average of Europe natural gas price: USD 16.12 per mmbtu
- Average of Australia coal price: USD 138.05 per mt

2022 (until October 2022)

- Global energy demand: N/A
- Average of crude oil price: USD 100 per bbl
- Average of Europe natural gas price: USD 41.23 per mmbtu
- Average of Australia coal price: USD 341.73 per mt

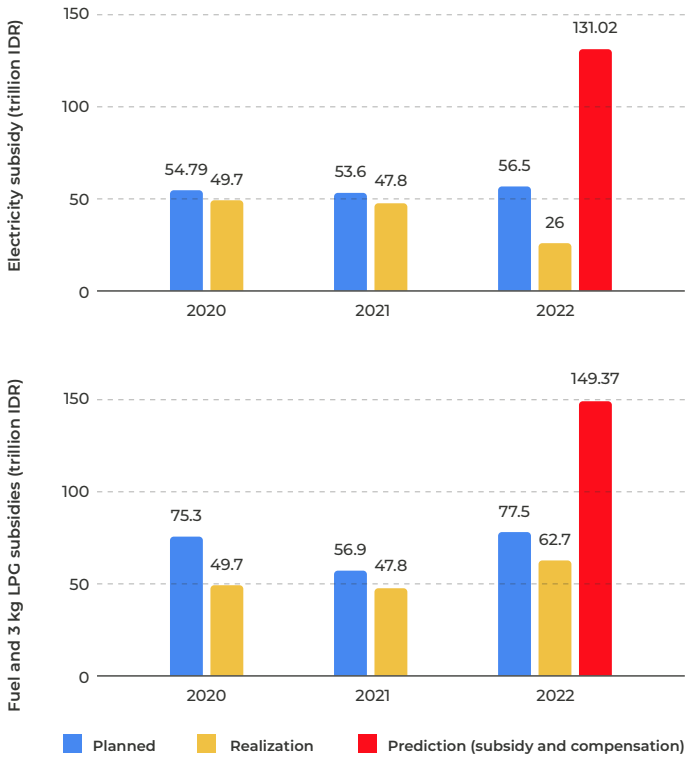


Source: Our World in Data (2021), World Bank (2022), WHO (2020), CNN (2022), Trading Economics (2022)

Indonesia is relatively insulated from the global energy crisis due to heavy subsidies on fossil fuels and electricity

- The global spike on the gas price has led to shifts in the demand of other energy sources, especially coal. Indonesia, as one of the largest coal producers in the world, produced 615 million tonnes of coal with the reference price of USD 308/tonne as per November 2022. As global coal demand increases with a more attractive price, Indonesia's coal companies then prefer exporting their products to selling them to the domestic market. It can be seen in the coal export to Europe that reached an all-time high (about 4 million tonnes) this year. This amount actually does not affect the export growth significantly since the export target is 497 million tonnes for 2022, yet it becomes an argument on the opportunities to maintain coal industry, forgetting the fact that coal export realization keeps decreasing in the last three years (MEMR, 2022).
- The increase in coal exports this year has affected the growth of state revenue. In Q1 2022, 95% of the coal and mineral mining sector state revenue target has already been achieved.
- This boom in coal exports endangered Indonesia's energy supply. To secure its national coal supply for power system, the government sets a Domestic Market Obligation (DMO) of USD 70/tonne, 3 times lower than the global price. There are also subsidies for other fossil fuels, such as the public fund's allocation of IDR 77.5 trillion for subsidizing fuel oil and LPG in 2022. Due to such regulations on coal and other fossil fuels subsidies, Indonesia is somewhat insulated from the global energy crisis. Without subsidies, Pertamax and Pertalite that are currently priced at IDR 13,900 and IDR 17,200 per litre would have increased to IDR 17,950 and IDR 17,200 per litre, respectively as per July 2022. Moreover, the sum of subsidies and compensations for those main energy sources is expected to be almost IDR 300 trillion this year.

Energy subsidy allocations in Indonesia's public fund (planned vs realization)

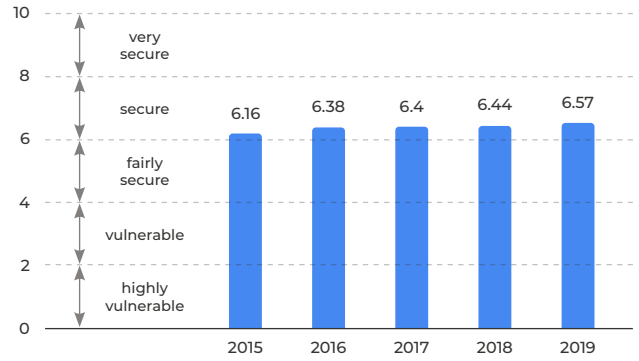


Source: IESR analysis
Note: realization values for 2022 is only until July 2022

Using the current main energy sources reserve is not a final solution to cope with Indonesia's energy crisis

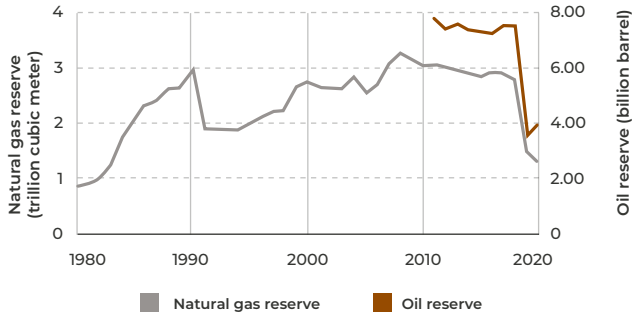
- Indonesia's energy security index calculated by the National Energy Council (DEN) is determined by four main indicators, namely availability, accessibility, affordability, and acceptability. Each indicator refers to the source and supply availability, access to the supply, price, and people's acceptability to the infrastructure.
- The index keeps increasing to reach the 'secure' category with approximately 0.1% of average annual change from 2015 to 2019. However, there are no published indices after 2019, since the 2022's index is still in the phase of analysis finalization, while in fact these indices are crucial to see the pandemic and energy crisis impacts. For instance, the issue regarding CFPP's operational day that is below the standard (only 5 out of 10 days—because of 38% coal production were exported in the beginning of 2022) caused the national power outage threat. The increased prices of fuel oil at the end of Q3 2022 is another proof that the government has limited public funds to provide one of the energy sources at affordable prices for all economic groups. These are some considerations to be included in the latest energy security index calculation, especially in the availability and affordability parameters.
- President Regulation No. 41/2016 about the procedures for overcoming the energy crisis states that the reserve of energy sources will be used when crisis hits Indonesia. The fact that gas and oil reserves keep decreasing makes this statement inapplicable to cope with Indonesia's energy crisis in a longer run, and thus the government must think about other solutions, such as using other energy sources that are readily available for utilization (i.e. renewables).
- Azzuni & Breyer (2020) suggest 15 indicators to calculate energy security index more comprehensively. They are availability, diversity, cost, technology and efficiency, location, timeframe, resilience, environment, health, culture, literacy, employment, policy, military and cyber security. By redefining Indonesia's energy security index analysis methodology following the aforementioned indicators, the index will be able to present a more accurate picture of Indonesia's energy security condition in a holistic view.

Indonesia's energy security index in 2015 - 2022



Source: MEMR (2020)

Oil and natural gas reserve in 1980-2021

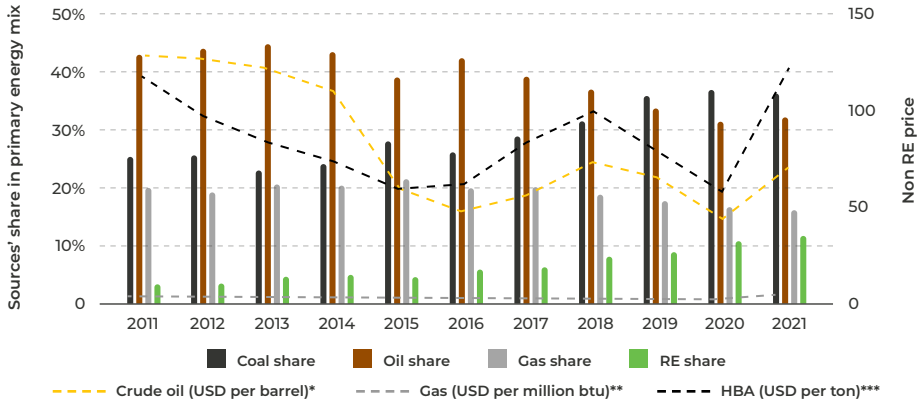


Source: Katadata (2021, 2022)

Renewable energy plays a critical role in making energy more affordable and reducing subsidy spending

- Since 2011, the growth of renewable energy share in the primary energy mix has been increasing, but in a slow pace with the annual growth of only 1-2%. Meanwhile, the shares of non-renewable energy in the primary energy mix keep increasing annually, although their raw materials' prices have positive growth rates, about 1.6-2 times higher in 2020 than in 2021 due to global demand. This proves that non-renewable energy is not suitable as a dominant energy source in the long run.
- Power sector, that is still dominated by coal, keeps receiving subsidy from the government to make its price acceptable. Due to the upward trend of fossil fuel price in mid-2021 until now, electricity subsidy is expected to reach IDR 131 trillion, 3 times higher than the value in 2021, for keeping the electricity price at IDR 415 per kWh for residential with 450 VA. If this electricity user group will be removed to reduce the subsidy for electricity and reduce PLN's oversupply, which then upgrade them to 900 VA, the electricity price for this group will be IDR 1,352 per kWh, which is more than 3 times the previous subsidized price.
- When renewable energy share reaches 23% and 100% in 2025 and 2050, respectively, as stated in IESR (2021), electricity price will be +1%, but it will be -50% compared to the value in 2020, affected by the lower system's LCOE. Consequently, public fund allocated for electricity will also be reduced in 2050. This shows that renewable energy inclusion in the system will be able to make electricity price more affordable and increase the government's savings.

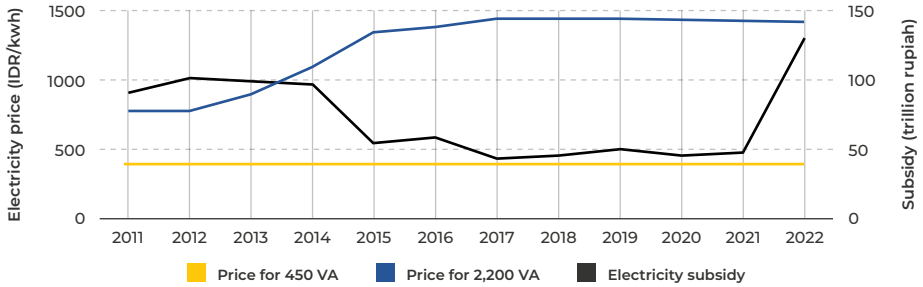
Shares in Indonesia's primary energy mix and non RE prices from 2011 to 2021



*) Historic prices deflated using the Consumer Price Index for the US
**) US Henry Hub price
***) Indonesia's coal reference price (Harga Batubara Acuan, HBA)

Source: MEMR (2021), BP (2021), MEMR (2022)

Electricity price and subsidy in 2011-2022



Note: Subsidy in 2022 is a predicted value and price in 2022 is only Q3
Source: Statistik PLN 2014-2021

2 Energy Transition Trends

- Energy Sector Overview
- Energy Transition in the Fossil Energy Sector
- Energy Transition in the Power Sector
- Energy Transition in the Transportation Sector
- Energy Transition in the Industrial Sector
- Energy Transition in the Building Sector
- Energy Transition at the Sub-national Level

2.1

Energy Sector Overview

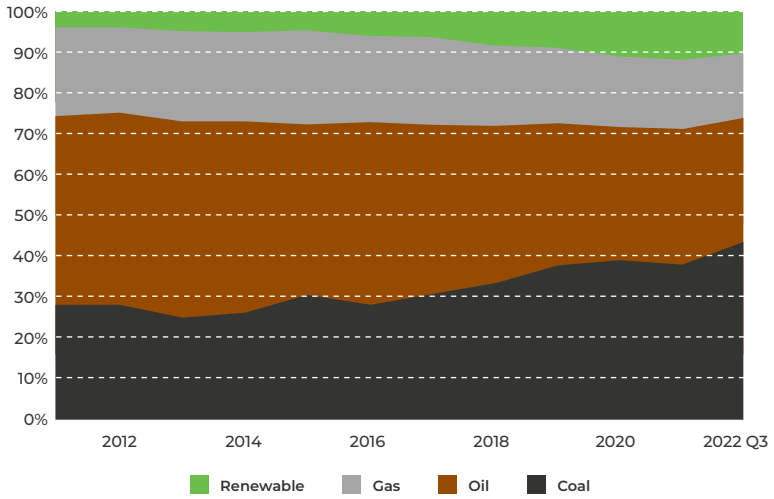
Julius Christian, Pintoko Aji, Shahnaz Nur Firdausi

- Current primary energy mix
- Energy intensity and electricity consumption
- Updates on the financing of energy transition
- Green hydrogen emergence

The share of renewables in the primary energy mix declines, further deviating from the target of 23% by 2025

- By the third quarter of 2022, the GDP grew by 5.72% yoy as economic activities have returned to pre-pandemic levels. Several energy-intensive activities, such as metal, electronic, and transportation industries even hit two-digits growth. Total primary energy demand is likely to exceed the 2019 level, and as the share of fossil fuel in energy supply increases, so do GHG emissions from the energy sector. By Q3 2022, the share of renewable energy in the primary energy mix declined to 10.4%, while coal share increased to an all-time high of 43%, making the 23% target by 2025 seems even more unattainable.
- Historically, biodiesel program has been the main driver of renewable increase in the primary energy mix, especially since the introduction of biodiesel subsidy from BPDPKS in 2016. The share of biodiesel rapidly increased from 0.7% in 2015 to 3% in 2019. However, the biofuel program has stagnated at B30 since 2019, hampered by the pandemic in 2020 and rising palm oil price in 2021-2022, resulting in slower growth to 4.4% share in 2021.
- In power generation, no significant increase in renewable share could be expected, as new renewable capacity additions in 2022 are limited. A number of notable large-scale renewable power plants started operating in 2022, including 90 MW Rantau Dedap geothermal power plant in Sumatra, 90 MW Malea hydropower, and 515 MW Poso hydro peaker in Sulawesi. On the other hand, new CFPPs with a much larger capacity of 4 GW has come online in Java this year. As a result, coal share in the power generation mix increased to 67.5%, while renewable energy share remained at just under 14%, showing no improvement compared to last year.

Indonesia primary energy mix 2011-2022

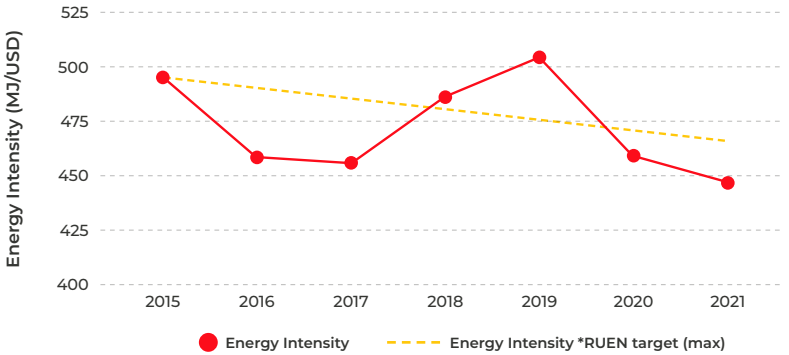


Source: 2011-2020 data from MEMR (2022), 2022 Q3 data from MEMR's preliminary data per November

Despite relying heavily on the residential sector, SMEs have helped Indonesia achieve its energy intensity goals

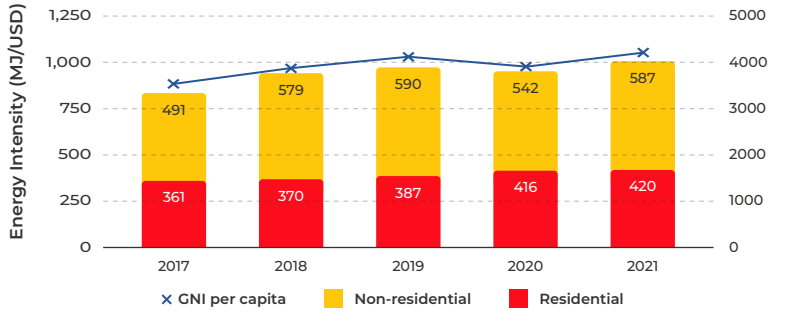
- Indonesia's energy intensity has been declining at 1.7% annually from 2015, which is on track with RUEN target of 1% reduction per year. However, energy consumption was excessive in 2018-2019, due to a 70.9% and 66.57% growth in fossil fuel combustion (coal) in the industrial sector in 2018 and 2019, respectively. When the pandemic hit in 2020, both economic activity and energy consumption fell, resulting in lower energy intensity. During the recovery period, energy demand returned, but not as fast as economic activity, hence a further decline in energy intensity.
- There is a strong correlation between national income and electricity consumption over time in all countries (Energy for growth hub, 2021). At 1,007 kWh per year, Indonesia's per capita electricity consumption is on the lower end compared to other countries at GNI per capita of around USD 3,750. This is due to the low rate of electrification across all sectors, as electricity only comprises 19.8% of Indonesia's final energy demand. Electricity demand is particularly low in the transportation and industrial sector, at only 0.05% and 23%, respectively, in 2021.
- About 42% of electricity consumption comes from households, which is remarkably higher than the global average of 30%. This high share of household consumption might be driven by the high number of home-industries in Indonesian economy, as SMEs contribute to 60% of total GDP (CMEA, 2022). Meanwhile, at only 587 kWh/year, per capita consumption in productive economic activities is only around half of other countries, reaffirming the low rate of electrification in Indonesia's energy system.

Energy intensity for 2015-2021



*GDP constant price LCU
Source: MEMR (2021), Worldbank (2022), RUEN (2017)

Total electricity consumption and GNI per capita

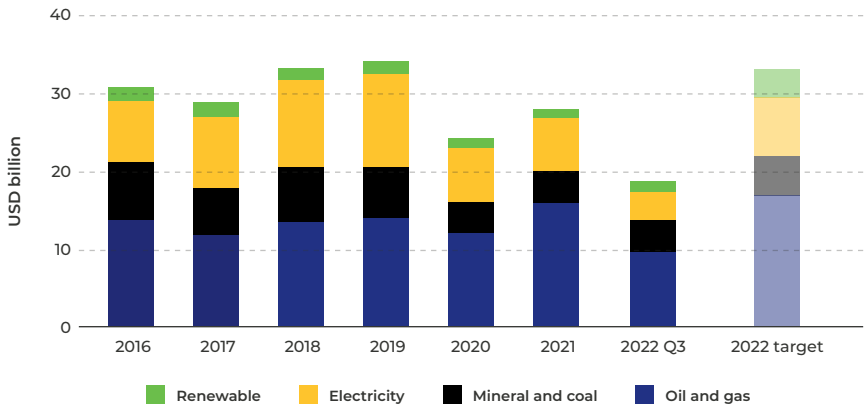


*GNI Atlas method (USD)
Source: MEMR (2021), Worldbank (2022)

Delays in policy and regulatory upgrades cause a stagnant improvement in renewable energy investment

- For 2022, the government targeted to attract USD 33.5 billion of investment in the energy sector : USD 17 billion in oil and gas, USD 7.6 billion in power sector, USD 5 billion in coal and mineral, and USD 3.9 billion in renewable energy. Renewable energy investment target saw the most significant increase from the previous year, but was still lower than other sub-sectors.
- The overall investment in the energy sector failed to meet the target as only USD 18.7 billion obtained by Q3 2022. Only the coal and mineral mining sector managed to get close to the target, achieving 80% by Q3 following the high coal price.
- The increase in investment targets was not supported by sufficient regulatory changes, including delays in the stipulation of the New and Renewable Energy Bill and the Presidential regulation on renewable energy tariffs, resulting in a low rate of investment realization in renewable energy. By Q3 2022, investment in renewable energy only reached USD 1.35 billion, less than 35% of this year's target of USD 3.97 billion.

Investment allocation in energy sector (2016-2021)



Source: 2016-2021 data from MEMR, 2022b, 2022 Q3 from MEMR's preliminary data per November

- The long-awaited replacement of MEMR Regulation No. 50/2017, which is the major barrier in renewable investment, was finally issued in September 2022. However, instead of introducing Feed-in-Tariff as previously anticipated, the Presidential Regulation No. 112/2022 only introduced the new price-ceiling mechanism for renewable energy, which could provide better investment returns for developers. This new regulation should be able to attract investors for renewable energy projects next years, although the actual result will still depend on PLN's procurement process.
- The New and Renewable Energy Bill has been passed from the parliament to the government, and the government has responded, but the issuance will be further delayed due to disagreements on several clauses. Instead of focusing on supporting renewables, the latest draft include clauses that incentivize the utilization of fossil fuels as alternative energy sources (i.e. coal downstream), indicating prolonged support for fossil fuels and creating mixed signals to investors.

USD 20 billion will be mobilized to accelerate power sector decarbonization, but not sufficient for 1.5°C pathway

- As announced at the G20 summit, the Just Energy Transition Partnership (JETP) coalition countries has committed to mobilize USD 20 billion over the next 3-5 years to accelerate emissions reduction in the power sector. The partnership will later develop an investment plan that aims to accelerate peak emission in the power sector by 2030 and reach net-zero emissions in the power sector by 2050, which include, among others, doubling the renewable energy generation to at least 34% by 2030 and early retirement of coal power plants.
- While the emission reduction commitment under the agreement is a notable improvement, it is not sufficient to keep the global temperature increase below 1.5°C. Several other estimates point to the need for more ambitious measures, with power sector emissions peaking before 2030, increasing the share of renewable energy to about 50% by 2030, and achieving net-zero emissions by the 2040s.
- Similarly, the committed fund is still far from what is required for the 1.5°C compatible pathway. Previous study estimated that USD 4.6 billion is needed by 2030 to early retire 9.2 GW of Indonesian coal fleet to comply with the 1.5°C target (Cui et al., 2022). Other study by Transition Zero estimated that to early retire Indonesian CFPPs costs on average USD 1.2 billion per GW. On top of that, IESR (2022) estimated about USD 116 billion is needed to build the renewable energy infrastructure until 2030, excluding those already listed in RUPTL 2021-2030. IEA (2022) suggested an even higher additional investment requirement of USD 35 billion per year in the power sector until 2030 to comply with the 1.5°C pathway.

Comparison between climate commitments in JETP with 1.5°C compatible pathways in previous studies

	JETP	CAT	IESR	IEA
Peak emission (year)	2030	2025	2025	<2030
Peak emission ($MtCO_2$)	290	200	316*	250
Emission intensity (tCO_2/MWh)	–	50-250	–	–
Renewable share in 2030 (%)	34%	50-85%	45%	60%
Coal share in 2030 (%)	–	5-10%	45%	–
Net-zero in power sector (year)	2050	–	2045	2040

*) Peak emission occurs at high electricity demand of 600-700 TWh/year, significantly higher than PLN's projection of around 400 TWh/year

Source: Climate Action Tracker (2019, 2020), IESR, Agora Energiewende, & LUT University (2021), IEA (2022)

Green hydrogen projects are emerging, but commercialization will remain difficult without policy support

- In its yet-to-be-legalized NZE roadmap, the government targets 328 MW green hydrogen production capacity to be installed in early 2030s with investment requirement of USD 0.8 billion. The capacity would rapidly ramp up beyond 2050 to reach 52 GW in 2060 with total investment estimated to be USD 25 billion. However, sectors that will utilize green hydrogen remain unclear.
- The cost of producing green hydrogen is still prohibitively expensive due to a combination of high cost of electrolyzer and renewable electricity and low capacity factor of renewable energy. The production cost of green hydrogen in Indonesia is estimated to be around USD 3-12/kg, depending on the technology and project location (IEA, 2022; IESR, 2022). The cost is expected to drop to around USD 2/kg at the locations with best resources, which is competitive with hydrogen production from fossil fuel with CCUS. However, this requires policies to help lower the renewable energy production cost as it is the main contributor to green hydrogen cost.
- Its versatile application potential has attracted interests from various industries (i.e., energy, chemical, metallurgy). Six collaborative research projects have been announced this year, although nothing has entered the commercial phase yet.

On-Going Projects of Green Hydrogen Development	Status
Pertamina geothermal green hydrogen in Lampung	The pilot project is targeted to start operating in 2023 with the capacity of 100kg/day and is currently undergoing environmental permit finalization (PPI, 2022)
Pertamina green hydrogen for mobility project in West Java	On-going technical assessment (PPI, 2022)
PT Pupuk Indonesia hybrid and stand alone green ammonia in Aceh and West Java	Feasibility studies (FS) for hybrid green ammonia in Aceh and West Java and pre-FS for stand alone green ammonia in West Java (PTPI, 2022)
PT HDF Energi hybrid solar PV and wind power plant in Sumba	Pre-FS from January 2022
Fortescue Future Industries (FFI) to support PT Gunung Raja Paksi Tbk (GRP) in using green hydrogen	Have signed MoU
Pertamina, Keppel, and Chevron exploration of green hydrogen and green ammonia projects	Have signed a joint study agreement to explore primarily on the island of Sumatra, Indonesia

2.2

Energy Transition in Fossil Energy Sector

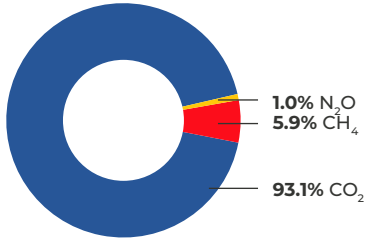
Dr. Raditya Yudha Wiranegara

- Methane emissions
- Coal price
- CCS/CCUS
- Diversification in the fossil fuel industry

Unabated methane emissions from coal, oil, and gas extraction could hinder the opportunity to slow global warming

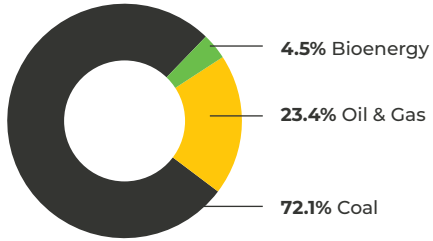
- Indonesia has signed the Global Methane Pledge along with other countries during the COP 26 in Glasgow, which would see a collective effort to curb methane (CH_4) emissions by at least 30% from 2020 level by 2030; thus, eliminating over 0.2°C warming by 2050. However, methane emission mitigation discourses in Indonesia's energy sector are relatively low compared to CO_2, as reflected in the latest MoEF GHG inventory report.
- According to the report, methane emissions account up to 34.47 million tonnes of CO_2-eq, or 6% of the total GHG emissions in the energy sector (MoEF, 2022). On the contrary, IEA latest data shows that Indonesia's methane emissions stand at 4.4 million tonnes, an equivalent to 131.1 million tonnes of CO_2-eq (IEA, 2022). This is significantly higher than the MoEF data, suggesting that emissions from the sector are underreported.
- Indeed, methane emissions are still lower than CO_2. According to 2020 data, Indonesia's CO_2 emissions were 589 million tonnes (Ritchie and Roser, 2020). Yet, given its potent Global Warming Potential (GWP), which is 29.8 times higher than CO_2, the methane issues can not be taken lightly. Its reduction could actually slow global warming by 30% and prevent 0.5°C increase by the turn of the century (Ocko et al., 2021).
- The government needs to step up efforts to inventory methane emissions, particularly in the energy sector, prior to formulating any abatement measures. In the latest NDC, specified reduction targets are only available for the waste sector. Thus, the government must include methane emission reduction targets for the energy sector, should the government decide to reevaluate its NDC.
- Furthermore, many have thought that oil and gas extraction contributes to most of the methane emissions. On the contrary, IEA data has clearly shown that methane emissions from the coal mining in Indonesia is actually higher than its fossil-peers. Almost three-quarter of the total methane emissions comes from the coal mining, which is often labelled as Coal Mine Methane (CMM) (Tate, 2022).

GHG Emissions in Indonesia Energy Sector



Source: Laporan Inventarisasi Gas Rumah Kaca (GRK) dan Monitoring, Pelaporan, Verifikasi (MPV) 2021 (2022)

Annual CH_4 Emissions in Indonesia

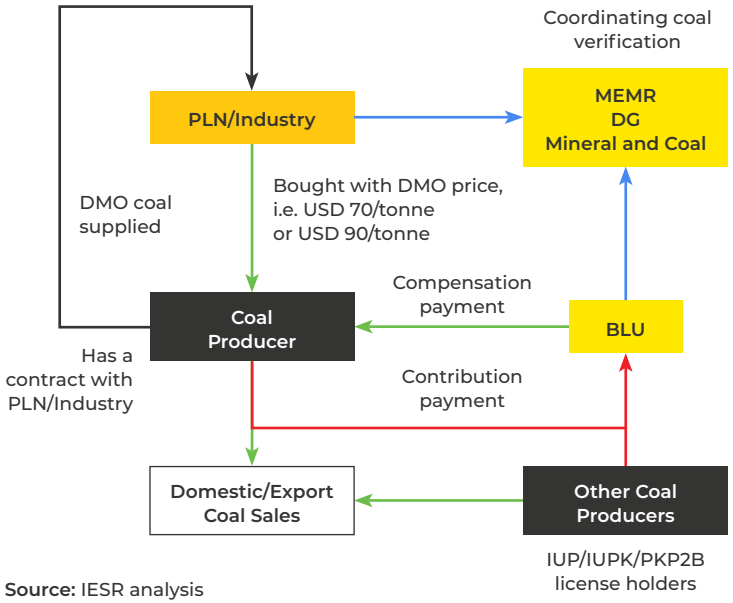


Source: IEA Methane Tracker Database (2020)

Government's new pricing scheme could prolong coal utilization and dependence, hampering the country's efforts to meet its NZE targets

- On January 1, 2022, the government banned coal exports due to a shortage of supply to the country's coal power plants. The decision was short-lived. Just eleven days later, the government lifted the ban.
- To prevent another shortage, the government then proposed a scheme that would allow coal producers to be compensated for the price difference between the DMO contract and the global market. The compensation is sourced from the collective contribution of all licensed coal producers in Indonesia, amounting potentially up to IDR 137.6 trillion.
- The mechanism on the compensation and contribution will be similar to the one that has been used by Badan Pengelola Data Perkebunan Kelapa Sawit (BPDPKS) in the palm industry. A government agency under the provision of the MEMR will be tasked in carrying out the scheme.
- Factors included in calculating the contribution are the proportion of DMO to the domestic-export sales and the calorific value of coal. The contribution will also be charged with VAT and will be adjusted every three months.
- A presidential regulation is currently being prepared for a scheme that is targeted to be implemented in early 2023. Derivative regulations at the ministerial level are also required, i.e. in the Ministry of Finance, particularly on the formulation of the contribution and compensation.

Illustration of the proposed scheme



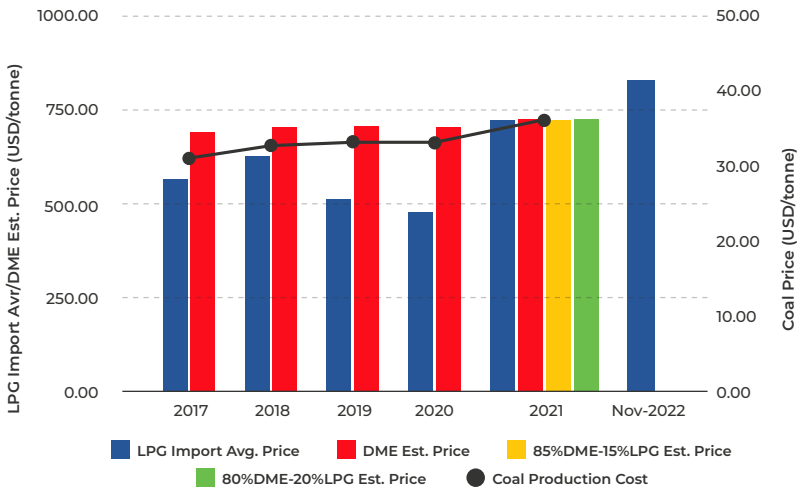
Source: IESR analysis

- For once, coal producers will be credited for helping to secure the domestic supply, whilst at the same time receive the global market price. With a potential revenue increase, the scheme should further encourage them to begin diversifying their portfolio towards green businesses. Nevertheless, the effectiveness of the scheme depends on the coal global price, which is quite sensitive to geopolitical instability. Beyond 2030, coal demand, particularly in the power sector, will likely to reduce as the government is planning to early retire a number of its coal power plants, putting the scheme into question: what will happen then?

