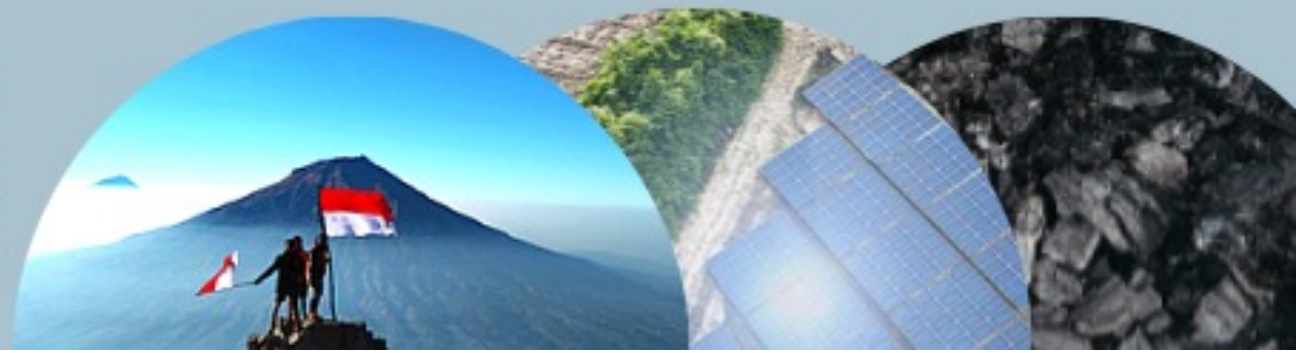

# Financing Indonesia's Coal Phase-out: A Just and Accelerated Retirement Pathway to Net-Zero


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# Indonesia has signaled its openness to adopting a more ambitious net-zero target and a 2040s coal phaseout with international support

- Coal-fired power plants (CFPPs) account for two-thirds of Indonesia's power generation and over a quarter of the country's total CO2 emissions.
- At COP 26, the minister of the Ministry of Energy and Mineral Resources (MEMR) signed the Coal to Clean Power Transition statement, agreeing to consider accelerating coal phaseout into the 2040s, conditional on receiving additional international financial and technical assistance.
- The plan proposed by PLN includes a 2056 phaseout of CFPPs and no new coal beyond 2023 (allowing completion of plants already under construction or have reached their financial close).


- To accelerate the no new coal and phaseout timelines to be in line with the 1.5°C-compatible pathway, additional support is requested to address broader socioeconomic impacts (e.g., stranded assets, job losses, investment to scale up renewables to meet growing demand, etc.)
- Various financing mechanisms are under discussion, including South Africa's Just Energy Transition Partnership and Asian Development Bank's Energy Transition Mechanism (in partnership with Indonesia and the Philippines).
- Identifying the most beneficial strategies will require refinement of how to evaluate the just transition financing needs and how to effectively allocate the limited resources to achieve the best outcome in the near term and set a robust pathway towards the long-term goals.

# This research develop a feasible plan and associated financing needs for retiring Indonesia's CFPP fleet in support of national 2050 net-zero emissions and the global 1.5°C target

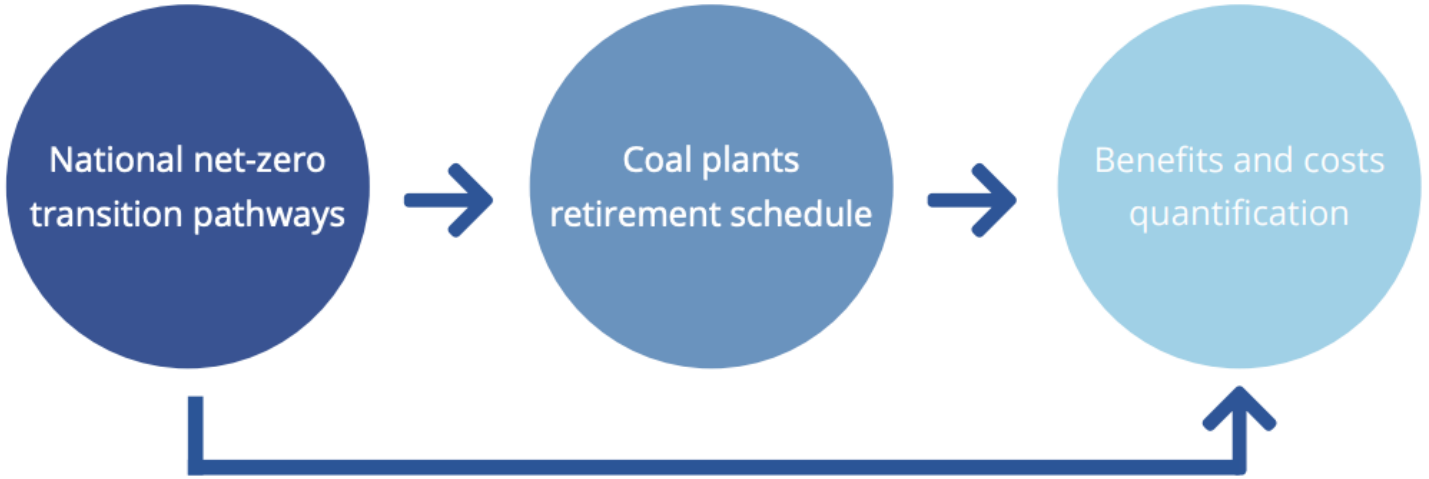
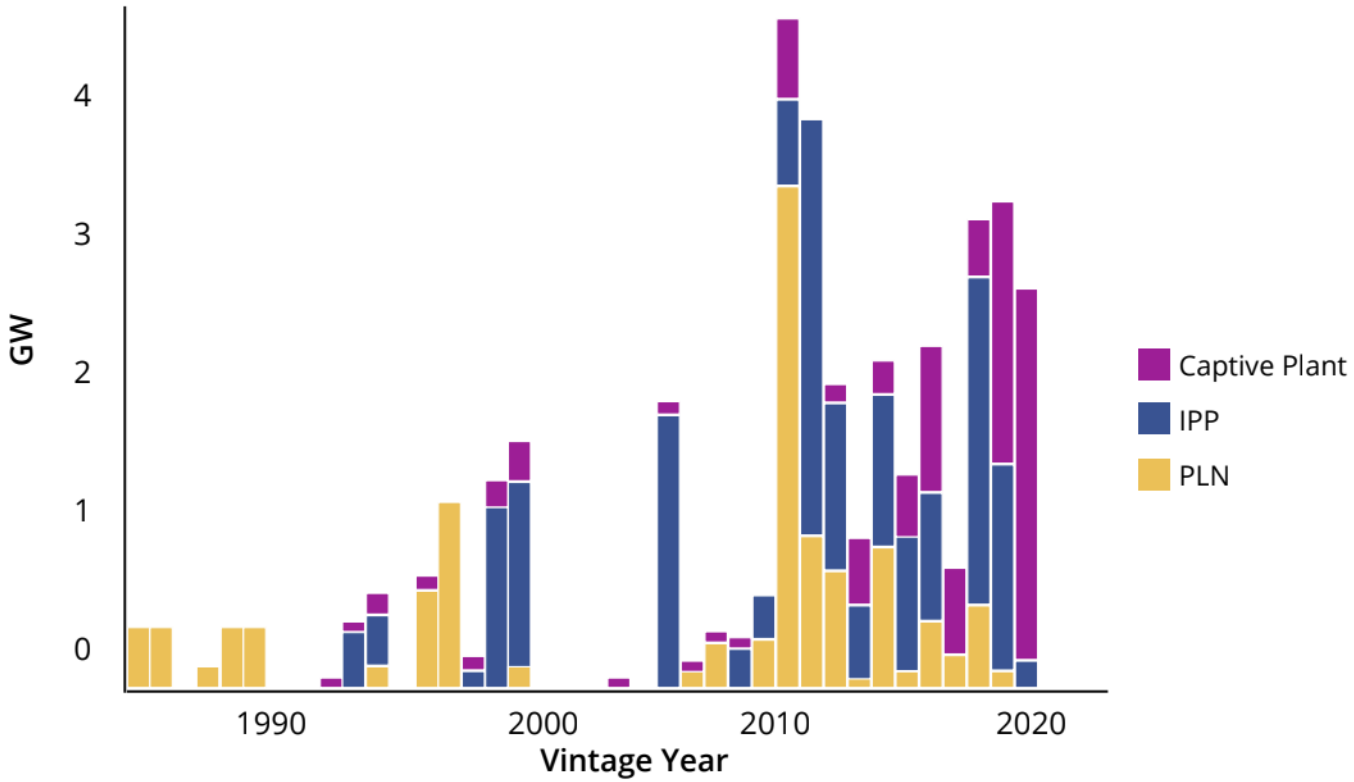



