TransitionZero

Two billion reasons

How Indonesia can get ahead of the net zero curve

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Empowering our partners with open data products to shape a clean energy future

We are a climate analytics not-for-profit established in 2021. We build **open** energy transition products without usability compromises and **partner** with mission-aligned organisations to help **scale** a global standard for energy transition planning

Table of Contents

About FEO

What is Future Energy Outlook and why is it needed?

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Future Energy Outlook

Accessible and auditable model, tool, and data platform

Data Sources

Web-scraping market and generation data

Satellite data & machine learning for asset properties and activity

Local partners & TZ analysts for data quality and completeness

Modelling Suite

Capacity expansion for planning and investment

Grid dispatch for pricing and operations

Materials and impacts of the energy transition

Platform Layer

Federated access to numerical solvers

API Backbone for scalability

Single-entrypoint authentication

Interfaces

Web app for exploring, sharing, and creating analysis

Blogs & reports with TZ flagship analysis

Python client for programmatic access

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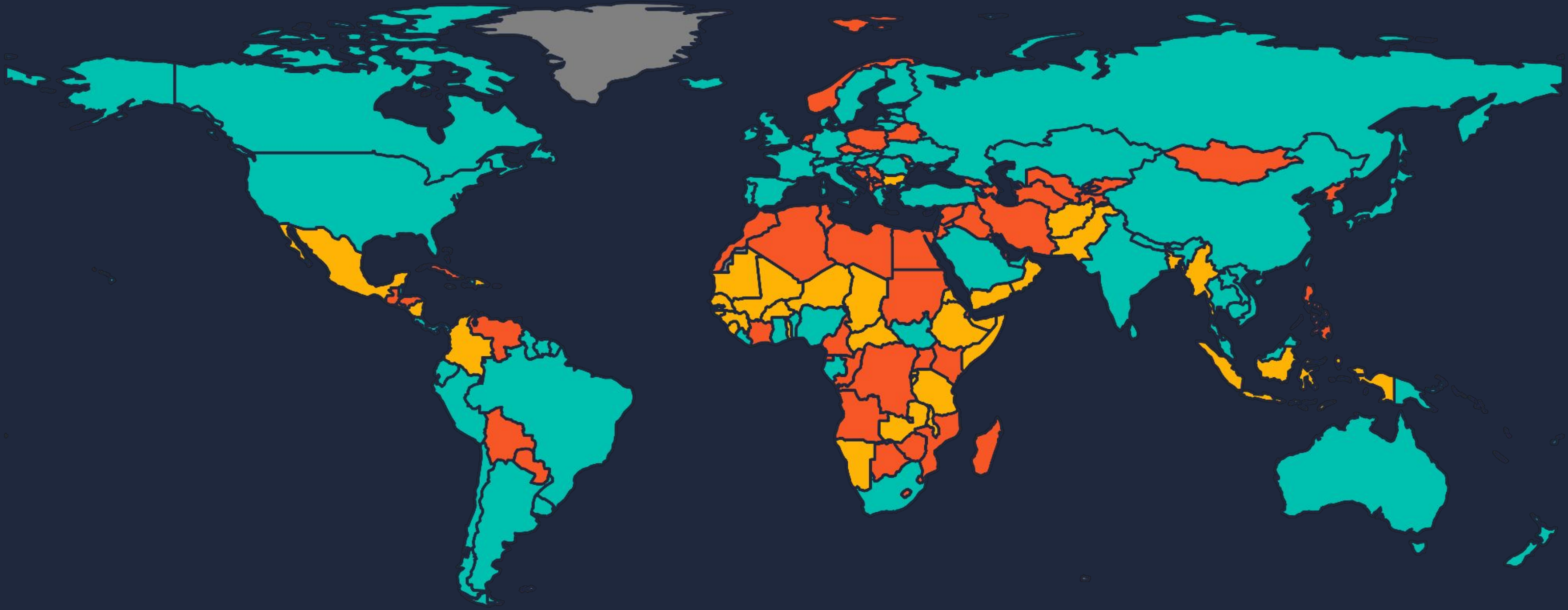
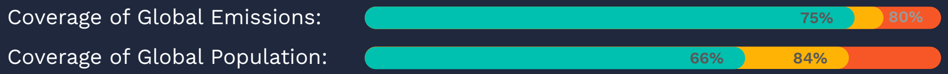
Net zero ambition

Most of the world now has pledged to be net zero





Implemented Policy[1] Proposed Policy[2] No Ambition[3]

Data from Net Zero Scorecard (2023) Energy & Climate Intelligence Unit:
[1]: “Declaration/pledge”, “In Policy Document”, and “In Law” categories; [2]: “Proposed/In Discussion” category; [3]: No data

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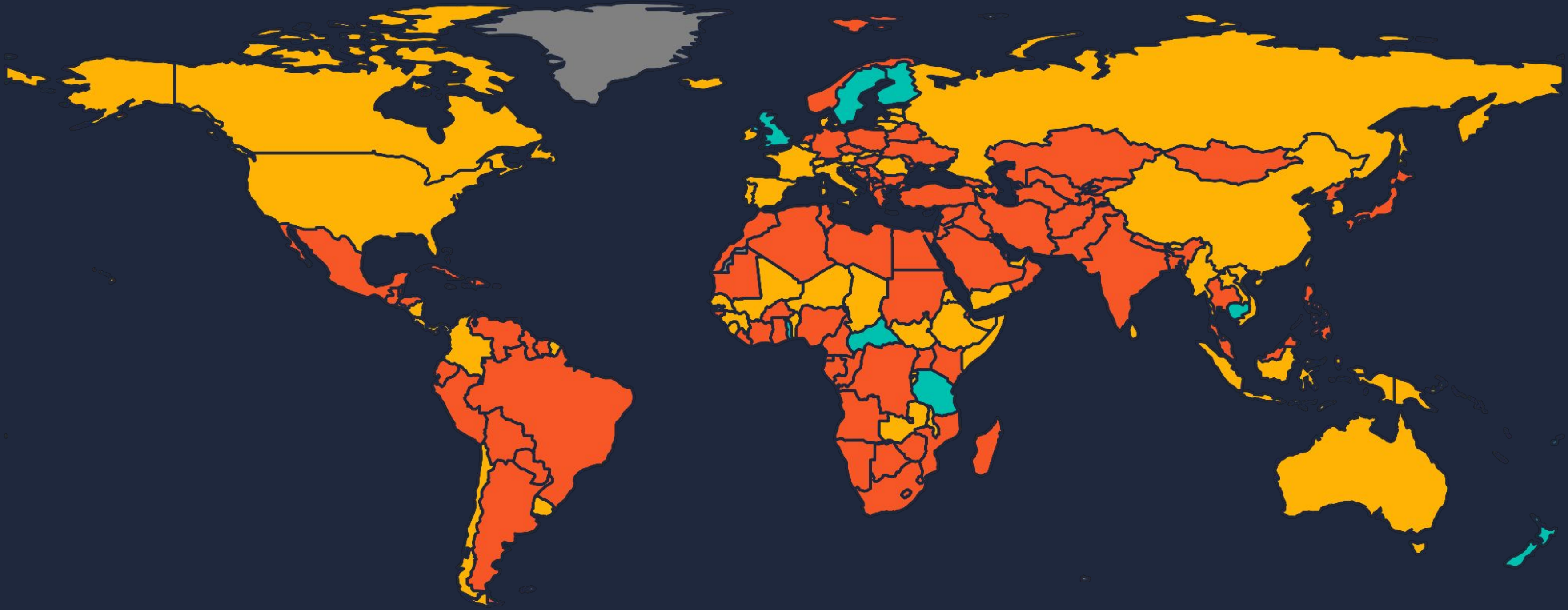
Ambition-to-action gap