The government is still struggling to find the right formula to set the coal price for DME to be economically viable

- To reduce LPG imports, the MEMR plans to produce DME through coal gasification. The potential saving is estimated at IDR 9.1 trillions (Kontan, 2022a). The first production facility is expected to come online in Q4 of 2027 and will be built at Tanjung Enim, South Sumatra. The facility will have the capacity to produce 1.4 million tonnes of DME from processing 6 million tonnes of coal, which will be supplied by PTBA. Around USD 2.3 billion will be invested in the project.
- Once the facility begins its production, the DME will be sold at a fixed price of USD 378/tonne DME (USD 604/tonne LPG-eq), assuming that the coal price is USD 19–21/tonne (Kontan, 2022b). From the 2021 annual report of PTBA, the coal production price can be estimated at USD 35.7/tonne. Our analysis shows that the DME, without CCS, should be sold at USD 724/tonne LPG-eq. Even with LPG blending, the price will still be higher than that of LPG in the same year at USD 717.90/tonne LPG-eq. At 15% DME blending, the price is estimated at USD 719/tonne LPG-eq, whilst at 20% DME blending, the price is estimated at USD 718.8/tonne LPG-eq. Our analysis also suggests that the potential savings from reduced LPG imports could actually be 36.9% lower than the government estimates, if the production cost of DME is included.

Historical comparison between LPG import average price and DME estimated price in reference to coal production cost



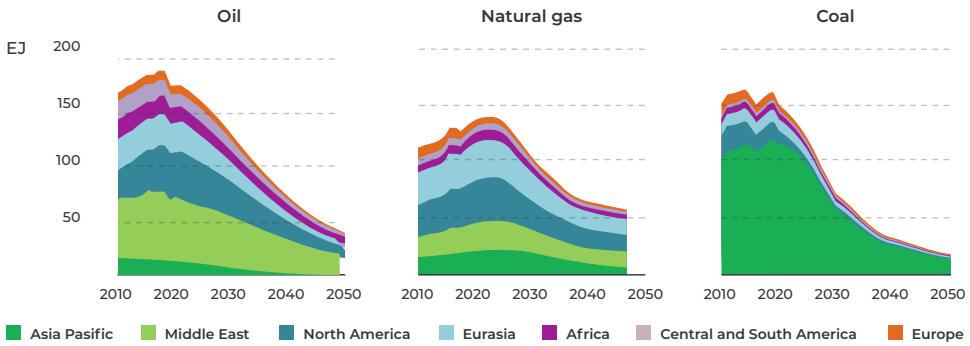
Source: IESR analysis

- Even with the low-calorie coal targeted for the project, the price currently stands at USD 54.46/tonne (JWC, 2022), which would push the DME price even higher than the estimates above. To overcome the coal pricing issue, PTBA recently proposed two schemes. The first scheme is through the government-proposed BLU batubara, encouraging coal producers to sell with a price that could meet the targeted DME price. In return, coal producers will receive the compensation of the price difference with the global market price. The second scheme is the cost plus margin. It is a work in progress, particularly on the calculation of the margin. Clearly, the government will have to step in to achieve the targeted DME price.
- In addition, DME production is considered energy-intensive, resulting in a much higher CO_2 emissions compared to the production of LPG. For every 1.4 million tonnes of DME produced, about 4.26 million tonnes of CO_2-eq is emitted, five times the emissions of LPG production (AEER, 2020). Even with CCUS, the life cycle emissions of DME production is still relatively higher than the LPG, as reported by IEA (IEA, 2022a).

Some underperforming projects should raise the concern of developing new CCS/CCUS projects in the oil and gas industry

- In the pursuit to meet the country's lifting target, the government is considering the use of CCS/CCUS technology to boost the production of its existing oil and gas fields through EOR/EGR. Another objective is actually related to emission reduction, as some of these fields contain high CO_2 concentrations. Tangguh is one of the example of CO_2-rich gas fields, measuring up to 15% CO_2 (Ghi, 2021).
- To date, Indonesia has 15 CCS/CCUS projects, most of them (almost 80%) are under Pertamina's flag (Koran Jakarta, 2022), see Appendix B. These projects are expected to be on-stream within the next two to eight years. The largest one in the list that will be on-stream soon is the EGR/CCS Tangguh, operated by BP Berau Ltd. Scheduled to be on-stream in 2026, the project is currently being prepared for the Front-End Engineering Design (FEED). With a CO_2 potential storage of 25–33 million tCO_2 for 10-15 years, the project's investment cost is estimated to be close to USD 3 billion (BP, n.d.), which translates to the CO_2 capture cost of USD 90-120/tonne CO_2. The number is still relatively high compared to the range estimated by IEA for a natural gas processing plant (USD 15–25/tonne CO_2). With projections of declining global oil and gas demand beyond 2030, planned projects are at risk of techno-economic uncertainty.
- High investment in the technology could potentially face lower revenues due to the projected decline, resulting in longer returns. This is further compounded by the price fluctuation of the commodity, which is overly sensitive to geopolitical instability. The capture rate is also an issue, with some of the running projects are underperforming. Few successes, as in the case of Norway, are notably accompanied by strong regulations, such as high carbon taxes and stringent environmental regulations (Adhiguna, 2022).

Fossil fuel supply by region in the Net Zero Emission by 2050 Scenario



Source: McGlade (2022)

There is a growing appetite amongst fossil fuel companies to diversify their portfolio towards green businesses

- It has been observed that several fossil fuel companies listed on the Indonesia Stock Exchange (IDX), state-owned or private, have started to diversify their business towards low-carbon industries. Some have set their NZE emissions targets and undertaken initiatives to reduce GHG emissions in their core activities and plan to incorporate more renewable energy developments in their business portfolio.
- Two out of three oil and gas producers have already set their NZE targets. The first company plans to reach NZE for scope 1 & 2 GHG emissions (direct emissions from reporting company and indirect emissions from the generation of energy consumed by reporting company) by 2050 and the second one plans to reach NZE for scope 3 GHG emissions (all indirect emissions from the reporting company's value chain) by 2060. The other company, an SOE, has aligned its target with the government's NZE target by shifting its line of businesses towards biofuel, hydrogen, renewable energy, CCS/CCUS for E2E business, EVs and batteries, and carbon trading.
- Only three out of twenty two coal producers have already came up with the NZE targets. Two companies have pledged to achieve the target by 2030 and 2050, respectively. One company, an SOE, plans to achieve its NZE target by 2060, aligned with the government's target.
- In terms of allocated CAPEX, only six fossil fuel companies have actually used it to diversify their business portfolio, with the highest being more than 50%.

Fossil fuel company transition strategies

Company	Business Diversification Strategy	Current Green Businesses	CAPEX on Green Businesses	Market Cap (IDR billion)
Medco Energi Internasional	Subsidiary	Geothermal and solar PV power generations	Not specified	26,895.77
Pertamina Indonesia (not listed in IDX)	Subsidiary	Geothermal steam, solar PV, biogas and geothermal power generations	14% CAPEX in 2022-2026	Not specified
TBS Energi Utama	Acquisition, Subsidiary, Joint-Venture	Hydro and wind power generation, two-wheelers EV	>50%	5,192.23
Bukit Asam	Subsidiary	Solar PV power generation	Not specified	42,626.44
Indika Energy	Subsidiary, Joint-Venture	Solar PV power generation, biomass production, two-wheelers EV	39%	15,213.76
Indo Tambangraya Megah	Subsidiary	Rooftop solar PV	~5%	45,931.45
Mitrabara Adiperdana	Subsidiary, Joint-Venture	Biomass and solar PV power generation	~5%	8,897.72
United Tractor	Acquisition, Subsidiary	Hydro power generation	6%	101,832.69

Source: IESR analysis

2.3

Energy Transition in Power Sector

Akbar Bagaskara, Daniel Kurniawan, Faris Adnan Padhilah, His Muhammad Bintang, Pintoko Aji, Dr. Raditya Yudha Wiranegara

- Power sector overview
- Updates in solar power
- Grid flexibility

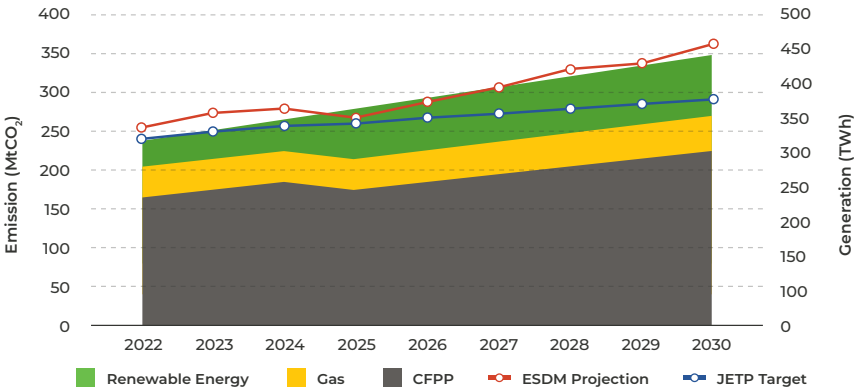
Transition in the power sector is becoming more prominent; transformation in the grid must follow suit

- Indonesia's power sector today contributes around 40 percent of the total emission. Indonesia's enhanced Nationally Determined Contribution (NDC) stated that Indonesia has pledged to achieve 23% of renewable energy share by 2025 and reduce emissions by 31.2% (unconditional) and 43.2% (conditional) by 2030 compared to business-as-usual (BAU). To date, the renewable energy share in the power generation mix is 12.8%, with 8.52 MW of capacity.
- Indonesia is working on the energy transition in the power sector to fulfil the stated target. In the existing plan of MEMR, natural retirement of CFPP and deployment of the renewable energy are the steps to achieve NZE by 2060. However, during the G20 event, the Indonesia JETP was launched, announcing a joint commitment to peak power sector emissions (290 $MtCO_2$) in Indonesia by 2030 and achieve NZE by 2050. The JETP will include actions to increase the renewable energy share to at least 34% by 2030 and early retirement of CFPP. In contrast, PLN has proposed to keep 19 GW of CFPP, which would later be retrofitted with CCUS by 2040, as contingency. However, the technology has only been employed in less than 10% of the global CCS/CCUS projects so far, underlining the immaturity of the technology, in terms of financing and technicality. Another option considered is nuclear power. However, such technology is also facing some uncertainty like CCS/CCUS, thus affecting its integration in the development plan.
- Nearing 2025, PLN heavily relies on hydro, geothermal, and biomass to achieve the 23% of renewable energy share. Several projects, especially hydro and geothermal, have the potential for delay, and the deployment of biomass faces the pricing challenge. Thus, there is a risk that renewable energy targets will not be met. On the other hand, solar PV has become increasingly competitive, and its deployment can be quite rapid, thanks to its short construction times. Hence, utilization of solar PV could fill the gap in reaching the renewable energy target. Solar PV deployment is also supported by the fact that several studies and analyses, including by MEMR, IEA, IRENA, and IESR, have shown that solar will play a vital role in Indonesia's deep decarbonization in the energy sector.
- However, solar PV, which is included in the variable renewable energy (VRE), is intermittent due to its dependence on weather conditions. Higher reliance on VRE will subsequently require electricity grids to be flexible enough to keep supply and demand in balance at all times. Hence, transformation in the grid flexibility is a must to accommodate the high share of the VRE. Grid flexibility is the system's ability to adapt or withstand sudden changes in the supply or demand. The fundamental trait of grid flexibility consists of technical flexibility, contractual flexibility, and operational practices.

Power sector's emissions will peak beyond 2030 as a consequence of coal-fired power plants domination

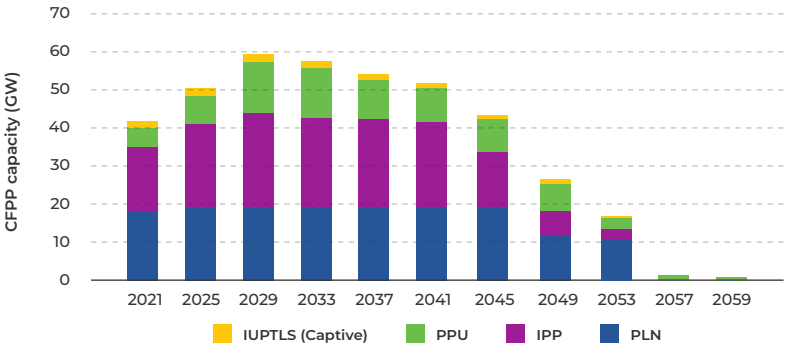
- Coal-fired generation still accounts for about 60% of the power generation share. In the RUPTL 2021-2030 projection, such domination is still likely to happen within this decade. Moreover, electricity generation accounts for more than 40% of total emissions in the energy sector as a consequence of the coal domination.
- In the enhanced NDC, the power sector is planned to reach emissions of about 369 $MtCO_2$ by 2030 and peak emissions in 2037 to achieve the net-zero emission by 2060 or sooner with the aid from developed countries.
- As the first step towards Net-Zero Emission, MEMR develops a projection that shows the declining CFPP capacity until 2060. The development of CFPPs in RUPTL PLN is only for the ones that are already under construction or ongoing projects, and those that are implementing the phase out of the existing CFPP through natural retirement or depending on the plant's life time.
- During the G20 event, the Indonesia Just Energy Transition Partnership (JETP) was launched, aiming to reduce the peak of Indonesia's power sector emissions to 290 $MtCO_2$ by 2030 and reach net-zero emissions in the sector by 2050. In fact, due to the 23% RE target in the energy mix, projected emissions are almost similar to the JETP target in 2025. However, the stagnant progress of the RE development in the following years widens the gap between MEMR projections and JETP targets.

Generation and emission projection



Source: RUPTL 2021-2030, MEMR

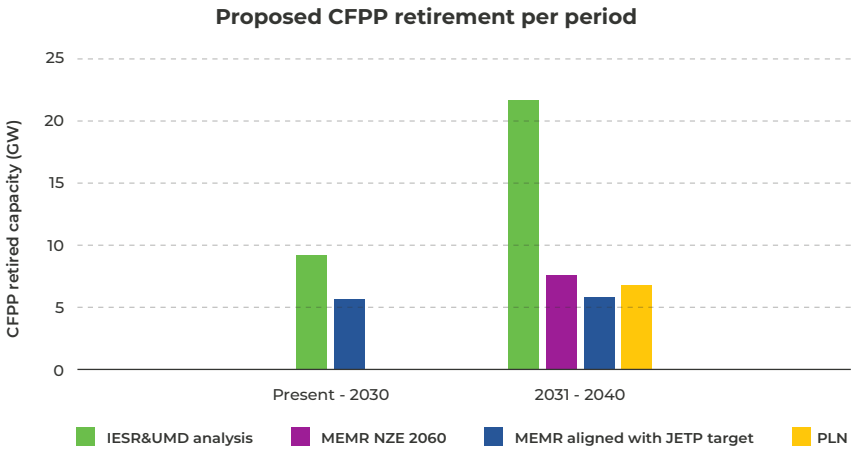
CFPP capacity projection based on MEMR NZE scenario 2060



Source: MEMR

Presidential Regulation No. 112/2022 mandates the creation of a roadmap for the early retirement of CFPP

- Presidential Regulation (PR) No. 112/2022 was issued in September of this year. One of the main takeaways is that MEMR should prepare a roadmap for the early retirement of CFPPs as part of energy transition effort in the power sector. MEMR should coordinate with MoF and MoSOE in the development of the roadmap.
- The roadmap for early retirement of CFPP should at least include avoidance of CFPP emissions, strategies for successful implementation of the roadmap, and alignments between various other policies. Furthermore, the early retirement program should also consider the technical aspect such as supply and demand balance of the electricity. Renewable energy should be used to fill the gap that left by the retired CFPP. Moreover, it is stated in the PR that the development of new CFPPs has already been prohibited, except for CFPPs committed in the latest RUPTL or before the PR was issued.



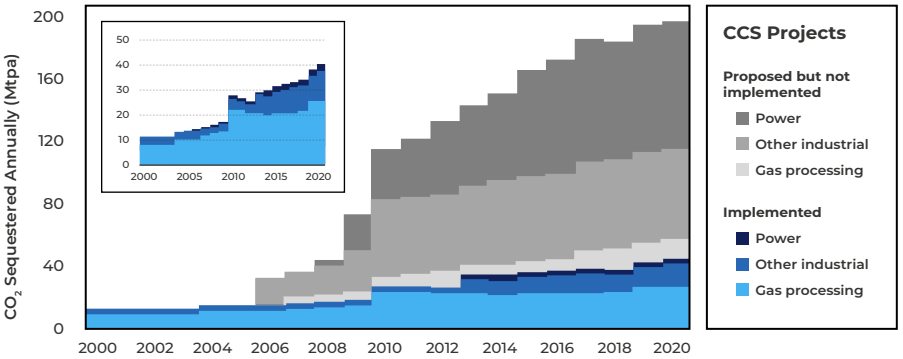
Source: IESR & UMD analysis, MEMR, PLN

- As it stands, there is an effort to synchronize several CFPP retirement roadmaps proposed by MEMR and PLN. Each roadmap is different in terms of capacity and period of retirement. Furthermore, there is a need to align with the emission target from the JETP, since JETP has committed to mobilize USD 20 billion over the next 3-5 years to accelerate emission reduction in Indonesia's power sector. MEMR has already proposed a roadmap, which still needs to be evaluated on the techno-economic aspect with other stakeholders, that aligns with the emission target with a total of 11 GW of CFPP being the subject of early retirement.

The failure of 90% of CCUS projects in the power sector worldwide should raise concerns about PLN's NZE strategy

- According to IEEFA analysis, the use of CCUS in the power sector accounts for only 6% of the CCS/CCUS projects globally, with the rest comes from fields such as natural gas processing and industrial process (Robertson and Mousavian, 2022). Moreover, an analysis of the CCS/CCUS database curated by US National Energy Technology Laboratory has indicated that around 90% of the proposed CCS capacity for the power sector was never actually built (Abdulla et al., 2021).
- To date, there have been only two coal power plants that have been retrofitted with CCUS, namely Petra Nova and Boundary Dam. The Petra Nova, however, was indefinitely suspended in 2020 due to its uneconomical operational financing and persistent technical troubles. One project, namely Kemper, was a part of the coal integrated-gasification combined-cycle (IGCC) project. It was an utter failure, abruptly stopped at the implementation stage, leaving the CC power plant to operate on natural gas instead of the gasified coal.

Comparison of global proposed and implemented annual CO_2, sequestration



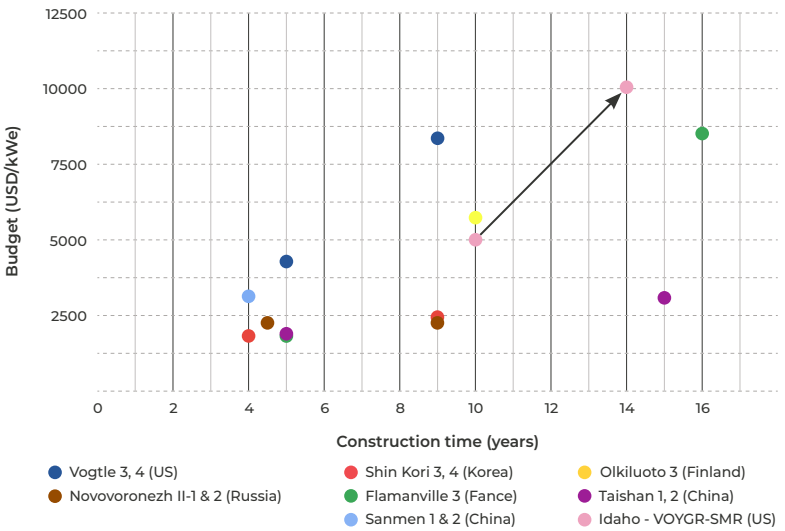
Source: Adapted from Abdulla et al. (2021)

- Enormous amount of capital has been invested in these projects. The first two retrofitted projects and the IGCC required USD 2.5 billion and USD 7.5 billion, respectively. Indeed, government incentives were back then pouring in to kickstart these project. Yet, the capturing process has not performed as expected. Prior to being mothballed, the total captured CO_2 at Petra Nova is 17% less than its goal. Similarly, the capture rate at Boundary Dam has been only hovering around 50%, far below its actual target at 90%. This is further compounded by the potential derating of the power plants capacity and efficiency, in the case of Boundary Dam, to be as high as 40 MW and 14% point, respectively (Glennie, 2015).
- The reality of these projects should be a red flag for PLN that plans to keep 19 GW of CFPPs as options as CCUS will step in by 2040. A joint-study by World Bank, ITB, and PLN has clearly shown that the LCOE of CFPP-CCUS in 2040 will range between USD 7.7 - 8.7 cents/kWh at 90% capture rate, higher than the baseline without CCUS (World Bank, 2015). On the other hand, a utility-scale solar PV with 25% battery storage could reach close to USD 4 cents/kWh (IESR, 2022). PLN must consciously take into account these considerations to avoid foreseen risks in the CCUS technology that would potentially threaten the achievement of net-zero future.

The high cost issues and technological immaturity limit the utilization of nuclear power plant in NZE plan

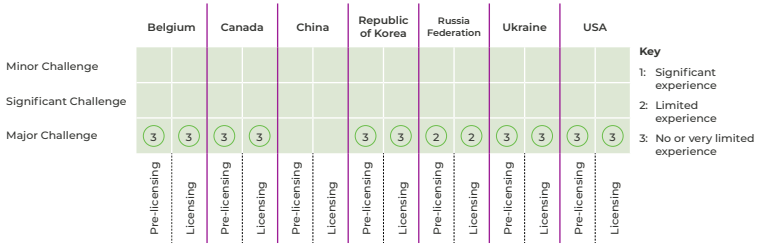
- Nuclear energy has been included in the MEMR's net-zero emissions roadmaps. By 2040, nuclear energy is expected to generate nearly 31 GWe. With that capacity, it is projected to require an investment of USD 216 billion (or around USD 6.9 billion/GW), compared to hydro or geothermal that only need USD 2.3 or 3.2 billion/GW.
- Indonesia has planned to establish the Nuclear Energy Program Implementation Organization (NEPIO) in order to accommodate the plan to build the first nuclear power plant, but the governmenthas not made any decision yet regarding the formation of this organization.
- According to some cases in some countries, the construction of nuclear power plants has a high risk of cost and lead time overruns. The UAMPS Project, the first small modular reactor (SMR) in Idaho, USA, with a capacity of 50 MWe × 12 SMRs (VOYGR-12 600 MWe), is also at risk of cost overrun. It was originally estimated to cost USD 3 billion, but could potentially increase to USD 6.1 billion with an increase in LCOE from USD 5.5 cent/kWh to around USD 9.4-12.1 cent /kWh. Since SMR was chosen for Indonesia's NZE, its potential cost could be more than USD 216 billion, because no commercially tested project exists yet.
- Another technology, molten salt reactor (MSR), has not matured yet, but its developers, have tried to promote its penetration by collaborating with Bangka Belitung regional governments, certain universities, and SOEs. While MSR technology has been researched in many countries for decades, most respondents from the World Nuclear Association (WNA) agreed that licensing MSRs is a major challenge, and that their respective countries had no or limited experience with MSR design, operation, and thorium-based fuel manufacturing.

Construction costs and timelines of selected cases



Source: NEA (2020)

MSR-SMR design maturity assesssment

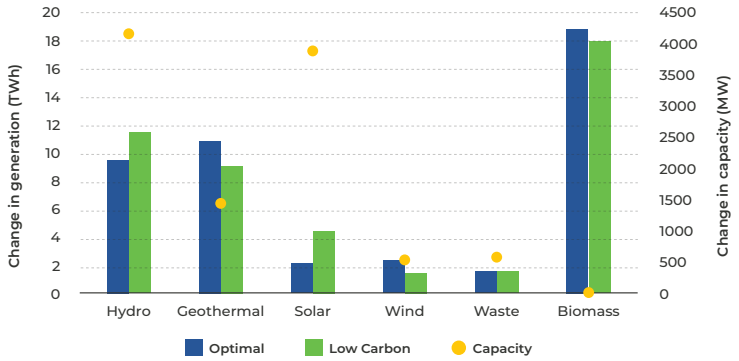


Source: WNA (2021)

Heavy reliance on hydro, geothermal, and biomass is holding back the fulfillment of the 23% RE target, while solar actually has huge potential

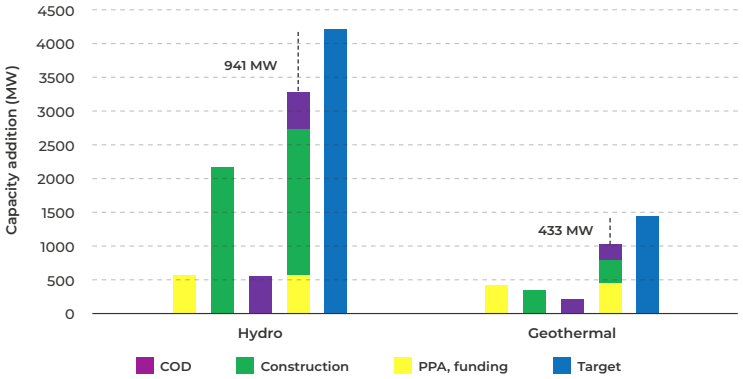
- In RUPTL, the growth in renewables generation from 2021 to 2025 will be 45–46 TWh, with biomass taking a large share of growth at around 40–42%, followed by hydro and geothermal at 21–25% and 20–24%, respectively. At the same time, the electricity generated from non-renewables is also expected to grow by 24 TWh. In terms of capacity addition, hydropower and geothermal are still preferable to PLN due to their dispatchable nature and suitability as baseload generator.
- Despite the low addition of biomass power plant's capacity, biomass is expected to play a significant role in the energy mix. The utilization of biomass is mostly in CFPPs through co-firing.
- The new geothermal and hydro capacity deployment needs to be closely monitored since several projects seem to be delayed. For instance, the only realized hydropower project in Java-Bali system, PLTA Jatigede, is still under construction (97%), although its COD is actually in 2021. The other hydropower projects in the system are micro hydro, which still cannot be tracked. Geothermal and hydropower power plant projects have several problems that hinder their installation, including exploration risks (only for geothermal), development permits, and installation time. Delays in these types of generators will pose a threat to the renewable energy mix target by 2025.
- The plan forecasts relatively little use of solar PV due to the current high upfront cost of the technology in Indonesia. However, solar PV has become increasingly competitive and its deployment can be quite rapid, thanks to its short construction time. Hence, the utilization of solar PV could fill the gap to reach the renewable energy target.

Growth in renewables generation and capacity in the RUPTL



Source: RUPTL 2021-2030

New geothermal and hydro capacity target by 2025 and realization

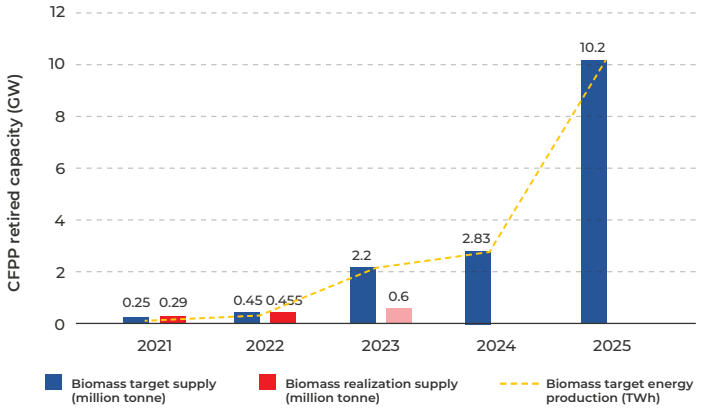


Source: RUPTL 2021-2030, PLN Consolidated Financial Statements June 2022, IESR analysis

Indonesia is aiming to leverage biomass co-firing in the existing CFPP to reach the RE target, but price remains a challenge

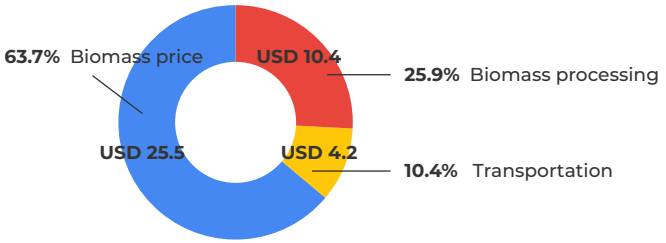
- According to Indonesia's target of energy mix in 2025 (RUPTL), biomass is expected to generate up to 19,7 TWh, with 12,71 TWh (64.6%) coming from the co-firing scheme in some CFPPs. This ambitious co-firing target will consume approximately 10.2 million tonnes of biomass starting from 2025. However, the scheme faces enormous challenges, especially with regard to biomass supply. By the end of October 2022, 0.455 million tonnes of biomass (around 90% sawdust, 3% woodchip, 5.17% palm shell, and 1.57% others) have been fed into CFPPs from 0.45 million tonnes target of 2022. On the other hand, for 2023, PLN has only signed about 0.6 million tonnes of the target of 2.2 million tonnes. Even if 1 million tonnes is confirmed by the end of 2022, there is still a gap of 1.2 million tonnes that cannot be filled.
- In calculating the biomass cost component, transport plays a relatively minor role (11%), but to meet the economic equivalent of coal, the feedstock distance is limited (360 km for Java, 300 km for Sumatra, Kalimantan, and Sulawesi, and 187 km for Maluku and Papua) and maintenance costs due to fouling or boiler adjustments are excluded. Otherwise, the sales price for co-firing is particularly unappealing for biomass producers because it is capped at USD 70 per tonne, whereas it can reach USD 240 per tonne if sold to Japan or Korea. To accommodate the need of co-firing supply, the government has assigned state-owned enterprises linked to biomass suppliers.
- The ambitious target of 10.2 million tonnes by 2025 is planned to include 5 million tonnes of industrial waste and 5.2 million tonnes of energy forestry. Perhutani plans to expand energy forestry to 65 hectares by 2024, using the authority granted by PP No. 77/2010 to manage 2.4 million hectares of forest in Java-Madura. According to Perhutani's plan, annual production should be around 20 million tonnes in order to meet 9 million tonnes of biomass. Perhutani has implemented the plan for *gamal* and *kaliandra* plants on 31 thousand hectares until the end of 2021. PT PLN intends to establish PLN Primary Energy Indonesia as a subholding company to ensure the supply of biomass.

Co-firing target and realization



Source: MEMR & PLN report

Biomass cost components in USD



Source: PSE UGM
Notes: transportation cost per 50 km; Woodchip, in Java Island

Several new technologies may present opportunities to increase the RE share, especially tidal sources

- Indonesia has significant renewable energy potentials, but only a small portion has been utilized. Out of 3,684 GW of Indonesia's renewable energy potential, only 10.8 GW has been utilized as of September 2021; and tidal energy hasn't been utilized at all.
- Dutch-based tidal energy developer, Tidal Bridge BV, has delivered a feasibility and connectivity study for 30 MW Tidal Power Plant in Larantuka Strait to PLN. Following the acceptance of the documents, PLN and Tidal Bridge signed an MoU for the development of tidal power plant. With the acceptance of the project, the project enters the final phase of its development. The environmental and social impact assessment has been conducted, and further contract signing is in progress.
- UK-based tidal energy developer, SBS, has signed a two-year memorandum of understanding (Mou) with state-owned enterprise Indonesia Power (IP) for the development of 10 MW tidal energy project in Larantuka Strait, which is located in between the Flores and Adonara islands. Following the signing of the MoU, a proposal for a feasibility study from SBS, which was submitted in April 2022, has now been approved for immediate start. Previously, the same developer also had a development agreement with PLN to develop 150 MW tidal power plant in Lombok Strait.
- Another project to tap renewable energy potentials is the Renewable Project by HDF energy in East Nusa Tenggara. HDF energy announced the signing of an MoU with the BBSP KEBTEK of the MEMR of Indonesia on joined studies to support the project. The power plant will be consisting of solar PV and or wind power to generate electricity, and some portion of the electricity will then be stored in batteries or used to produce hydrogen. This scheme intends to produce entirely non-intermittent-renewable 24/7 energy with zero GHG emissions.