**Figure 1.** Research Overview

- Step 1: develop the pathways for national 2050 net-zero emissions using a global integrated assessment model (the Global Change Analysis Model, GCAM).
- Step 2: develop detailed plant-by-plant retirement schedule based on fulfilling multiple national priorities (i.e., air quality, health, economic benefits) simultaneously and that also achieve the 2050 net-zero target.
- Step 3: estimate the magnitude of financing needs by systematically quantifying the benefits and costs of implementing a just, rapid coal-to-clean energy transition.

# Indonesia's CFPP fleet is relatively new and still growing, but the expansion plan is expected to introduce overcapacity issue




*Data source: Global Coal Plant Tracker, January 2022; Authors' adjustments*

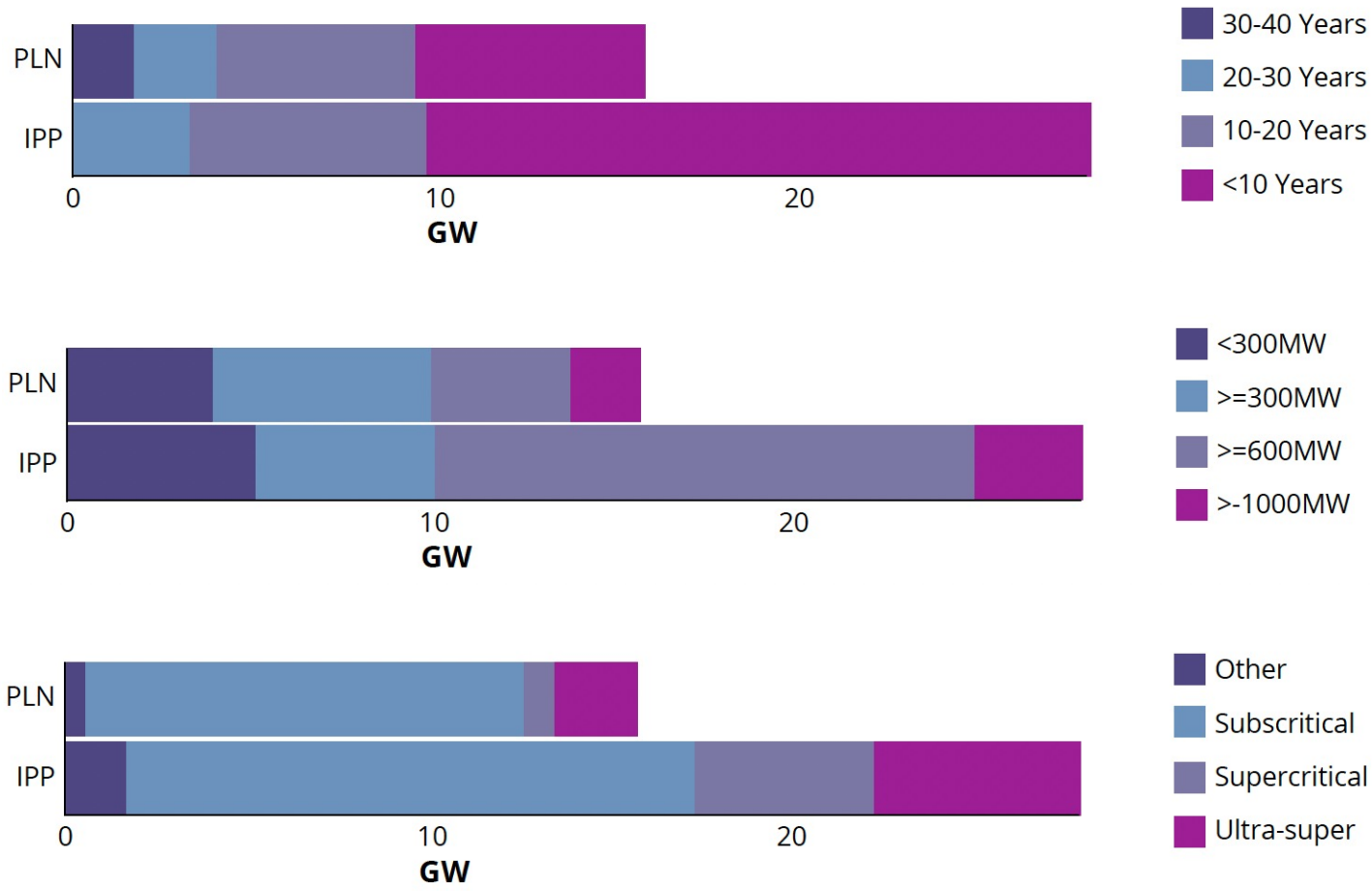
<u>Existing capacity (chart left):</u>

- Indonesia has 86 coal power plants in operation, a total installed capacity of 40.2 GW, ranking the 7th globally.
- 26 plants (12.5 GW) are owned by PLN, 32 plants (18.5 GW) are owned by IPP, and the remaining 23% capacity are off-grid captive plants.
- Indonesia's CFPP fleet is relatively new, about 75% was built after 2005.

<u>New projects:</u>

- The 19 projects (10.8 GW, 11 new plants & 8 expansion) under construction are very likely to be implemented.
- The 3 projects (1.5 GW, all new plants) that have signed power purchase agreements (PPAs) also face challenges to be stopped.
- The 11 projects (8.7 GW) at early development stages are more likely to be cancelled.

# IPP owns most of the newer, larger, and more efficient plants, and most of the new capacity are developed by IPP




Our analysis focuses on the existing and construction/PPA projects owned by PLN and IPP (72 plants, 43.4 GW). Among these:

- IPP owns 27.7 GW and PLN owns 15.7 GW.
- IPP owns majority of the capacity built within the past decade, while the oldest plants (30~40 years) belong to PLN (top chart).
- IPP owns majority of the units larger than 600 MW (middle chart).
- IPP owns majority of the units with super- and ultra super-critical technologies (bottom chart).
- Out of the 12.3 GW of new capacity to be added, 9.2 GW is developed by IPP, including all three new projects with PPA contract.