Most countries do not have a credible net zero plan



Coverage of Global Emissions:

Coverage of Global Population:

Detailed Plan

Incomplete Plan

No Plan

Data from Net Zero Scorecard (2023) Energy & Climate Intelligence Unit

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Costly and closed

Most tools and data underpinning net zero plans are inaccessible

	Bespoke consultancy (e.g. McKinsey)	Subscription consultancy (e.g. BNEF)	Industry (e.g. Shell Scenarios)	Intergovt. orgs. (e.g. IEA WEO)	CSOs and Think tanks (e.g. RMI CEP)	Academia	Future Energy Outlook
Cost	$250k-$1mm per country	$25k-75k per year	Public report and excel	Public report and excel	Public report	Free	Free
Data Inclusion	Proprietary / Closed	Proprietary / Closed	Proprietary / Closed	Proprietary / Closed	Varies - closed and open data	Open, publicly available data	Open, publicly available data
Coverage & spatial resolution	Single country or region per engagement	Global (11 regions)	Global (unknown)	Global (11 regions)	Single country or region per engagement	Global (skewed to 'Global North')	163 countries (at the state / province level)
Transparency of model, data, and results	Report and excel outputs	Report and excel outputs	Report, partial dataset, and excel outputs	Report, partial dataset, and excel outputs	Report, partial dataset, and excel outputs	FOSS*; code, data, report	FOSS*; Code, data, report, and UI
Reproducibility	n/a	n/a	n/a	n/a	n/a	Coding experience required	Interactive open platform; Bespoke scenarios <10 mins

*FOSS: Free and Open-Source Software

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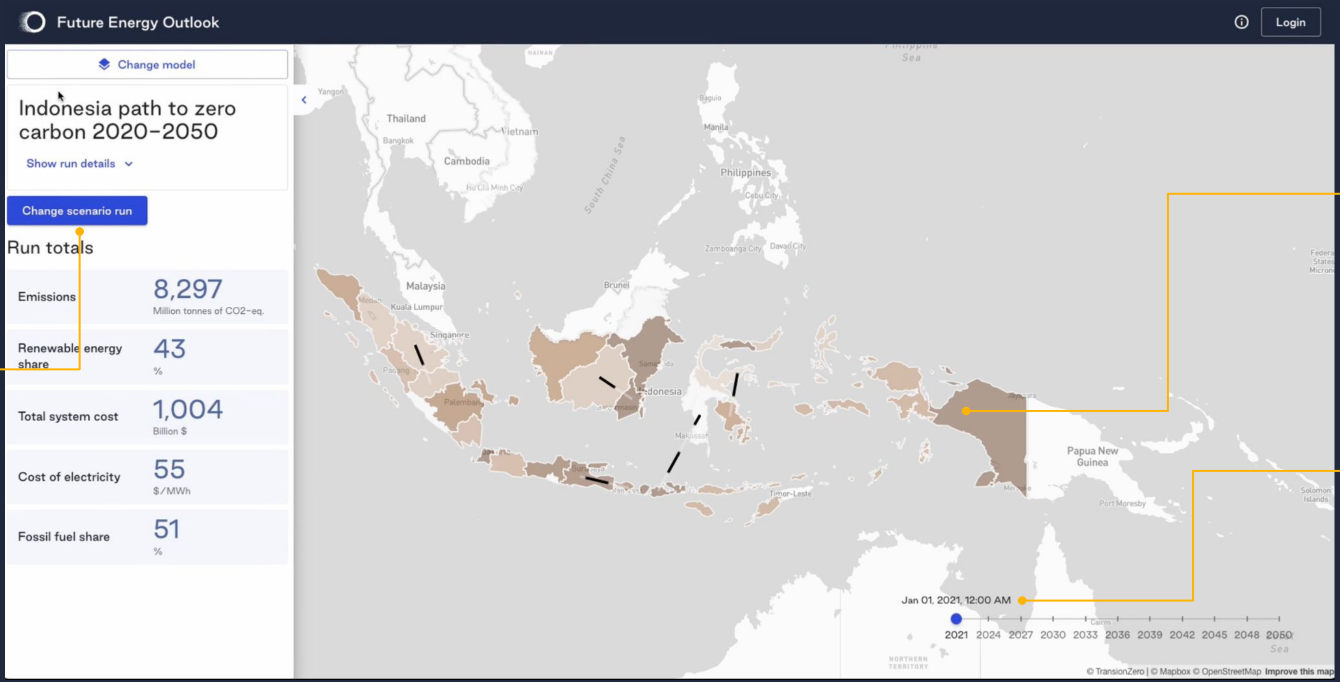
FEO Indonesia

Unparalleled spatial and temporal capacity expansion model in an accessible and auditable tooling environment



Auditable and **replicable** model environment

34 nodes modelled for Indonesia

Hourly temporal resolution

Source: TransitionZero (2023)

Key findings

Scenario analysis to show how Indonesia can save money by closing coal plants early

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Designing the future

Four electricity system futures based on policy decisions and regulatory reforms

Scenario	Coal capacity by 2030	New coal capacity beyond 2030	Emissions reduction target
Current Policies (CPS)	'Under construction' coal power plants included (13 GW)	No new capacity (due to lack of financing)	None
Least Cost (LCS)	'Under construction' coal power plants included (13 GW)	Yes, provided that new coal build reduces overall system costs	None
Net Zero by 2060 (NZS-60)	'Under construction' coal power plants included (13 GW)	No new capacity (due to lack of financing)	Peak power sector emissions of 290 $MtCO_2$ by 2030.
Early Coal Retirement (ECRS)	'Under construction' coal power plants included (13 GW). Early retirement of least profitable coal plants (up to $20 billion PPA buyout budget)	No new capacity (due to lack of financing)	None

Source: TransitionZero (2023)

TransitionZero

Close 21 GW to save $2 billion

Closing 21 GW of coal early can save Indonesia $2 billion while maintaining system reliability

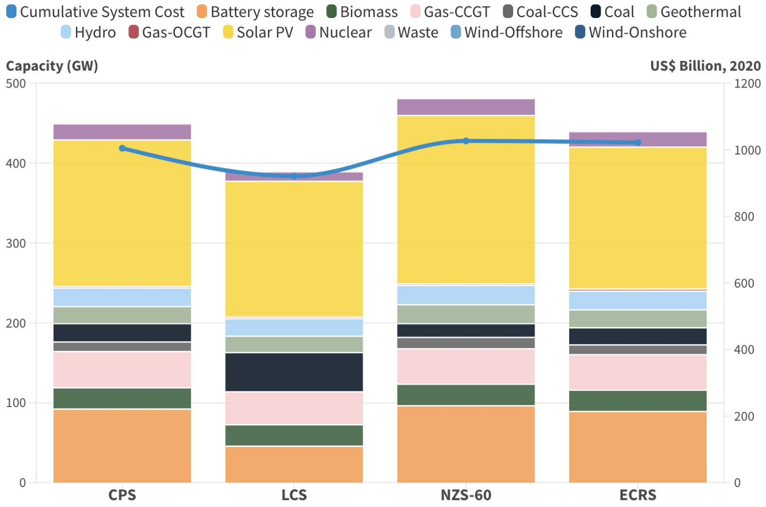
- We developed four scenarios to illustrate different energy futures under different policies: Current Policies (CPS), Least Cost (LCS), Net Zero by 2060 (NZS-60) and Early Coal Retirement (ECRS).

- ECRS saves $2 billion, avoids 1.3 gigatons of emissions from closing 21 gigawatts of coal while maintaining system reliability.

- Solar PV dominates the energy mix from 2040 under all scenarios modelled for FEO, regardless of emissions targets.