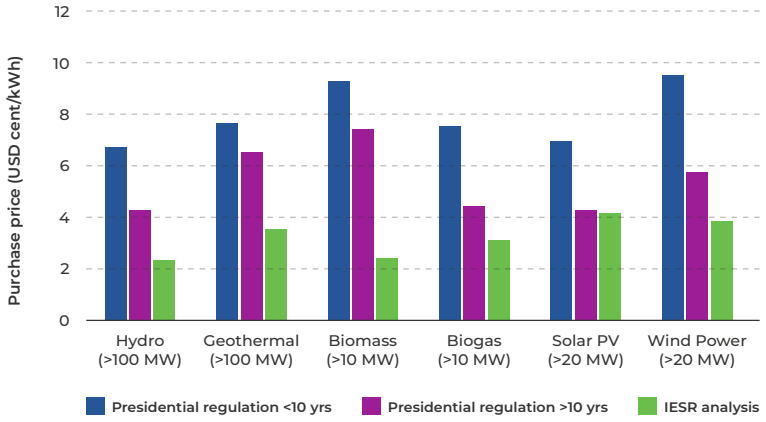
Several tidal power plant project initiatives in Indonesia

Developer	Location	Capacity (MW)	Status
SBS - UK	Lombok Straits	150	Exclusive site development agreement with PLN in 2015, (extended in 2017)
	Larantuka Strait	10	MoU with IP for development study in 2021
Tidal Bridge		30	MoU with PLN for development study in 2019
Nova Innovation		7	Feasibility study in 2021

Source: IESR analysis

New pricing regulation improves the bankability of RE projects, but still depends on PLN's implementation

Purchase price comparison of several RE technologies in Java



Source: Presidential Regulation on Renewable Electricity Purchase, IESR analysis

Profit margin calculation of several RE technologies in Java

Technology	First 10 years (%)	After 10 years (%)
Hydro (>100 MW)	65	44
Geothermal (>100 MW)	54	45
Biomass (>10 MW)	74	67
Biogas (>10 MW)	58	31
Solar PV (>20 MW)	41	2
Wind Power (>20 MW)	59	32

Source: IESR analysis

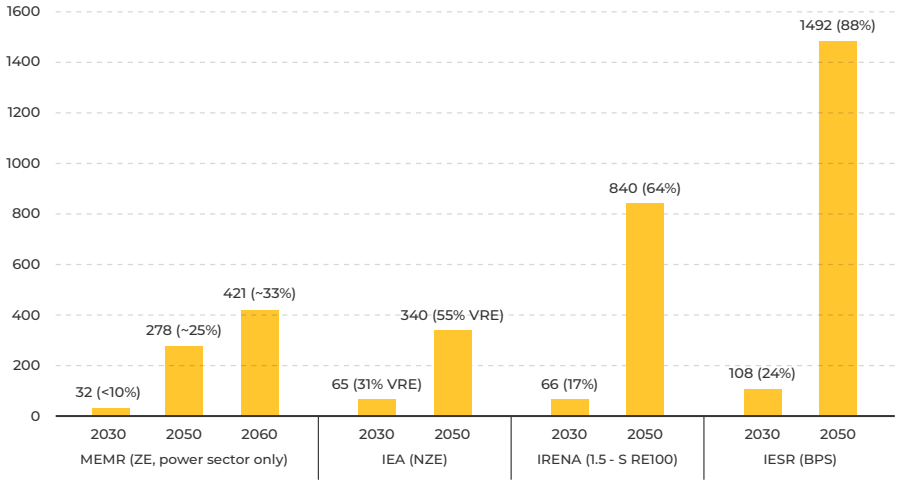
- The new purchase prices that are regulated in the Presidential Regulation No. 112/2022 (Presidential Regulation, 2022) do not include the Feed-in Tariff scheme. Only two schemes are mentioned in the new regulation, i.e. the ceiling price and B2B negotiation.
- In the new pricing regulation, the prices do not depend on the average cost of power generation (BPP). Instead, all types of renewable energy projects will be given ceiling prices, which takes locational factors into account to encourage renewable development and investment. In the previous draft, it will only be implemented for geothermal projects that require high exploration costs and other large scale projects.
- Without benchmarking with the BPP, which is artificially cheap due to the domestic market obligations (DMO) of coal, the renewable energy project's bankability and profitability will improve compared to the previous regulated purchase prices. Furthermore, compared to our LCOE calculation, the profit margin is adequate . However, the comparison should be evaluated further, especially for projects outside Java due to the higher upfront costs.

Solar is set to play a vital role in Indonesia's deep decarbonization

- In 2022, solar has finally made its way into a larger part of Indonesia's net-zero emissions pathways. Several studies and analyses, including by MEMR, IEA, IRENA, and IESR, have shown that solar will play a vital role in Indonesia's deep decarbonization by 2060 or by mid-century. In its net-zero power sector modeling by 2060, for example, MEMR projected that solar will take up at least one-third of total electricity generation in 2060, with about 420 GW of installed capacity (about 60% of total installed power capacity).
- The IEA, under an official cooperation with the MEMR, reported similar findings that solar, together with wind, will play a vital role in Indonesia's deep decarbonization. By 2030, installed solar capacity should reach 65 GW (out of 140 GW of renewables installed capacity, where renewables should represent one-third of electricity generation in 2030). By 2040, nearly 90% of electricity supply will come from renewables and unabated coal will be phased out. Solar and wind together will provide about 55% of electricity generation and maintain a similar share from 2040 to 2060.
- Similarly, IRENA projected that in all scenarios it developed, solar will play a key role in Indonesia's pathway to net-zero emissions by 2050. In its 1.5°C aligned (1.5-S) scenario, installed solar capacity will reach 800–840 GWp by 2050, representing about 79–84% of total installed capacity in the same year. Last year, IESR, Agora Energiewende, and LUT University (2021) also explored an accelerated and 1.5 °C-aligned scenario for Indonesia, in which solar is projected to make up 88% of solar electricity generation and 1,500 GWp of installed solar capacity by 2050.

Solar capacity and generation mix in Indonesia's NZE energy sector pathways

Installed capacity, GWp (electricity generation share, %)



Source: MEMR, IEA, IRENA, IESR analysis.

Notes: MEMR scenario modeling only covers the power sector and limited end-use sector, whereas scenario modeling done by IEA, IRENA, and IESR covers the entire energy sector (i.e., the power sector and the entire end-use sectors: industry, transportation, and buildings sectors). MEMR scenario refers to Zero Emission (ZE) scenario in MEMR's net-zero power sector by 2060 modeling. IEA scenario refers to Net Zero Emissions by 2050 (NZE) scenario in IEA-MEMR's study on An Energy Sector Roadmap to Net Zero Emissions in Indonesia. Solar capacity and generation mix in the IEA model are estimated because the value is not specifically broken down (grouped together with wind as VRE). IRENA scenario refers to a 1.5°C aligned scenario that utilizes a 100% renewables system (1.5-S RE100) scenario in IRENA's Indonesia Energy Transition Outlook. IESR scenario refers to the Best Policy Scenario (BPS) in IESR-Agora Energiewende-LUT's study on Deep Decarbonization of Indonesia's System.

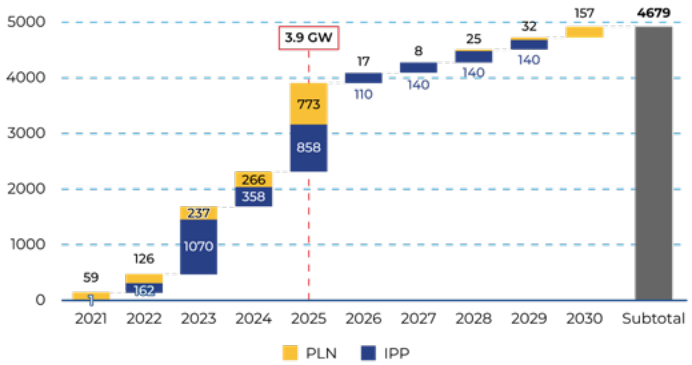
Despite its increased importance in net-zero energy sector modeling, Indonesia's solar deployment remains minuscule

- By Q3 2022, Indonesia's solar deployment has only reached 0.2 GWp*, with electricity generation share of less than 1%. From power system planning perspective, PLN did plan to add 4.68 GW of solar by 2030 in RUPTL 2021. About 3.9 GW is expected to come online by 2025, where 2.45 GW will be procured using IPP scheme and 1.45 GW will be procured directly by PLN. However, as of Q3 2022, there are only eight IPP projects totaling 585 MWp in the pipeline. Given the short time frame, PLN risks not meeting its capacity addition plan, which also means the 23% target by 2025.
- In 2022, one year after the release of RUPTL 2021–2030, no solar auctions have been scheduled except for the diesel-to-renewables conversion program in March 2022. The first phase of the program aims to convert 212 MW (out of 499 MW) diesel plants in 183 locations into solar+storage projects using location clustering (8 clusters), while the remaining 287 MW will be carried out in the second phase in a yet specified time frame. The first to be tendered were two out of eight clusters: Jawa–Madura (cluster IV) and Kalimantan 1 (cluster V), replacing 19 MW and 17 MW of diesel generator capacity, respectively. The RFP originally expects PPA signing of the two clusters by October 2022, but seems to be facing a delay.
- Floating solar keeps gaining traction in 2022. As of Q3 2022, there are at least three projects totaling 325 MWp in the pipeline (auctioned) and eight projects totaling 731 MWp that are still in pre-development stage (not yet auctioned). In October 2022, a state-owned construction company also signed an MoU with a Singaporean partner to develop a 2 GWp floating solar project in Cilamaya, West Java. Partnering with PLN's subsidiaries (PLN Indonesia Power or PLN Nusantara Power) under a 51:49 project equity structure seems likely to be the preferred project development style going forward, although this might undermine the principles of an open auction.

*) Official statistics of MEMR. Only includes installation within PLN's business concession. Installations in non-PLN business concessions may be grossly underreported

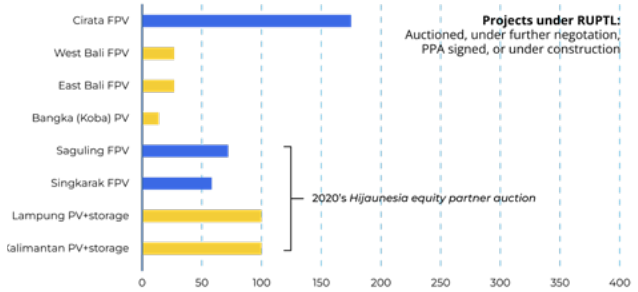
Solar capacity addition plan in RUPTL 2021-2030

Capacity, MWp



Source: PLN, IESR analysis.

Utility-scale (IPP) solar project pipeline in Indonesia, within PLN's concession

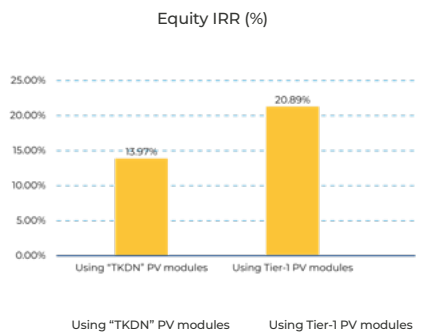


Source: IESR analysis.

Presidential Regulation No. 112/2022 provides more room to improve returns for developers, but the imposition of high LCR on PV modules will likely become a hurdle in solar auctions

- While the much-anticipated presidential regulation is expected to provide more room to improve returns for developers, the imposition of high local content requirements on PV modules (supposedly 60% starting in January 2019) will likely still become a major hurdle in solar auctions. This is because the so-called "TKDN" PV modules are not only sub-par in terms of efficiency (quality), but also higher in price compared to Tier-1 PV modules, resulting in a lower expected rate of return and lowering the developers' ability to bid competitively.
- For a 100 MWac ground-mounted PV project, at 100% of ceiling prices (for both year 1-10 and year 11-25 tariff staging), projects that use "TKDN" PV modules can only receive a maximum equity IRR of 14%, leaving not much room for a competitive bidding. On the other hand, projects that use Tier-1 PV modules can reach a maximum equity IRR of almost 21%, meaning there is still room for developers to bid more competitively (for example, when targeting a 10-12% of equity IRR).
- The sub-par aspect of "TKDN" PV modules also has a detrimental effect on financing. Generally, the bankability of a project that uses "TKDN" PV modules has not been be deemed "bankable" to receive financing at all. It is still a big question mark whether or not projects that are currently in the pipeline will even use "TKDN" PV modules (certainly not at 60% LCR PV modules, as there is no single PV manufacturers who has achieved it yet).
- Rethinking the LCR policy and domestic PV manufacturing readiness will be key to realizing cost-competitive solar projects in the short term (at least by 2025). At the same time, it is also important for Indonesia to start preparing a long-term industrial policy strategy on PV manufacturing and then aligning LCR with domestic manufacturing capability (e.g., until 2030 as a start as already stated in Presidential Regulation No.112/2022 and the JETP's Joint Statement.

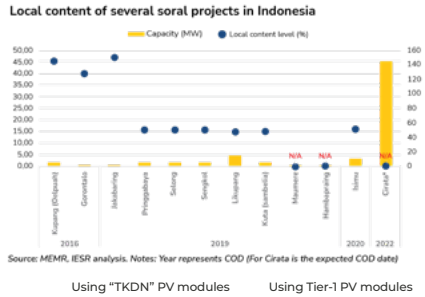
Equity IRR comparison for a 100 MWac ground-mounted PV (at 100% ceiling price)



Source: IESR analysis.

Assumptions:
(i) tariff is set according to Perpres 112/2022 (at 100% of its ceiling price, for year 1-10 and year 11-25 staging) to reveal the maximum equity IRR possible; (ii) a standard 1.3 DC/AC ratio is used; (iii) using a 1.0 location factor (Java).

Local content of several solar projects in Indonesia



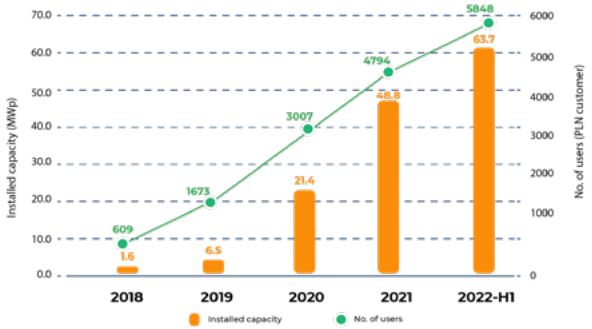
Source: MEMR, IESR analysis.

Notes: Year represents commercial operation date (for Cirata it is the expected commercial operation date)

MEMR 26/2021's implementation has been stalled by PLN's maximum capacity limitation, putting the government's 3.6 GWp by 2025 rooftop solar PV target at risk

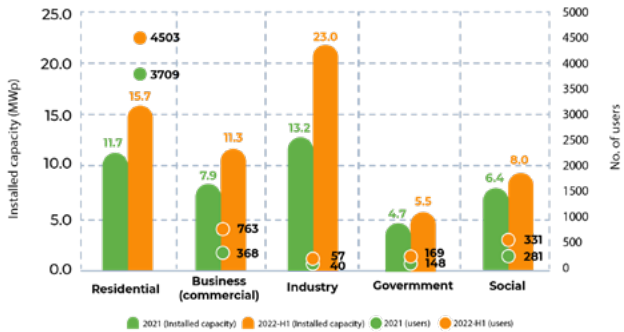
- The implementation of MEMR 26/2021, which revises the net billing (1:0.65) scheme for rooftop solar PV into net metering (1:1), has been stalled since its formal enactment in February 2022. This was caused by PLN's maximum capacity restriction in March 2022, ostensibly due to overcapacity and system reliability concerns. The restriction limits potential rooftop solar PV customer's installation capacity to only 10–15% of its installed power connection, despite the fact that according to hosting capacity studies by Gadjah Mada and Udayana University, technical limitations exist at a system level, not an individual power connection level, and that the Java–Bali system is capable of hosting as much as 15% solar penetration using flexibility means in the system.
- The restriction affects different segments differently as they are playing under different economics and business models. The C&I sector, for example, might still be able to find a good business case under the 10–15% maximum capacity limitation—although it may not be the most optimum. In contrast, for residential sector, under the limitation, assuming a typical 2200 VA installed power connection, households can only install a single panel (300~400 Wp), which is not optimum for cost savings and the return on investment. This is quite unfortunate since the residential sector is the largest driver for rooftop solar PV user growth. The maximum capacity limitation has also hindered the effectiveness of the one-year Sustainable Energy Fund (SEF) grant that provides incentives for rooftop solar PV users (using a voucher cashback). Altogether, the limitation puts the government's 3.6 GWp by 2025 rooftop solar PV (PSN) target at risk.
- As of November 1, 2022, MEMR and PLN are said to be finalizing the technical instruction of MEMR 26/2021 to determine the capacity limitation that will be formalized into a ministerial decision by the end of 2022. According to EBTKE, the maximum capacity limitation will be based on the potential rooftop solar PV user's minimum load to avoid solar electricity excess (export) to the grid (to avoid exacerbating the overcapacity issue).

Rooftop solar PV installed capacity and user growth (PLN customer only), 2018–2022 H1



Source: MEMR, IESR analysis.

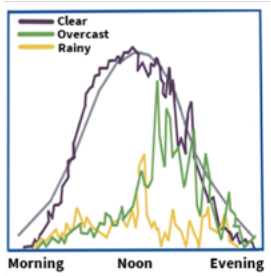
Rooftop solar PV growth by segment, 2021–2022 H1



Source: MEMR, IESR analysis. Notes: 2021 data breakdown is as of Nov 2021. Data from special service tariff group excluded for graph clarity

Flexibility requirements of the future power grid should be addressed against the forthcoming integration of variable renewable energies (VREs)

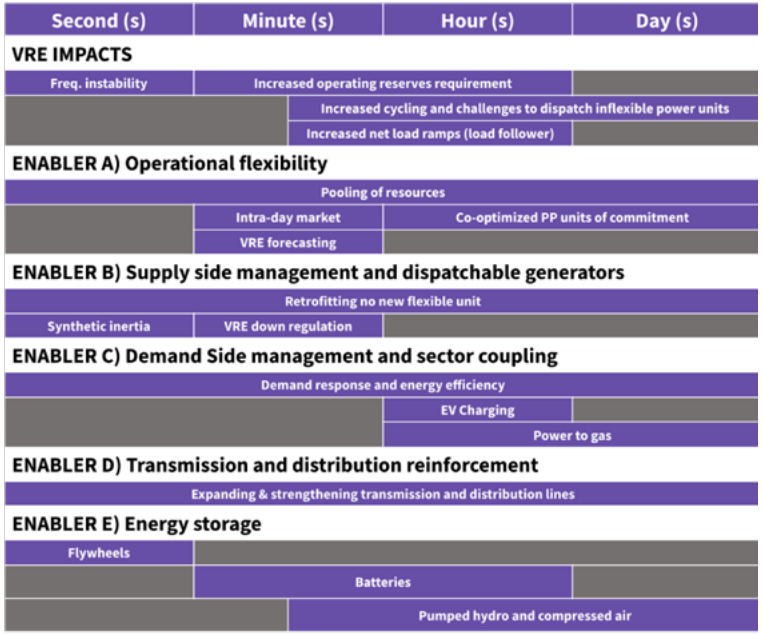
- The future power grid should be a flexible system capable of accommodating supplies from various generators, especially VREs, while being more reliable and cost-effective to maintain system balance. Since naturally intermittent solar PV and wind are expected to contribute around 55% of electricity generation by 2040, and their installed capacity will further increase until 2060 (IEA, 2022a), they will be the main drivers in shaping grid conditions in Indonesia. Grid development plans, therefore, must begin to address the foreseen impact of renewables intermittency and identify appropriate solutions to ensure the existing system has enough flexibility to take high VRE penetration.



- Solar PV and wind intermittency exists over multiple time frames, but with different characteristics. For example, a part of solar PV variability is deterministic (i.e., sun intensity is available during daytime and has repetitive ramps). Therefore, the future power grid in Indonesia may need multiple assets that can compensate for the daily ramps or distribute the time-limited generation of solar PV, which will be the dominant VRE technology according to the current roadmap. Nevertheless, the integration strategy of VREs should depend on their penetration level and the economic feasibility of the solutions.
- Among various proposed solutions, enablers to enhance the power grid flexibility are generally listed as flexibility in grid operation, supply and demand side management, interconnection (transmission and distribution) assets, and energy storage. In practice, the implementation of one enabler might be prioritized over the others, largely due to the amount of investment needed. A recent study indicates that the investment required to provide flexibility to the power grid is between USD 425 billion to USD 738.3 billion*, about one-third of the total investment to decarbonize the power sector (IRENA, 2022; IESR, 2021a).

*) Total required CAPEX for flexible assets (new hydropower, storages, and grids HV) until 2050 (IESR, 2021a)

Summary of the impact of VRES integration on the power system and the identified solutions for the respective timescale



Adapted from IRENA. (2018). Power system flexibility for the energy transition: part 1 - overview for policy makers.

Current PLN grid development is insufficient to accommodate the long-term power sector commitment to integrate high share of VREs

- In Indonesia, the current power system is not yet prepared to welcome high VREs penetration. The power system is facing an oversupply and is dominated by CFPPs with a high minimum off-take obligation, which hampers the uptake of cheap renewables and other more flexible power plants. Correspondingly, the system has a high reserve margin requirement (35%) and already has a large minimum and peak net demand gap before high VRE penetration.
- With several existing challenges, efforts to increase grid flexibility must be carried out more ambitiously so that the decarbonization target can be achieved. IEA highlighted three points, which can be used as a measure to enhance system flexibility, that must be considered simultaneously: 1) technical flexibility, 2) contractual/institutional flexibility, and 3) operational practices (IEA, 2022b). In this regard, PLN's grid flexibility planning is apparently centered on technical flexibility development, particularly by expanding the capacity of flexible power plant assets.
- In the Java-Bali system, for instance, the plan to reinforce the grid and VRE provision is focusing on the deployment plan of fast-response CCGT and pumped hydropower storage (PHS), with the capacity of each technology is expected to increase by around 2 GW before 2030. Apart from CCGT and PHS, there are also agendas for BESS adoption and interconnection expansions that are still in the early stages of planning.
- Besides adding new power plants, several other untapped flexibility resources should be considered, including the existing CFPP that can be transformed to operate flexibly and substitute the need for new gas turbines. Although gas turbines indeed could provide more flexibility, unlike PHS, its high share in the electricity mix could burden future operational costs, given the gas price volatility and projection that Indonesia will become a net gas importer in 2030 due to the decline in domestic production (IEA, 2022a). It will reflect the present reliance on oil imports to operate diesel generators.

Java-Bali power system's technical flexibility implementation status

Technical Flexibility	Remarks
Power Plants	· Implementation of free governor and automatic generation control (AGC) to respond to the generation-load mismatch · Fast ramping power plants addition in the pipeline · Flexible CFPP planning
Grids and Interconnections	· Planning on >12 thousands kms transmission line extension by 2030 · Development of Java-Bali 150 kV loop protection · Sumatra-Java interconnection study
Storage	· Nearly 2 GWh pumped hydropower storage addition target before 2028 · Planning on 600 MW BESS adoption for spinning reserve
Demand response	Standardized EV charging station
Digitalization and smart grids	Planning on smart grid implementation

Characteristics and flexibility challenges:

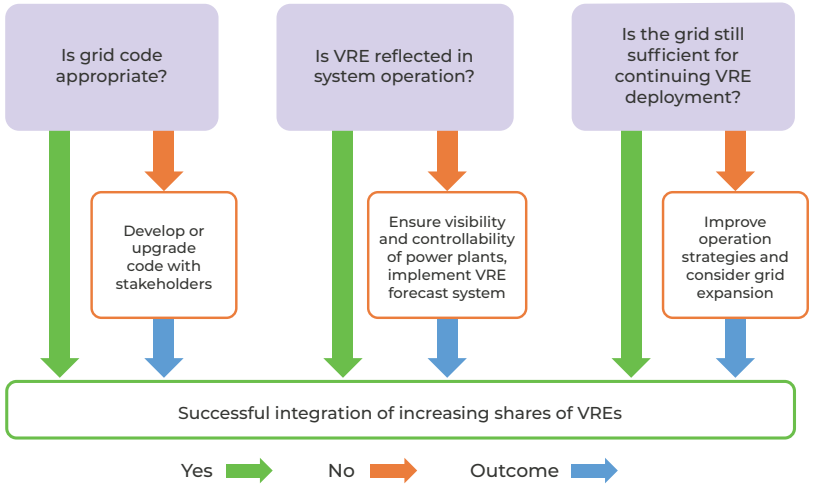
- Inflexible thermal power plants due to the requirement to operate with high capacity factors to obtain low cost per unit of output.
- Weak connections relative to the power demands, requiring new transmission line to run in parallel
- Long distance between the center of demand and supply capacity with limited transfer capacities might results in voltage instability.

Source: IRENA, PLN, and IESR analysis

Harnessing potential flexibility resources and improving system operation can be an initial effort to provide VREs to the grid

- The cost of VRE integration can be higher than the cost of its technology. At the current penetration level of less than 1% VREs in the power generation mix, their intermittency will have no relevant impact on the power system (typically must be at least 3% to become noticeable). Thus, less capital-intensive flexibility resources, namely contractual flexibility and system operational practices, could be prioritized. These two resources are correlated as additions to unlock the room for renewables in the generation mix. The availability of the earlier would allow effective utilization (dispatch) of existing generation fleets.
- The existing rigid minimum thermal power plants off-take, PPA, and fuel supply contracts in Indonesia are huge constraints to realizing the flexible grid. Meanwhile, enhanced contractual flexibility is estimated to save 5% of annual operational costs worth USD 0.8 billion in 2030 (IEA, 2022a). Since a direct approach to revising PPA with IPP may face legal complexities, the effort to enhance the flexibility of existing assets should start with PLN's generation fleets. In this case, it would require the current grid code to be updated, for example, by specifying the required flexible generation criteria (e.g., minimum load, ramp rates, and start-up times).

An example of the approach to prepare a power system for increasing VRE penetration



Source: Adapted from IEA. (2017). Getting Wind and Sun onto the Grid

- In addition to the grid code, real-time monitoring and forecasting infrastructure must be established to improve operational flexibility and enable optimal governance of systems that have surging VREs (i.e., minimizing power system imbalance). To date, intra-day VRE forecasting with up to a few minutes ahead is not yet available in Indonesia, although PLN recently suggested that it is already in the planning. Establishing the system operation infrastructure may require stakeholders (i.e., policymakers, PLN, IPP, and research institutions) in Indonesia to participate collectively.
- Although the VREs penetration remains at a low level, the pathways to NZE, which needs more than 20 GW (instead of PLN's planned 4.7 GW) solar capacity by 2030 (IEA, 2022a; IESR, 2021a), will require a higher pace of grid enhancement. Indonesia has a unique opportunity to prepare a regulatory framework and develop pilot projects for grid expansion (i.e., flexibility enablers) in a system that reaches the 2nd phase earlier. The odds would help stakeholders to find the local best practice to be adopted in other bigger systems.

Existing thermal power plants could contribute to enhancing grid flexibility and increasing VREs' share in Indonesia's power system

- Future planning should include strategies to enable power system flexibility as VRE penetration level increases. Technically, supply side flexibilisation using the existing generation fleet in the power system can be considered. Hydro, diesel engine, and gas turbine-based power plants have already been designed with high ramp rates and quick start-up time, two out of three yardsticks of flexible power plants, with the other having a lower minimum operational load.
- To date, Indonesia has about 27 GW of hydro, diesel engine, and gas turbine-based power plants installed nationally, with more than 13.2 GW were installed In the Java-Bali system. According to PLN's latest RUPTL, the system will be adding 4 GW of these power plants. Going forward, relying solely on these power plants may not be sufficient, constituting additional sources of flexibility from other forms of generation to maintain future supply-demand balance.

Potential flexibility improvements in thermal-based power plants

Type of plant	Status	Start-up time	Minimum load (%Pnom)	Avg. ramp rate (%Pnom/min)
Hard coal	Average plant Post flexibilization	2-10 h 80 min-6 h	25-40% 10-20%	1.5-4% 3-6%
Lignite	Average plant Post flexibilization	4-10 h 75 min-8 h	50-60% 10-40%	1-2% 2-6%
CCGT	Average plant Post flexibilization	1-4 h 30 min-3 h	40-50% 20-40%	2-4% 8-11%
OCGT	Average plant Post flexibilization	5-11 min 5-10 min	40-50% 20-50%	8-12% 8-15%
ICE (incl. gas and diesel engines)	Average plant Post flexibilization	5 min 2 min	20% 10%	>100% >100%

Source: IRENA (2019)

- Despite being a baseload generator, some coal-fired power plant (CFPP) units could actually be considered for flexible operation. ERIA, in its latest report, projected a surge in Indonesia's future Grid Fluctuation Index (GFI) post 2035, thus suggested the flexibilization with the CFPPs to be the major option accordingly (ERIA, 2022). Indeed, there are limitations, which could be overcome through a certain retrofit and/or a change in the operational procedure.
- PLN has proposed a conversion of its several CFPP units in the Java-Bali system into flexible generators, targeting 20% of minimum operating level and 5%/min ramp rates (Mirza, 2022). In total, these power plants would give an additional 4 GW, hence making the flexible generators potential capacity in the Java-Bali system to be around 21.2 GW. The targets are certainly ambitious, considering that Indonesia's CFPP units still operate with minimum load of 53%-80%, average ramp rates of 1%/min, and start-up time of 4-10 hours. It remains unclear on what kind of retrofit or changes to apply in order to achieve the target. Moreover, some of the proposed units are actually already or close to reaching its operational lifetime, which are off to be phased out immediately, i.e. Suralaya unit 1–4 and Paiton unit 1. In one of its research, IESR even enlisted these units as Low Hanging Fruits due to their poor technical performance, profitability, and environmental impact (Cui et al., 2022).

Operating CFPPs flexibly is a possibility; the financing mechanism of such an operation and the PPA T&Cs remain a challenge

- There are a number of practices exemplified by countries, such as Germany, to enhance CFPPs flexibility. Weisweiler power plant was retrofitted with gas turbine units (repowering), resulting in its increased ramp rates, from 6 MW/min to 10 MW/min. In another plant, Bexbach, saw a 64% reduction in its minimum load down to 12.5% simply by operating a single mill burner without the support of oil firing.
- IESR (2022) suggested a few recommendations to unlock CFPPs flexibility. On the plant level, young power plants, 5 years or lower, are more likely to perform better, particularly in terms of emissions, solely due to their prime conditions. There are about 9 GW of these young plants, with the majority located at Kalimantan and Sulawesi. From the point of a view of system, Sulawesi has a quite interesting energy mix, in which renewables are expected to reach 51.2% by 2030, consisting of solar PV (28.36%), hydro (27.7%), geothermal (4.55%), and wind (2.73%). With such varieties, Sulawesi system would be a perfect testing ground to operate its CFPPs flexibly. In terms of LCOE, a flexible CFPP is quite comparable to other typical flexible generators, such as large hydro and CCGT.
- Non-technical features remain a challenge. Long tenor and high degree of capacity factor in the CFPPs PPA need to be revisited and renegotiated. Negotiation should address lower ToP scheme, for its current figure at 80%, and encourage CFPP owners to participate in market-based mechanisms for the procurement of the flexible operation. These mechanisms could be in the form of ancillary services and capacity markets. An independent body is required to regulate the markets and bidding process.

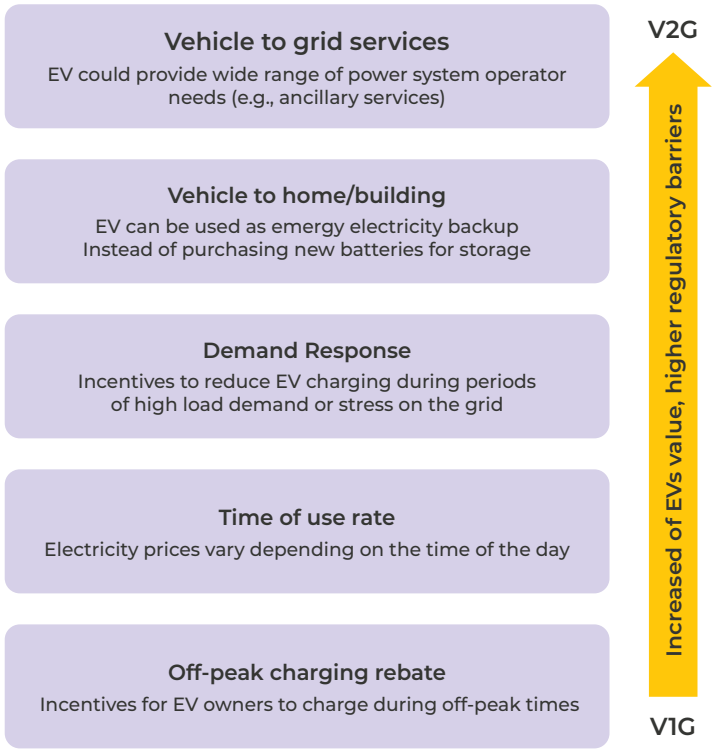
Options	Minimum load	Start-up time	Ramp rate	Limitations
Indirect firing	X		X	Fire stability
Switching from two-mill to single-mill operation	X			Water-steam circuit
Control system and plant engineering upgrade	X		X	Fire stability/ thermal stress
Auxiliary firing with dried lignite ignition burner	X			Fire stability and boiler design
Thermal energy storage for feedwater pre-heating	X		X	N/A
Repowering		X		N/A
Optimized control system		X		Thermal stress
Thin-walled components/ special turbine design		X		Thermal and mechanical stresses
New' turbine start		X		Turbine design
Reducing wall thickness of key components			X	Thermal and mechanical stresses

Source: IESR analysis

Decarbonization of road transportation will aid VRE integration, increasing power system flexibility

- The growth in the use of EVs in Indonesia could have a positive impact on the power system, in addition to reducing GHG emissions from the transportation sector. Significant EV adoption would bring unheralded electricity demand for the EV charging. Electricity consumption for road passenger EVs is estimated to reach almost 270 TWh by 2060 (IEA, 2022a). Meanwhile, in the acceleration scenario (IESR, 2021a), the need for transportation electrification will reach 136 TWh and 499 TWh in 2030 and 2050, respectively, about 15 times higher than the projections of the National Energy Plan.
- EVs and their electricity demand need to be viewed as an asset to increase power system flexibility. By somehow synchronizing the charging of EVs with times of the day when electricity demand is low, or when there is excess power generation (e.g., at high solar PV penetration), managed charging may provide power system operators with the flexibility to adjust load profiles, known as V1G. However, EV owners may ask for a compensation for meeting the utility's expected charging times. Common charging time incentives include time-of-use rate, off-peak charging rebates, and demand response programs. When supporting regulations are available, EVs may also be used to supply electricity to the grid under the vehicle-to-grid (V2G) concept.
- In the future, investment in infrastructure would be needed to utilize V1G or V2G. Although the estimated number of charging points reaches 1.3 and 10 million units by 2030 and 2060, respectively, most of them are household slow chargers. Meanwhile, once the power system has high solar PV penetration, EVs as power generation absorbers should be charged during the daytime and would require more public/office chargers that cost about 25 times higher.