*Data source: Global Coal Plant Tracker, January 2022; Authors' analysis*

# We combine the bottom-up plant assessments and the top-down net-zero pathway from a global integrated assessment model (GCAM) to develop the retirement schedule for individual CFPP

72 PLN and IPP coal plants (43.4 GW) either operating or under construction/PPA as of May 2022

Plant-by-plant retirement priority

**Dataset of existing coal-fired power plants**

**Plant-by-plant retirement algorithm**

**Retirement pathway**

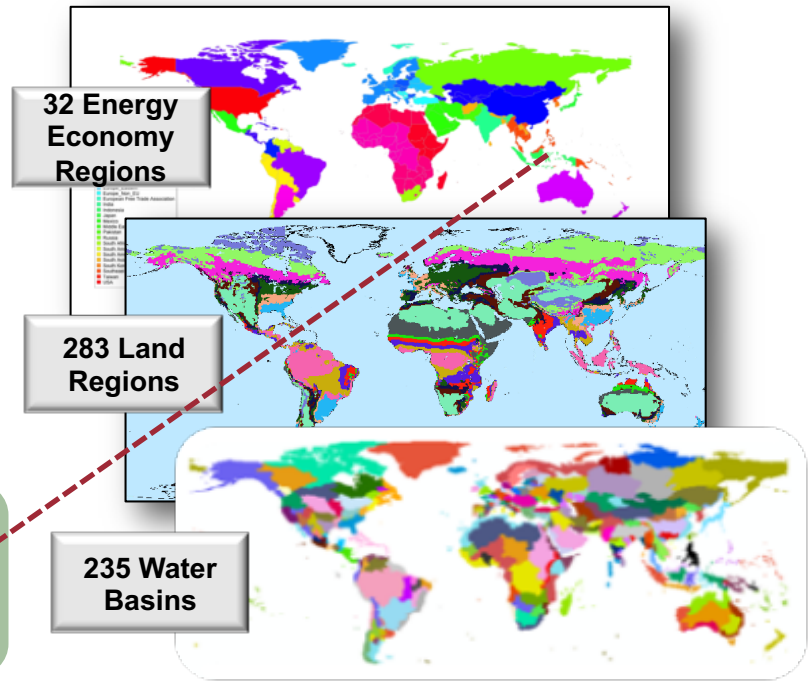
Plant-by-plant retirement pathways

GCAM
Global 1.5°C emission pathways and energy scenarios throughout 2100

**Deep decarbonization scenarios by** GCAM

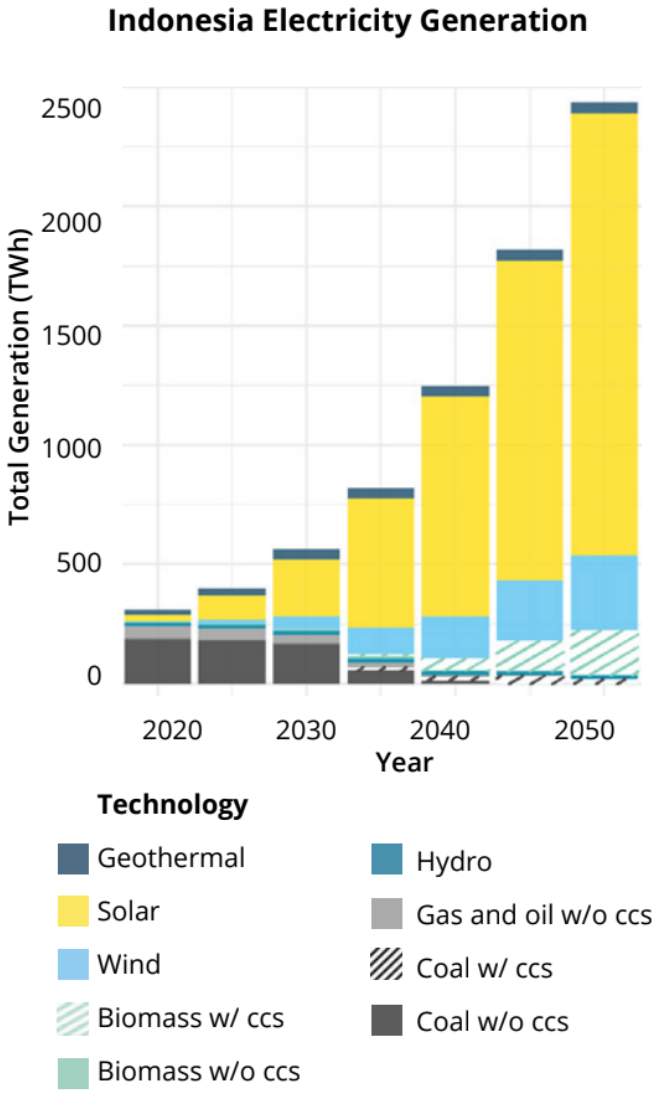
**National coal power generation pathways**

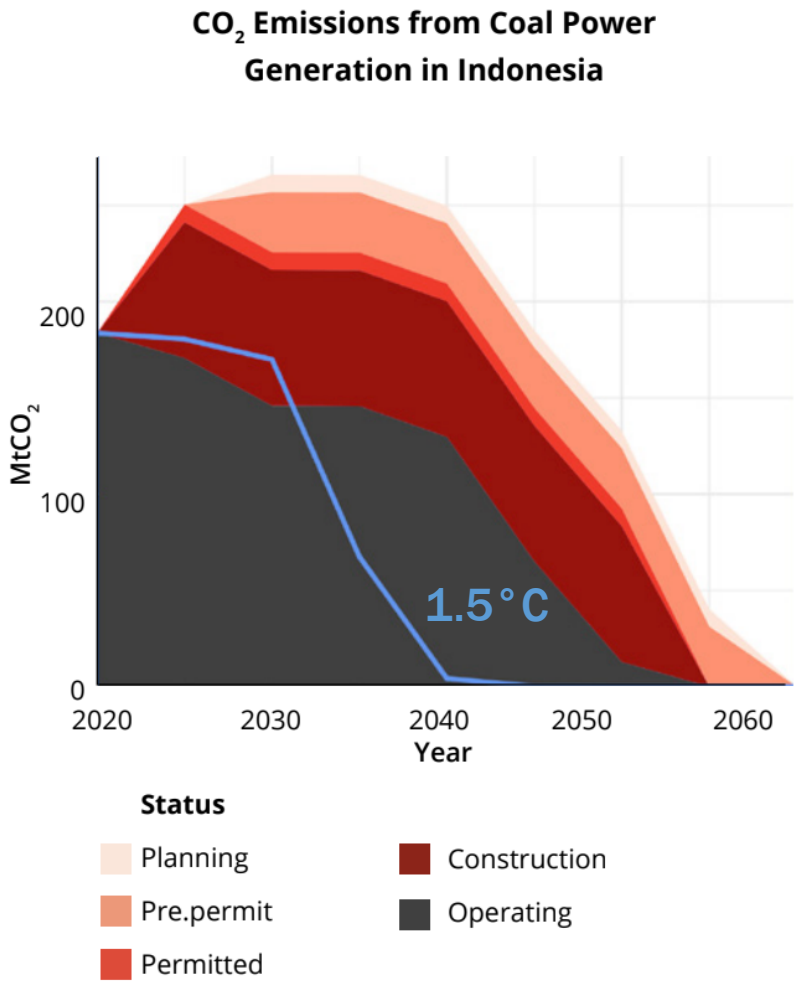
Indonesia coal power generation pathways