Here comes the sun

FEO Indonesia capacity mix and total system cost in 2050 by scenario



Source: TransitionZero (2023)

Main assumptions

Deep dive into energy demand, grid-connected capacity, resource availability and grid reliability assumptions

TransitionZero

Estimating electricity demand

Estimating future demand in the power sector is built up using a bottom-up approach

Electricity demand is estimated based on sectoral demand – split into industrial, commercial, residential and public use – and collected at the provincial level.

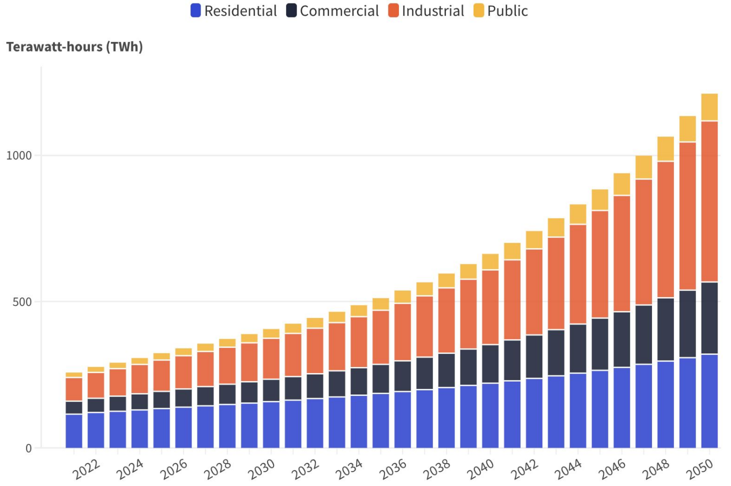
Demand projections are then made on a sectoral-provincial level, guided by RUPTL 2021-2030 demand projections and analyst research.

Hourly demand profiles for each province are used to capture daily and seasonal variations in electricity demand.

Because FEO is only concerned with demand and consumption in the power sector, direct energy consumption of primary fuels such as oil, gas, and coal is not modelled in the current exercise. There are plans to incorporate these elements in future developments of FEO.

Growing demand

Sectoral electricity demand from 2021 to 2050



Source: RUPTL 2021-30, TransitionZero (2023)

TransitionZero

Grid-connected capacity

Using plant data to align with ground truth on future generation capacity

For accuracy, we first mapped out the existing installed capacity. In this exercise, we have aligned with the plant list based on the Global Energy Monitor (GEM) as the backbone of dataset. We then cross-checked the data set against government energy documents and plans, including the RUPTL 2021-30, as well as with other internal sources.

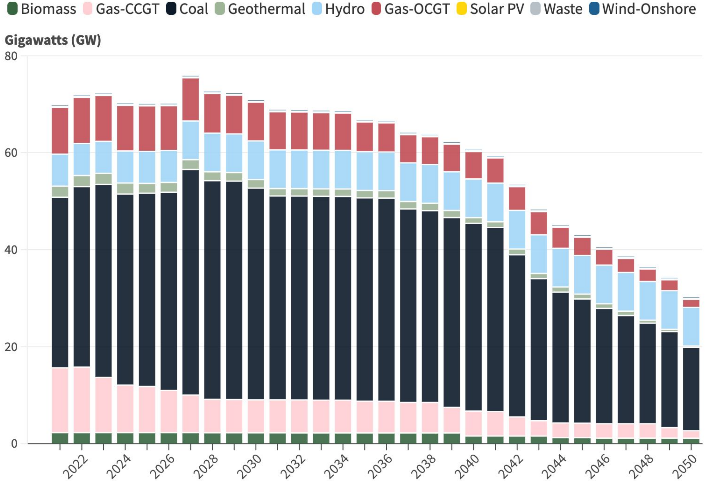
We included named plants that are under construction in our plant list, which we assumed would likely go ahead following Presidential Regulation 112/2022.

Named plants that are not yet under construction are not included in our plant list, as they may be scrapped following the government's formal ban on the development of new coal-fired power plants. Captive coal plants are also excluded from the modelling.

Beyond these named capacities, new build decisions are based on optimization parameters, which will be described in detail in later sections, but new coal build is constrained, except under a LCS. Coal retirements are optimized according to asset-level profitability, data from the Coal Asset Transition (CAT) Tool and provided in the Appendix.

Named fleet outlook

Named existing and under-construction capacity by fuel type from 2021 to 2050



Source: RUPTL 2021-30, TransitionZero (2023)

Resource availability of coal

Allocating Indonesia’s domestic coal resources for power needs amidst an energy transition

Indonesia has sufficient domestic coal resources to meet its needs. However, strategic decisions regarding export vs. domestic consumption and the allocation across different sectors need to made, which may affect coal availability to the power sector.

Annual coal production in Indonesia has hovered between 500-700 Mt. Despite policy interventions, domestic coal production has seen various challenges, leading to stagnation in production levels. The coal resource availability for this FEO exercise assumes:

700	Mt/year coal production	Future coal production will stay at its current 700 Mt per year, of which 25% is available to the power sector.
175	Mt/year coal for power	Of all coal production kept as domestic market obligation (DMO), a third is used by heavy industry (cement and smelting) and the remaining is used by power. Based on our understanding, the bulk of domestic production is already tied to international export contracts. We believe our estimates err on the conservative side.
$70	/tonne regulated price of coal	At the regulated price for 6,322 kcal/kg coal to power. This translates to about US$50/ton for 4,500 kcal/kg coal commonly used in the power sector. We believe that domestic production should be able to cater to future power generation fuel demand, and thus, Indonesia would not be exposed to international pricing.

Resource availability for coal is currently allocated on a country level, rather at a provincial level. Future editions for FEO will be refined to include resource potential at a provincial level and include cross-provincial transport costs.

Resource availability of gas

Allocating Indonesia's domestic gas resources for power needs amidst an energy transition

Gas production in Indonesia has been declining in recent years with gas lifting declining from 8,415 MMcfd in 2011 to a projected 5,441 MMcfd this year, representing a 35% dip.

Recognising the steady decline, the Indonesian government has taken steps to reverse the trend, including introducing better fiscal terms for new gas developments, with the goal of doubling gas production to reach 12,000 MMcfd in 2030. However, due to a relatively sluggish outlook and delays in existing developments, we assumed a more conservative stance, assuming that annual gas production will increase steadily to reach 7,500 MMcfd by 2026, and stay constant thereafter.

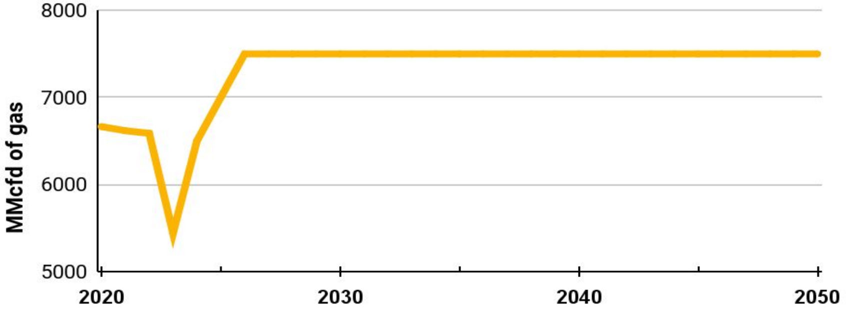
Not all of the gas production in Indonesia will be made available for power sector consumption. We have assumed that the current 20% allocation to power will stay constant. Domestic gas made available for power sector consumption will be priced at a regulated price of US$7/MMBtu at plant gate.

Consumption beyond allocation gas quantities will be exposed to international LNG prices. This will be priced at a conservative 12% Brent plus regasification tariffs. New-build regasification costs are an average of the existing LNG terminals in Indonesia to fully reflect the system cost.