Electric vehicle value in power system

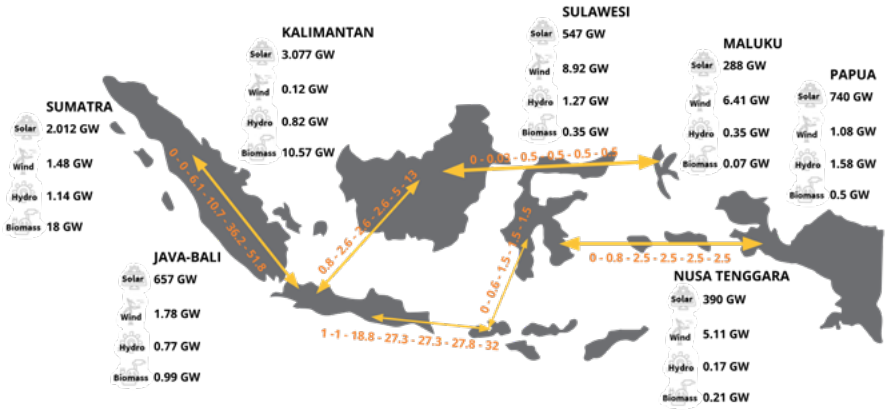


Source: Strategen Consulting, IESR analysis

Interconnection reinforcement will optimize the grid while providing a better foundation for renewables penetration in Indonesia

- As an archipelagic nation that has long been centralized, Indonesia indispensably needs more aggressive grid interconnection development. In IESR's deep decarbonization scenario, the electricity demand in the Java-Bali power system will increase to about 417 TWh in 2030, accounting for 76 % of the country's total demand. By then, the region's RE potential might not be utilized adequately to meet the demand, given the time needed to construct high-output REs (i.e., geothermal and hydropower), and large-scale solar PV deployment in Java may face land use challenges. Importing electricity from nearby islands with high RE resources and low demand, hence, can be a prominent solution.

Illustration of required inter-island interconnection capacity and renewables potential in different islands



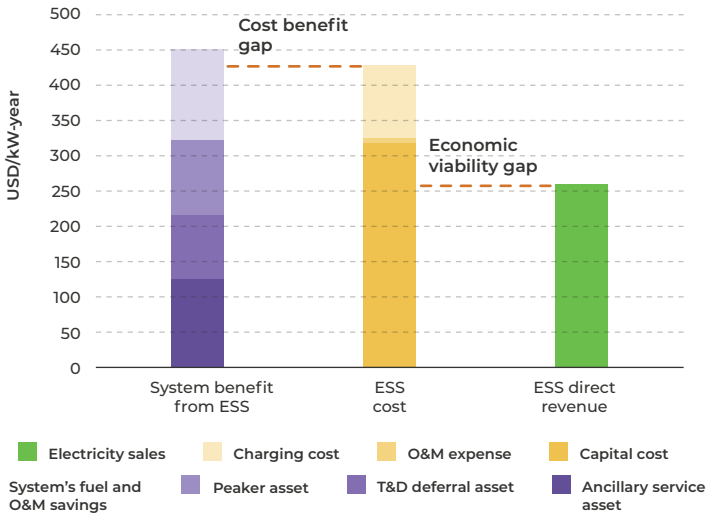
Source: IESR analysis.
Note: The number of renewables capacity are technical potential according to IESR study, not the installed capacity.

- Inter-island HVDC connection is not only resolving the future supply and demand mismatch and improving the system's reliability, but also (most importantly) allowing higher RE penetration to achieve the emission reduction target. However, before connecting the islands, each island must already have suitable transmission lines, for instance, the interconnection in the Sumatra and Kalimantan systems must be reinforced first. Java-Bali system, in this case, already has an 'ultimate network roadmap' that would install Java-Bali 150 kV loop protection. Nevertheless, as building inter-island connections may take a long time (up to decades), careful planning must be immediately carried out.
- In the deep decarbonization scenario, the establishment of Java-Kalimantan and Java-Nusa Tenggara transmission lines, each with a capacity of around 1 GW, should be started by 2025 to accommodate Java's 4.6% supply-demand deficit in 2030. As the deficit is expected to increase to 45.5% and 82.1% by 2040 and 2050, respectively, a high capacity interconnection with Sumatra, Kalimantan, and Nusa Tenggara systems of about 96.8 GW will be needed (IESR, 2021a), which is consistent with IRENA's recent study that expects a 93 GW inter-island connection to Java (IRENA, 2022).

The need for early ESS adoption is supported by falling prices and increasing global market size, prompting the readiness of the regulatory framework

- Although ESS has been included in PLN's VRE development strategy, the type of ESS technology, expected capacity, and applications have not been determined. The grid's needs of ESS must be clarified to prioritize development (e.g., the scale of short-duration ESS for grid stabilization or long-duration ESS for load shifter/distributed generation reliability) and attract prospective developers. On the other hand, the current grid code (MEMR Regulation No. 20/2020), which requires only 10% of ESS capacity compensation for VRE installation, may need to be updated. To meet NZE commitment, the integration of high-share VRE generations would require different roles of ESS in power systems, such as long-duration or high-capacity storage.
- The conviction that Indonesia has not yet needed ESS at the current level of VRE penetration needs to be reviewed. ESS may not be considered as the most suitable integration option for low RE penetration levels, mainly due to its high capital requirements and the need of at least around 30% VRE penetration for it to be a priority (DEA and MEMR, 2021). However, It deserves reassessment, considering that BESS' price decline surpassed the projections (USD 300/kWh vs USD 140/kWh in 2020 (IRENA, 2013; BloombergNEF, 2021)) due to the massive expansion of the global EV market. Moreover, geographical conditions leading to higher VRE penetration in smaller systems may encourage quicker adoption of ESS and require immediate preparation of the regulatory framework.

Illustrative example of economic value of BESS in Indonesia



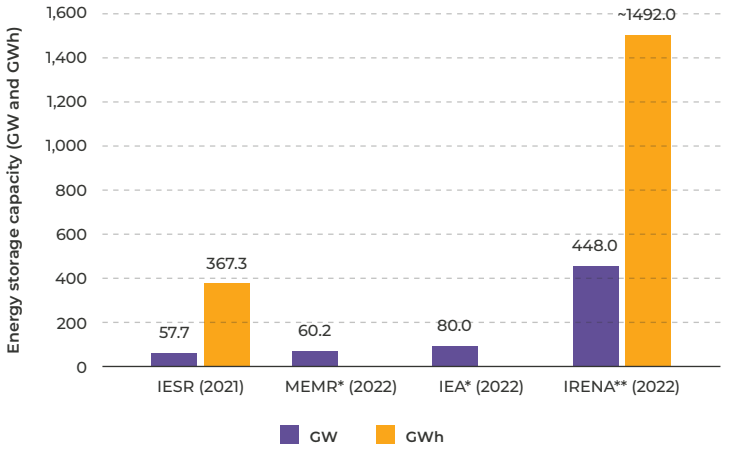
Source: IESR analysis

- In Indonesia, ESS should be economical if it is used for single or multiple high-value applications such as ancillary services, system deferral, load/generation shifting, and many more. Unfortunately, the value of these applications is not well defined. Research institutions (e.g., BRIN) and universities may need to step forward to provide a comprehensive study on various ESS technologies, including their technical aspects, value chain, and economic assessment. It would help the power sector stakeholders to determine ESS development strategies and operation regulations. The availability of such policy frameworks would make early adoption of ESS feasible and possibly more affordable.

ESS implementations have progressed, but are still insufficient to support utility-scale VREs

- In September 2022, the Upper Cisokan pumped-hydropower-storage (PHS) project is reported to begin its construction after securing USD 850 million in financing. The 1,040 MW PHS that is targeted to start operating in 2027 is financed by AIIB, WB, and PLN (approximately with 50:30:20 ratio), with an estimated WACC of 5%. It is expected to provide almost 1.5 TWh of annual electricity to the Java-Bali power system, which would cost around USD 3.6 cent/kWh. PLN considers the utilization of the PHS not only to operate as a peaker, but also to be activated as a spinning reserve, and is expected to save approximately USD 61 million in annual operating costs (AIIB, 2022). According to AIIB's project documents, the financing for Upper Cisokan PHS also includes preparation costs of the subsequent development of the Matenggeng PHS project.
- While PLN has planned to harness PHS use to improve grid stability, the battery energy storage systems (BESS) deployment in Indonesia is still limited to off-grid systems. There are a few solar PV+BESS hybrid systems commissioned this year, such as in Selayar and Nusa Penida Islands, which have a combined BESS capacity of around 2 MWh. In these two projects, the lithium-ion type BESS is used instead of the lead-acid one. The experience of MW order Li-ion BESS deployment is an important milestone. However, it should also start to be deployed on large power systems. Based on several studies, Indonesia needs at least 57.7 GW of energy storage consisting of BESS and PHS. The utilization of BESS is expected to be much higher due to geographical and resource availability constraints of PHS.

Indonesia energy storage capacity demand to achieve NZE target



Source: MEMR, IEA, IRENA, and IESR

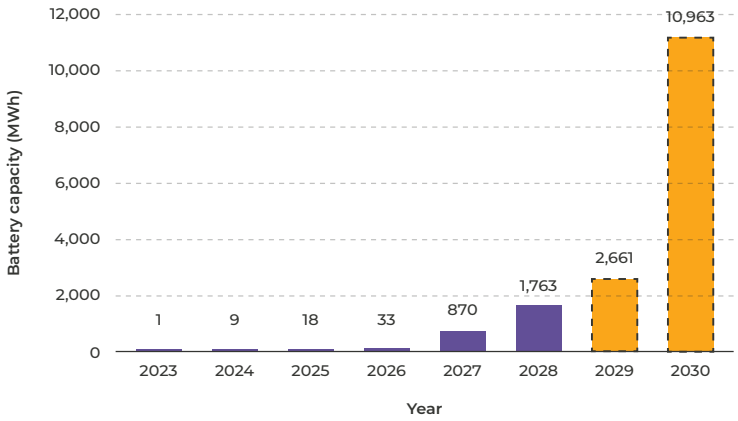
Note: Energy storage technology includes PHES and BESS;
(*) The amount of storage capacity (GWh) is not mentioned in the documents;
(**) BESS duration is not specifically mentioned and is assumed 1 hour.

- In terms of BESS options, there are at least five different types of BESS technology producers seeing the potential for development in Indonesia. They are lead-acid, lithium-ion, redox flow, sodium-sulfur, and liquid metal battery manufacturers. Each BESS technology has unique characteristics and merit in a particular application. However, with the absence of a market for storage services and an unclear strategy to harness BESS, the manufacturers might be wondering when and where their products will be needed.

Domestic EV battery industries will possibly fulfill the BESS demand in the power sector if they diversify the downstream industry

- The establishment of the EV battery ecosystem in Indonesia should be able to stimulate the development of BESS for power sector applications. However, despite several studies projecting the demand increase in capacity, the BESS market has not been well-established, and the required allocation of domestically produced batteries is not yet defined. In the IBC consortium, for example, the investment allocated for the BESS development facility is relatively small (USD 40 million out of USD 15.3 billion of total project investment).
- Based on the minimum BESS installation projection of 56 GW of BESS capacity by 2060 (MEMR, 2022), the domestic battery production seems to be able to meet the demand. For example, IBC alone could produce 50 GWh of batteries in 2030, for export purposes only. However, it should be noted that BESS consists of different types of components (e.g., battery packing, battery management system (BMS), and balance of system (BoS)) from those found in EVs, which are possibly more expensive due to the lower economy of scale. Therefore, domestic industries also need to develop supply chains and build their capacities to produce non-cell components for BESS.

Estimated capacity of EV battery reaching end-of-life



Source: IESR analysis.
Note: purple: potential capacity from on-the-road EVs; orange: potential capacity if EV adoption target is achieved

- Stakeholders in Indonesia should be aware that the large-scale battery factories currently being developed are using nickel-based materials. Generally, the nickel-based battery is about 20% more expensive than the nickel-free one (i.e., lithium-ion phosphate battery (LFP) that is considered as a more suitable choice for stationary applications due to its longer cycling ability). Although domestic battery manufacturers suggested there will be a 30% price reduction from domestic production of nickel-based batteries, it is worth considering establishing an upstream industry to produce by-products, as cell-level production lines are relatively similar for lithium-ion batteries with different chemistries.
- The downstream industry that refurbishes EV batteries has great potential in Indonesia besides the material-level recycling. By 2030, EV batteries in Indonesia that reach their end-of-life may reach over 10 GWh*. Meanwhile, the estimated market potential of rooftop solar PV in Indonesia, which is known as one of the biggest markets for used batteries, is about 6.5 GW (IESR, 2021b). In this regard, residential solar PV users are also showing enthusiasm to use the battery in their system, particularly used batteries from EVs, which according to residential PV system owners cost only about half of the brand-new ones (less than USD 100/kWh).

*) Assuming NDC target, 13 million electric motorcycle and 2 million electric passenger cars, is achieved. The number only comes from electric passenger cars and motorcycles

2.4

Energy Transition in Transportation Sector

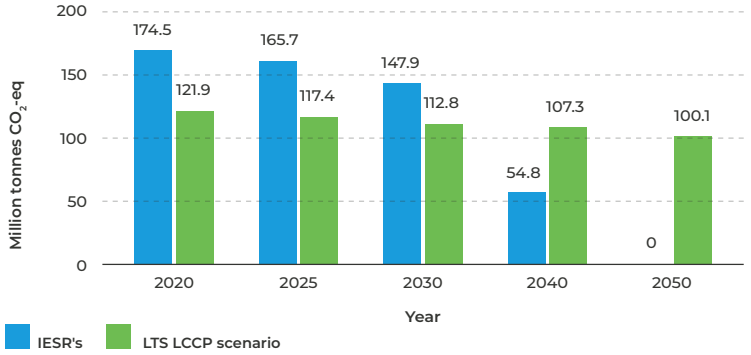
Faris Adnan Padhilah, Ilham Rizqian Fahreza Surya, Pintoko Aji, Shahnaz Nur Firdausi

- Transport sector overview
- EV road transport status
- Charging infrastructure status
- EV national policy
- Maritime and aviation transport
- Updates on clean fuels

Electrification and clean fuels play important roles to decarbonize Indonesia's transportation sector

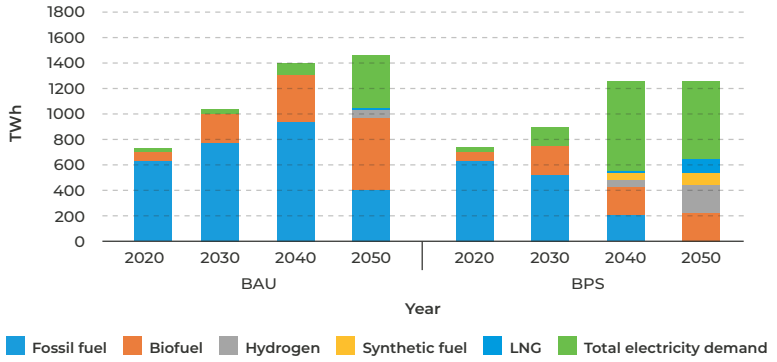
- Transportation sector contributed to a quarter of Indonesia's energy sector emissions in 2020 (27% of Indonesia's total GHG emissions). As the top three contributor to energy sector emissions, decarbonization of the transportation sector is therefore crucial for Indonesia to reach its net-zero goal. Based on IESR's net-zero emission by 2050 pathway, the GHG emissions from transportation need to be reduced by 3 Million tonnes CO_2-eq each year until 2030 and 7 Million tonnes CO_2-eq each year from 2030 to 2050, and will reach zero emission by 2050 (IESR, 2020). As a comparison, according to LTS LCCP scenario, the transportation sector GHG emissions will be reduced by 20 Million tonnes CO_2-eq in 2050.
- Over 90% of emissions from the transportation sector comes from road transportation (MoEF, 2022). In road transportation sub-sectors, the avoid, shift and improve framework can be used to decarbonize the sector. Avoid means reducing the distance travelled, shift means using cleaner energy sources such as biofuel and electricity, while improve means increasing the energy efficiency of vehicles. When it is techno-economically feasible, direct fleet electrification should be the main priority for decarbonizing the sector. However, at the moment, most of the electrifications are implemented in E2W, E3W, and light-duty vehicles.
- In hard-to-abate sub-sectors, such as heavy-duty trucking, shipping, and aviation, however, fuel switching to clean fuels will play a larger contribution due to techno-economical constraints. With the existing infrastructure and technologies, it could swiftly uptake biofuels and provide near-term emission reductions. According to IESR pathway, synthetic fuel and hydrogen will play important roles in the long term due to decreasing cost, technological improvement, and land limitation.

Transport sector GHG emission projections due to ambitious decarbonization



Source: IESR, Agora Energiewende & LUT University (2021) and MoEF (2021)

Transport sector energy demand projection 2020-2050



Source: IESR, Agora Energiewende & LUT University (2021) and MoEF (2021)

EV adoption might remarkably increase next year; government's involvement is needed to push the adoption more

- This year, EV adoptions are increasing significantly compared to the previous year, presumably triggered by several factors such as the rising gasoline fuels price, which has been identified as one of the factors to foster EV adoption in Indonesia (IESR, 2020). Moreover, the price gap between E2W and its ICEV competition are closing, and some comparable models are in the similar price range. The government also promotes EV more intensively this year. Last not but least, there are more models available to compete with conventional vehicles.
- There are several barriers obstructing EV adoption in Indonesia, such as high upfront cost, inadequate charging infrastructure, limited government incentives, and lack of consumer knowledge and awareness (Candra, 2022; Maghfiroh, 2021; IESR, 2020). Due to these barriers, EV target is still far from NDC's 2030 target. The adoption of E2W & E3W only reached 0.2% of the NDC target, while the adoption of E4W reached 0.4%. E-bus adoption is also still far from the target of the bus operator, with only 0.58% of the 2030 target.
- In order to reach Indonesia NDC target, adoption barriers must be resolved. The big adoption rate this year, along with the government adoption (President Instruction No. 7/2022), will help to solve the adoption barriers. Initially, it will affect the number of charging infrastructure as investors see that the demand is growing. The increasing number of EV will also lead to improved consumer knowledge and awareness, which will trigger EV purchase and keep the EV industry growing. Indirectly, EV manufacturers will also compete to make EV affordable for consumers.
- Government intervention is still needed to promote E-bus adoption as the incentives for E-bus is still lacking compared to lightweight EVs. Bali and Jakarta can be taken as examples to promote E-bus. Bali is planning to deploy E-bus in its National Strategic Tourism Areas (KSPN). Whereas Jakarta, through Transjakarta, uses E-bus as its intercity bus, targeting 100% E-bus in 2030. Initiatives from international agencies must also be welcomed, for example ADB's proposed partnership with DAMRI to provide electric buses and their charging stations in Jakarta areas (ADB, 2021).

EV annual adoption status

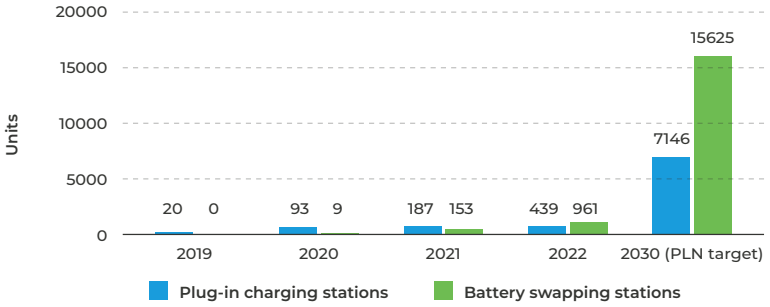
Year	E2W & E3W	E4W	E-bus
2019	1,300	40	0
2020	2,047	229	0
2021	5,748	2,012	30
2022	25,782	7,679	58
2030 (NDC & private target)	13 million	2 million	10,000
2030 (IESR Target)	110 million	3 million	2,4 million

Source: CNN (2022) and IESR (2021)

A better strategy in charging infrastructure investment is needed to match with EV adoption growth

- The availability of charging infrastructure is important for EV adoption. A lack of charging infrastructure can create a psychological problem for consumers to adopt EV, known as range anxiety, which means consumers do not feel safe about the travelled distance offered by the EV as they still have difficulties in finding the charging infrastructure. Due to the G20 agenda, the number of plug-in charging stations and battery swapping stations has increased by November 2022, especially in Greater Jakarta area and Bali. At the time, both areas contributed to 6% of PLN's 2030 construction target. However, In order to meet IEA recommendation of 1 charger for 10 EV, the charging infrastructure investment needs to be intensified. Based on IEA recommendation, Indonesia needs to increase its plug-in charging stations to 200 thousand for E4W by 2030.
- Nationally, the plug-in charging station business is dominated by PLN. It owns 52% of the charging stations in Indonesia, or 224 stations in 135 locations (PLN, 2022). However, this is not the case in Jakarta where private sector players including car dealerships, shopping malls, and hotels have more charging stations than PLN. Meanwhile, Type 2 charging with lower capacity power (<22 kW) is still the dominant type.
- From the investment point of view, the battery-swapping station looks more attractive than the plug-in charging station. First, it has a cheaper investment cost. Second, it does not need special government business permits to operate. Third, the demand is created through ride hailing and logistics companies that are interested in using EV in their business. However, the lack of battery standardization becomes a problem for battery swapping stations' adoption. The current number of swapping stations cannot be used as a reference to subside consumer's range anxiety as they are exclusive for a specific brand of E2W.

Charging infrastructure implementation yearly and 2030 target



Source: DGE (2020), CNN (2022), PLN (2022)

Charging infrastructure operators, charging types and station units in Jakarta areas (2022)

Private	AC Type 2 7-11 kW	81
	AC Type 2 22 kW	17
	DC CHAdeMO 60 W	2
	DC CCS/CCS2 50-60 kW	6
PLN	AC Type 2 7 kW	6
	AC Type 2 22-50 kW	37
	DC CHAdeMO 24-30 kW	5
	DC CHAdeMO >50 kW	7
	DC CCS 2 24-30 kW	5
	DC CCS 2 >50 kW	7
Pertamina	AC Type 2	5
	DC CCS	4
	DC CHAdeMO	3

Source: PLN (2022), Pertamina (2022), EVCuzz (2022), Starvo (2022), Hyundai (2022)

National policy: incentivizing manufacturers is the viable option to reduce EV prices

- This year, the government issued two more EV policies to boost EV adoption, the Presidential Instruction No. 7/2022 on EV Adoption for Government Official Vehicles and MoT Regulation No. 15/2022 on Conversions of other than 2W Vehicles. The latter complements 2020's conversion policy where only 2-wheelers were allowed to be converted. MEMR led the the conversion pilot project in 2021 and successfully converted 100 ICEV 2W vehicles into E2W. With the ambition to boost EV adoption, this year, it boosted the pilot project target by up to 1000, had 7 authorized conversion workshops, and cooperated with 3 local conversion component manufacturers to reduce conversion costs. To support the local component manufacturers, Ministry of Industry (MoI) also issued Ministerial Regulation No. 6/2022 on technical requirements, the national EV roadmap, and the local content requirement (LCR) guidelines.
- There are policy gaps between Indonesia and more developed EV markets such as South Korea and Singapore, one of them is cost reduction subsidy. Those countries grant an average of 15 - 25% reductions from EV on-the-road prices, depending on the types. There is also a gap in incentives for manufacturers. Incentivizing manufacturers can be done through market guarantee mechanism like Business-to-business (B2B) bulk-buying. Currently, ride hailing and logistics companies started their own fleet's electrification initiative. However, their adoption can be spurred further, for instance by regulating the corporate fleet vehicles emissions like in the European Union (EU) (IEA, 2021). This could ramp up B2B adoptions. After B2B, the next phase is government adoption, in which policy tools such as Advance Market Commitments (AMC) can give assurance of a viable initial market before retail (individual consumers) market develops.

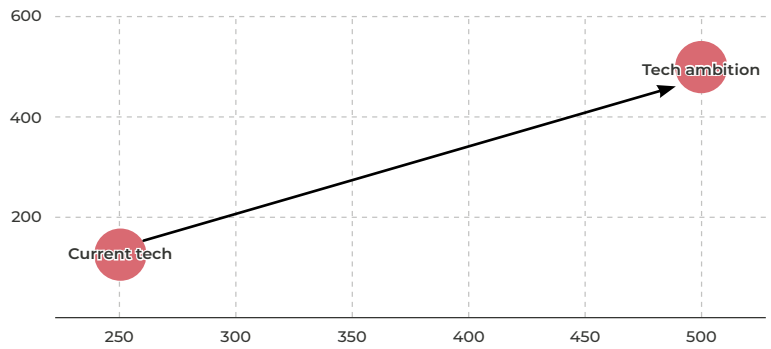
Existing policies on EV

Existing non-fiscal policies	Existing fiscal policies
• **MEMR Reg. No. 13/2020:** Standardization of charging plugs and electricity tariff policy for public electric vehicle charging station and public electric battery vehicle replacement • **Ministry of Transport (MoT) Regulation 44/2020:** EV testing and certification process • **MoT Reg. No. 45/2020:** Regulates special vehicle with electrical motor including safety requirement, riding behaviour, and vehicle lane • **MoT Reg. No. 65/2020:** Legitimize the conversion of 2W to E2W, and regulates the component of conversion vehicle, requirement to convert to conversion shop for Small Medium Enterprises (SME) workshop, along with safety requirements and administration process • **MoT Reg. No. 15/2022:** Regulate the conversion of other than 2W vehicles • **MoI Reg. No. 6/2022:** Technical requirements and LCR guideline	• **Government Reg. No. 74/2021:** The government reduces sales tax on luxury goods based on emission level of vehicle, battery electric vehicle (BEV) is exempted from sales tax on luxury goods(PPnBM) due to this regulation • **Ministry of Home Affair (MoHA) Reg. No. 1/2021:** BEV maximum yearly tax and transfer fee is only 10% of its imposition fee calculation • **Ministry of Finance (MoF) Reg. No.120/2021:** Reapply 25-100% sales tax on luxury goods (PPnBM) for conventional vehicles based on vehicle's engine size as a part of post-covid economic recovery program.

The low energy density of batteries makes their use in heavy-duty transportation systems impractical for large scale

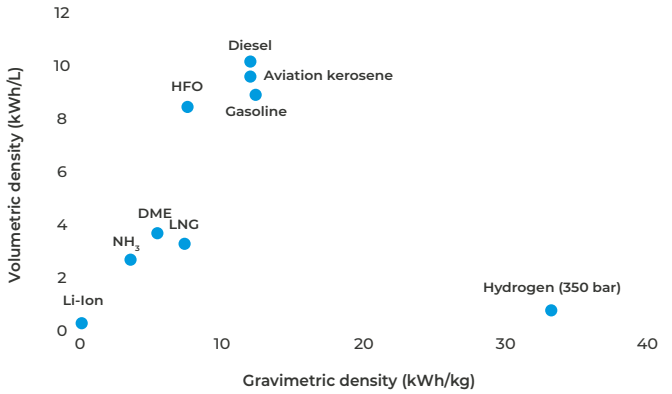
- Due to power-to-weight ratio constraint, electrification in aviation sector remains a challenge. Currently, battery technology is only 0.25 kWh/kg, and even with the goal of developing a battery with a capacity of up to 0.5 kWh/kg, cruise aircraft can only fly around 500 kilometres. Because of that, most electrification schemes allocations have been designed for starter planes, which were registered in the E-HAPI ICAO database as a total of 31 development aircrafts.
- Due to technical hurdles of e-aircraft, the use of bio jet fuel or sustainable aviation fuel (SAF) is still a practical interim solution in the context of decarbonization. The J.24 program in Indonesia (2.4% biofuel) is still in the development phase and cannot fulfil MEMR regulation 12/2015 mandates to implement 3% biofuel. The testing results show that the performance difference between J.24 and fossil fuel avtur is 0.2–0.6%. This indicates that the technological constraint is one of the reasons why the goal has not been achieved.
- Few Indonesian SMEs have demonstrated that the electrification of low gross tonnage (GT) vessels is feasible, despite facing challenges in CAPEX. E-boat still has an expensive CAPEX, which can reach 11 times the fuel based boat. However, its maintenance and fuel costs are significantly less expensive, allowing a five-year payback period for the benefit-cost relative to the ICE boat.
- Battery-powered (Li-ion) vessels are still the least desirable zero emission vessels (ZEV) solution for large vessels due to their poor volumetric density (30 times the HFO). Compared to alternative zero-emission vessels (ZEV) schemes such as biofuels and RFNBOs/synthetic fuels (fuel cell or ICE), the revenue loss effect from battery-powered vehicles is greater due to the cargo capacity decrease, particularly for big boats (cruises, tankers, containerships, bulk carriers, RoPax).

Cruise range limitation of energy spesific



Source: ICCT (2022) Notes: 9 passengers plane

Energy density of selected fuels

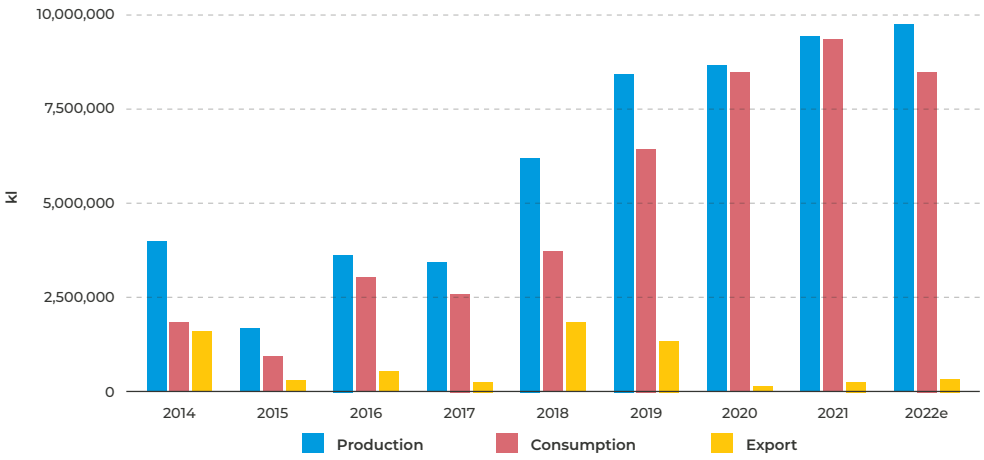


Source: US DOE (2015)

With current biodiesel production over capacity, biodiesel blending need to increase to B40 to avoid idle capacity

- Indonesia's biodiesel production has reached 9.68 million kl in October 2022. MEMR has increased the volume allocation for biodiesel in 2022 from 10.15 million kl to 11.02 million kl.
- Biodiesel exports appear to have started a comeback from around 28,000 kl in 2020 to 180,000 kl in 2021, and further to 250,000 kl in 2022 (September) (APROBI, 2022). The removal of export levies from July to December 2022 also plays part in increasing export quantity in 2022.
- The total capacity of biodiesel production from 23 companies has now reached 16.65 million kl, 65% of which is produced by 5 major company groups. These biodiesel producers are located in Sumatra, Java, Kalimantan, and Sulawesi, with the capacity of 7.8, 4.9, 3.5, and 0,5 million kl, respectively. The total capacity is expected to reach 19.5 million kl in 2023 (APROBI, 2022).