http://jgcri.github.io/gcam-doc/index.html

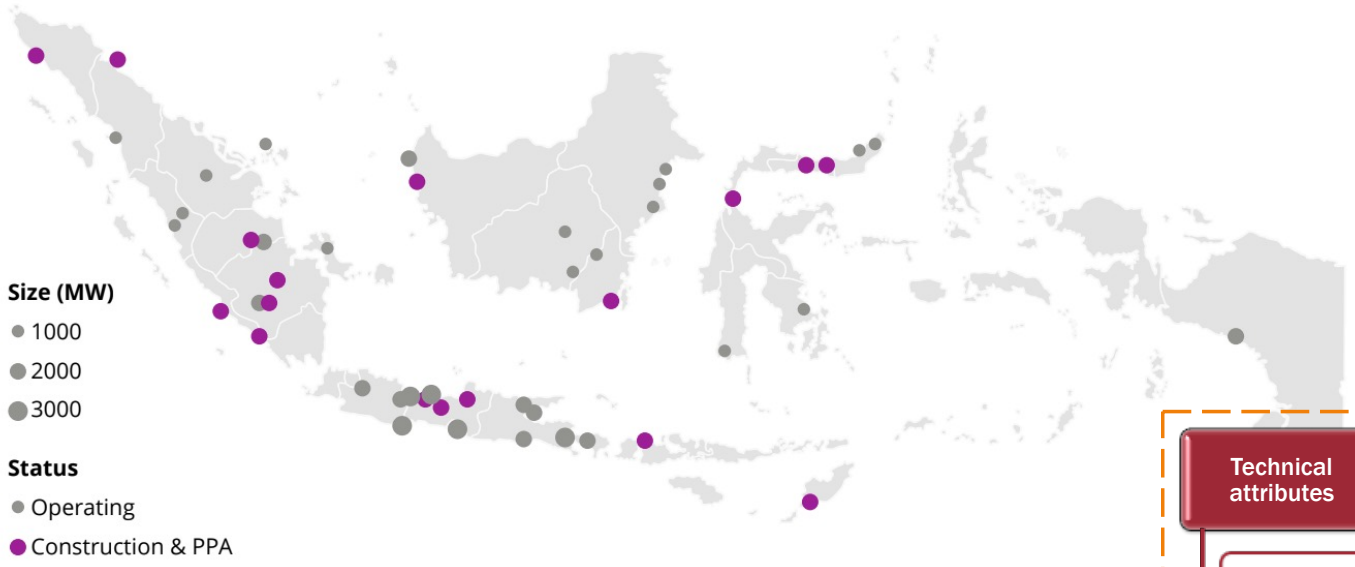
# The pathways in line with 2050 net-zero emissions and global 1.5°C show Indonesia's coal power generation decreases by 11% in 2030, by over 90% in 2040, and is completely phased out by 2045.



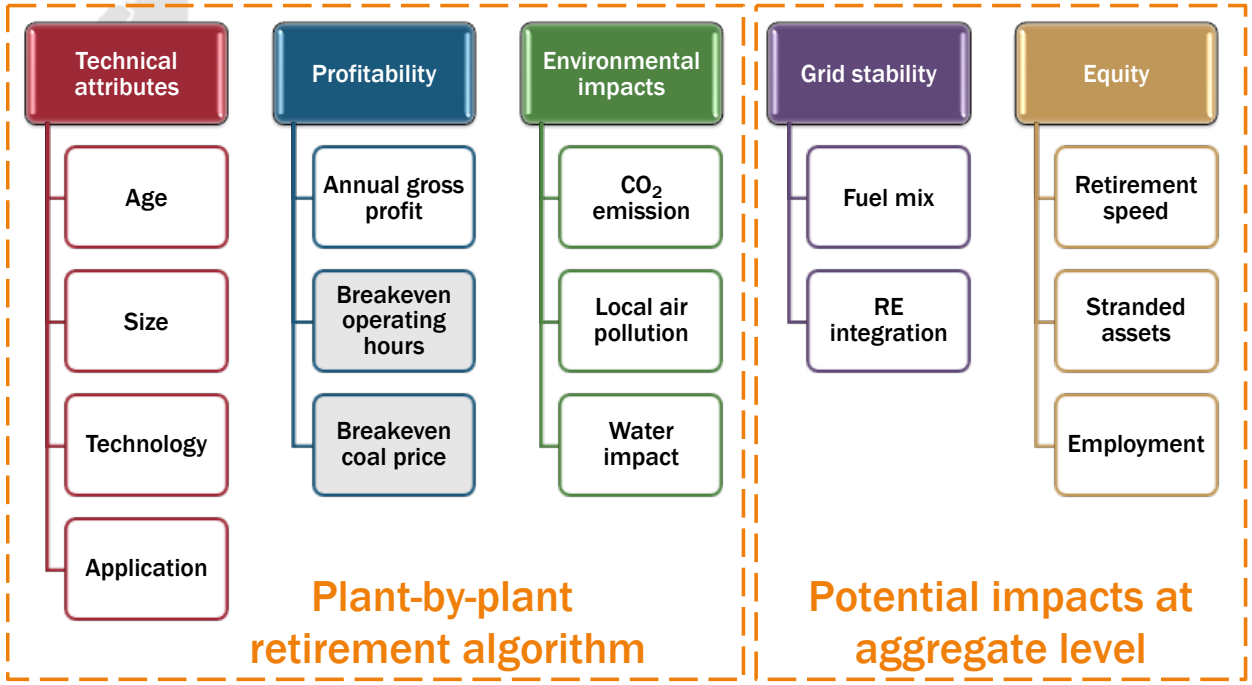

- Stacked bars on the left show Indonesia's electricity generation by technology under the GCAM pathway in line with global 1.5°C and 2050 national net-zero emissions.
- Single lines show the corresponding coal power generation CO2 emissions under 1.5°C, in comparison with the trajectory for operating, under construction, permitted, planned, coal power capacity over time assuming a 30-year lifetime at today's utilization levels (solid areas).
- 1.5ºC-compatible pathway requires closing CFPPs before the designed 30-year lifetime; continued coal builds will further shorten it.

# Based on a multi-criteria scoring system, we rank the retirement priority of individual coal plants (operating + construction/PPA)




This system estimates the approximate retirement priority for each of the operating and construction/PPA plants (see map) based on, for example, technical attributes such as relative age, size and efficiency, economic performance such as annual gross profits, and environmental impact such as, CO2 emission intensity, local air pollution and health impacts, water risks.

We apply a five-dimensional analytical framework to develop the plant-by-plant retirement priority ranking and plan.



# Based on a multi-criteria scoring system, we rank the retirement priority of individual coal plants (operating + construction/PPA)

We take three steps to develop the retirement priority:

1. Assign a normalized rank score [0,1] for each metric. A lower score closer to zero indicates worse performance.
2. Average the individual metric scores under each dimension and get a normalized dimensional score [0,1].
3. Take the mean of the dimensional scores as a combined score [0,1].

A lower score of the combined metric indicates that the plant could be retired early due to poorer technical attributes, poor economic performance, and higher environmental impact, while a higher score closer to one indicates the plant could be the last to retire.