Resource availability for gas is allocated on a country level and omits any potential midstream transportation costs, such as pipeline and regasification costs, that may be incurred.

A steady lever on gas

Estimated domestic gas availability based on production from 2020 to 2050



Source: TransitionZero (2023)

Resource availability of renewables

Tapping into Indonesia's abundant renewable energy resources

Resource availability for renewable energy is often classified into technical availability and economic availability. We are interested in the **total resource availability**, under the assumption that – with time, and technological development – the cost and technology hurdles will be gradually removed. The resource potential for individual RE resources are retrieved from the following sources:

- **Geothermal:** 'Volcanostratigraphy of Batukuwung-Parakasak Geothermal Area, Serang Regency, West Java', U. Sumotarto, 2019
- **Solar PV:** 'Beyond 443 GW - Indonesia's Infinite Renewable Energy Potentials', IESR, 2021
- **Wind:** 'Beyond 443 GW - Indonesia's Infinite Renewable Energy Potentials', IESR, 2021
- **Biomass:** 'Beyond 443 GW - Indonesia's Infinite Renewable Energy Potentials', IESR, 2021
- **Hydropower:** International Hydropower Association, 2019

Waste-to-energy and nuclear are not capped. However, given the high costs associated these technologies, their buildout is minimal. The hourly RE profiles for solar PV, onshore and offshore wind, are retrieved from Renewables.Ninja.

Let renewables runneth over

Indonesia's renewable resource availability in GW

Region/Grid	Solar PV	Hydro	Onshore Wind	Biomass	Geothermal
Jawa	187.1	4.2	0.8	1.0	10.3
Kalimantan	3000.1	21.6	0.1	10.6	0.1
Maluku	277.6	0.7	4.9	0.1	0.5
Nusa Tenggara	364.7	0.4	6.0	0.2	1.2
Papua	721.1	22.4	0.2	0.5	0.1
Sulawesi	486.3	10.2	6.5	0.4	1.9
Sumatera	1712.5	15.6	1.2	18.0	12.4

Sources: IESR 2021; Sumotarto 2019; International Hydro Power Association 2019

System cost optimisation

Optimising actual generation based on costs

While resource availability caps the maximum generation in the FEO model, FEO optimises for least cost (in the absence of additional constraints), which ensures that (1) the cheapest source of generation is dispatched, and (2) the cheapest generation technology is being built to meet demand.

To ensure that the cheapest source of generation is dispatched
The FEO model optimises based on the merit order. For every timeslice, dispatch decisions are based on short-run marginal costs, which separates fixed costs from variable costs.

To ensure the cheapest generation technology is being built
The model optimises for the lowest overall *costs to the system* over the entire model period when deciding to build a new power plant. The lifetime costs includes not only the CAPEX of the plant, but also the operating and maintenance costs, fuel costs, carbon cost, and costs associated to the grid to absorb the new plant. This means that variables such as lower capacity factors of coal plants (leading to higher fixed costs per unit of power consumed) and grid enhancement costs associated with the introduction of higher volumes of intermittent renewables will all be included in the decision on what generation technology to employ when building a new plant.

We have also considered emerging technologies. Nuclear plants are able to enter the market starting 2039, but the decision to build nuclear plants depends on model optimisation and constraints. In addition, the model includes new build Coal with CCS.

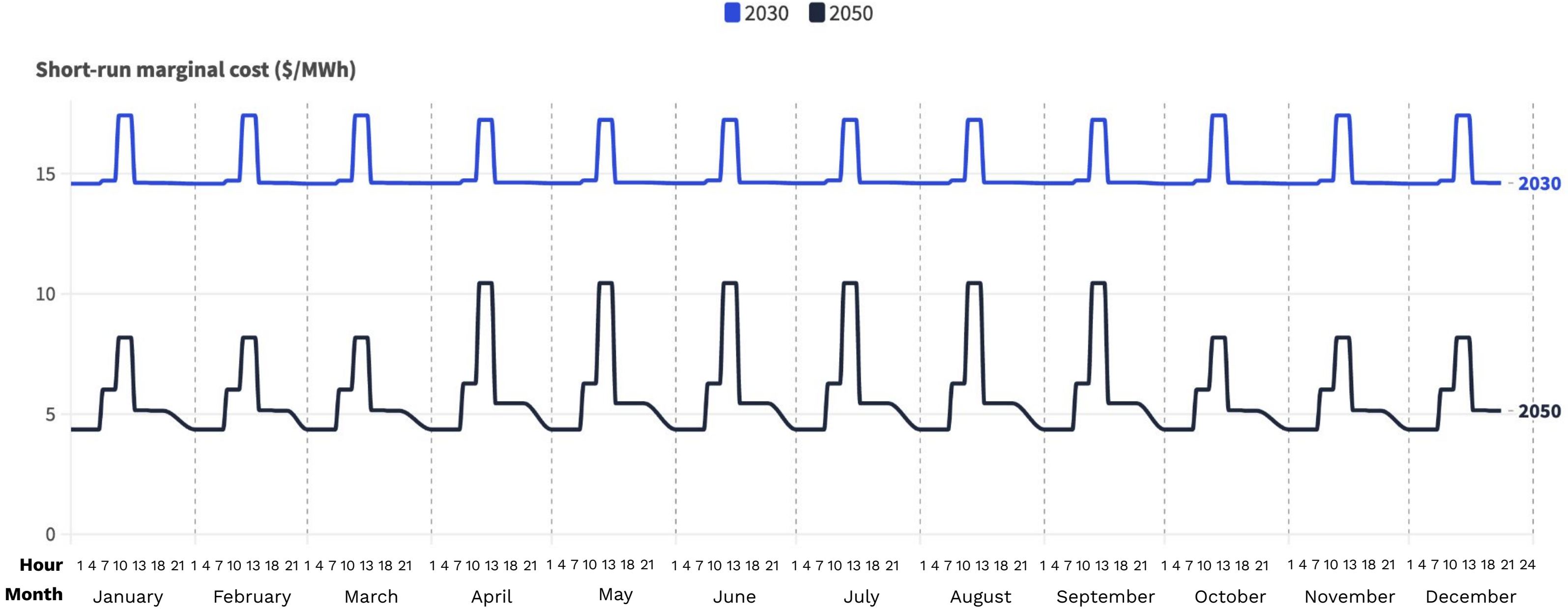
Technology costs employed in the model are listed in the Appendix. Battery storage costs are based on NREL, while cost estimates for other technologies are retrieved from OSeMOSYS Global and PLEXOS World.

Cost optimisation

Renewables to get more affordable over time

Variable renewable evolution

Short-run marginal costs for Indonesia in 2030 and 2050, averaged across days in the month for each hour



Source: TransitionZero CAT (2022)

Grid reliability

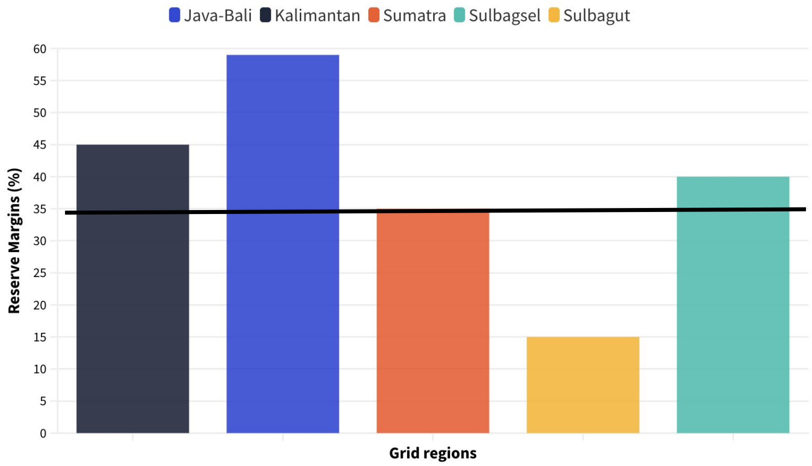
Ensuring the reliable and consistent operation of grid systems is just as vital as producing power

To account for full systems stability, intra- and inter-province transmission capacity are included in the modelling. These are represented with links to associated power plants, and are included in the estimated costs and losses. Inter-island links are assumed to be subsea cables costing 1100 $/kW of capacity.