Biodiesel production, consumption, and export (2014-2022)



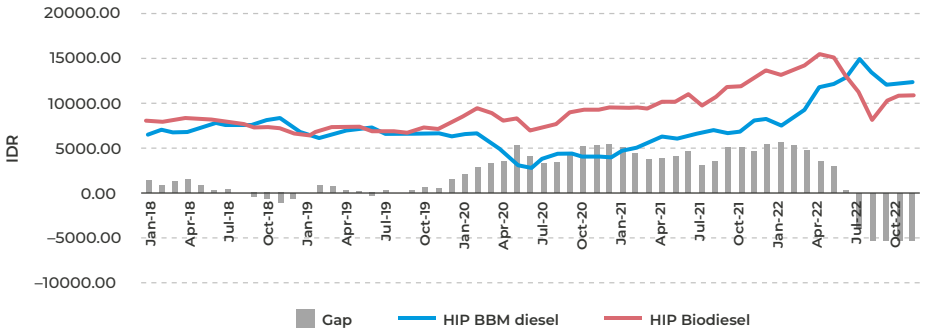
Source: IESR (2021) and APROBI (2022)

- MEMR estimated around 15 million kl is needed to increase 40% blending ratio of biodiesel. Therefore, with current biodiesel production capacity, Indonesia could increase biodiesel blending from B30 to B40. However, B40 is not technically proven, since the road test has not yet finished. After several delays, B40 road test is currently entering its final stage and expected to finish by the end of the year for both B40 (biodiesel 40%) and B30D10 (biodiesel 30% and green diesel 10%). The road test has successfully run through 50,000 km for small vehicle (<3.5 ton) and 40,000 km for bigger vehicle (>3.5 ton). Although the B40 and B30D10 fuels did not have a negative impact on the test vehicle's performance (ESDM, 2022), there is not yet official announcement to decide whether to implement B40 program next year.

Maximizing biodiesel consumption will financially benefit Indonesia when diesel price is higher than biodiesel

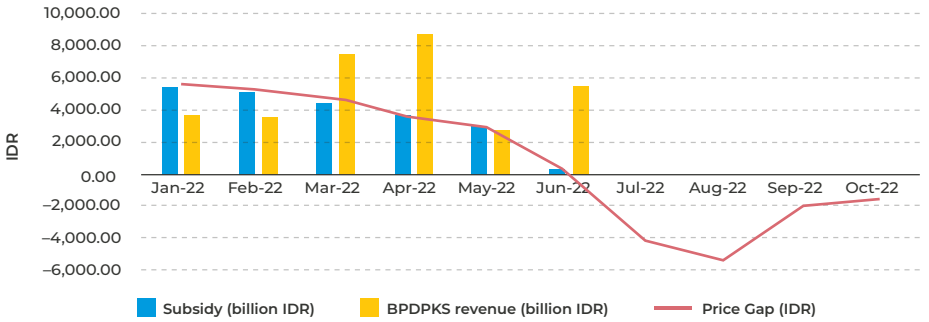
- The main challenge in developing biodiesel and further increasing its blending ratio is the fluctuation of commodity price. Therefore, the realization of B40 has undergone several delays, and is expected to be implemented in 2023, depending on B40 road test result. Moreover, there is not any legal basis yet for the implementation of B40 program.
- The MEMR previously stated that palm oil export shares were only sufficient to fund the B30 program. To develop B40, more budget is required. However, based on IESR's analysis, BPDPKS revenue should be enough to accommodate the B40 program, since it was skyrocketing due to the rising export levies and declining price gap between biodiesel and diesel.
- The increasing price of diesel and declining price of biodiesel narrowed their price gap in January-June. Furthermore, in July-October 2022, the diesel price was still rising when CPO price dropped even more, which resulted in negative price gap. Indonesia's CPO price declined due to the massive oversupply and struggles in restarting exports since banning in April-May.
- BPDPKS revenue was skyrocketing in March-April due to doubled export levies. For instance, CPO export levy was USD 175 in January-February, USD 335 in March, and USD 375 in April (MOF, 2022). After that, it was significantly dropped in May due to export banning. The revenue was zero from July to December due to the removal of export levies. The subsidy was also zero since biodiesel price was lower than diesel price.

Biodiesel price, diesel price and gap



Source: World Bank (2022); MEMR (2022); IESR analysis

Biodiesel price gap, subsidy required, export levy revenue

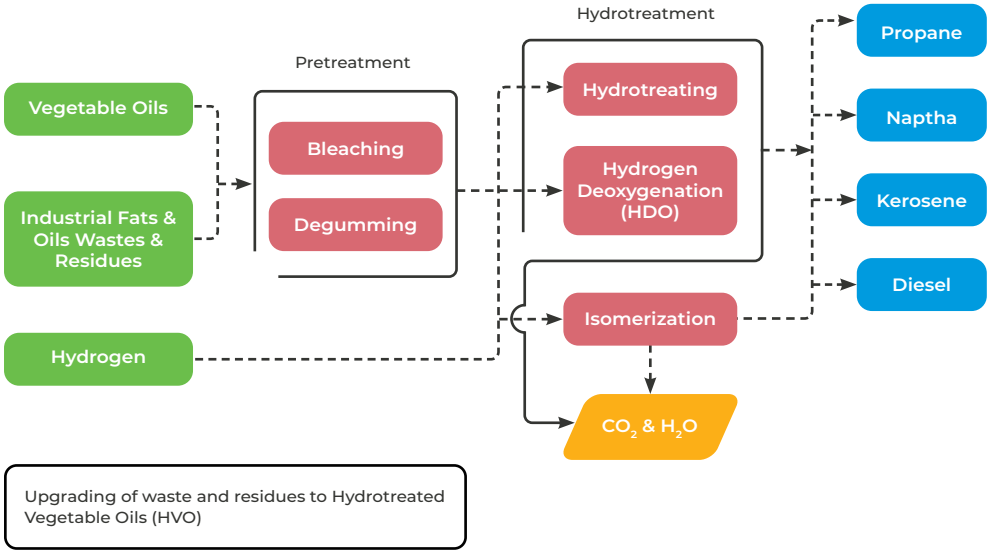


Source: IESR analysis

Despite a major breakthrough in the production of green diesel, its high price and inadequate capacity remain as barriers for green diesel utilization

- Bioavtur J2.4 palm-based SAF and green diesel 100% have been successfully tested in PT Kilang Pertamina's Cilacap Refinery. In its first phase, the Cilacap Refinery is currently producing 3,000 barrels/day of green diesel through co-processing, which combines Refined Bleached Deodorized Palm Oil (RBDPO) and crude oil. The second phase is expected to produce 6,000 barrels/day of pure green diesel, SAF, and *bionaphtha* in 2026, a delay from the previous 2024 target. In addition, green fuels produced by Cilacap Refinery have received an International Sustainability and Carbon Certification (ISCC) and contributed to reducing carbon emissions by up to 65–70% compared to fossil fuels.
- The role of green diesel 100% (D100) is crucial for the implementation of B40. One of the B40 types is B30D10, which is 30% Biodiesel (B100) + 10% green diesel (D100) + 60% diesel oil. To fully use B30D10 as biodiesel B40, it is estimated that 9.7 million kl of green diesel or 168 thousand barrels/day of green diesel production is needed by 2030.

Hydotreated Vegetable Oils (HVO) process for hydrocarbon fuels



Source: Singh & Kalligeros (2018)

- The construction of "Merah Putih" catalyst plant has officially began in March 2022 and is expected to operate in 2023. Estimated investment required is around IDR 286 billion, with installed capacity of 800 tonnes/year. The plant is one of the Green Fuel National Strategic Programs (PSN), aiming to produce catalysts for green fuel.

2.5

Energy Transition in the Industrial Sector

Julius Christian

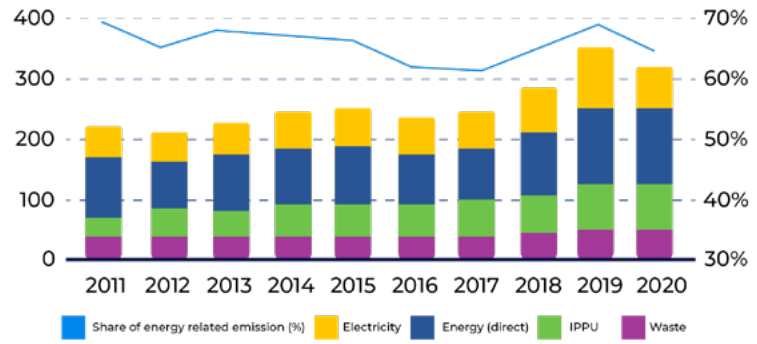
- Cement industry
- Ammonia
- Iron and steel

Energy use, especially from heavy industries, contributes to the majority of industrial GHG emissions

- Industrial GHG emissions are dominated by energy emissions, both from direct combustion and electricity use, at around 60-70%. In 2020, emissions from direct fuel combustion for industrial heat contributed 105 $MtCO_2$-eq, while indirect emissions from electricity uses is estimated at 82 $MtCO_2$-eq*. Emissions from industrial waste and industrial processes contributed 58 and 57 $MtCO_2$-eq, respectively. Cement industry contributes over 50% of the process emissions, followed by ammonia and iron & steel at 16% and 11%, respectively.
- Fossil fuel combustion, particularly coal and natural gas, are the major source of energy in the industry sector, while biomass and electricity only took around 30% of the total consumption. Nevertheless, there is an increasing trend of electricity share in industrial energy use from only 9% in 2011 to over 19% in 2021. However, as the electricity generation in Indonesia is emission-intensive, the electrification trend has not resulted in reduced GHG emissions. On the other hand, oil consumption has declined from 19% in 2012 to only 7% in 2021.
- Few industries, i.e. iron, steel, and metallurgy, cement, and pulp and paper industries contributed to about 70% of the direct energy emissions in industry (IEA, 2022). Iron, steel, metallurgy, and cement industries are major coal consumers outside of power sector. Chemical industry, particularly ammonia, is a major gas consumer for its energy sources and process feedstock. Other industries such as textile, food and beverages, and pulp & paper also use coal at a considerable amount.

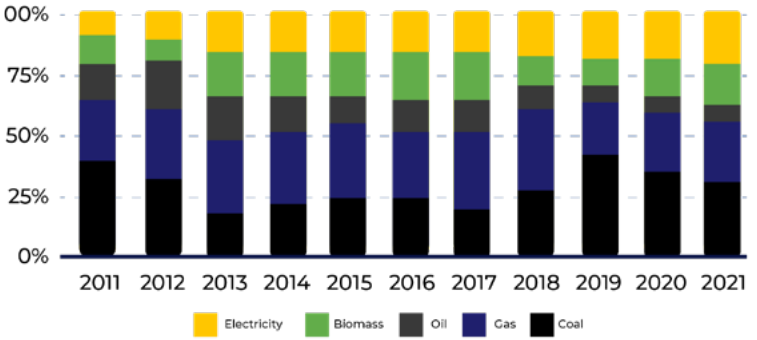
*) This estimation assumes electricity GHG emissions intensity is equal for all user segment. Actual electricity GHG emissions intensity for residential and industrial use might be different as many industrial areas usually have their own off-grid electricity networks separated from the national grid.

Historical GHG emission from industrial activities



Source: MOEF (2022), IESR analysis

Share of energy sources in industry

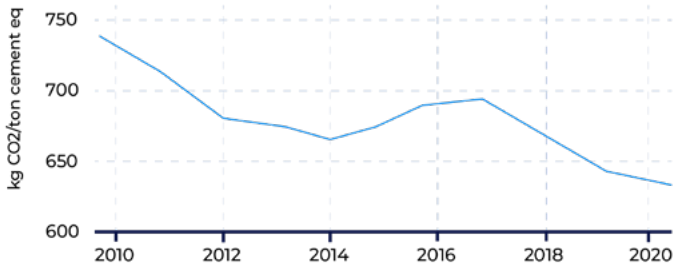


Source: MEMR (2022), IESR analysis

Emission intensity in cement production declines as the industry switches to alternative material and energy sources

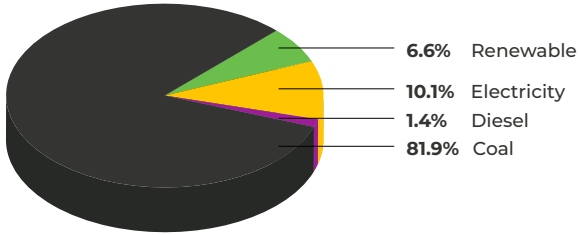
- Cement industry is the largest GHG emitter in the industry sector, mainly driven by its process emissions. In term of energy emission, it came second behind the iron and steel industry. The emission intensity from two largest cement groups responsible for 75% market share was around 0.65 tCO_2/tonne cement equivalent in 2021, and have been in the declining trend. IEA (2022b) estimates that average emissions from cement production should decrease to 0.43 tCO_2/tonne to be compatible with the 1.5°C pathway.
- Clinker production is the most energy- and emission-intensive process in the cement industry. Reducing the use of clinker in cement production is the key to reducing emissions. IEA (2022b) estimates the clinker-to-cement ratio should decline to 0.65 by 2030. The largest cement groups have reached a ratio of 0.7 in 2021, which is on par with the global average, but still far from the best practices. As a comparison, China had the lowest average ratio at 0.58 in 2014 (IEA, 2018).
- Some of the cement production facilities have started to use renewable energy such as biomass and RDF for fuel supply and solar power for electricity. In 2021, renewables accounted for about 6.6% of energy supply in the two largest cement groups.
- Implementation of carbon capture technologies will be necessary in the long term to decarbonize the cement production. However, its development has not seen any substantial progress despite the issuance of the Ministry of Industry Regulation No. 12/2012, which targets CCS technology to be implemented in 2016–2020.
- There are several regulations supporting green cement. The Ministry of Industry has established the green industry standard for cement in 2018, although the standards are too low, e.g. the emission intensity standard is 0.75 tCO_2/tonne cement. The Ministry of Public Works and Housing mandated the use of non-ordinary portland cement in its construction projects through the Ministerial Instruction No. 4/2020.

Average emission intensity from cement production in Indonesia



Source: Asosiasi Semen Indonesia

Average energy mix in two largest cement groups



Source: IESR analysis

Interests in green ammonia technology as an alternative low-carbon technology emerge among traditional ammonia producers

- Indonesia's NDC only identified process efficiency improvement as the main strategy to reduce emissions from ammonia production, targeting to reduce natural gas consumption to 35 GJ/tonne by 2030. Current best available technology for conventional steam methane reforming (SMR) ammonia requires 28 GJ/tonne (assuming excess steam produced is used somewhere else) (IEA, 2021).
- Pupuk Indonesia, the parent company of five state-owned companies responsible for around 80% of ammonia production, has already developed a 40-years roadmap, which aims to reduce its carbon footprint by 2.4 MtCO_2 by 2030 and 2.8 MtCO_2 by 2040. Its strategy includes process optimization, energy efficiency improvement, renewable energy and biomass co-firing, and CO_2 utilization (in liquid CO_2, soda ash, and urea plants*) for the short- and medium-term. In the long-term, it plans to develop blue (beyond 2030) and green ammonia (beyond 2050). In terms of process efficiency, it has already managed to produce ammonia at an average energy consumption of 37 GJ/tonne in 2020.
- Green hydrogen from renewable electricity could be used to replace natural gas as a feedstock to cut emissions in green ammonia production. However, urea production, currently the main market for ammonia, from electricity-based ammonia will need additional sources of CO_2, which will further increase the cost. There have been some interests in developing green ammonia, although all projects are still limited at MoU or joint study agreement stage. In addition, the fact that green ammonia is considered as a potential energy carrier for the low-carbon energy system also attracts energy companies to explore the business. Green Ammonia Indonesia, a subsidiary of Kaltim Parna Industry, appears to be the most advanced in the industry. It has already started the feasibility study for a 300,000 tonnes per year green hydrogen production from hydropower in North Kalimantan, with an estimated investment of USD 300 million, targeting initial production by 2026.
- Equipping the existing SMR process with CCUS (blue ammonia) could be a more scalable measure in the short term as it would reduce emissions by around 90% at only a 10-25% increase in cost compared to up to 115% cost increase for electrolysis-based process (IEA, 2021). Moreover, the CO_2 from process emission is highly concentrated and often utilized for various purposes such as urea production.

Low-carbon ammonia project initiatives in Indonesia

Partners	Technology	Year	Status
Pupuk Indonesia Pertamina Mitsubishi	Green hydrogen and green ammonia value chain and CCUS development	2022	MoU
Green Ammonia Indonesia	Green ammonia production from hydropower	2022	Feasibility study and market sounding
Pama Raya Namhae Chemical Posco International	Green ammonia production and ammonia storage development	2022	MoU
Panca Amara Utama ITB Mitshubishi JOGMEC	CCUS for ammonia production	2021	MoU for joint study (production target 2025)
Kaltim Pama Industri ITB	CCUS for ammonia production	2021	Feasibility study

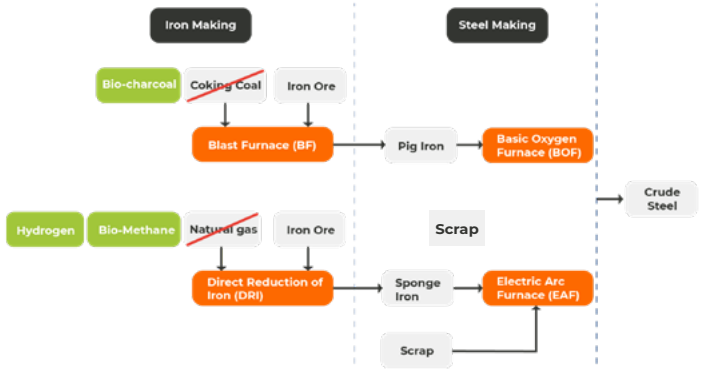
Note: *Companies in italic are existing ammonia producers*

*) Urea production utilizes CO_2, which reduces the process emission. However, the CO_2 will be later emitted during application on agricultural land.

Emissions from iron and steel production will escalate in the next decade as carbon-intensive technologies are being developed

- There are two main routes of crude steel production from iron ore (primary production), the blast furnace-basic oxygen furnace (BF-BOF) and the direct reduction iron-electric arc furnace (DRI-EAF). In addition, scrap iron could also be recycled using the EAF technology (secondary production). Their emission intensity differs significantly from BF-BOF as the most emission intensive, followed by DRI-EAF, and scrap-EAF being the least intensive (IEA, 2020).
- Emissions from energy use have increased by four times in the past decade (IEA, 2022), mostly driven by the increase of BF-BOF plants. Indonesian steel production had mainly used electric arc furnace, which is less emission intensive than BF-BOF process. However, BF-BOF plants have been growing rapidly, with 7.5 Mt per year total capacity added in the past decade, and is expected to continue growing. A total of 29 Mt/year of primary steel production capacity is currently planned until 2030, at least one third of those are identified to be BF-BOF plants.

Iron and steel production routes



Source: Adapted from Desport et al. (2022)

- With most of Indonesia's primary steel production facilities are relatively young, replacing with new low carbon technologies will result in stranded assets. Emission reduction measures in the existing plants will be necessary before they enter retirement age. Substituting coal with bio-charcoal in BF or natural gas with bio-methane in DRI could be a short-term alternative, although supply chain sustainability might be an issue.
- In the long-term, hydrogen could be used to replace natural gas as a reducing agent in DRI plants, although its implementation is uneconomical in the near future. Nevertheless, there is already an interest from Gunung Raja Paksi, which has signed an MOU with FFI, an international green hydrogen developer, to conduct a feasibility study on using green hydrogen in its DRI plant.

Estimated emission intensity of iron and steel production in Indonesia (tCO_2/tonne crude steel)*

	BF-BOF	DRI-EAF	Scrap-EAF
Direct	1.2	1	0.04
Indirect	1.6	0.6	0.48
Total	2.8	1.6	0.52

*) Based on emission intensity in IEA (2020), adjusted to Indonesian electricity emission factor for the indirect emission.

2.6

Energy Transition in the Building Sector

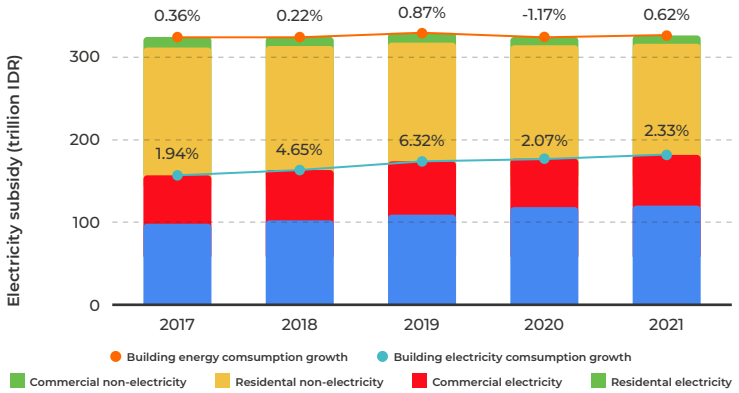
Pintoko Aji, Fathin Sabbiha Wismadi

- Energy in building sector
- Green building
- Space cooling
- MEPS

In the last five years, increasing the share of electricity in the building sector has helped to limit the growth of total building energy demand

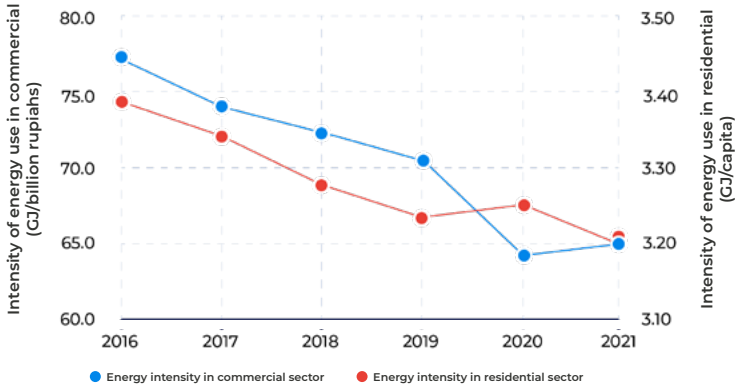
- There is an increase in electrical consumption in the building sector with the annual growth rate of 3.94%, but the trend for its energy consumption remains stable (0.18%) because it is an offset from a decrease in energy consumption from non-electrical uses. Even so, the share of non-electrical uses still dominates the building's energy consumption at 44.3%, 32% of which came from LPG used for cooking. The use of LPG is the largest contributor to direct emissions from building, accounting for roughly 28 $MtCO_2$-eq. Responding to this phenomenon, as well as addressing the issue with LPG imports and subsidies, the government has set a target of converting 8.3 million families to electric stoves by 2022; however, this objective has not yet been reached.
- During the COVID-19 outbreak in 2020, the decrease in electricity consumption in the commercial sector (5.4 TWh) was offset by an increase in the residential sector (8.9 TWh). Meanwhile, compared to BAU, electricity consumption in the residential and commercial sectors was projected to grow by 4.8 TWh/year and 2.9 TWh/year, respectively. This shows that the decrease during the pandemic "lockdown" could avoid 4.2 TWh from the overall increase of the building's electricity consumption.
- Building sector has a decreasing annual energy intensity. In the residential and commercial sectors, energy intensity was reduced by 1.38% and 2.64% per year, respectively (excluding during COVID-19 outbreak in 2020-2021). In 2021, the residential sector had an energy intensity of 3.2 GJ/capita, while the commercial sector had an energy intensity of 64.9 GJ/billion rupiahs.

Energy and electricity consumption in the building sector



Source: MEMR (2022)

Energy intensity in the building sector

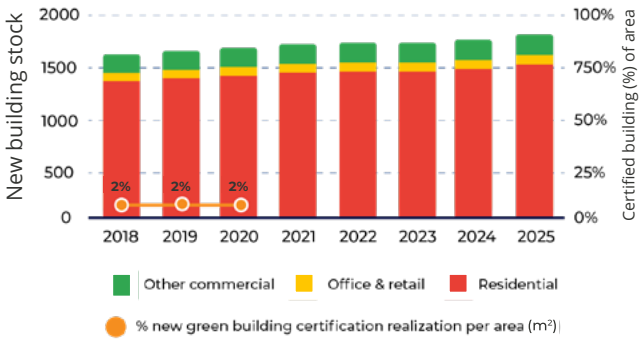


Source: MEMR (2022); BPS (2022)

Public disinterest and incongruous sector targeting cause a modest growth of green building stock

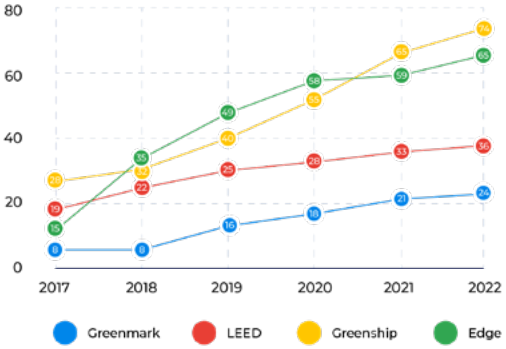
- Green building certification (called Bangunan Gedung Hijau or BGH) is now mandated for some new building criteria under the Government Regulation No. 16/2021 (Appendix C). However, due to the lack of qualified professionals who can act as BGH certification assessors, the regulation is currently still not being effectively implemented. The technical guidelines for assessing the performance of green buildings for BGH are still being evaluated and implemented for certain pilot projects. This implementation preparation phase is targeted to complete in 2026. To accelerate this phase, more capacity building in relevant areas of expertise is needed.
- Most certified green buildings are commercial buildings certified voluntarily by Greenship, Edge, Greenmark, or LEED certification (with the total of 199 certified buildings). Unfortunately, the proportion of certified new green buildings in all new developments in Indonesia (measured in square meters) remains at 2% in 2020 study. Greenship, as the most popular green building certification in Indonesia today, only managed to provide 0.02% energy savings out of national energy demand (291 GWh/year) and reduced 0.03% of national CO2 emissions (259 kt/year). One of the reasons for the low energy savings in green building is that its implementation is still mainly in the commercial sector, although residential energy consumption and building stock dominate the building sector.
- Certified green buildings will receive incentives in the form of reduced building approval fees (PBG) and reduced service fees from the local government (based on Government Regulation No. 16/2021). However, there is still no clear incentive scheme from many local governments. Currently, there are only five cities that have local green building policies: Jakarta, Bandung, Samarinda, Semarang, and Bali (ongoing policy development). One of the good practices to encourage energy efficiency of buildings while increasing their property value as a form of incentive is to procure building energy labels which has been successfully implemented in several countries (e.g., Spain, Austria, the United Kingdom, Denmark, etc).

Growth of new green building stock in square meters



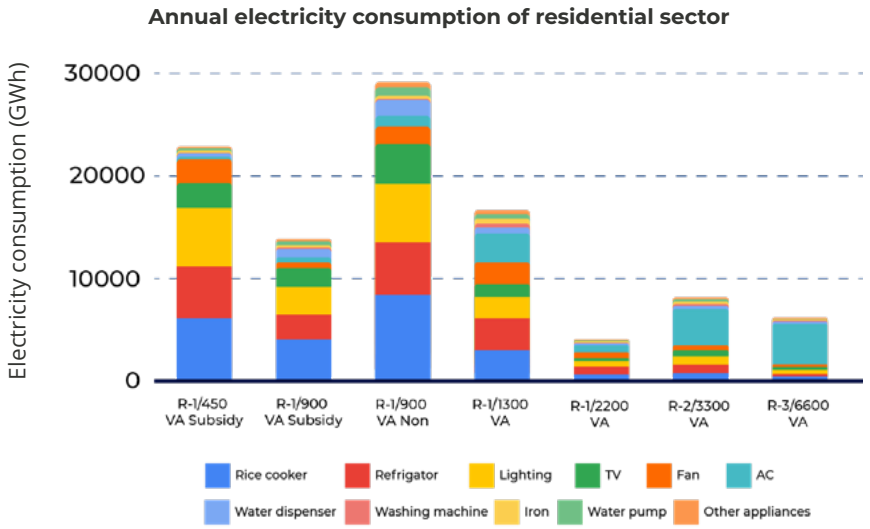
Source: IFC (2020, 2022)

Growth of new green building stock in square meters



Source: SLEB (2022), GBIG (2022), SBH (2022)

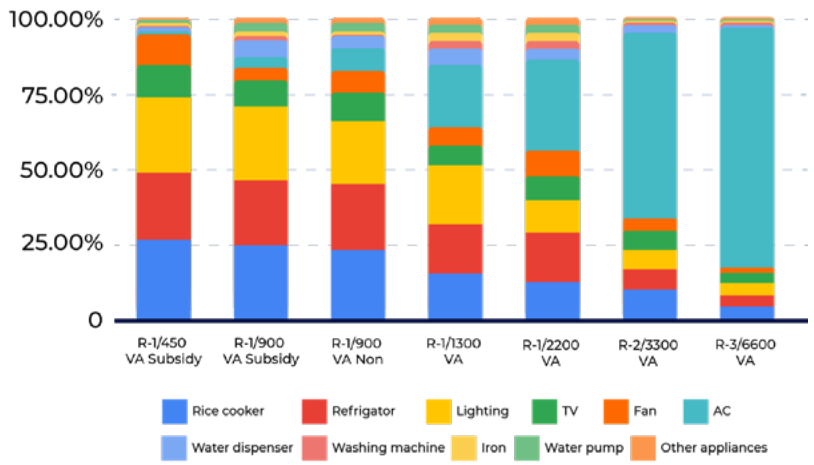
The increased potential for space cooling rises the urgency to provide efficient air conditioning for homes



Source: CLASP & IPSOS (2020)

- Houses with 450VA and 900VA account for 68.1% of the nation's total monthly electricity consumption, greater than other PLN's residential tariff groups. This is due to their large proportion on the residential building stock. However, their emphasis on energy-saving potential will differ from other PLN residential tariff groups, as their share of energy use is largely influenced by other appliances outside the AC (rice cooker, refrigerator, and lighting), which accounts for 47.4% of the total annual electricity consumption.
- Only 8.8% of Indonesian households have air conditioning, but every 1% increase in AC penetration results in a considerable increase in energy demand in the residential sector (1,676.5 GWh per year). The increase in AC penetration mostly occurs in residentials with higher tariff groups (≥ 1300VA) as their share of energy use from ACs accounts for around 20-80% of their total energy consumption with 18-82% of AC penetration rate. Even though their portion of the building stock is low (17.2%), their share of AC consumption accounts for 17.8% of the residential annual electricity consumption.

Share of energy used from residential appliances



Source: CLASP & IPSOS (2020)

Potential energy savings of some energy efficiency strategy

Energy Efficiency Effort		Potential Energy savings
Building Envelope	Ceiling Material	1%
	Walls (material and WWR)	1-9%
	Sun shades 60-120cm	1%
MEPS	HVAC COP 4.2	21%
	LED light	2%
Behaviour	Ceiling fan hybrid	16%
	AC set pooint 25 C	8%

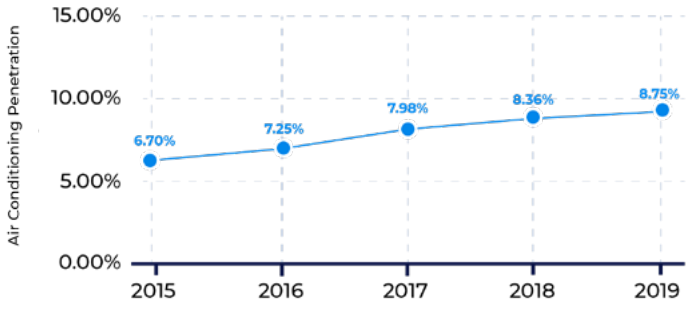
Source: GBPN (2022)

- To address the appliances' energy efficiency issue, the MEMR applies energy labelling with several ratings for appliances called MEPS (Minimum Energy Performance Standards). By using AC with a 4.2 Coefficient of Performance, up to 21% of potential energy saving can be obtained by a building (equivalent to a reduction of up to 11.048 GWh of residential's annual electricity consumption). However, this strategy will have an incremental cost of IDR 3.5 million/unit. Further reductions in electricity consumption can be achieved through greater use of MEPS-labelled appliances at home.
- Behavioral changes to achieve indoor thermal comfort are another energy-saving measure that can be carried out more affordably and without significant changes to building construction. Unfortunately, most Indonesians are unaware of the fact that raising air conditioner's setpoint to above 25°C can save about 8% of their electricity. It is evident in how 70% of them continue to keep their air conditioners set at or below 20°C.