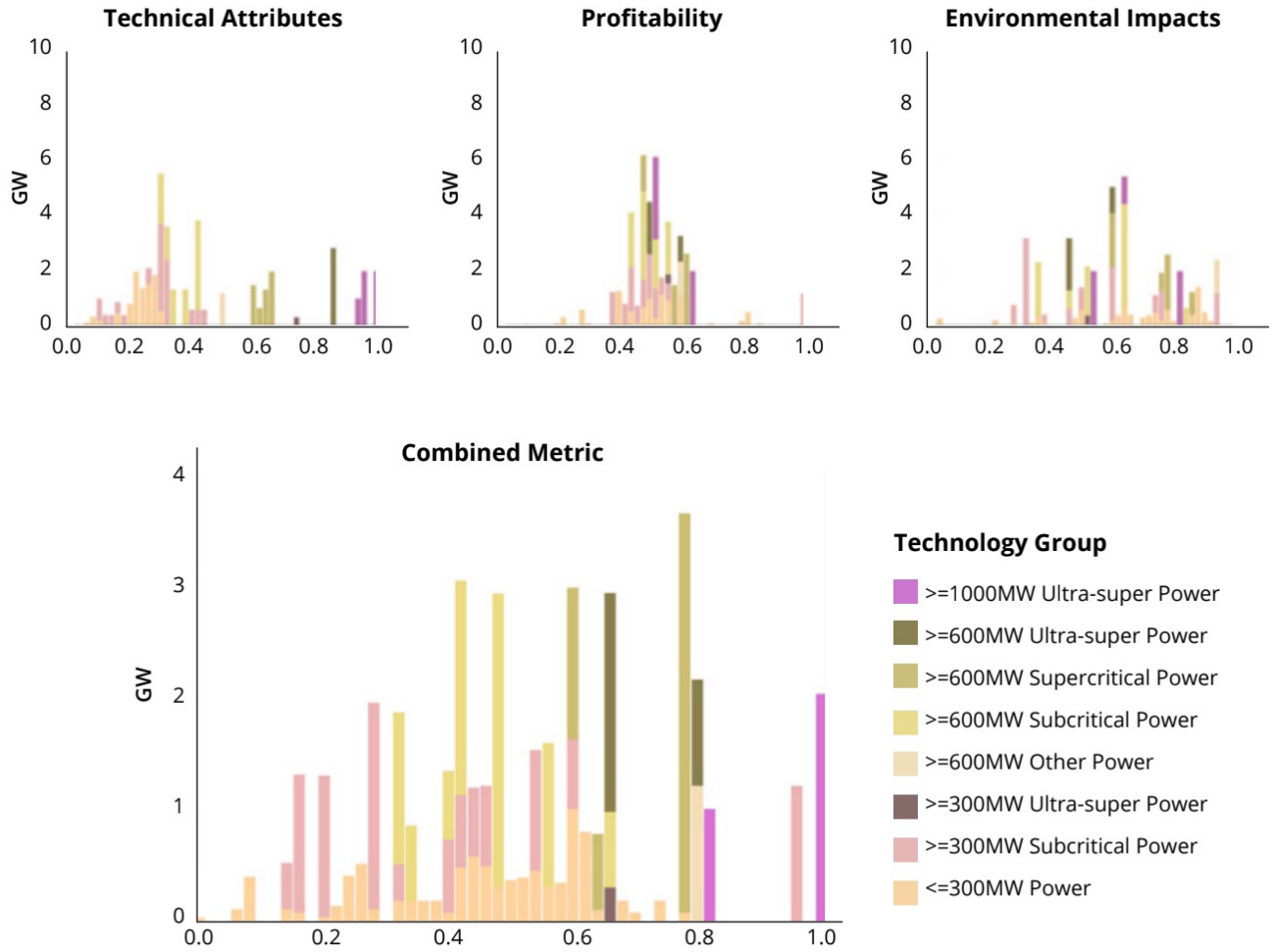



**Figure S3.** Scores of technical attributes, profitability, environmental impacts, and the combined score of the three dimensions for individual coal plants.

# We also identify low-hanging fruit plants for rapid shutdown to help achieve other societal goals

- 12 coal plants, 30 units, a total of 4.5 GW, are identified as the LHF plants that can be retired quickly in the near term, i.e. between 2022 and 2023, due to the poor technical, economic and environmental performance.
- Some plants are retired due to their ageing conditions as they reach the end of their economic lifetime, such as Banten Suralaya and PLN Paiton in the Java-Madura-Bali system, Bukit Asam Muara Enim for the Sumatra system and Asam-asam for the Kalimantan system.
- Some others have caused air quality and public health issues. Having constructed close to residential areas, Cilacap Sumber and Ombilin power plants have been subjected to complaints for closure from the residents due to the Fly Ash Bottom Ash (FABA), knowingly for causing respiratory problems.

**Table 1.** Overview of the LHF plants

| Subnational | Plant | Capacity (MW) | Year | Retirement | Technology |
|---|---|---|---|---|---|
| Bangka-Belitung | Bangka Baru power station | 60 | 2014 | 2023 | subcritical |
| Banten | Banten Suralaya power station | 1600 | 1984 | 2023 | subcritical |
| Banten | Merak power station | 120 | 2014 | 2023 | subcritical |
| Central Java | Cilacap Sumber power station | 600 | 2006 | 2023 | subcritical |
| East Java | PLN Paiton power station | 800 | 1994 | 2023 | subcritical |
| Lampung | Tarahan power station | 100 | 2007 | 2023 | subcritical |
| South Kalimantan | Asam-Asam power station | 260 | 2000 | 2022 | subcritical |
| South Kalimantan | Tabalong power station | 200 | 2019 | 2023 | subcritical |
| South Kalimantan | Tabalong Wisesa power station | 60 | 2013 | 2023 | cfb[16] |
| South Sumatra | Bukit Asam Muara Enim power station | 260 | 1987 | 2023 | subcritical |
| West Java | Cikarang Babelan power station | 280 | 2017 | 2023 | subcritical |
| West Sumatra | Ombilin power station | 200 | 1996 | 2023 | subcritical |

[16] Circulised Fluidised Bed, one type of boiler used in the subcritical steam-cycle technology


**Figure 4.** Location of the LHF plants

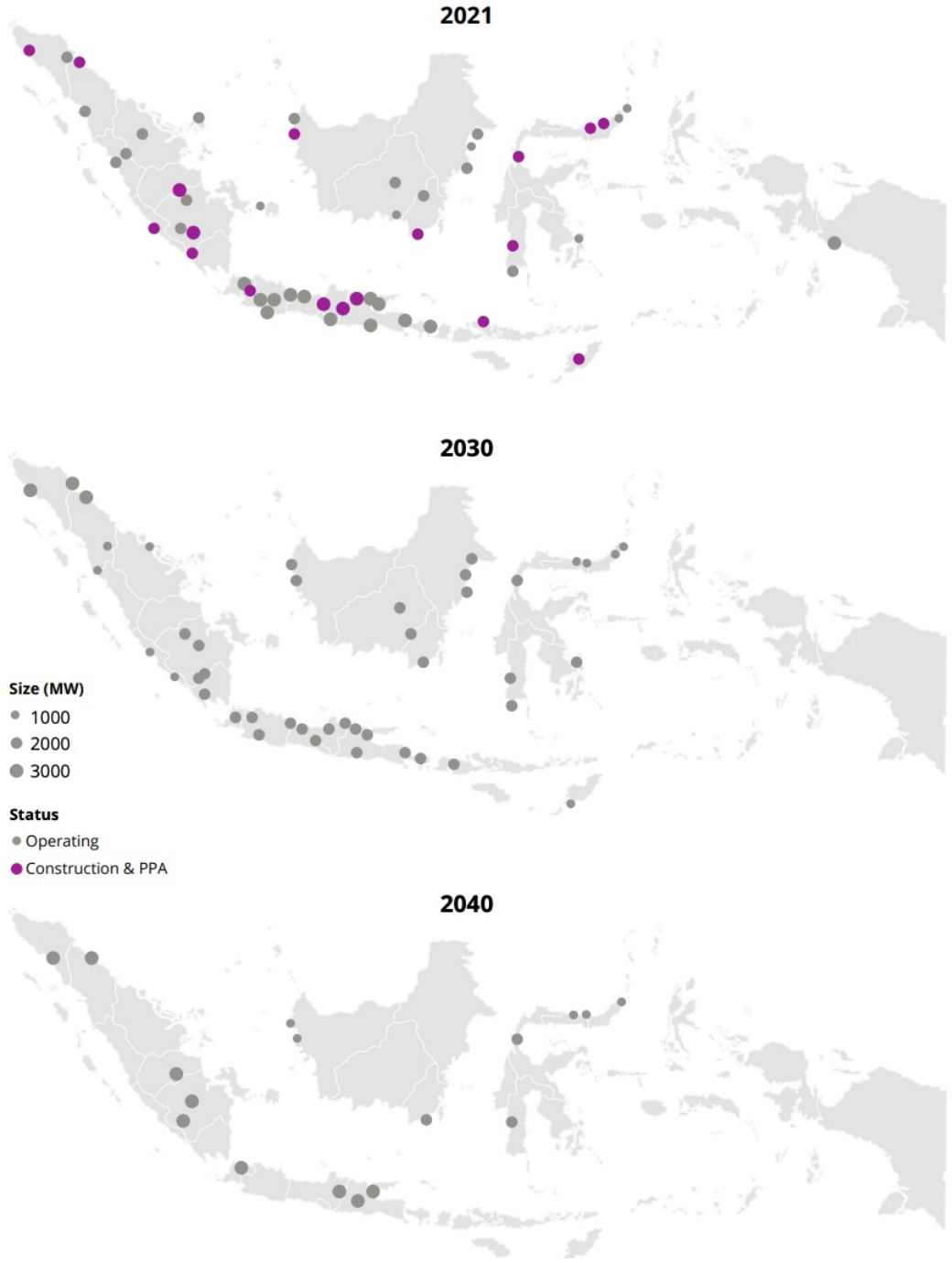
# Combining the national 1.5°C coal power pathway from GCAM and the plant ranking, we develop the retirement schedule for individual CFPPs