The model was configured to reduce reserve margins to 35% by 2030, and maintain it at that level, to drive out excess capacity and improve system efficiency while ensuring a safe generation margin to meet peak demand in all scenarios. The Reserve Margin target is from RUPTL 2021-30.

Reducing excess capacity

Current versus 2030 target reserve margins by grid



Source: TransitionZero CAT (2022)

Results

Quantifying the impacts on system cost, capacity, generation, and emissions reduction

Early coal retirement is a win-win

Of the five scenarios, it delivers the most emissions reduction at little extra cost to the system.

Under ECRS+PPA, it is assumed that all the additional system costs fall on Indonesia. Under that scenario, the total system cost represents a $18 billion increase from the current policy with the retirement of 21.7 GW of coal capacity by 2030, which helps Indonesia avoid over 137 million tonnes of CO_2 emissions ($MtCO_2$) – the largest reduction in emissions over the short term. From there, CO_2 emissions to 2050 would drop by one-fifth from the current policy trajectory of 8,300 $MtCO_2$.

The cost of abatement is an estimated $16 per tonne of avoided CO_2. This includes the capital investments, fuel costs, and operating expenses needed to expand and operate Indonesia's power system.

This highlights the timely potential of mobilising the JETP. If the $20 billion covers part of the $1.022 trillion system cost expenditure under ECRS to buyout the lowest performing power purchase agreements, the carbon abatement cost drops to -$2 per tonne of avoided CO_2.

Progress & trade-offs

FEO Indonesia's 2060 headline metrics by scenario

Scenario Name	Cumulative Emissions (million tonnes of CO_2)	Total System Cost ($ Billions)	Cost of Abatement ($/tonne of CO_2)
CPS	8,105	1,004	-
LCS	9,179	921	77
NZS-60	6,100	1,027	11
ECRS	6,970	1,002	-2
ECRS+PPA	6,970	1,022	16

Source: TransitionZero (2023)

Electricity system costs

Balancing system costs with carbon emission reduction potential

While LCS yields the lowest system costs over time for Indonesia, cumulative emissions would be 12% higher than CPS and diverge significantly from a net zero target.

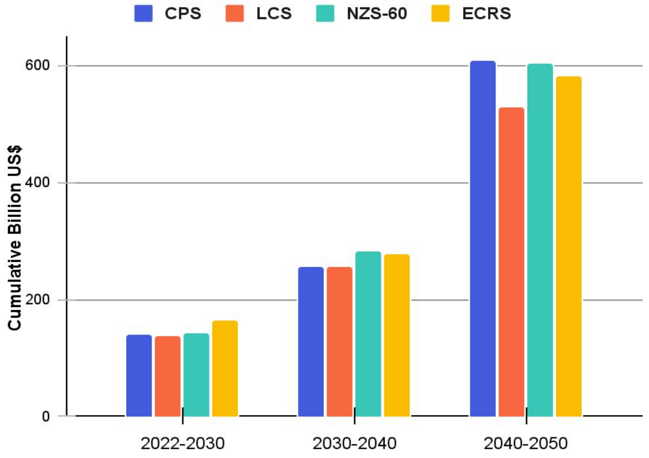
The ECRS and NZS-60 increase the total system cost slightly from CPS, owing to significantly more investments in new and renewable energy and a more robust build out of interconnectors.

ECRS requires the highest upfront spending, as a result of front-loading the capacity needed to ensure security of supply from 2030 to 2040 after coal plants are brought offline. System cost under this scenario increases to $160 billion in 2030 but stabilises to be within range of Current Policies and Net Zero by 2060 scenarios in later years.

The NZS-60 has the highest cumulative system cost as it requires a significantly larger build out of renewables to achieve the target. However, cumulative emissions would be 14% lower than ECRS and 25% lower than CPS.

Current Policies cost the most

FEO Indonesia's total system cost over time by scenario



Source: TransitionZero (2023)

Emission reduction potential

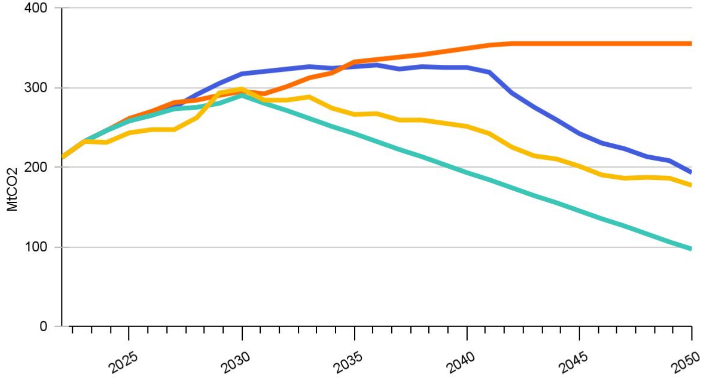
Combining coal closures with emission targets is the most effective strategy for rapid decarbonization of Indonesia's power sector

Under the ECRS, cumulative emissions decreases by 14% from CPS, effectively avoiding over 1.1 billion tonnes of CO_2 between 2022 and 2050. Emissions under this scenario are aligned with NZS-60 until the mid-2030s after which they diverge slightly. A cumulative 49 $MtCO_2$ would be avoided in the first five years as carbon-intensive coal plants come offline.

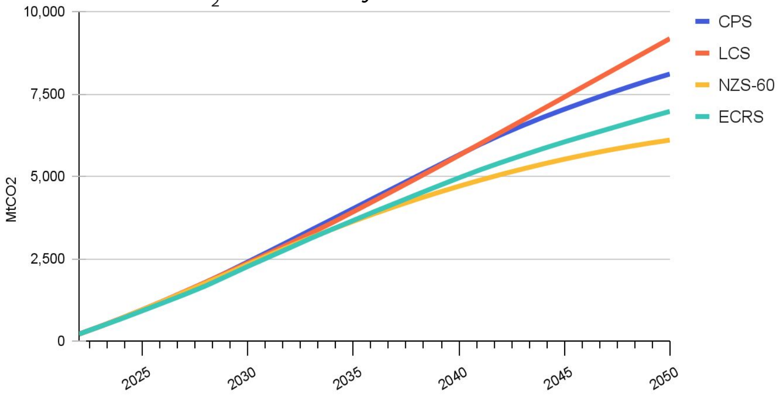
In the 2023-28 period, the ECRS avoids 87 $MtCO_2$ more than optimising Indonesia's power sector to achieve net zero by 2060. There are two main reasons for this: legacy coal commitments, and limited JETP funds. Plant closures under the ECRS outpace planned coal additions over the first five years. Emissions reductions are back-loaded in the 2030s and 2040s when optimising for Net Zero by 2060; the majority of emissions cuts are seen from 2030 onwards.