To increase MEPS effectiveness, better MEPS ratings and public awareness are required

- Studies show that all countries have a positive correlation between people's income and AC ownership. The penetration and variety of household appliances also increase as monthly expenditure rises. Households spending more than IDR 6 million/month have a much higher penetration rate for air conditioners and other high-power appliances. With national goals and forecasts calling for a rise in GDP per capita and per-capita income that will concurrently grow, and with the penetration of AC increasing by an average of 0.5% year, the MEPS rating must be adjusted at regular intervals, so that with each new sales penetration, the appliance performance can be ideally increased.
- The national electricity consumption might be reduced by up to 10 TWh per year with a 15% improvement in appliance standards. With this concern, the MEMR has set a target for the issuance of the MEPS regulation for each appliance, prioritizing appliances that have a large proportion of electricity consumption. Regulations for ACs, rice cookers, fans, refrigerators, and LED lamps have been issued, while regulations for washing machines, TVs, induction stoves, water pumps, etc. will be finalized by 2023. By 2025–2030, the MEPS rating will be reviewed and improved. Even so, efforts are needed to increase public awareness as Indonesian residential occupants have only 6.5% awareness of energy efficiency labeling (MEPS).

Penetration growth of ACs in residential



Source: Susenas 2015–2019 from BPS

Roadmap of MEPS implementation program

Year	MEPS Implementation Program	Status
2021	Air Conditioner	Issued regulations
2022	Rice cooker, fan, refrigerator, LED lamp	
	Washing machine, TV	Regulation finalization
2023	Blender, iron, induction stove, water pump, chiller, electric motor, showcase	
2024	Boiler, MEPS rating revision	
2025-2030		MEPS rating revision

Source: MEMR (2022)

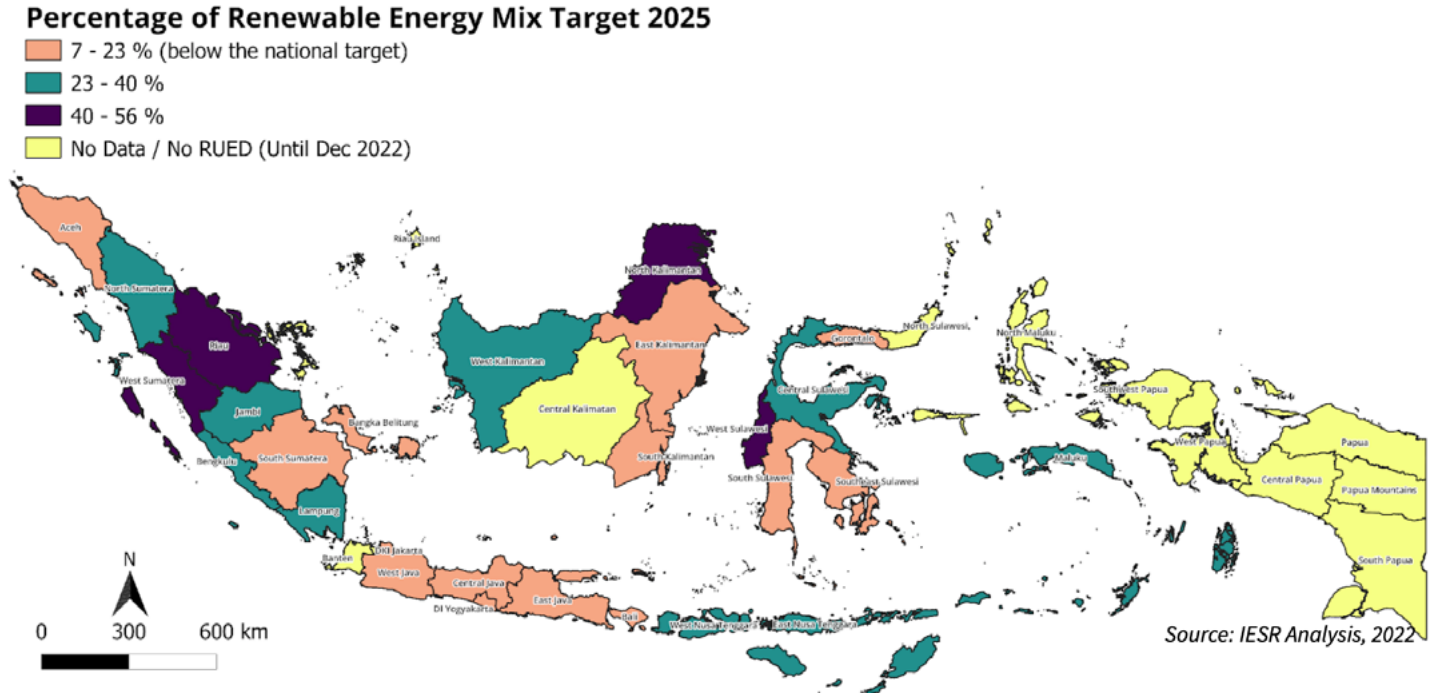
2.7

Energy Transition at the Sub-national Level

Anindita Hapsari, Martha Jesica Solomasi Mendrofa

- Updates on RUED
- Updates in Central Java, Bali, West Nusa Tenggara, and West Sumatra

Nearly half of the RE targets in RUED are lower than the national target; sub-national RE potentials must be optimized

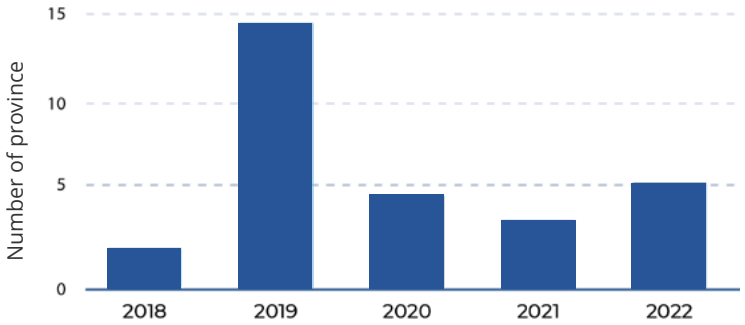


Indonesia is targeting 23% of RE in the national energy mix in 2025. However, 46.2% of provinces that have already had RUED set their RE targets below the national target. These provinces include Aceh, South Sumatra, Bangka Belitung, West Java, Central Java, Yogyakarta, East Java, Bali, East Kalimantan, South Sulawesi, Gorontalo, and Southeast Sulawesi. Nevertheless, some provinces such as West Sumatra, Bengkulu, Lampung, North Kalimantan, Nusa Tenggara Barat, and West Sulawesi set their RE share target above the 2025 national target, even higher than the country's 2050 target, which is 31% of RE use. The fact that 12 provinces are still targeting the RE mix beneath the national target is a source of concern in the energy transition, since it is important for provinces to optimize their regional potential and be in line with the national target. The optimum scenario in each province is determined based on the use of RE to meet the provinces' energy needs (MEMR, 2016).

Setting a more ambitious RE target in RUED and accelerating its implementation are crucial to achieve 2025 objectives

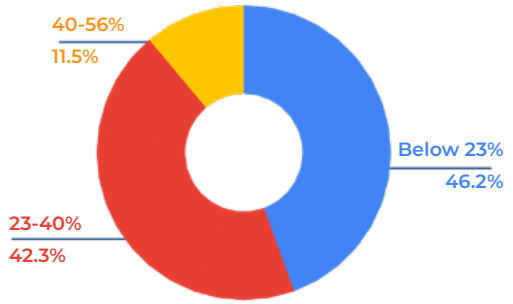
- By Q4 2022, 27 out of 38 Indonesia's provinces (71.05%) have made progress in developing RUED; the latest additions were five provinces that have released their RUEDs in Q4 2022. Although the RUED development process was stalled in 2020 due to the impact of sub-national governments dealing with COVID-19, four RUEDs have been produced in 2020 and 2021. The central government must urge the remaining seven provinces (four new provinces in Papua are excluded) to speed up their RUED developments if it aims to legalize all RUEDs by 2023, according to the National Energy Council's target.
- In terms of 2025 RE share target specified in the RUED, 12 provinces have set their targets below 23% (e.g. Central Java & Bali), 11 provinces have set their targets to 23–40% (e.g. NTB), and three provinces have set their targets to 40–56% (e.g. West Sumatra). According to the RUED, the largest renewables potentials in most provinces are solar, biomass, and hydro.
- Based on PLN data in Q3 2022, the national RE share in the power sector achieved 12.6%, almost achieve target in 2022 (Katadata, 2022). Achieving the 23% RE target is challenging under the current state budget. The annual government budget will only account for 0.83% of the required annual budget to achieve the target in 2025, indicating the necessity for non-public funding sources to fill the financing gap, while the share of regional public budget spending for RE in 2021 remains insignificant (IESR, 2022). Sub-national governments' limited authority in determining RE corresponds to their limited budget allocation. (BisnisID, 2022).
- To ensure the impact of RE development at the local level, the national and sub-national governments must quickly encourage RUED realization and implementation. The stipulation of provincial RUEDs should be immediately accompanied by supporting policies, such as provincial government regulation, governor's letter, and local government-specific budget allocations to ensure equitable RE development.

RUED realization per year (2018-2022)



Source: Complication of RUED Provinces

RE shared target percentage per province (based on RUED)



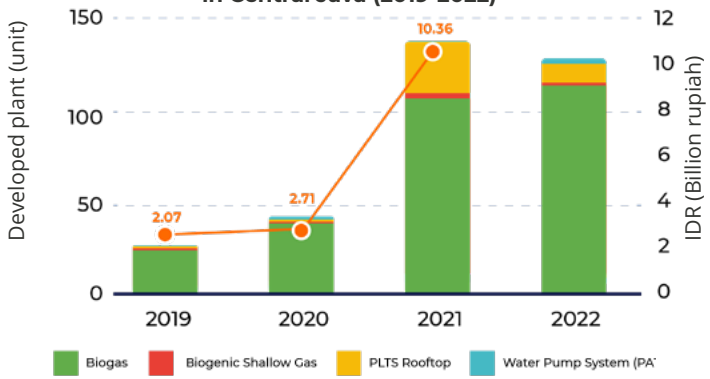
Source: IESR analysis from RUED target 2025, (2022)

The government of Central Java has committed its public budget to the promotion of green recovery following the effects of COVID-19

- Green economic recovery as a government stimulus for economic recovery from the COVID-19 impact, which targets the SME and community, continues to be carried out in 2022. It aligns with the commitment to focus on RE development, mainly on energy independence at the site level. Green economic recovery accelerates the ongoing RE development.
- According to the data from APBD 2022*, from around IDR 9.8 billion of the RE infrastructure budget that is allocated for the green economic recovery (RE development & installation), biogas has the largest budget (IDR 4.2 billion), followed by rooftop solar PV and PATS. As stated by the Central Java EMR Office, the current biodigester program with a small capacity can achieve a wider target than the communal size with the same budget. It confirms biodigester's achievement as the highest realization of infrastructure development over last 3 years.
- Around IDR 1.9 billion is allocated for the installation of PATS in 3 villages to boost farmer's income from the agriculture sector. PATS could enable farmers to harvest 2–3 times a year, while reducing emissions from combustion (202,500 tonnes of CO2 is released per 75,000 kiloliters of fuel for 276,000 Ha of non-irrigated rice field, as estimated by a case study in Central Java in 2019 (IESR, ESDM Jateng, 2022).
- According to the information provided by the Central Java EMR Office, the total of built RE infrastructure reached its highest number (137 units) in 2021, in alignment with the highest amount (IDR 10.4 billion) of RE budget spent in the same year for all types of RE, including the non-green economic recovery RE type (micro hydro plant). Based on an estimate using 2022 budget proportion as a reference, approximately 98.20% of the 2021 budget is allocated for green economic recovery.

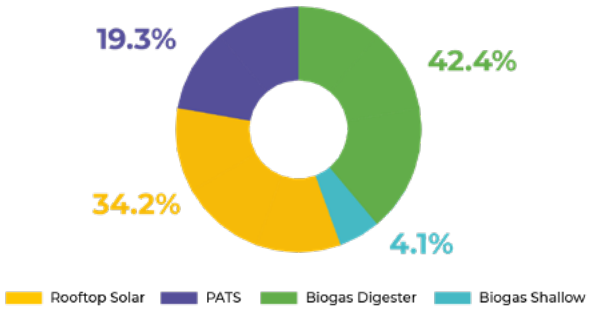
*) based on APBD data as of October 2022

Budget realization & developed infrastructure in Central Java (2019-2022)*



Source: Central Java EMR Office, (2022)

Shared installation budget percentage from APBD 2022 (in total: IDR 9,836,000,000)*



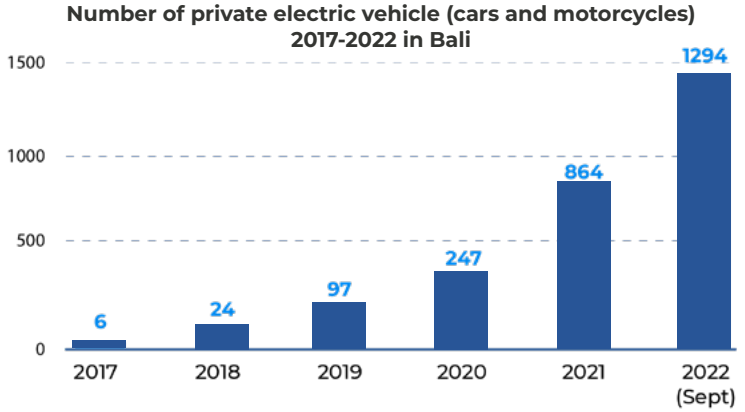
Source: Central Java EMR Office, (2022)

Bali issued supporting regulations as catalysts to advance efforts to increase electric vehicle adoption

- Bali has issued a regulation about RUED and two regulations on the mainstreaming of EV (see table below). In 2020, Bali stipulated the Local Government Regulation No. 9/2020 about the RUED, in which the province has set a target of 11.15% renewable energy mix by 2025. However, Bali only had 1.29% of renewable energy share in its energy mix in 2021. Nevertheless, in 2019 Bali also issued the Governor Regulation No. 48/2019 about the use of Battery-based EVs, which sets the commitment to build a healthy ecosystem for EVs and results in the increasing number of EVs in Bali.
- Bali is the first province in Indonesia to issue a regulation on EV. Number of EVs in Bali has increased in average by 2.5 times per year the issuance of the regulation, from 97 units in 2019, to 247 units in 2020, 864 units in 2021, and 1,294 units in 2022. Compared to the national level in 2022, the number of EVs in Bali is almost 6% of the total number of EVs in Indonesia, which is not significant, but increases every year. Besides, Bali also has 21 charging stations, 6 public battery exchange stations, and around 100 battery swap places across Badung and Denpasar, owned by Indonesian SEOs and companies.

EV Related Regulation		
Regulation	**Subject**	**Summary of content**
Governor Regulation No. 48/2019	The Use of Battery-based EVs	There are fiscal and non-fiscal incentives to accelerate the use of battery-based electric vehicles
Governor Instruction No. 11/DISHUB/2021	Procurement of Battery-based EV within the provincial government	Instruct government agencies, area management authorities, SOE/LOE, and public transportation companies to gradually use battery-based electric vehicles

Source: IESR Analysis from Compiled Regulation, (2022)



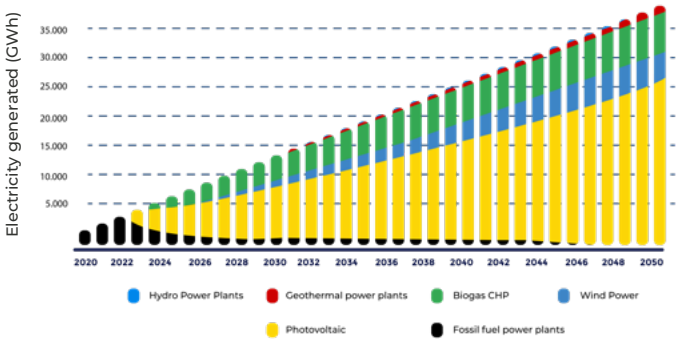
Source: IESR Analysis from Data Number of Registered EV in Bali's Department of Transportation, (2022)

- This year's G20 Summit in Bali also hastens the development of EV infrastructure. During the G20 Summit, all vehicles used in the venue were EVs, including about 400 electric motorcycles, 300 electric cars, and 32 electric buses. The central government worked with the brand owner agency to handle EV procurement, so further use of these EVs after the event is authorized by each brand.
- After the release of the EV regulation in 2019, the number of EV increased by 150% or 2.5 times in 2020, and then increased again by 250% or 3.5 times in 2021, after targeting renewable energy mix on RUED. The increase in the number of EVs, infrastructure, and services shows that the presence of local regulations encourages the EV industry ecosystem, as the presence of regulations attracts investors to use Bali as a test bed.

NTB is a frontrunner in the energy transition by aiming to achieve NZE 2050 earlier than the national target

- NTB's RUED targets a 35% renewable energy mix by 2025, exceeding the national target. RE power plant capacity in NTB in 2022 reached 45.2 MW, accounting for 13% of the province's total energy sources.
- NTB aims to achieve the NZE 2050 target, earlier than the central government. However, the NZE 2050 roadmap is still being developed and is expected to be finalized by Q1 2023 to be in time with the revision of the RUEN and NTB's RUED.
- NTB has developed a scenario in the power, transportation, industry, and building sectors to meet the NZE 2050 target. NTB plans to generate 100% renewable electricity, starting with photovoltaics and progressing to biogas CHP, biomass, and wind power plants. According to the scenario, solar PV will dominate NTB's power generation by 2050 with a share of 68%. In the transportation sector, NTB aims to have about 82% electric vehicles and the remainder hydrogen vehicles by 2050. NTB's goal in the residential sector is to obtain a cooking supply of 5,000 GWh biogas stoves by 2050. Finally, in the industrial sector, NTB focuses on energy saving and the use of hydrogen and synthetic fuels for heating and fueling.
- NTB has 20 MW of solar PV and 15 MW of hydro power plants until 2022. Aside from the existing RE power plants, there are plans to construct a 115 MW wind power plant and a 20 MW biomass power plant in Lombok Island using grants and soft loans from foreign funds. In this initial stage of energy transition, the Jeranjang Coal Power Plant in West Lombok also utilizes Refuse Derived Fuel (RDF) with a maximum of 5% biomass RDF mixing (Mulhidin, 2022). In addition, NTB has notable local initiatives such as co-funding 8,471 units of biogas household by public, local and international organisation.
- All the progress NTB has made in the energy transition is commendable, positioning NTB as a frontrunner in the energy transition. NTB's progress proves that declaring an optimistic target can also be a strategic move to overcome financial constraints.

Generated electricity towards NTB NZE 2050



Source: NTB 100% RE Modelling for WNT by ISE ICLEI, (2022)

Installed Capacity of Operated and Planned Renewable Energy Power Plants in West Nusa Tenggara 2022

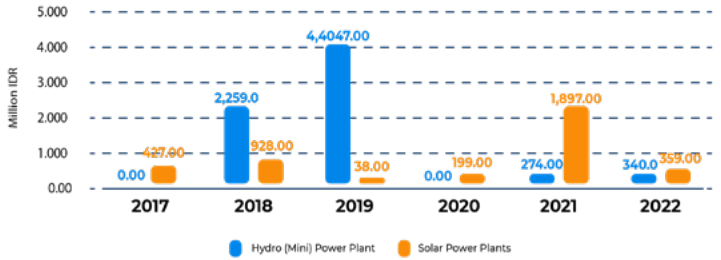
Types	COD Capacity (MW)	On planning Capacity (MW)	Status on planning	Power plant locations
Solar power plant	20	10	COD plan 2023/2024	Central and East Lombok
Mini-hydro power plant	14.4	0	-	North, West, and East Lombok
Micro-hydro power plant	1.35	0	-	Mataram, West & East Lombok
Biomass power plant	0	20	COD plan 2025/2026	West Lombok
Wind power plant	0	115	COD plan 2025/2027	East Lombok
Geothermal power plant	0	20	FS has not started yet	Lombok Strait and Alas Strait

Source: Data Inventory of NTB Energy and Mineral Resources Agency, (2022)

Hydropower is one of the most potential renewable energy to be utilized as power source in West Sumatra

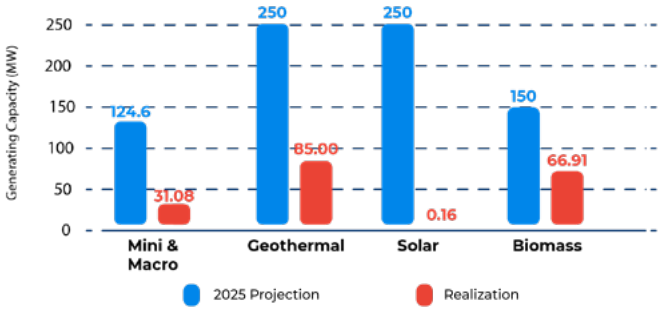
- West Sumatra as one of the provinces that target the highest RE mix in 2025 (51.7%) has made a fairly concrete path in the development of its renewable energy over the last 2 years, in which the province's RE mix reached 27.72% and 28.19%, exceeding the national achievement of 11.20% and 11.5%. The administration of West Sumatra has demonstrated its commitment to meeting the target by raising the RE budget (for 2022-2026) by an average of 3% in its RPJMD. In 2022, the budget for RE is IDR 0.36 billion.
- According to its RUED, hydropower and solar are the two main potentials for RE in West Sumatra. With the common use of mini- and micro-hydropower plants in remote areas and huge hydropower potential, West Sumatra is accelerating the achievement of its annual target of high REmix. West Sumatra has abundant water resources and hydropower potential that have not been utilized. The local mastery of the technology, ease of operation, and low operating and maintenance cost make mini and micro-hydropower plants the primary source of RE for community use (Sumbarprov, 2017). According to the RUED, solar power potential is 5.8 GW, hydropower potential is 3.6 GW, and micro-hydropower potential is 1.3 GW.
- During the 2017–2022 period, mini-hydropower plant had the largest budget realization in 2019 with the construction of 2 units of mini-hydropower plants, while solar power plants had the largest budget realization in 2021 with 58 infrastructure units built in that year. From the province's 2025 generating capacity projection data, there is still a gap between the installed and target capacity of 4 types of RE in 2022, with the largest being in solar and geothermal.
- According to the West Sumatra EMR Office, installed solar PVs for communal (offgrid) use in 2022 are less than 50 units. For biomass, the 2022 detailed progress from the total of 66.91 MW realization in 2017–2022 is available.

Hydro (mini) power plant and solar power plant budget realization (2017 - 2022)



Source: West Sumatra EMR Office (2022)

Projected vs realized generating capacity of RE power plants in West Sumatra in 2017-2022



Source: RUED West Sumatera (2019), West Sumatra EMR Office (2022)

3

Energy Transition Finance Trends

Fabby Tumiwa, Farah Vianda, Ichsan Hafiz Loeksmanto

- Global energy transition investment
- Public budget allocation
- Green sukuk
- Energy Transition Mechanism
- Bilateral and multilateral financing

Investing USD 20–29 billion annually in renewables supply, energy efficiency, energy storage, and network infrastructures by 2030 is required for Indonesia to reach net-zero emission by 2050

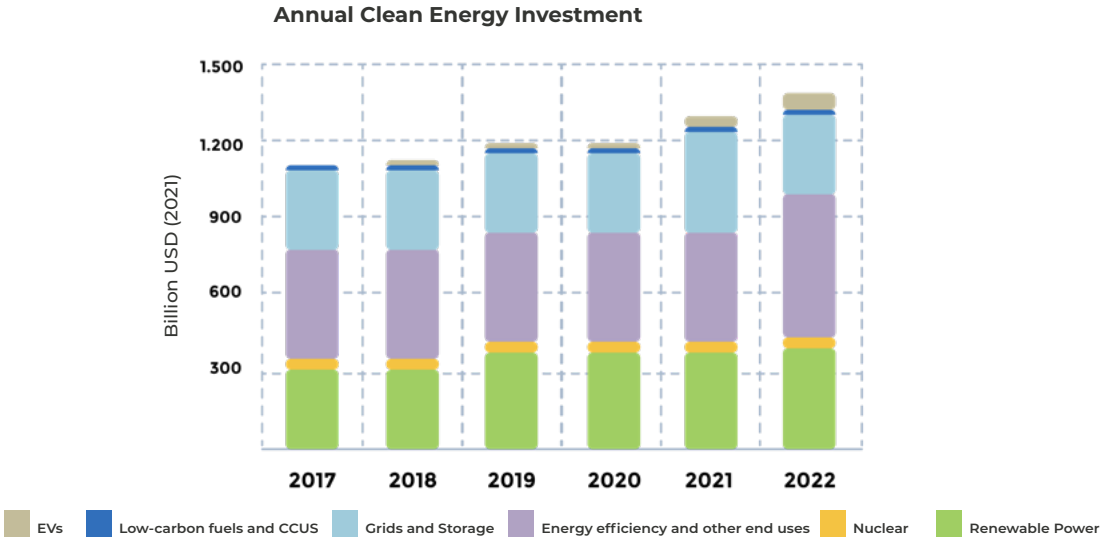
- IRENA's Indonesia Energy Transition Outlook with 1.5°C scenario and net-zero emission by 2050 showed that Indonesia's energy sector would need between USD 73 billion and USD 76 billion in total investments between 2018 and 2050. In the shorter term, from 2018 to 2030, IRENA estimated that Indonesia would need to invest USD 44 billion in Solar PV, USD 22 billion in hydropower, USD 17 billion in other renewable energy technologies, USD 75 billion in grid, and USD 5.5 billion in energy storage.
- Under the 1.5°C pathway, IESR's Deep Decarbonization (DD) estimated that from 2021 to 2030 Indonesia will need to invest between USD 20 and USD 25 billion annually to meet 100% renewable energy by 2050. Also, the country will need to spend USD 60 billion every year from 2030 to 2040 to speed up efforts to cut carbon emissions.
- Both IRENA's IETO and IESR's Deep Decarbonization identified that solar PV is the top technology eligible for financing. This is because solar resource is largely available, its cost declines rapidly, and it is faster to build.
- In order to meet the financing needs of the energy transition, Indonesia needs to obtain more funds from private sources, find ways to deal with the risks brought by financing, and use public finances as leverage.

Energy Transition Investment in Electricity (2022-2030)

Technology	Investment requirement from IRENA's IETO (USD Billion)	Investment requirement from IESR's DD (USD billion)
Solar PV	44	45.6
Hydro	22	36.2
Geothermal	15	79.1
Energy Storage	5.5	7
Grid (HV)	43	3.3
Biofuels/Biomass & Waste	19	2.3

Source: IESR (2021) and IRENA (2022)

Global clean energy investment has reached a new high as the world diversifies its energy sources and accelerates its decarbonization efforts



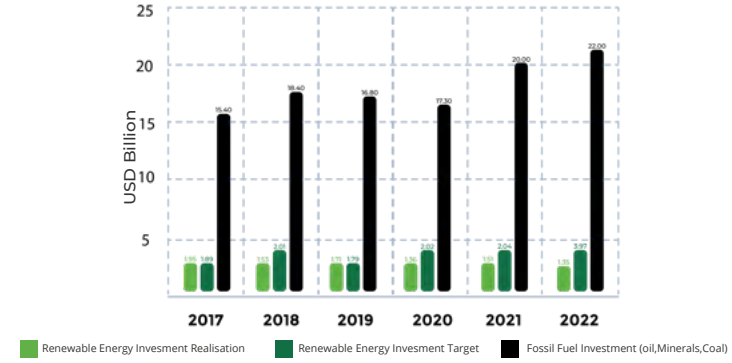
Source: IEA (2022)

- Reaching Net-Zero Emission by 2050 requires huge investment, accounted for 4% of GDP by 2030 (IEA, 2022). Annual energy investment must increase from an average of USD 2 billion today to USD 4.5 billion in 2030. Investment in energy transition has been gaining more steam in 2021 and 2022. The clean energy investment reached USD 1.1 trillion in 2021 and is expected to be USD 1.4 trillion by the end of 2022, two-third of the total USD 2.4 trillion of global energy investment.
- Investment in renewable energy is USD 489 billion, energy efficiency USD 369 billion, electricity network USD 318 billion, and energy storage USD 18 billion, increased by 6%, 12%, 3% and 50% from previous year, respectively. In the power sector, renewable power generation investment in 2022 reached USD 472 billion, almost four times of the investment in coal and natural gas power plants.

Public budget allocation remains high for fossil fuel subsidies; investment in renewable energy remains insufficient for Indonesia to achieve 23% of renewables by 2025

- The average annual investment realization for the renewable energy (RE) sector from 2017 to 2021 was only USD 1.62 billion, well below the USD 8 billion annual investment required for Indonesia to meet its 23% RE target by 2025. As of Q3 2022, RE investment realization had only reached USD 1.35 billion, accounting for 34% of the ambitious annual target of USD 3.97 billion. In comparison, investment realization for fossil fuels is already USD 13.70 billion, which is significantly greater than the amount invested in RE.
- In terms of public budget allocation, throughout 2018-2020 the total public budget for climate mitigation in the energy sector allocated by the MEMR Directorate of Renewable Energy and Energy Conservation (Ditjen EBTKE) only accounted for USD 67 million per year. If this trend of public budget persists until 2025, the annual government budget will only account for 0.83% of the USD 8 billion required to achieve 23% RE share in 2025. Other funding sources are required to close the funding gap.
- Fossil fuels in Indonesia still benefit from government subsidies. Throughout January-October 2022, the government has channelled IDR 404.32 trillion subsidies for fossil fuels, consisting of IDR 95.4 trillion for fuel and gas, and IDR 40.79 trillion for electricity subsidy, along with IDR 268.13 trillion fuel and electricity compensation for PT. Pertamina and PT. PLN. With 88.5% of Indonesia's energy mix relying on fossil fuels (oil and gas at 50.5% and coal at 38%), competition with subsidized fossil fuels continue to put renewables at a competitive disadvantage, further hindering investor's confidence in investing in renewable energy.

Investment realization and targets for renewable energy and fossil fuels (2017-2022)



Note: ** USD 1.35 billion of Investment realization in 2022 is an accumulation as per November 2022, and value of fossil fossil fuel investments in 2022 only accounts for targets set for 2022.

Source: MEMR, 2022; MEMR, 2021; MEMR, 2017; International Institute for Sustainable Development, 2021; IESR, 2019.

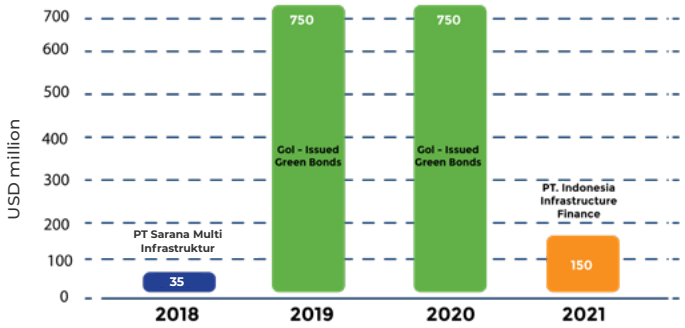
Indonesia Energy Subsidy 2019 - October 2022

	2019	2020	2021	JAN - OCT 2022
Fuel and Gas Subsidy	84.2	47.7	47.7	95.4
Electricity Subsidy	52.7	61.1	56.61	40.79
Fuel and electricity compensation	0	92.77	50.1	268.13
Total	136.9	201.51	190.5	404.32

Source: Ministry of Finance, 2022

Green Sukuk proceeds allocated to RE have only recently grown, and sovereign green bonds continue to support renewables

Green bonds (non-sukuk) issued by government and state-owned enterprises



Source: IESR analysis

Green sukuk use of proceeds for re

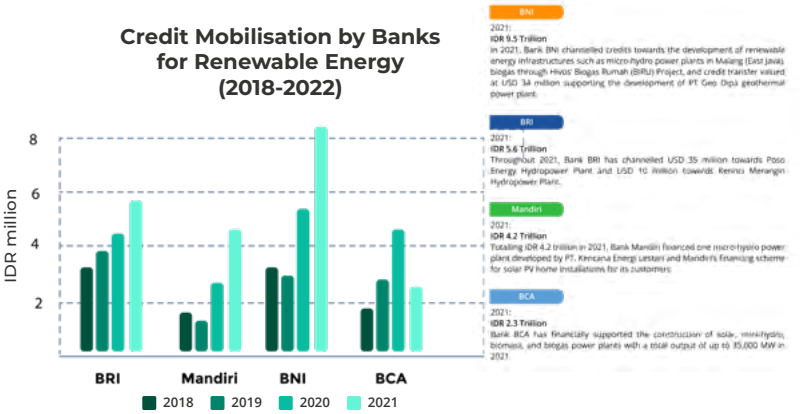
Green Retail Sukuk		
Year	Value of Use of Proceeds For RE	% for RE from total proceeds for all sectors
2021	USD 84.3 million	22.80%
2020	USD 72.29 million	21.1%
2019	USD 42.9 million	0

Global Green Sukuk (GGS)		
Year	Value of Use of Proceeds For RE	% for RE from total proceeds for all sectors
2021	USD 164.8 million	21.9%
2020	0	0
2019	USD 42.9	5.4%

- In terms of sovereign debt instruments, the government has issued sovereign green bonds, bringing the total of USD 1.5 billion, as well as green bonds totaling USD 153 million issued by state-owned enterprises such as PT. SMI and PT. IIF. Furthermore, the government has issued Green Sukuk with a total value of IDR 45.4 trillion (USD 2.8 billion) for the period 2019-2021. However, Green Sukuk use of proceeds allocated for renewable energy had only recently shown a trend of growth, with Green Sukuk use of proceeds in 2021 mostly used to fund RE projects from previous fiscal years, i.e., projects from fiscal year 2017. This demonstrates the lack of bankable RE projects to be funded by Green Sukuk proceeds, as well as the difficulties encountered by the government in justifying RE proceeds allocation to investors through proper monitoring, reporting, and verification measures for projects in the RE sector.
- Specifically for non-sukuk green bonds, government-issued green bonds (sovereign green bond) issuance in foreign currencies (FCY) dominates the bonds issued in Indonesia, totalling USD 2.2 billion throughout 2019-2021 (ADB, 2021). In comparison, domestic green bond issuance (LCY) accounts for only 0.01% (USD 49.68 million) of the total green bond issuance throughout 2018-2021. The low share of LCY is one of the indicators that demonstrate the unattractiveness of domestic green bond market, the reliance on foreign currency lending, and the increased exchange rate risk of green projects.
- Since the OJK regulation on green bonds was issued in 2017, only two private companies have issued green bonds and used the proceeds solely for Renewable Energy Projects, further demonstrating the prevalence of government-issued green bonds. Small instances of corporate-issued green bonds in Indonesia for renewables are due to the uncertain fiscal and non-fiscal incentives to support green bond issuance, the novelty of Indonesia's green taxonomy, and the availability of bankable projects suitable for investor appetite.