- The national coal power generation constraint from GCAM is met by retiring coal plants one by one starting from the lowest to highest combined score at today's utilization levels.
- We then apply a minimum guaranteed lifetime (20 years) to plants that are retired before that age, except for the LHF plants. Retirement schedule for PLN and IPP plants are as follow:

**Table 2.** PLN and IPP coal plants retirement schedule

| # of Plants, GW | PLN Retirement | IPP Retirement | Total Retirement |
|---|---|---|---|
| 2022-2030 | 8 plants, 5.0 GW | 10 plants, 4.2 GW | 18 plants, 9.2 GW |
| 2031-2040 | 18 plants, 7.6 GW | 21 plants, 14.1 GW | 39 plants, 21.7 GW |
| 2041-2045 | 5 plants, 3.1 GW | 10 plants, 9.4 GW | 15 plants, 12.5 GW |

- With minimum lifetime, some plants are now retired later than needed to meet the national coal generation constraints from GCAM, average utilization will decline from 5,935 hours today to 4,807 hours by 2030, and 1,090 hours by 2040.



# The pathways show similar retirement speeds across different power systems

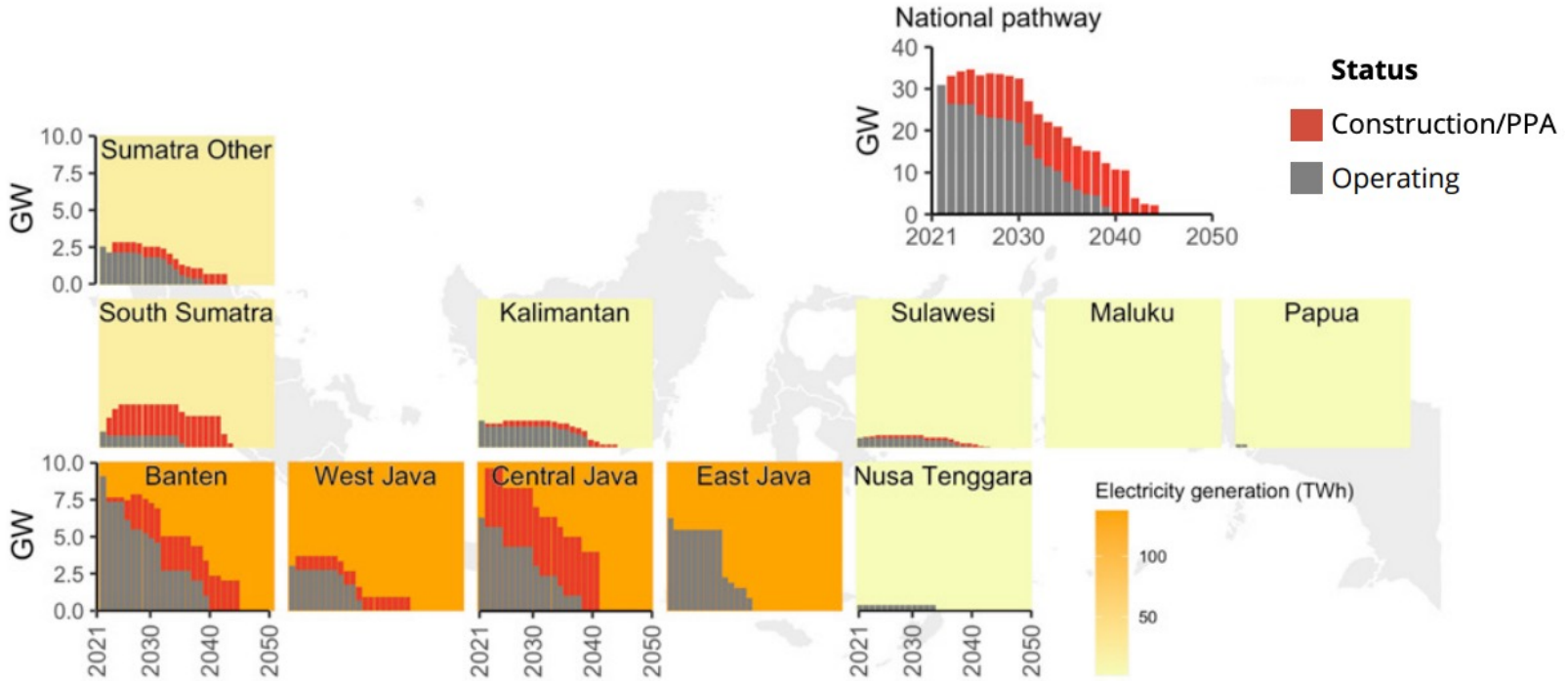



**Figure 6.** Coal retirement pathways by region. The bars show the total coal-fired power capacity in operation by year in each region, colored coded by projects' status today.

Increases in CFPP capacity are observed in the Java-Bali and Sumatra systems due to new projects already under construction.

Both regions are expected to face serious overcapacity issue if the expansion plan under current PLN electricity supply business plan (RUPTL) is followed.

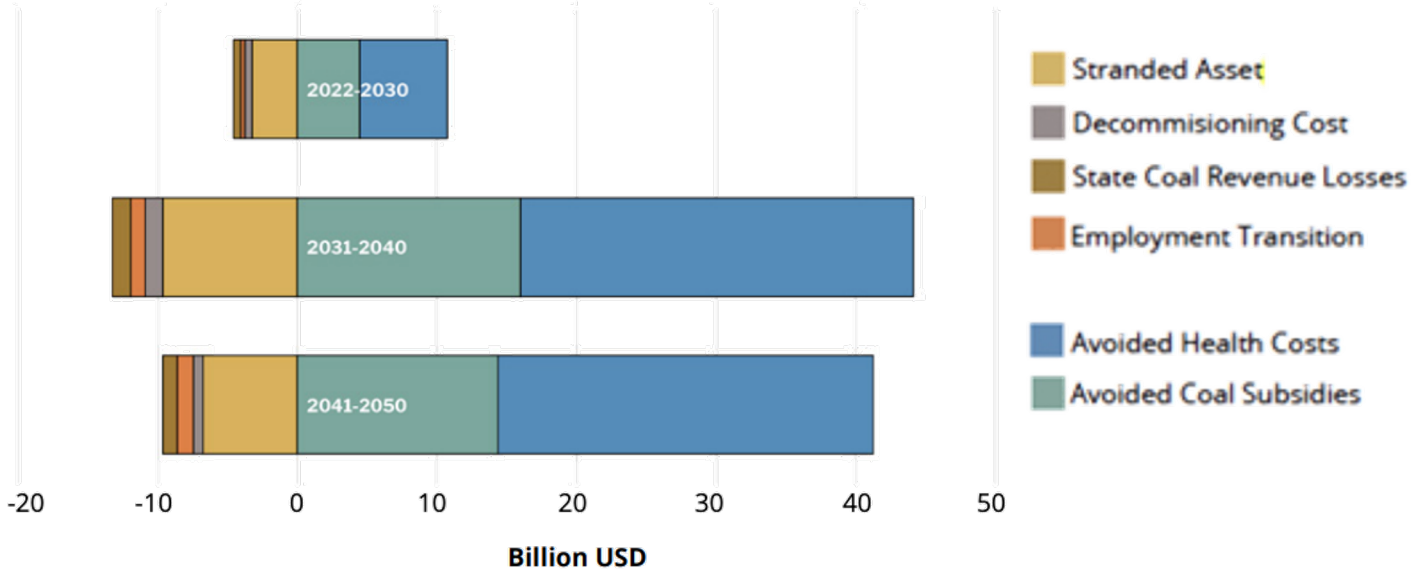
Therefore, canceling projects that have not started construction or signed the PPAs, plus the retirement of older CFPPs in the Java-Bali system can help address the overcapacity issue.