Near-term & Long-term emission reduction

Annual CO_2 emissions by scenario



Cumulative CO_2 emissions by scenario



Capacity mix

Technological allocations are similar across the modelled scenarios

- Solar PV dominates the capacity mix after 2030 in most FEO scenarios, as its cost-competitiveness guarantees it a central role in the energy transition. By 2030, Indonesia will need between 15 GW and 21 GW of solar capacity in operation. NZS-60 requires this to nearly triple to 77.5GW of solar by 2040 – between 28% to 32% higher than other scenarios. Current RE targets and policies do not sufficiently support this level of ambition; RUPTL 2021-30 has only 5 GW target for solar PV capacity by 2030.

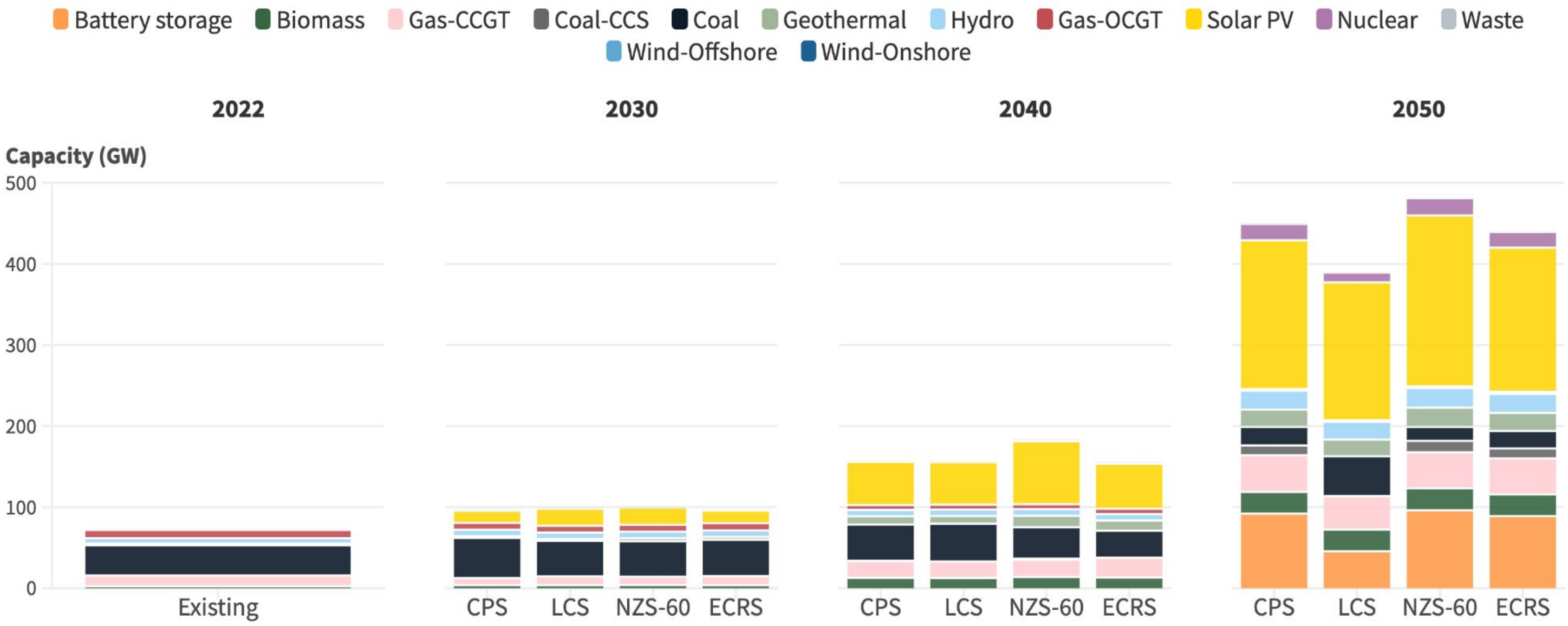
- Baring policy interventions to reduce the cost of battery storage, the technology will not play a significant role until costs fall in the 2040's.

- Nuclear power starts to penetrate the mix in 2040, except in the LCS. By 2050, between 12 GW and 21 GW of reactors could be in operation through heavy subsidies. This would require PLN and regulators to address concerns around seismicity risks, high capital cost, tariff structuring, financing, and delivery delays.

- The lack of development and policy support for most renewables is a major barrier. Development timelines for a solar project take at least 1.5 to 2 years in Indonesia. PLN's auctions and market incentives have not been sufficient in jumpstarting RE deployment. Policy reform and targets will be crucial in ensuring that the necessary RE capacity makes it on the grid in due time.

Capacity mix by scenario

Solar PV in Indonesia will need to scale massively within the next two decades



Source: TransitionZero (2023)

TransitionZero

Generation mix by scenario

Coal generation swings across scenarios

- Total generation varies across scenarios during to differences in transmission losses. Two key interrelated determinants of the total generation is the presence of cross-provincial electricity trade and the split between coal generation and solar generation. Solar generation is typically further away from demand sources, while coal generation is closer to demand sources. However, transmission losses may not always be a bad thing, if it leads to a more resilient system overall. Moreover, transmission losses can be minimised as the technology improves.

- Battery storage is used to shift generation across different time slices, therefore battery generation is not reported separately.

- Coal generation varies significantly across scenarios, seeing 3% under NZS-60 and 23% under LCS.

- Solar proves king, with generation reaching 35% of generation under NZS-60, while maintaining a 30% share under LCS.

- Coal+CCS is not expected to feature prominently unless emissions constraints are present due to high cost barriers. Even then, Coal+CCS will also enter the generation mix in 2050.

- Gas’ share average out at 7% of generation in 2050 across scenarios, indicating that gas has a role, albeit a small one, across different energy futures.

- Onshore wind generation receives little attention, owing to poor wind resources resulting in high cost of generation. Offshore wind has not been discussed by the Indonesian government, and therefore is only considered to a limited extent.

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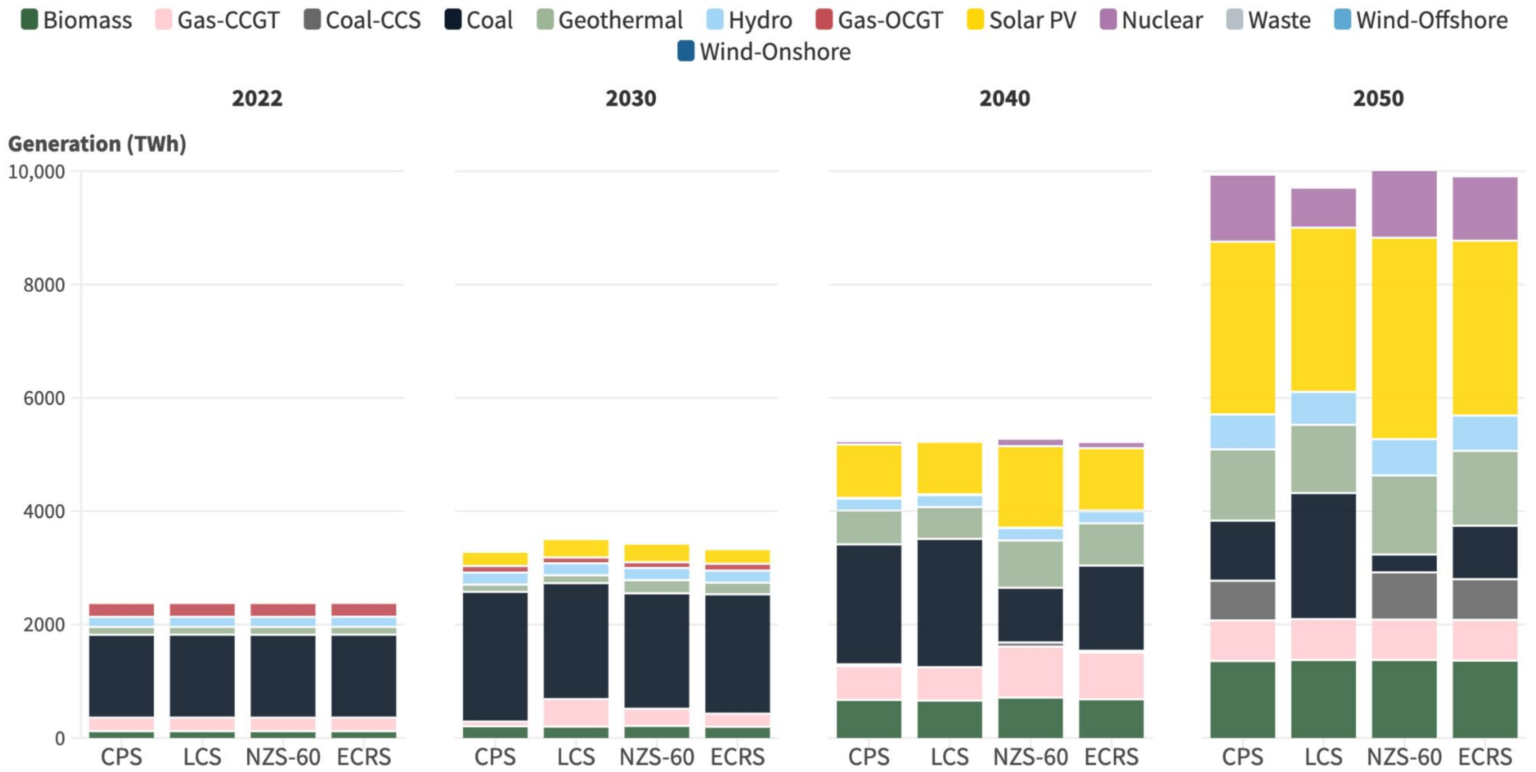
Generation mix by scenario