Indonesia's sustainable financing is improving as the the banking industry invests more in renewable energy, but the country's Green Taxonomy could use some work

- There are several local banks with the highest total asset value in 2021 towards both the fossil fuel and RE sector. For RE financing, BNI ranked the highest in terms of credit mobilization towards renewable energy (IDR 9.5 trillion), followed by BRI (IDR 5.6 trillion), Bank Mandiri (IDR 4.2 trillion), and BCA (IDR 2.3 trillion). In comparison, from January 2019 to November 2021 these four banks have financed coal for a total of IDR 94.4 trillion through loans and underwriting. It should also be noted that the total credits disbursed for RE are still minuscule compared to the sum of their sustainable portfolio, only 0.9%-5.5% from the amount of sustainable portfolios of these banks in 2021. Indonesian banks like BRI and BNI, and international banks operating in Indonesia such as CIMB Niaga, DBS, Standard Chartered, and United Overseas Bank (UOB) have formally announced that they will cease credit allocation towards Indonesia's coal sector.
- Financial Services Authority's Green Taxonomy Document Version 1.0, aims to remedy some of these challenges. Utilising a 'traffic light' approach, this document aims to encourage financial institutions, investors, and business actors to allocate their funding and investment in low-carbon economic activities and serves as a reference for disclosing information regarding funding and investments for green and non-green economic activities. Our analysis shows activities such as coal mining belong the yellow category, and in contrast, activities like RE power generation belong the same category as power generation from fossil fuels as green. Whereas, activities of government agencies in the fields of mining and excavation, electricity, water, and gas were automatically categorized as green.
- Our assessments show several key improvements to be taken into consideration for further development of the Green Taxonomy: 1) Incorporate a clear framework for how financial institutions can identify taxonomy classifications on their portfolios and loan books; 2) Create more specific criteria based on climate impact measurement; 3) Evaluate 'transitional activities' under the yellow category, particularly unabated oil, gas, and coal-fired power projects; 4) Align the taxonomy with international acceptable standards to compete with international market.



Source: IESR analysis

Category	Explanation
Green (do no significant harm, aplly minimum safeguard, provide positive impact to the environment and align with the environmental objective of the taxonomy	Bussiness activities that protects, restores, and improves quality of enviromental protection and management, as well as climate change mitigation and adaption, and comply with the governance standards set by teh goverment, and apply best pratices at both national and international levels.
Yellow (Do no significant harm)	Determination of business benefits for enviromental protection and management must still be conduced through measurement of othe best practices.
Red (Harmful activities)	The Business Activities that do not meet the yellow and green criteria/threshold.

Source: Indonesia Green Taxonomy Document Version 1.0 (2022)

Bilateral financing remains critical to Indonesia's successful energy transition investment

Bilateral Financial Support (2021 to 2022)

Country	Type	Total Amount	Details
United Kingdom	Technical and Financial Assistance	USD 29 million TA and USD 1 billion FA (JETP)	*UK's Menuju Transisi Energi Rendah Karbon Indonesia* (MENTARI) is a GBP 13.5 million (USD 16.6 million) program to support low carbon energy development and energy access in Indonesia. An additional UK Pact has total funding of GBP 14.2 (USD 17.5) million for energy, mobility, and policy reform. UK's commitment made under JETP will be channeled through a loan facility from the World Bank.
Japan	Memorandum of Cooperation	N/A	Collaborations on a net-zero energy transition roadmap development, technology development and dissemination (hydrogen, ammotnia, carbon recycling, and CCS/CCUS), and support in multilateral forums to accelerate technological cooperation.
United States	Project Grant	USD 38.8 million TA	Sustainable Energy for Indonesia's Advancing Resilience (USAID-SINAR) project (2021-2025). This program aims to mobilize USD 5 billion worth of private and public financing for investments in renewable energy and support the installation of 2,000 MW of RE.
Germany	Technical and Financial Assistance	USD 2 billion	A package of grant for TA and financial assistance to support energy transition by developing RE sources such as hydropower, mini-hydro, geothermal, and solar power plants, as well as provide training and capacity building. This is to support the government to meet the 23 percent renewable energy mix by 2025. Germany also provides technical assistance through various projects run by GIZ.
France	Technical Assistance & Loan	USD 544 million	A concession loan scheme for developing the Sustainable and Inclusive Energy Programme Policy, concession loans to PLN for transmission and distribution projects, grants for experts, and feasibility studies; opening opportunities for credit to state-owned banks for mini hydropower projects, among other RE technologies.
Norway	Technical Assistance	USD 28,7 million	Channelled through Indonesia Sustainable Landscape Management Multi-Donor Trust Fund (SLM-MDTF). The technical assistance aims to enable climate and green finance investments in Indonesia through operating and capacity building of BPDLH.
Singapore	Investment	USD 5 billion	Fund the development of a logistics hub in Tanjung Priok Seaport, and renewable energy projects in Batam, Riau Islands, Sumba Island, and West Manggarai (East Nusa Tenggara).
New Zealand	Project Grant	USD 3.6 million	Grant funding agreement for the "Renewable Energy: Accelerated Transition Indonesia (RE-ACT)" project, aiming to support the policy framework implementation, stakeholder engagement and capacity development, as well as providing a design of de-risking instruments and financing mechanisms.
Australia	Cooperation Project	USD 200 million	Climate and infrastructure partnership. No details available yet as of Q3 2022.
Denmark	Cooperation Project	USD 8.3 million (INDODEPP)	Technical assistance under government-to-government cooperation on energy modelling, energy policy and planning, exchange of experiences on system, regulation, and incentives for managing renewable energy integration, as well as development of institutional capacities and infrastructure related to energy system efficiency. INDODEPP runs from 2020 to 2025.

Source: IESR analysis

At least ten countries have committed to support Indonesia's energy transition through financial and technical assistance, grants or collaborative projects, through bilateral pledges and investment plan. The US, UK, and Germany are very active in the field of renewable energy and energy efficiency and provide a great support to reform relevant policies, coupled with investment mobilization target. However, based on recent pledges in the table above, the total value of financial support in various forms only reached at least USD 14 billion (including USD 1 billion from UK's commitment under JETP). It is only less than 37% of the total projected financing needs by 2025, indicating the need of more international support and private investment for energy transition.

Financing supports from multilateral development agencies for just energy transition have emerged, but achieving meaningful results requires better planning and coordination

Southeast Asia Energy Transition Partnership (ETP)

- ETP is a multi-donor partnership of government and philanthropic donor partners to support a sustainable energy transition in Southeast Asia (Indonesia, Philippines and Vietnam), with UNOPS as the fund manager. ETP managed USD 24–25 million budget to spur rapid deployment of clean energy. The total commitment is USD 16.6 million, with 5.5 million allocated for Indonesia. This partnership engages Bappenas as its political partner in Indonesia to work on:1) Modernizing and integrating electricity infrastructure; 2) Developing financial risk study; 3) Knowledge and capacity development; 4) Policy alignment (ETP, 2022a).
- Funding for the ETP is sourced from French Development Agency (AFD), Germany's Ministry for Economic Affairs and Climate Action, UK's Department for Business, Energy and Industrial Strategy, and Canada's Department of Environment and Climate Change. In addition, philanthropic donors includes the Children's Investment Fund Foundation (CIFF), IKEA Foundation, and Windward Fund (ETP, 2022b). As per November 2022, the ETP supports 17 projects in Indonesia amounted USD 1.39 million of USD 4 million total financial commitment in 2021/2022 (ETP, 2022c; 2022d).

Climate Investment Funds (CIF) Accelerating Coal Transition Programme

- In 2021, Indonesia proposed funding from Climate Investment Fund (CIF) under Accelerating Coal Transition (ACT) for the Energy Transition Mechanism (ETM) in Indonesia. The ACT programme will support accelerated retirement of coal plants, decommissioning and repurposing coal plants, mine closure (including just transition for the workers impacted by the closure), and scaling up renewable energy and storage.
- ACT will support Indonesia to strengthen the enabling policy and infrastructure readiness for CFPP retirement and replacement by RE generation in order to avoid 77 $MtCO_2$-eq greenhouse gas emissions and mobilize USD 2.2 billion in MDB co-financing and over USD 1.3 billion in commercial co-financing for retiring up to 2 GW of CFPP, reclaiming, reforesting, and restoring 150 hectares of mine area, and saving 3,504 GWh energy per year from CFPP closure and repurposing. Lastly, the financing will also be utilized to install RE up to 550 MW and energy storage capacity up to 380 MWh. The program seeks to support 1,160 employees of retired CFPP and coal mine with access to sustained income, and 3,200 direct beneficiaries of social plant and economic regeneration activities.

The Energy Transition Mechanism (ETM) as a blended finance platform has few pilot projects of coal phase out to test its effectiveness

CFPP Finalized for Early Retirement under ADB's Energy Transition Mechanism Country Platform (November 2022)							
Name of CFPP	Owner	Capacity	COD	Natural Retirement	Early Retirement	Total Transaction (USD million)	Retirement Financing Scheme
Cirebon-1	Cirebon Electric Power	660 MW	2012	2042	TBA	250-300	Blended Finance
CFPPs Finalised for Early Retirement under PLN Early Retirement Scheme (November 2022)							
Pelabuhan Ratu	PT. PLN	3x350 MW	2013	2045	2028	800	Acquisition model/spin-off scheme between PT. PLN and PT. Bukit Asam, refinancing through blended finance
Pacitan	PT. PLN	2x315 MW	2011	2045	TBA	800	Blended finance, spin-off scheme.

Source: IESR analysis

- Indonesia launched the Energy Transition Mechanism (ETM) Country Platform in G20 summit this year. The Minister of Finance announced that the ETM Country Platform aims to: (1) achieve optimum energy mix according to National Energy Policy; (2) reduce greenhouse gasses to achieve NDC and NZE in Indonesia's power sector (15 $MtCO_2$-eq by 2030 or 160 $MtCO_2$-eq by 2040) ; (3) shorten the economic performance of CFPPs; and (4) accelerate investments for Renewable Energy Power Plants. It is important to note that ETM shall support the acceleration of CFPP phase-out and RE deployment based on Indonesia's RUPTL 2021-2030, which aims to achieve 51.6% of RE and 48.4% of fossil fuel in the national energy mix by 2030.
- Recent updates following the formal launch of the country platform in November highlighted the country platform's high commitment towards early retirement of CFPPs. Early retirement will be done through the Carbon Reduction Fund Platform, particularly through spin-offs of CFPP assets where third parties will procure the assets in return for cash and equity, which will then be utilized to repay investors, similar with ADB's International ETM Platform CRF scheme (ADB, 2022).
- The government has identified 15 GW of CFPPs for early retirement, and have decided that Pelabuhan Ratu CFPP (3x350MW) and Pacitan CFPP (2x315MW) will undergo early retirement through the spin-off scheme. In addition, Cirebon-1 CFPP (660MW) has also been chosen for early retirement under an agreement between Indonesia Investment Authority (INA), PT. PLN, and Cirebon Electric Power (CEP). Currently, INA is also working on a pipeline of potential private sector transactions totalling 1.5 GW, which includes Cirebon-1 CFPP.

JETP could catalyze a rapid and just energy transition only if the investment plan accelerates coal phase-out and rapid renewable deployment before 2030 and leaves no one behind

- After a similar announcement at COP 26 last year, the Just Energy Transition Partnership (JETP) was officially launched for Indonesia during the G20 summit in November 2022. This program is a collaboration between the International Partners Group (IPG) and the Indonesian government, plus Denmark and Norway, co-led by Japan and the US during negotiations. The IPG will mobilize USD 20 billion over the next 3-5 years to help Indonesia transition from fossil fuels to renewable energy. Grants, concessional loans, market-rate loans, guarantees, and technical assistance fund this project equally from public and private sources. Except for UK's USD 1 billion financing through World Bank and USD 10 billion private investment from GFANZ, the amount of other countries' pledge to financial contributions is still unclear.
- JETP pursues a net-zero power sector by 2050 and a 34% renewable energy share in the power sector by 2030. These goals are supported by the Indonesian government's decision on putting the current CFPP project in RUPTL 2021-2030 on hold, limiting new coal fleets following Presidential Regulation No.112/2022, and reducing fossil fuel subsidies. JETP is expected to accelerate energy transition by providing support policy and strengthening enabling environment for RE, energy efficiency industry development, and sustainable finance market expansion. To achieve these goals, Indonesia must adjust the high local content requirement, develop local renewable energy industries, and work with financial institutions to unlock massive investment potentials to reach a net-zero economy. The USD 20 billion is only roughly 15% of total investment required by Indonesia to transform power sector following emission reduction pathway of 1.5°C Paris Agreement's goal. Therefore, the upcoming Investment Plan (IP) shall quadruple the existing pledge and identify the contribution coming from Indonesian public financing in the next six month.
- JETP also recognized the importance of the just transition principle for workers and communities affected by the early retirement of CFPPs. Domestic coal consumption limits will reduce emissions, but transition activities will affect society and the economy. Indonesia JETP program must develop a just transition roadmap that includes green job creation, social protection for vulnerable groups, and employer-led upskilling and reskilling programs to address these issues. South Africa's lack of transparency and public participation since the partnership's conception and planning is another important lesson. The inability of South African civil society to participate has led to tensions between the government and civil society. This experience provided an insight that JETP success requires transparency and inclusive political dialogue with non-government actors.

4

IESR's Energy Transition Readiness Framework

Dr. Handriyanti Diah Puspitarini, Dr. Raditya Yudha Wiranegara

- Energy Transition Readiness Framework Assessment
- Highlights on 2022's Transition Readiness Framework

Enabling environment to welcome energy transition in the power system is not yet improved from last year

- This year's transition readiness assessment was done following the framework that has been built since 2020. It must be noted that the framework is limited only to power system. There were some indicators added in the framework to improve the previous ones. In the techno-economic dimension, there were the inclusions of fossil fuel retire and replacement plans and LCOE comparison between fossil fuel and renewable energy. In the social dimension, there were numbers of renewable energy certificates and renewable energy research topic in the top ten universities. The detailed results can be read in Appendix D.
- Surveys to stakeholders and public was used to validate the results of desk study. Those surveys are done to 12 renewable energy developers and 500 public respondents. Specifically for public, the respondents were chosen randomly in the range of age 16-64 years old by considering that those are the active age category. The surveys results are in Appendix E and F.
- The assessment results show that there is no improvement in all dimensions compared to the last year results. Thus, significant changes are needed to enable energy transition in Indonesia.

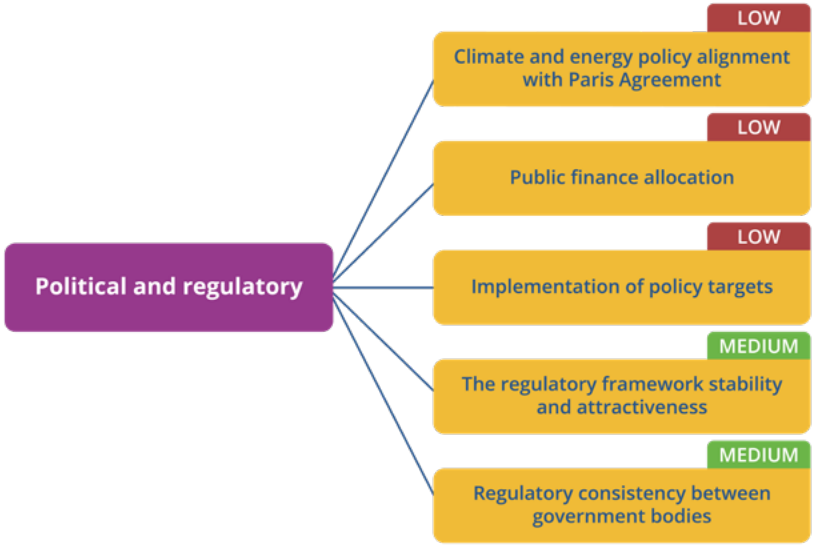
Dimension	Political and Regulatory					Techno-Economic	
Variable	Political Will & Commitment			Regulatory Framework Quality		Power System Planning	Economic of Energy Transition
Indicator	Climate and energy policy alignment with Paris Agreement	Public finance allocation	Implementation of policy targets	The regulatory framework stability and attractiveness	Regulatory consistency between government bodies	Power system planning suitability with high RE	Cost competitiveness of renewable technology
Rating	LOW	LOW	LOW	Medium	Medium	Medium	High
2021's rating	LOW	LOW	LOW	Medium	Medium	Medium	Medium

Dimension	Investment Climate for Renewable Energy Power Plant				Social	
Variable	Investment Climate for Renewable Energy Power Plant			Power Sector Investment Trend	Public awareness & acceptance	Human capital
Indicator	Investment risk	Barrier to entry	Access to capital	Trend and sufficiency of investment	Public awareness and support for renewables and coal phase-out	Integration of energy transition and employment policy
Rating	Medium	LOW	Medium	LOW	High	Medium
2021's rating	Medium	LOW	Medium	LOW	High	Medium

Source: IESR analysis

Improvements on some of the promising policy and regulatory frameworks are essential to accelerate RE development in Indonesia

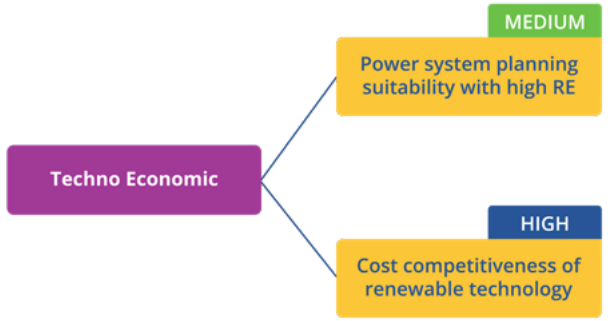
- Indonesia commits to reduce 31.89% GHG emission unconditionally and 43.2% conditionally. With only three years left until 2025, there has been no identifiable increase in the renewable capacity nationally to reach the 23% target. As per Q3 2022, the renewable additional capacity is 782 MW. Such a slow progress could potentially lead to the failure to reach emission targets.
- The lack of public budget allocation on the renewable energy sector and gaps on the longevity and consistency of Indonesia's regulatory framework are seen as the hurdles to reach 2025's target. The analysis on the budget allocation in the national economic recovery program shows that only 3.5% of public finance has been allocated to clean energy with the remaining still heavily supported fossil energy (Energy Policy Tracker, 2021). In a survey sent out to RE developers, 83.3% agreed that there is not enough financing to support the transition in the power system. On the longevity and consistency of regulations, Indonesia's regulatory framework scored a decent rating due to most of the regulatory frameworks' sufficient time frame. One regulatory-framework, however, the PLN RUPTL, gets updated almost every year, leading to frequent changes in the power system planning.



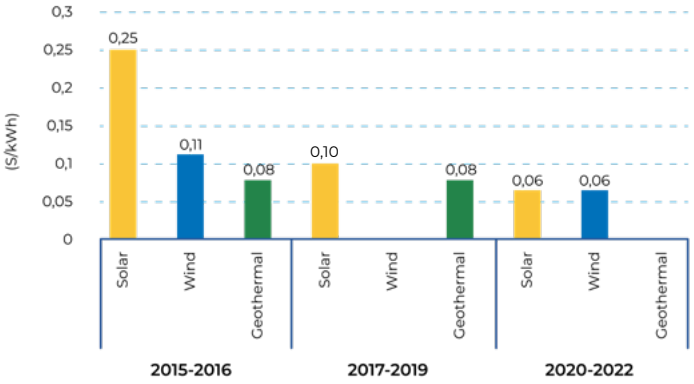
- Nearly 59% of developers consider the overall regulatory frameworks attractive, noting that some may still require improvements. Specifically on the process of obtaining permits, developers point out the needs of having one gate system to ease the process, simplification on licensing, and certainty on the process finalization period. Furthermore, FiT and procurement scheme are two improvements that are viewed as potential regulation changes that can attract more investors. Regarding the newly issued Perpres 112/2022, 75% of them believe that it would not accelerate RE development, since its implementation will depend on how PLN will carry out the procurement processes.
- Other supporting regulations in the CFPP emission standards, energy efficiency, rural electrification, and regional energy plan (RUED) are identified as modest. Indonesia's post-2019 CFPP emission standards, in particular, is actually on par with global best practices. However, the regulation is still lacking on the CO/CO_2 limits.

Renewable energy dominates the additional capacity planned in the latest RUPTL, yet its competitiveness has not been thoroughly weighed

- Power system planning for this year and next year still follow RUPTL 2021-2030 since there is no newly launched RUPTL. There is a plan to add 20.9 GW of renewable energy in 2021-2030, with a total of 648 GW in 2022, making the plan claimed to be the greenest RUPTL. However, the implementation is not yet aligned with the target. For instance, the newly installed solar power at utility-scale is only 0.2 GWp until Q3 2022 as recorded by IESR (2022a). Moreover, there is no updated grid code regulation established this year detailing the questions on the requirement to manage the system's supply-demand balance with the increasing share of VRE in the future.
- Fossil replacement and retirement plans also still follow RUPTL 2021-2030. In the replacement plan, the government plans to replace 3.7 GW out of 9.2 GW CFPPs with renewable energy. In addition to the previous asset revaluation, PLN also plans to refurbish and retrofit its aging units, hence extending their lifetime for another 10-20 years, indicating the opportunity to use old CFPPs that may disrupt the efforts to reach emission reduction targets. Moreover, RUPTL 2021-2030 also mentions an additional 13.8 GW of new CFPPs that could actually be reassessed, and either canceled or assets repurposed for renewable-based power plants, i.e. biomass.
- The competitiveness of renewable energy technology keeps increasing significantly. For instance, the price of the latest cheapest solar PV reaches USD 4 cent/kWh (without battery) and wind power reaches USD 5 cent/kWh, which are lower than the average coal (USD ~5-8 cent/kWh) and diesel power plants (USD ~13.4 cent/kWh).
- According to the RE developer survey, 58.3% of developers have access to cost competitive technologies. However, most of the technologies are imported ones, which makes LCR requirement a big issue.



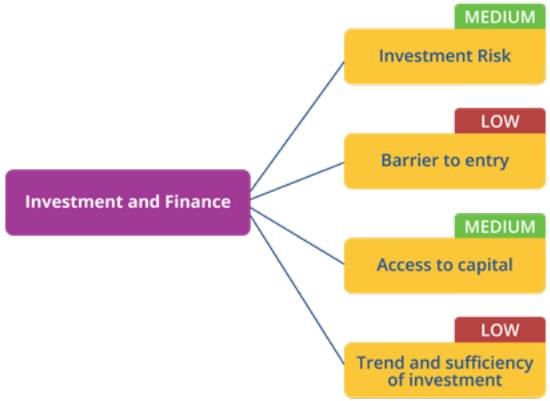
Indonesia's solar, wind, and geothermal, 2015–Q3 2022



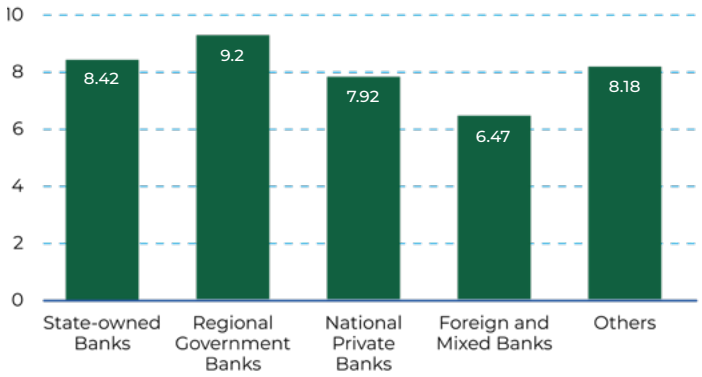
Source: IESR analysis

Renewable energy investment attractiveness can be improved by reducing risks, improving supporting regulations, and increasing the accessibility to the cheap capital

- Indonesia's investment risk has the grade of lower-medium according to the updates on Indonesia sovereign credit rating presented by OJK. Specifically for the investment risk for renewable energy project, it is still valued as medium risk. Furthermore, there are barriers to entry as investors in Indonesia, especially for foreign investors. This fact is supported by investment freedom index provided by Heritage Foundation that is still in the category of repressed, causes the unattractiveness to invest on projects in Indonesia.
- Indonesia needs USD 36.95 billion to reach 23% renewable energy by 2025 as estimated by MEMR. This year's investment target is USD 3.97 billion, yet only 34% of it has been obtained until Q3. Additionally, this year's target is lower than the fossil fuel's target (IESR, 2022b), indicating that investing in fossil fuel is more attractive than renewable energy until nowadays.
- The majority of surveyed RE developers stated that many improvements must be made to increase Indonesia's environment climate, especially for having higher renewable energy penetration. For instance, 75% of them state that procedures to get permit is time-consuming. Such conditions impacts the project finalization period, which then affects higher transaction cost and doubts in the investors' side regarding its return rate.
- Another issue causing unattractive investment climate in Indonesia is a high credit interest rate from the local and national banks compared to the foreign banks as documented by BPS (2022). This fact is supported by the statement of 91.7% of the surveyed stakeholders viewing that credit from local banks is accessible but with high interest rates.



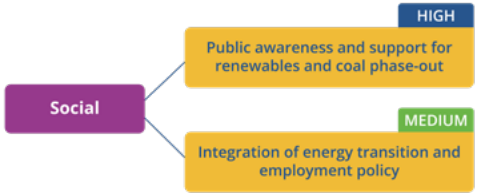
Credit interest rates by banks' group in September 2022



Source: BPS (2022)

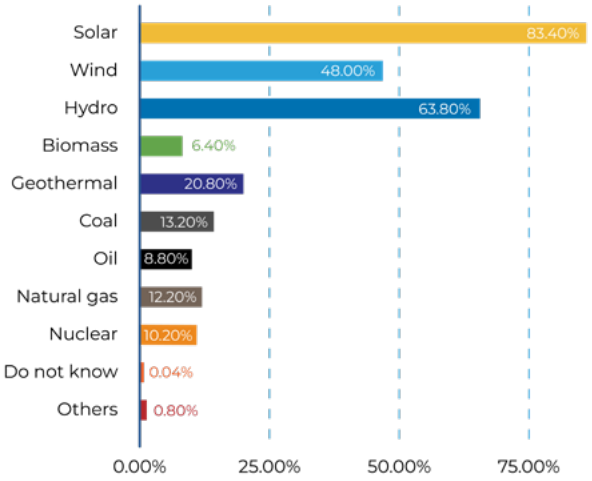
Public support for the energy transition has been consistently high, but there is still no clear strategy to prepare the workforce for the transition

- In our recent online survey to 500 Indonesians, 93% of them agree that climate change is an urgent matter requiring immediate action. Interestingly, the proportion of those saying the government policy is inadequate for climate mitigation is slightly on par with those saying the opposite, with the latter being 0.40% higher than the former. Deforestation and peatland degradation top the list of sectors contributing to climate change, followed by waste, energy and industry.
- The majority (83.4%) of the respondents believe that solar should be prioritized in Indonesian electricity generation, with the second and third most selected sources are hydro (63.80%) and wind (48%), respectively. Meanwhile, less support can be observed for coal, oil, natural gas, and nuclear. In the issue of coal phase-out, 74.8% respondents agree on retiring CFPPs early, indicating strong support to immediately cease the use of coal power plants.
- On the human capital preparation, there has been no notable improvement from last year's assessment. The government has not established any clear strategy in preparing the workforce required in the energy transition, let alone preparing existing workforce to shift from fossil-based generation to the renewable ones. This year's assessment also included the role of Indonesian universities within the research on renewable energy. Surprisingly, based on the available data, the observed trend at the top ten Indonesian universities has been declining for the past five years.



Survey response to question: Which energy source do you think should be prioritized in Indonesian electricity generation?

(respondent could choose maximum 3 option)



Source: IESR analysis based on public survey

4

Outlook for the Energy Sector

Dr. Handriyanti Diah Puspitarini, Dr. Raditya Yudha Wiranegara

- Energy Transition Readiness Framework Assessment
- Highlights on 2022's Transition Readiness Framework

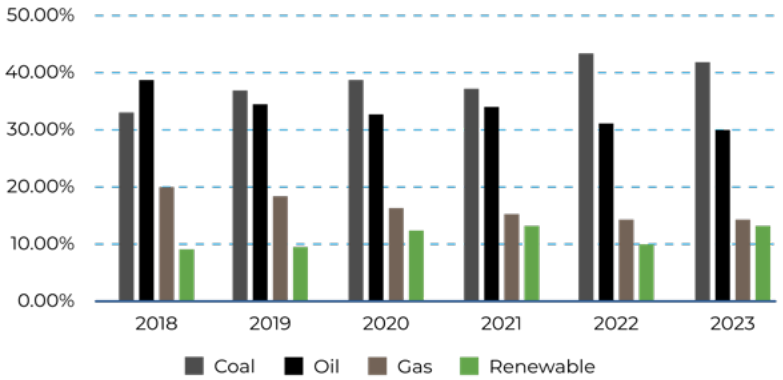
Regulatory support welcoming more renewable energy is expected to be established next year to accommodate JETP 2030's targets

- International pressures to address climate change issue has been coming to Indonesia since 2014. Recently, JETP for Indonesia was launched during the G20 event, giving Indonesia an addition of USD 20 billion to pursue a net-zero power sector by 2050 and a 34% renewable energy share in the power sector by 2030. Another international support comes in the form of ETM for funding the CFPP phase-out and achieving 51.6% of RE by 2030. These targets are a long-term signal from the government to show its commitment to the energy transition. RUPTL, as the foundation of Indonesia's power planning, is expected to have some changes in the context of new installed renewable energy in the system next year to align with 2030's targets. It means that procurement for renewable energy projects must start in 2023 and continue until 2025 in order to be operational before 2030. Grid code must then also be updated to regulate the flexibility of power plants to be able to supply the demand 24/7, with a high share of renewable energy.
- Some regulations on coal must be reevaluated next year. The implementation of carbon tax is long delayed. It is expected to contribute around IDR 194 billion to the public budget, but remains at IDR 30,000 per tonne CO_2-eq. BLU scheme that will be launched in the early 2023 will also slow the energy transition, since there is a pseudo-opportunity effect in this business. Thus, next year's decision making process must be able to address energy security issues because the energy crisis is happening on a global scale. Fossil fuels cannot be a solution to energy needs in the long run because not only do they have adverse effects on the environment, but also their reserves are not sustainable.
- Energy issue at the sub-national level is under the authority of sub-national governments. However, their RUED, a derivative of RUEN, still shows unambitious targets. Thus, sub-national governments need to revamp their targets and start to allocate their financial resources to accelerate the energy transition. Technical assistance from the central government is needed to improve the capacity of sub-national governments to formulate plans. Sub-national government's regulations governing budget allocation for energy projects need to be reformed to allow higher budget allocations. Moreover, DKI Jakarta and Papua, as representatives of the metropolitan and eastern provinces, respectively, have submitted their RUED and will start to discuss it next year. By having their RUED in the table next year, sub-national governments demonstrate their awareness on energy transition.
- Presidential Regulation 112/2022 gives another great potential to increase renewable energy share next year. However, the realization will depend on PLN's decision to respond these opportunities and start the procurement process. When more RE projects are announced next year, more developers and investors will have their eyes on them. By showing the eagerness to reach 2030's target starting from next year, the readiness for energy transition in Indonesia will definitely increase, especially in terms of politics and regulation, where a few years of stagnant change has been noted.