Note: the square map shows coal phaseout pathways in each island, where Java is shown by four individual states: Banten, West Java, Central Java, and East Java, Sumatra is shown by South Sumatra and the rest. Background color of the panels show total electricity generation of the island.

# We develop and apply a framework to assess the financing need for implementing the proposed retirement pathway through a just transition


The framework covers the economic, social, and environmental benefits (blue) and costs (green) or uncertain outcomes (yellow) that are either directly or indirectly from CFPP retirements for different stakeholders – the coal-related industry, government, and the public.

# The accelerated coal phaseout is feasible and beneficial from the economic and social perspectives

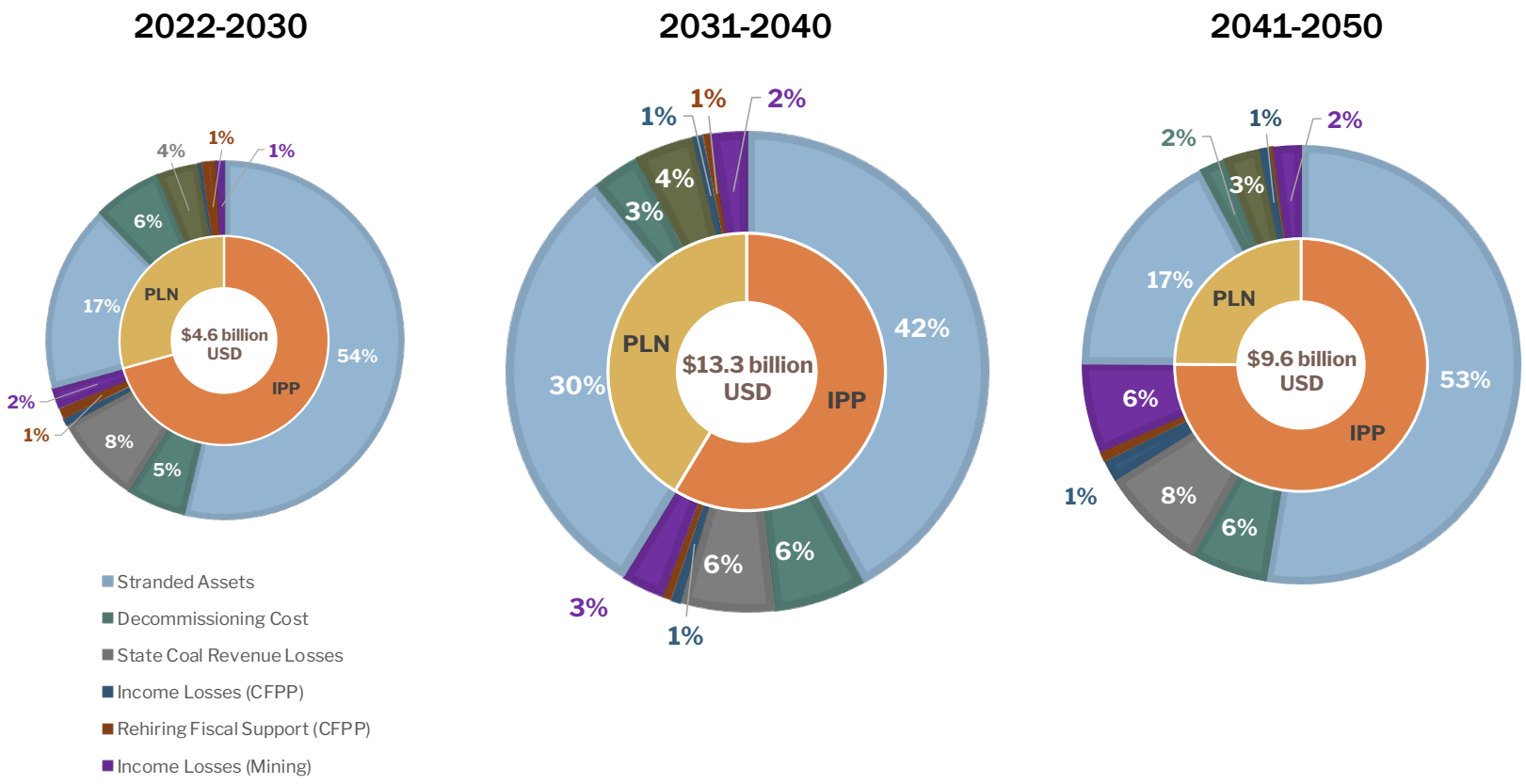



- Using the best data available, we estimate the retirement costs at $4.6 billion through 2030 and $27.5 billion through 2050.
- The total savings from avoided coal power subsidies and avoided public health costs amount to $34.8 and $61.3 billion, respectively.
- The quantified benefits are 2–4 times as large as the quantified costs in each decade.
- The large upfront costs of retirement necessitate substantial international support, despite the larger benefits gained in the long run.

| Metric (million USD) | 2022-2030 | 2031-2040 | 2041-2050 |
|---|---|---|---|
| Stranded Asset | 3,233 | 9,628 | 6,740 |
| Decommisioning Cost | 533 | 1,259 | 729 |
| Employment Transition (CFPP & Mining) | 272 | 1,041 | 1,161 |
| State Coal Revenue Losses | 542 | 1,363 | 1,012 |
| Avoided Coal Subsidies | 4,442 | 15,998 | 14,396 |
| Avoided Health Costs | 6,292 | 28,121 | 26,843 |