Differing technologies will be available to deal with intermittency



Source: TransitionZero (2023)

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Grid requirements are significant

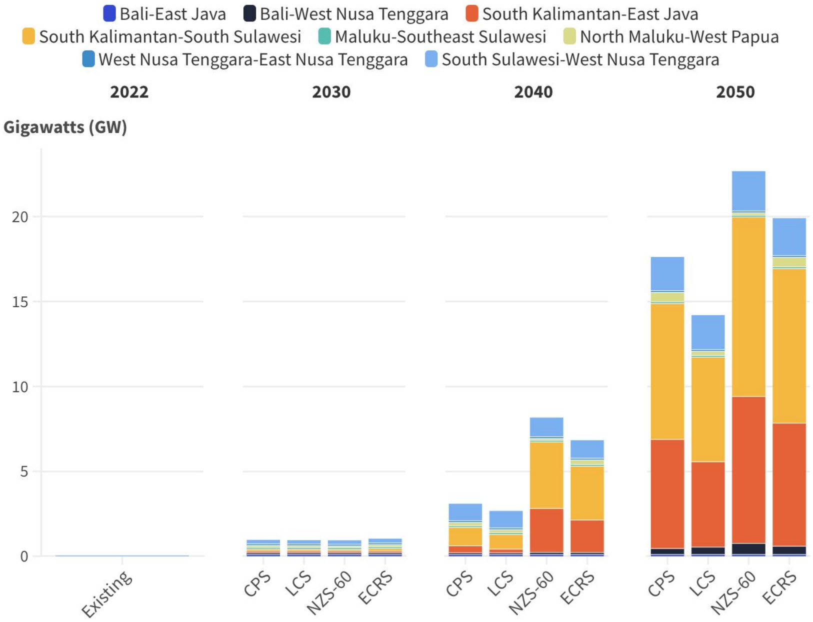
Indonesia's grid will need to expand to support coal retirements and RE integration

Higher RE penetration requires an optimized and expanded grid, as many RE sites are not located near traditional demand centers. Power markets and systems will also need to be designed to respond to intermittent, zero marginal cost power sources.

- The capacity of cross-province electricity interconnectors by 2050 ranges from 105 GW in the LCS to 173 GW for Net Zero by 2060 – an unprecedented expansion. Between 12 to 14% of interconnector capacity is inter-island, which requires subsea cables to be constructed.
- Reserve margins protect security of supply, but overcapacity is costly. Averaging 49% across the five main grid networks, Indonesia's reserve margins are far above the Southeast Asia's typical 25-30% margin. The Java-Bali grid currently retains excessive spare capacity and an estimated 60% reserve margin, maintained with great cost to the system and government budget.
- Capacity payments made to independent power producers cover fixed operations, maintenance costs, and initial capital outlay. They are paid regardless of the plant's generation. Banten hosts 8.8 GW of installed coal capacity; of which, 7.3 GW of coal in Banten could be prioritised for early closure due to their poor performance.

Connecting islands

FEO Indonesia's inter-island electricity interconnectors



Source: TransitionZero (2023)

Policy Guidance

How FEO Indonesia's insights can be used for productive energy systems planning

Policy Guidance

01

ECRS can deliver the most savings and emissions reductions, leading to an emissions trajectory in line with net zero scenarios until the mid-2030s.

02

Cross-province electricity interconnectors and the supporting grid infrastructure play a crucial role in unlocking the renewable potential required to achieve Indonesia's energy transition, while maintaining reliable supply of electricity for consumers.

03

Solar PV dominates the power capacity and generation mix across all scenarios. However, Indonesia's current policies and market structure are not yet designed to ensure its rapid and cost-effective deployment.

Policy Guidance

04

Total System Costs are similar across the four scenarios (~$900 - >1000 billion).

The additional cost in the ECRS and NZS-60 are largely due to the requirement of larger solar PV and battery storage capacity, combined with a greater need for inter-island electricity interconnectors to move this renewable energy to demand centres.

05

Cost of abatement ranges from $77/tCO_2$ in the LCS to $-2/tCO_2$ for the ECRS, relative to CPS.

This highlights that with effective planning and strategy, the simultaneous decrease of power sector emissions and total power system costs in Indonesia is possible.

06

Leveraging JETP is crucial and necessary. Beyond the JETP, more ambitious climate financing with bigger budgets would retire more coal capacity early and prevent Indonesia from reverting to a net increase in coal after the early retirement funds are spent.

Indonesia needs both a bold and ambitious JETP for early coal retirement and a concrete commitment to its 2060 net zero target, underpinned by interim carbon budget milestone targets to improve near-term accountability and ensure the power sector stays on track.

Policy Guidance

07

The social costs of energy transition is not to be forgotten. Beyond economic costs, modelling the social costs of decarbonisation, including the potential job losses, economic decline in emissions-intensive sectors, all need to be accounted for to better understand the trade-offs.

08

Better tools are needed to ensure that policymakers and other decision-makers are equipped with the right data to help them prepare for a managed energy transition.

These tools should cover both the economic and social aspects and help provide a harmonized view on the costs and benefits of the energy transition. Comprehensive and transparent analyses will help garner support and ensure buy-in on transition pathways and prevent a chaotic transition, which will only increase overall costs.