There will be more opportunities to increase renewable energy share and clean fuels utilization next year to rebalance the current condition

- From 2011 to 2021, the share of fossil fuels in the primary energy supply showed a negative annual growth trend, especially for gas and oil. However, it increased this year due to the spike of energy demand responding to the economic growth during the post-pandemic situation. With the international aids to reduce emissions in the energy sector, next year will be a rebalancing period for this condition affecting the increase in the renewable energy share. Moreover, this year's transition readiness assessment shows an improvement in the cost of renewable energy technologies, making them stay cheaper than fossil fuel-based technologies. The lowest notable price of renewable energy this year comes from wind power, which is half the price in 2016. This can actually motivate PLN to increase RE, but it will depend on the regulations enabling this decision.
- Notable for next year's renewable energy growth is the increase in the installed capacity of geothermal, hydro, and solar power plants. For instance, the increased capacity of 55 MW in the Patuha Geothermal PP, the Peusangan and Asahan hydropower operations will add 45 MW and 174 MW, respectively, and the Cirata floating PV will add 145 MWac of solar power. Rooftop solar PV will also add to renewables growth, although it will likely still be hampered by the capacity limitation.

Projected energy share in 2023 using linear regression based on historical trends



Notes: Data for 2022 is until Q3 and the linear regression is only based on the historical trends, without considering other aspects such as political, technological, and economic aspects

Source: IESR analysis

- Biofuel production also keeps increasing this year and its trend will continue to be positive next year. With an intensive research and development in the catalyst technologies for biofuels, processes needed to produce biofuels can become cheaper and more efficient (Arya et al. (2021), Manikandan et al. (2021), and Kang et al. (2022)). If B40 and B30D10 can be implemented next year, it will be able to increase the use of clean fuels in the transportation sector, thereby reducing GHG emissions. Since the price of fuel oil has been more expensive since the beginning of this year, it will also tigger the reduction of oil demand for domestic use and export purposes, and the increase in biofuels demand. According to EU Renewable Energy Directive II, 65% of vehicles and 80% of electricity, heating, and cooling will run on biofuels by 2026, reducing global dependence on fuel oil.
- There will be 400,000 E4W and 1.7 million E2W on the road by 2025, as projected by MEMR. Until this year, there are only 25,782 E2W and E3W and 7,679 E4W on the road, meaning that there are still big gaps to fulfill the 2025 targets. Next year, more E4W from mid- to high-end brands will be launched, which is expected to attract customers from more diverse economic levels. The increased number of electric vehicles will be one of the solutions to address oversupply issue in the power system, especially in Java-Bali system.

More investment in renewable energy projects is expected due to international pressure and aid to reduce emissions by 2030

- There is no improvement on Indonesia's investment climate this year, although there is a great opportunity to increase renewable energy share, especially in the power system, due to the availability of international funds. The fund should allow the investment climate to thrive, from the regulation to the implementation. However, many improvements must be made in the financial sector, especially on de-risking instruments, including reducing barriers to entry for investors and increasing access to cheap capital for developers. The earliest effort that can be done is by encouraging local banks to give a lower interest rate to RE developers.
- The attractiveness of renewable energy projects has also become RE developers' concern. According to RE developers survey, three main financial supports are needed by developers, namely FiT, fiscal incentives, and soft loan. Additionally, RE developers see that the implementation of a clear procurement process, Presidential Regulation 112/2022, tariff schemes, and a simplified process for obtaining permits will result in a positive trend on the renewable energy investment as soon as those are updated and run well by the government next year.
- The implementation of JETP and ETM next year will give a sign to investors about Indonesia's commitment to pursue energy transition. First, the government will strive to finish a comprehensive investment plan within 6 months after the JETP was signed, which will be in May 2023. Once the plan is established, investors will be able to clearly see business opportunities to contribute to the 2050 NZE target and 2030 target of 34% of renewable energy. Second, ETM, which focuses on the coal retirement, will be seen as a chance to deal with the retirement process, more demand to retire CFPP, and shift into renewable energy. The existence of international aids will be able to restructure RUPTL next year. Furthermore, the government's commitment will impact on the attractiveness of renewable energy projects in Indonesia.
- For the energy transition in the transportation sector to be successful, it will be necessary to start subsidizing EV ownership next year. The subsidy can take the form of purchase price reduction and/or other incentives, which must be studied further so as not to widen socio-economic disparities. Public budget that is currently allocated to fuel oils subsidies and compensations should be further analyzed for its effectiveness in reducing GHG emissions and promoting economic growth compared to shifting budget allocations to subsidize electric vehicles. With such subsidies, there will be more investors to build the electric vehicle and battery industry. The more industries that are built, the cheaper the future cost.

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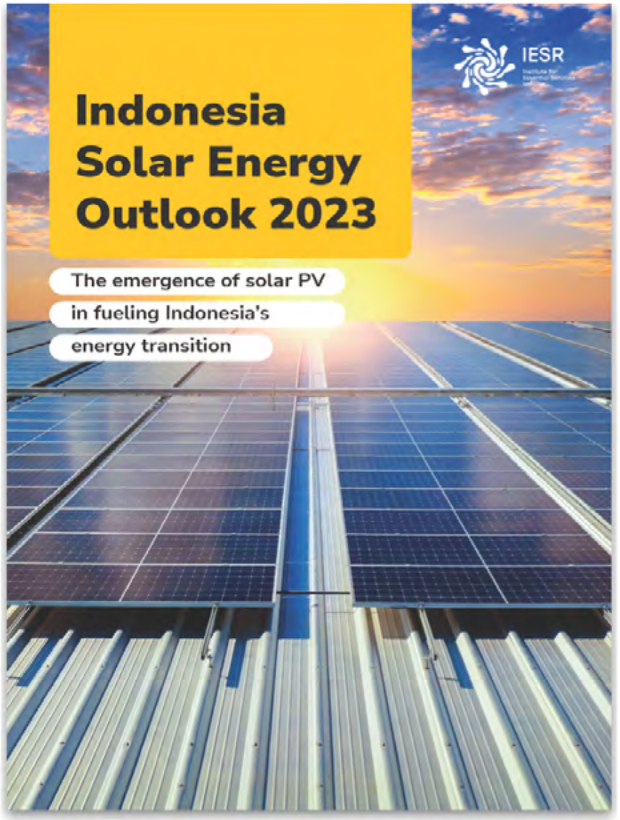
Appendix A - ISFO 2023 and ISEO 2023

https://iesr.or.id/pustaka/indonesia-sustainable-finance-outlook-isfo-2023



https://iesr.or.id/pustaka/indonesia-solar-energy-outlook-2023

Appendix B - Status of CCS/CCUS Projects in Indonesia by August 2022

Projects	Conducted By	Status	Onstream Target Schedule	CO2 Stored Potential
Tangguh EGR/CCUS	bp Berau Ltd., study was conducted by CoE-ITB	FEED Preparation POD Ubadari and Vorwata; EGR/CCUS has been approved	2026/2027	25 to 33 million tonnes CO2 for 10-15 years
Gundih CCUS/CO2-EGR	Pertamina, CoE ITB, JGC, J-Power, JANUS & Supported by METI Japan	Phase-2 Study to mitigate uncertainties & risks	2026	3 million tonnes CO2 for 10 years
Sukawati CO2-EOR	Pertamina, LEMIGAS, JAPEX & Supported by METI Japan	Study CO2-EOR as CCUS by Pertamina; subsurface study by Pertamina, LEMIGAS and JAPEX	Pilot: 2026-2027; full scale: 2031	7 to 14 million tonnes CO2 for 15 years
CCS Sakameang	Repsol Sakameang B.V.	Site selection; preparing lab test for feasibility	2027	30 million tonnes CO2 for 15 years
Abadi CCS/CCUS	Inpex Masela Ltd.	FS with ITB completed in July 2022	-	70 million tonnes CO2 by 2055
Joint study on blue ammonia & CCS in Central Sulawesi	Pertamina & PT. Panca Amara Utama, JOGMEC, Mitsubishi, ITB	JSA finalisation, preparing required data (by Pertamina), FS completed in July 2023	-	19 million tonnes CO2 for 20 years
East Kalimantan CCS/CCUS study	PT. Kaltim Parna Industri & ITB	Pre-feasibility study (surface facilities)	2028	10 million tonnes CO2 for 10 years
Study of CCUS for coal to DME	Pertamina & Chiyoda Corporation	Joint study agreement signed, preparing access data & CA, FS completed in December 2023	-	26 or 31 million tonnes CO2 for 20 years, depending on scenarios
Arun CCS	Carbon Aceh & PEMA	MoU signed; preparing for JSA, expected to in 2022	2028	-
Ramba CCUS (CO2-EOR)	Pertamina	Internal study	2030	-
Central Sumatra Basin CCS/CCUS Regional Hubs	Pertamina & Mitsui	Preparing required data & CA	2028	-
East Kalimantan & Sunda Asri Basin - CCS/CCUS Regional Hubs	Pertamina & ExxonMobil	Subsurface evaluation	2028	-
CO2 Capture & Utilization to Methanol - RU V Balikpapan	Pertamina & Air Liquide	JSA signed, conducted until 2023	-	-
CCUS study	Pertamina & Chevron	Discussion on field candidate; preparing JSA	-	-
Pilot test CO2 huff and puff Jatibarang	Pertamina Region 2 - Zone. 7	Validating the simulation result & preparing injection well; JSA with JOGMEC has been signed	Pilot: October 2022	-

Source: (Agung, 2022)

Appendix C - Energy efficiency regulations in building sector

	Regulation	Building/Appliances (Mandatory)		Energy efficiency effort
Green building	Government Regulation 16 2021 on Green Building and Ministerial Regulation of The Ministry of Public Works and Housing of Republic Indonesia 21 2021 on Performance Assessment on Green Building	≥ 50.000 m²	Mix-use buildings, Offices	Rank system, Incentives, Penalties, Mandatory and recommended building. Performance assessment contents (energy efficiency): Building orientation, Facade design, Roof and wall albedo, Natural ventilation, Overall Thermal Transfer Value (OTTV), Roof Thermal Transfer Value (RTTV), Window-to-Wall Ratio (WWR), HVAC system, Artificial & natural lighting, Smart lighting, Vertical transport, Energy efficiency calculation by SNI 6197:2020, SNI 6389:2020, SNI 6390:2020, Electrical installation by SNI 0225:2020 & submetering, Building management system (BMS), On-site renewables plan, Water management
		≥ 20.000 m²	Health care	
		≥ 10.000 m²	Assembly (School, Religious, Civil, Clubs)	
		≥ 5.000 m²	Shops, Restaurants, Cafes, Markets	
		≥ 5.000 m²	Warehouse, Carparks	
		≥ 5.000 m²	Factories & Laboratories	
Minimum Energy Performance Standard (MEPS)	Regulation of Minister of Energy and Mineral Resources Number 14 of 2012 on Minimum Energy Performance Standard	HVAC		HVAC Standard by Ministerial Decree of Minister of Energy and Mineral Resources Number 103.K/EK.07/DJE/2021
		Refrigerator		Refrigerator Standard by Ministerial Decree of Minister of Energy and Mineral Resources Number 113.K/EK.07/DJE/2021
		Fan		Fan Standard by Ministerial Decree of Minister of Energy and Mineral Resources Number 114.K/EK.07/DJE/2021
		Rice Cooker		Rice Cooker Standard by Ministerial Decree of Minister of Energy and Mineral Resources Number 115.K/EK.07/DJE/2021
Behaviour	Regulation of Minister of Energy and Mineral Resources Number 14 of 2012 on Energy Management	Government		Energy management, Energy audit, Operational (HVAC, lighting, lift, computer, photocopier, water heater, capacitor bank, energy diversification), Incentives
		BUMN/State-Owned Enterprise (SOE)		
		BUMD/municipally-owned corporation		
		BHMN/state legal entities		

Appendix D - Energy Transition Readiness Framework (1)

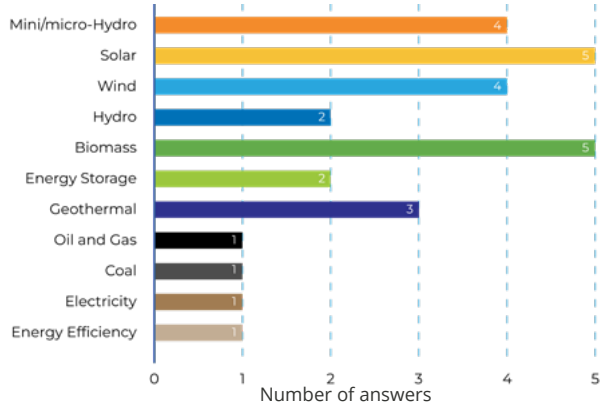
No	Dimension (s)	Variable (s)	Indicator	Key points to assess indicators	Assessment methodology	Source of data	Low	High
1	Political and regulatory	Political will/ commitment	Key policy documents clearly stated the target to transition the energy/power system towards a low-carbon energy/ power system that is aligned with the Paris Agreement	1. NDC target 2. NZE target 3. KEN/RUEN 4. RP JMN/RP JPN 5. LTS 6.Grand energy strategy	Self-assessment	NDC document Climate Action Tracker KEN/RUEN RPJMN/RPJPN LTS document Grand energy strategy	Current key policy target is insufficient to decarbonize power sector and limit global warming below 2 C	Current key policy target is sufficient to decarbonize power sector and limit global warming below 1,5 C
			The government provides financial and fiscal support for power system transition decarbonization	Amount & percentage of public finance allocated for supporting the climate change and energy transition	Self-assessment Survey to RE developers	Public finance 2021 MEMR budget Secondary data from news and webinars Survey results	Total public finance allocated for RE is lower than fossil fuel (>10%)	Total public finance allocated for renewable energy is higher than fossil fuel
			Implementation of energy transition targets/plan	Government achievement in 2021 aligning with decarbonization targets in power sector	Self-assessment	Directorate general of electricity quarterly report Secondary data from news and webinars	Renewable installed capacity addition less than RP JMN target	Renewable installed capacity addition exceed the RP JMN target
		Regulatory framework quality	The existing regulator support has accelerated RE deployment	1. Annual regulation stability assessment 2. Regulation attractiveness to increase the implementation of RE	Self-assessment Survey to RE developers	Regulatory changes frequency in 2016-2021 Survey results	The regulatory framework in the power sector is constanly changing and viewed by stakeholders as a barrier	The regulatory framework in the power sector is stable (following transparency, lonevity, and certainty criteria) and able to attract investment
			The consistency between various government bodies regulations related to the deep decarbonization in power system	1. Air quality regulations 2. Energy efficiency regulations 3. Green building regulations 4. Rural electrification regulations	Self-assessment	Air quality regulations Energy efficiency regulations Green building regulations Rural electrification regulations	Other related regulations (e.g. regulations of air quality, energy efficiency, green building, rural electrification, and RUED) are not in line with efforts to decarbonize the power sector	Other related regulations (e.g. regulations of air quality, energy efficiency, green building, rural electrification, and RUED) are in line with efforts to decarbonize the power sector
2	Investment and finance	Investment climate (for RE power plant)	Investment risk	1. Country credit ratings and risk premium 2. Availability of derisking instruments	Self-assessment Survey to financing institutions	S&P, Fitch, Moody's, PWC country risk premia Survey results	Country risk premium is high and instruments to derisk investment in RE power projects are inavailable	Country risk premium is low and instruments to derisk investment in RE power projects are available
			Barriers to entry	Investment freedom for foreign and local sources	Self-assessment Survey to RE developers	Investment freedom index from heritage foundation Survey results	Investment freedom index is low and permit process is considered as a barrier to RE development	Investment freedom index is high and new RE project permit/license project is streamlined
			Access to capital	Easiness to get credit	Self-assessment Survey to RE developers	Getting credit parameter in the WB ease of doing business Survey results	The ease getting credit is high and local banks provide capital with unattractive interest rates for renewable energy projects	The ease getting credit is high and local banks provide capital with attractive interest rates for renewable energy projects
		Power sector investment trend	The sufficiency of RE investments	1. Level of investment realization compared to investment needed 2. RE investment growth 3. Investment of RE compared to FF plants	Self-assessment	Secondary data from news and webinars MoEF and MEMR press releases	Investment level is similar as previous year and insufficient to support power sector decarbonization and achieve the Paris Agreement target	Investment level is keep increasing and sufficient to support power sector decarbonization and achieve the Paris Agreement target

Appendix D - Energy Transition Readiness Framework (2)

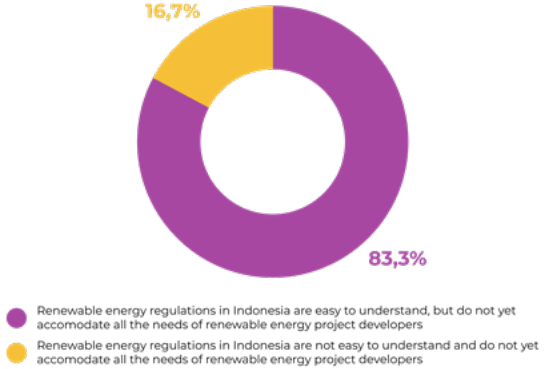
No	Dimension (s)	Variable (s)	Indicator	Key points to assess indicators	Assessment methodology	Source of data	Low	High
3	Techno-economic	Power System Planning	The power system planning with high RE integration	1. Planned installed capacity of RE plants compared to fossil fuel plants 2. Updated grid code and must run status for RE power plants 3. Fossil fuel retirement plan 4. Fossil fuel replacement plan, e.g. 3.7 GW out of 9.2 GW and dedieselisation programmes	Self-assessment Expert interview	Directorate general of electricity quarterly report Secondary data from news and webinars Latest grid code regulation compared to the previous one Recent RUPTL interview results	Planned RE capacity is lower than planned fossil capacity, power system planning and grid codes prevent flexibility and higher integration of RE into the grid	Planned RE capacity is higher than planned fossil capacity, power system planning and grid codes allow flexibility and higher integration of RE into the grid
			Cost competitiveness of renewable technology	1. RE tariff compered to fossil fuel 2. RE vs FF LCOE/S	Desk study expert interview survey to RE developers	Interview and survey results	RE tariff is higher than fossil fuel and developers are unable to use the most competitive RE technologies in their projects	RE tariff is lower than fossil fuel and developers are able to use the most competitive RE technologies in their projects, which locally produced
4	Social	Public awareness & acceptance	General public supports on energy transition	Public awareness of climate change, support for renewable energy deployment, and support for coal phase out	Public survey	Survey results	Public is not aware on climate change, support for renewables, support for coal phase out	Public is aware on climate change, support for renewables, support for coal phase out
		Human Capital	Government strategy	1. Government strategy/plan for employment in energy transition 2. Government plan for mitigating transition impact on employment	Self-assessment Expert interview	Interview and survey results	The government has no specific strategy for green skills development	Integration of green skills developments into government programs
			Capacity of human resources	1. Availability of potential workers 2. RE technician certification 3. RE research topic in top ten university in Indonesia	Self-assessment	Ministry of labor and Ministry of Education Culture, Research, and Technology reports Central Bureau of Statistics data ASEAN reports OECD reports World Economic forum reports Solar technicial certification from MEMR University's repository	Population graduated form tertiary school is below the averaged number of ASEAN countries, and not yet skilled (and familiar with) to enter green jobs	Population graduated form secondary school similar as OECD countries and skilled (and familiar with) to enter green jobs

Appendix E - RE developers' perception survey results (1)

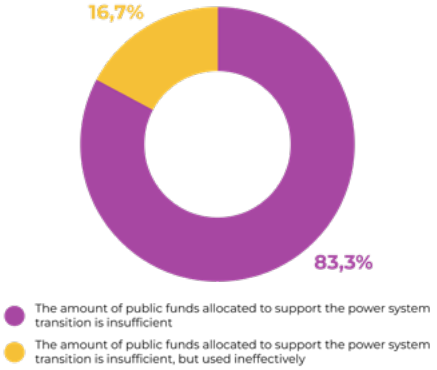
What is your main business?



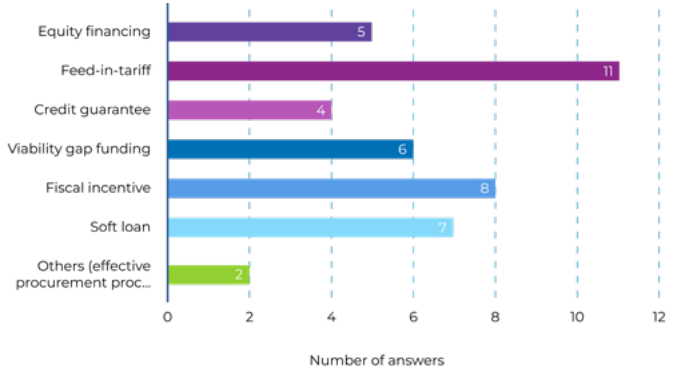
Do you think that renewable energy regulations in Indonesia are easy to understand and have accomodated all the needs of renewable energy project developers



What is your opinion regarding government support in financial and fiscal terms for the transition/decarbonization of the electricity system?

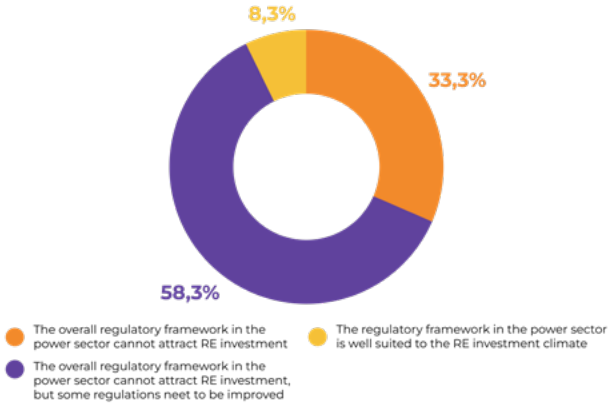


What kind of financial/fiscal support do you think needs to be increased to accelerate the energy transition in the power the power sector, if any?

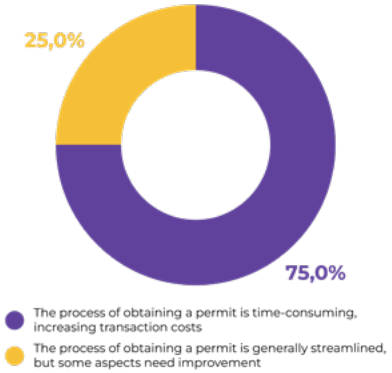


Appendix E - RE developers' perception survey results (2)

How do you think the existing regulatory framework in the power sector (ie tariff setting, incentives, taxation, etc.) creates an attractive investment climate for renewable energy?



What is yout view on the bureaucratic process in obtaining permits for RE development?



What needs to be improved in the process of obtaining permits for RE projects, if any?

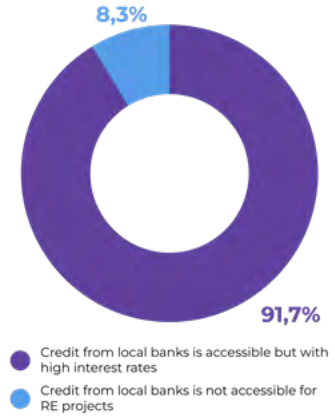
- List of PLN's selected suppliers
- Central and regional one gate system
- License from PLN for parallel operation and net metering
- Licensing process diagrams including multilevel processes
- SIPPA and IPPKH
- There are provisions that have entered the RUPTL (according to the quota) and in a direct election tender
- OSS needs to add the required licensing data base according to the KBLI
- The AMDAL process at the Ministry of Environment and Forestry currently takes a very long time.
- Regulations at the Ministerial and Regional Government levels need to be synergized, for example Regional Regulation on land use
- Ease of Environmental Licensing
- Simplification of licensing and certainty of the length of the process
- Human resources and IT systems from institutions related to licensing

Appendix E - RE developers' perception survey results (3)

Which regulations need to be improved to attract more investment in renewable energy?

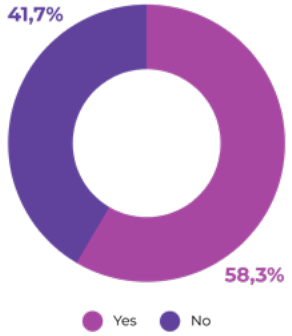
- FiT
- Procurement scheme at PLN. All existing regulations (Presidential regulation, MEMR regulation) are actually sufficient. But if PLN does not carry out the procurement process, no RE projects can be financed and built. Our main homework together is to oversee that PLN can discipline the procurement/tender process to meet the 2021-2030 RUPTL target
- Presidential regulation 112/2022, MEMR regulation 1/2015
- The tariff scheme should use FIT and the procurement scheme should be improved to make it more efficient and effective
- Presidential Regulation No 112/2002 (Feed in Tariff that meets economic value but is low enough by providing fiscal and non-fiscal incentive packages)
- The tariff adheres to a maximum criterion of a certain amount of money, causing the PLN team to not dare to make a decision, fearing one day being chased by the KPK
- Presidential Regulation on EBT Tariff
- Environmental Licensing
- About tariffs

What is your opinion on access to credit from local banks for RE projects?

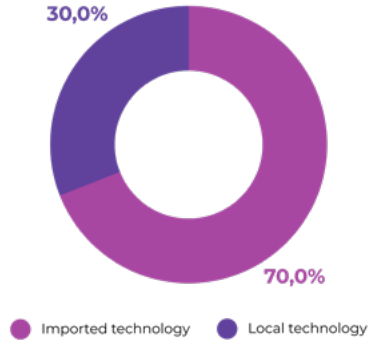


Appendix E - RE developers' perception survey results (4)

Do you think you can use renewable energy technologies at the most competitive costs in your projects in Indonesia?



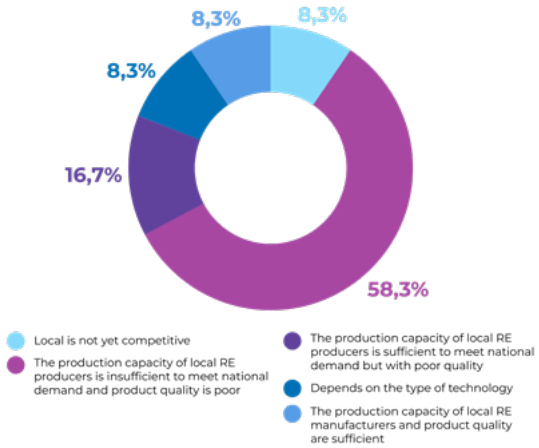
If you answered "Yes", what technology did you use?



If you answered "No", why? (eg LCR, import tax, etc.):

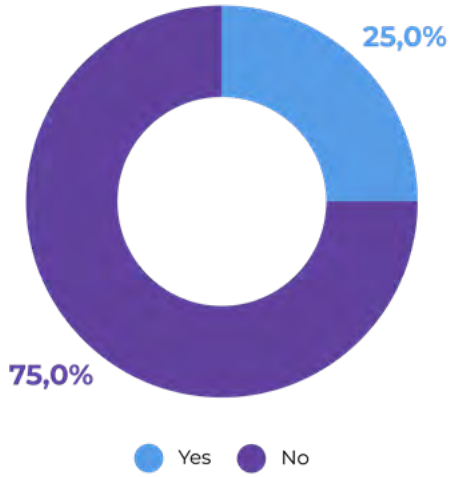
- LCR, Curtailment
- Developer prices are considered less competitive by offtakers/ utilities
- Taxes on imported raw materials to make goods in Indonesia are exempted, VAT taxes on LCR goods and services are reduced
- For gasification of biomass is not yet available in the country
- LCR, land acquisition process, licensing.
- Low tariffs are difficult to accommodate costs which are still relatively high for certain technologies

What do you think about RE production capacity and product quality of local manufacturers?



Appendix E - RE developers' perception survey results (5)

Is Presidential Regulation 112/2022 can accelerate the development of RE power plants in Indonesia?



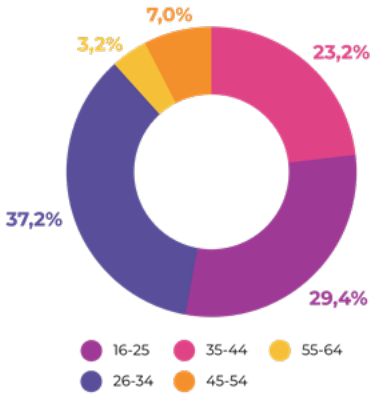
What is the impact of Presidential Regulation 112/2022 in the development of RE power projects?

- To be monitored, it returns to PLN whether PLN will carry out all the required procurement processes. Without a procurement process at PLN, the existing tariffs in the Presidential Regulation cannot be utilized.
- Still not having a significant impact.
- Not too influential before there were derivative regulations for its implementation.
- Feed-In Tariff that meets economic value, but is quite low by providing fiscal and non-fiscal incentives and imposing FIT for a certain period of 5-8 years. An attractive FIT is applied if the Developer invests in a period of 5-8 years.
- Not effective.
- There is no significant impact considering the prices set are generally unattractive.
- Hinder
- It seems that not much has been affected, because there are still many new PLTUs being built.
- Minor. Basically this rule doesn't give a wow effect. Business as usual. In practice, this rule is merely an affirmation of the importance of PLN's position in the development of RE projects. So, everything will return to PLN.
- Giving a glimmer of hope because at least it's still a little better than the last MEMR regulation.

Appendix F - Public survey results (1)

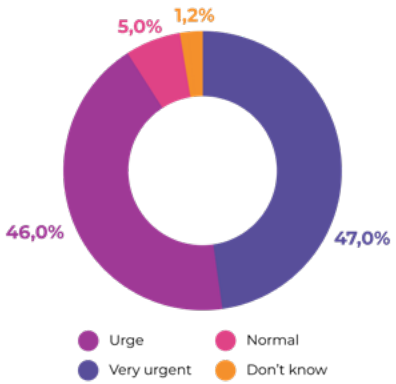
Gender

Count of Age

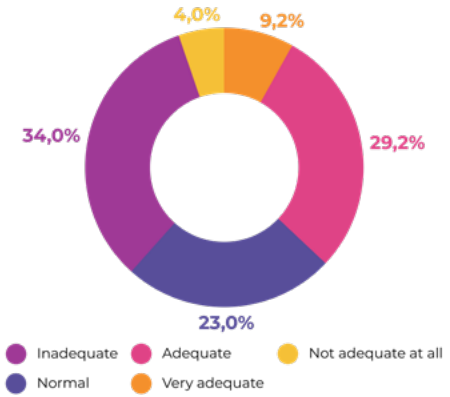


Appendix F - Public survey results (2)

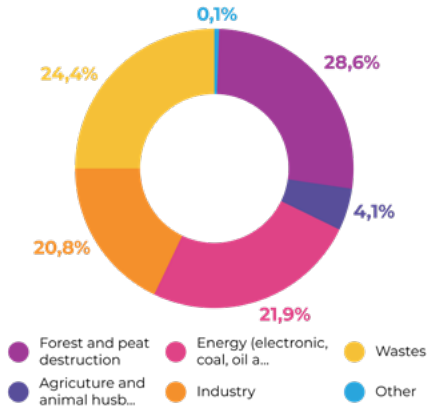
In your opinion, is climate change/global warming an urgent problem to be resolved?



In your opinion, are the current policies of the Indonesian government to deal with climate change/global warming sufficient?

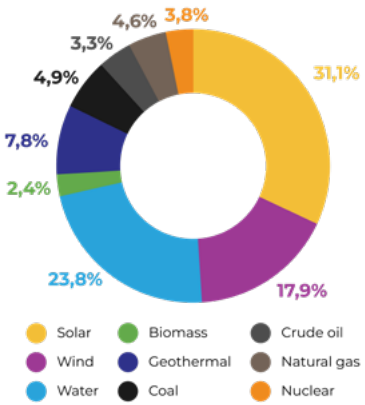


In your opinion, in Indonesia, which sectors contribute to climate change/global warming?



Appendix F - Public survey results (3)

In your opinion, what energy sources should be prioritized in electricity generation in Indonesia?



Do you agree if Indonesia accelerates the cessation of using coal as a source of electricity?

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