Appendix

Technology cost estimates

Capital cost of generation technologies out to 2050

Technology	Unit	2021	2030	2040	2050
Battery storage	USD_{2020}/kWh	330	198	173	149
Biomass	USD_{2020}/kW	1820	1820	1710	1710
Gas - Combined Cycle (CCGT)	USD_{2020}/kW	660	660	635	635
Coal - CCS	USD_{2020}/kW	3115	3115	2925	2925
Coal	USD_{2020}/kW	1480	1480	14567	1457
Geothermal	USD_{2020}/kW	3440	3440	3140	3140
Hydro	USD_{2020}/kW	2000	2000	1925	1925
Gas - Open Cycle (OCGT)	USD_{2020}/kW	730	730	705	705
Solar Photovoltaic	USD_{2020}/kW	560	560	485	485
Nuclear	USD_{2020}/kW	4000	4000	4000	4000
Waste	USD_{2020}/kW	1820	1820	1710	1710
Wave	USD_{2020}/kW	5100	5100	5100	5100
Wind - Offshore	USD_{2020}/kW	2980	2980	2750	2750
Wind - Onshore	USD_{2020}/kW	1280	1280	1180	1180

Source: Technology Data for the Indonesian Power Sector (February 2021), Directorate General of Electricity (Indonesia) and Danish Energy Agency

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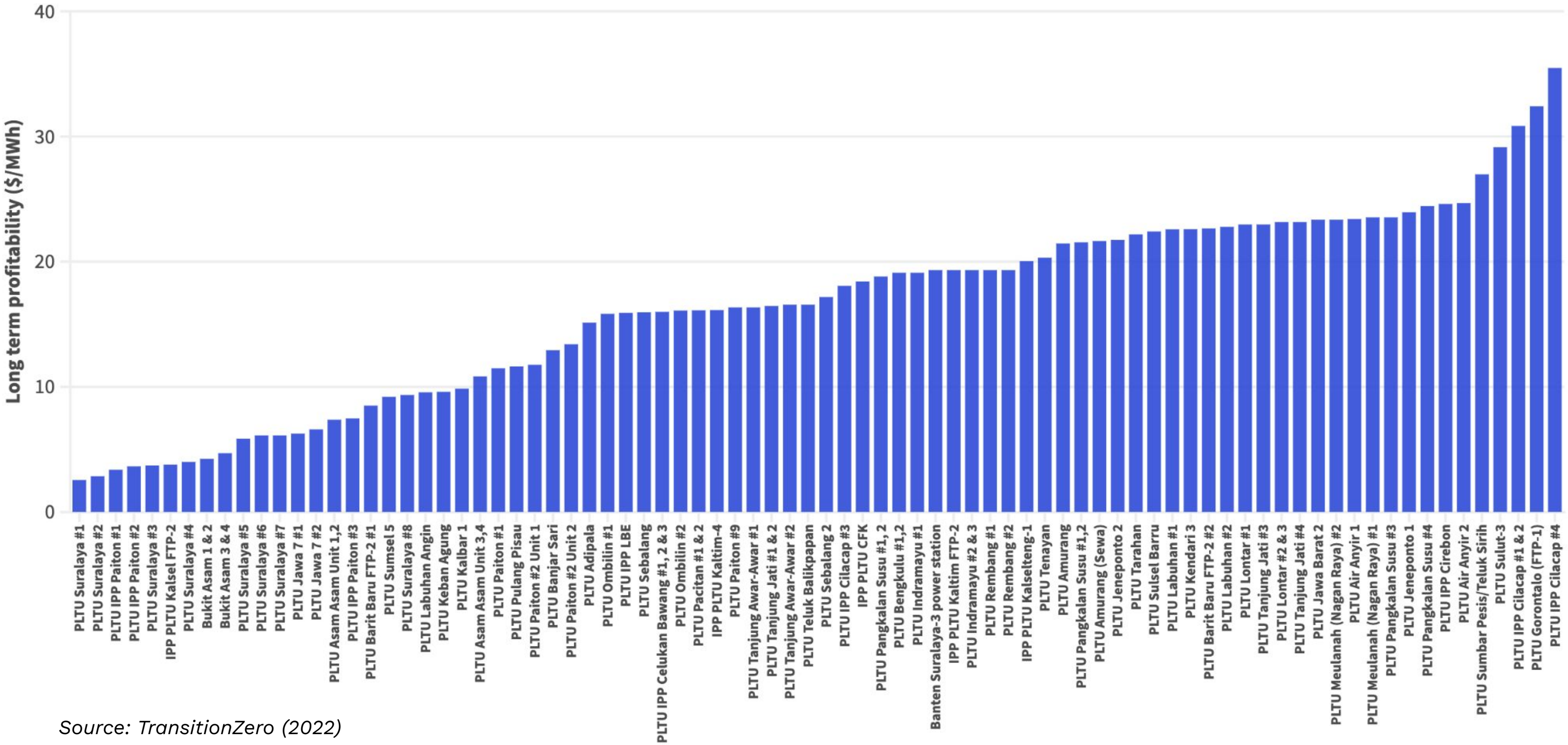
Asset-level coal retirement

Based on TransitionZero's Coal Asset Transition Tool



Source: TransitionZero (2022)

RUPTL 2021-30

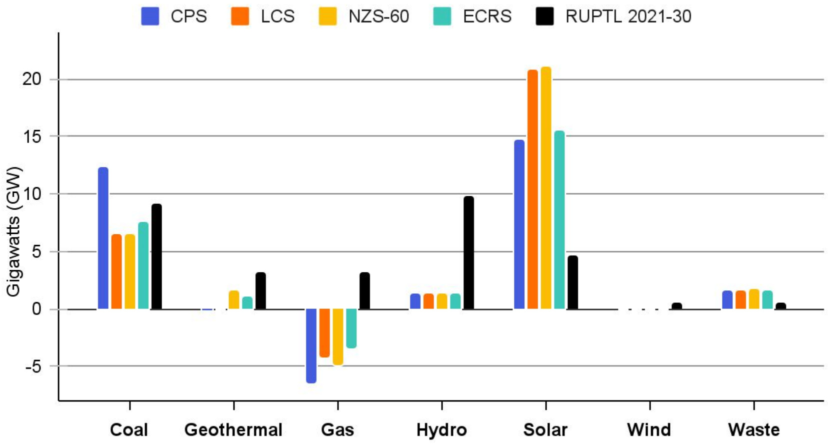
How the existing PLN Business Plan compares to FEO

RUPTL 2021-30 envisages a strong ramp-up in natural gas, biomass co-firing, hydro and geothermal power and a slower ramp-down of coal.

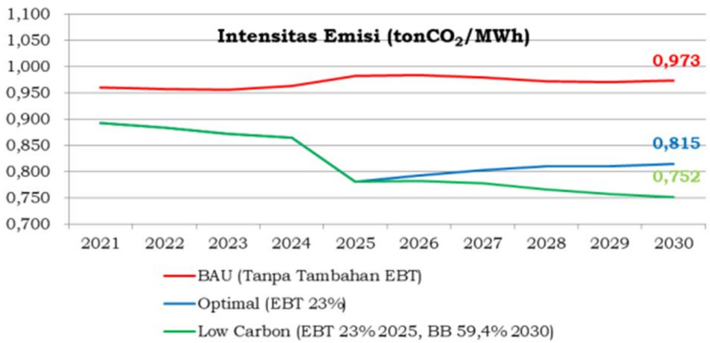
The FEO scenarios suggest that any cost-efficient optimisation of Indonesia's power mix will see a heavier reliance on solar by 2030, and the absorption of technologies like batteries, biomass and geothermal from 2030 to 2050.

FEO results suggest between 15 to 21 GW by 2030 will be needed to meet system demand alongside emission reduction.

Comparison of capacity additions to 2030



Source: TransitionZero (2023), RUPTL 2021-30



Source: RUPTL 2021-30

Under the existing RUPTL, the average grid emissions factor by 2030 is 0.82 tCO2/MWh. Under FEO, the current policies would increase the emissions factor by nearly 5% while a 'Net Zero by 2060' scenario would decrease it to 0.78 tCO2/MWh. While the technology mix is vastly different, both FEO and RUPTL trend towards the same emissions destination for the end of this decade.

With the RUPTL currently under revision, there is a need to send clear policy and market signals to encourage and support rapid renewable uptake. This needs to align with the JETP and MEMR commitments.

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