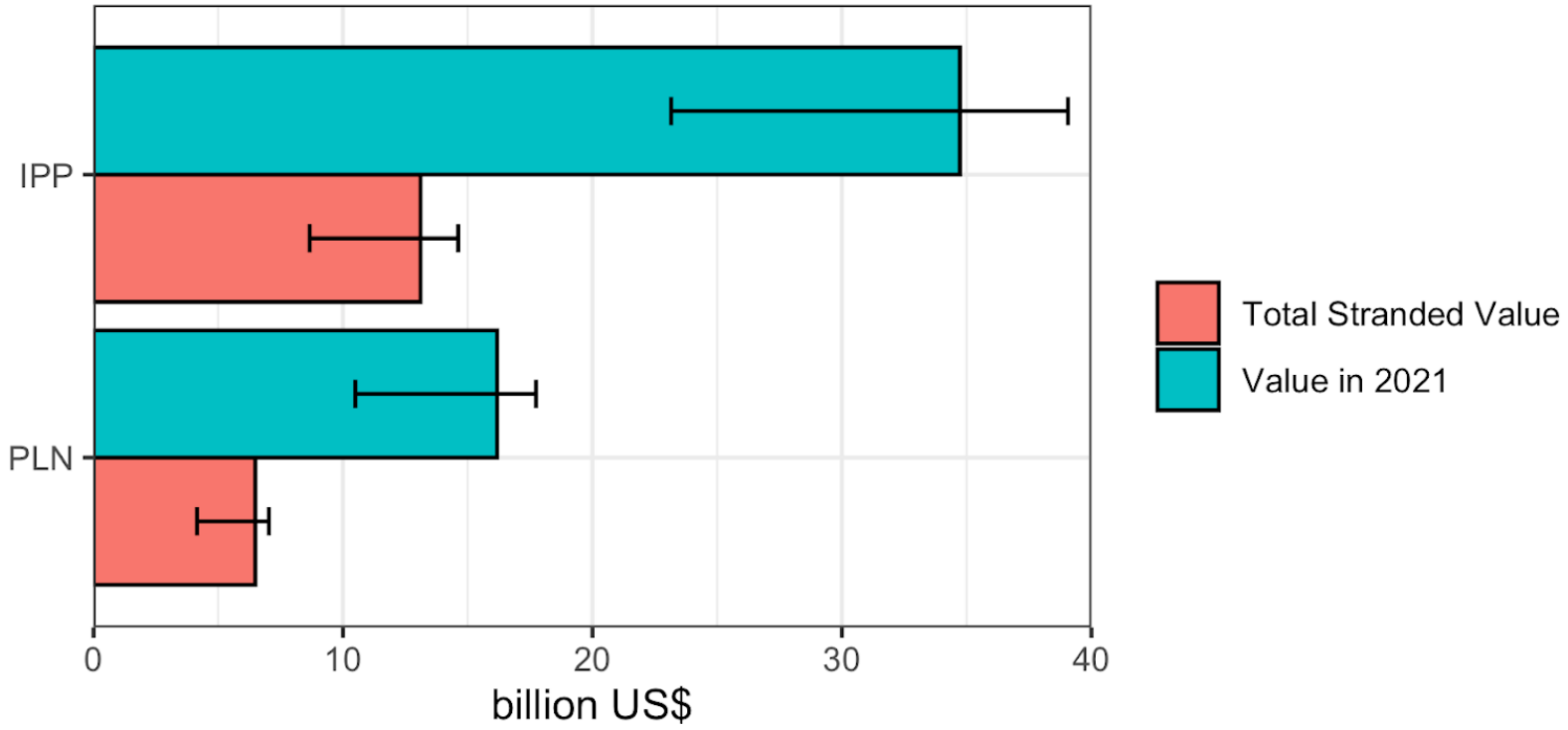
**Figure 7.** Benefits and costs for implementing the accelerated coal retirement plan in a just way. Benefits are shown as positive numbers and costs as negative numbers on the top bar chart; Benefits are shown in blue and costs in purple in the bottom table.

# Retirement costs are dominated by stranded assets; about 2/3 of the costs are associated with IPP plants.




- About two-thirds of the costs are associated with IPP plants, with the remaining one-third attributed to PLN plants.
- The implementation and retirement of the 3 PPA projects cost 1.4 billion$ and 1.2 billion$, respectively, which can be otherwise invested directly in renewable energy if these projects are cancelled (8.6 and 7.5 billion$ for the 19 projects already under construction).
- The accelerated coal phaseout can reduce cumulative CO2 by 341 MtCO2 through 2030 and by 2,297 MtCO2 through 2050, and cost approximately $12-13 per ton of CO2 removed.

# With a minimum of 20 years' lifetime, less than 40% of today's CFPP assets value will be stranded.



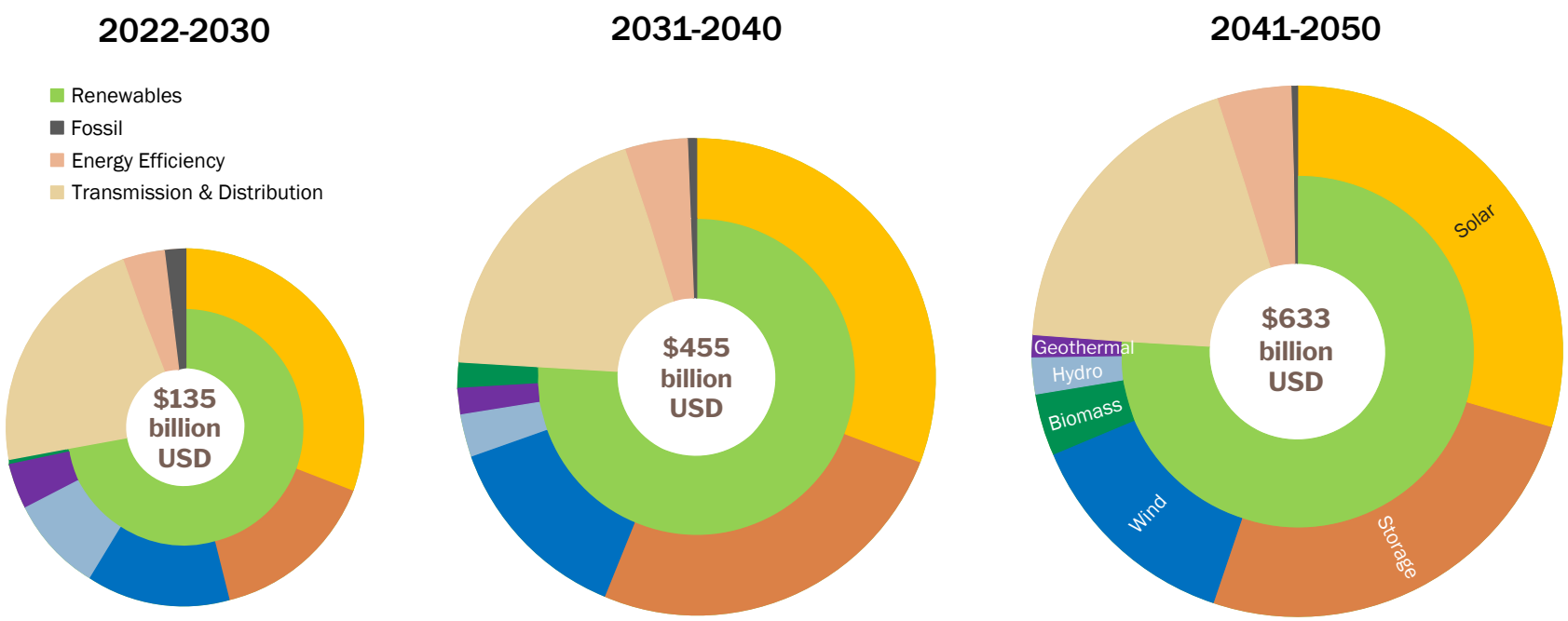

**Our method of stranded assets calculation focuses on the remaining value of the initial investment due to early retirement from the 30-year designed lifetime with a linear depreciation.**

Stranded Value = (BAU lifetime – plant age at retirement) / BAU lifetime x plant capacity x capital costs

2021 Value = (BAU lifetime – plant age in 2021) / BAU lifetime x plant capacity x capital costs

BAU lifetime = 30 years

# To replace coal and meet increasing demand, energy investments shift rapidly to renewables, storage, transmission, and energy efficiency.




- Over 1.2 trillion USD is needed to replace coal power generation and meet increasing electricity demand 2022-2050, dominated by renewables, storage, transmission & distribution, and energy efficiency.
- The investment must scale up to reach 135 billion$ between 2022 and 2030. In comparison, the total energy investment (including fossil fuels) has surpassed 35 billion$ for the last five years, where RE investment is about 1.5-2 billion$ annually.
- Most of the investments are expected to come from the private sectors, while the public sector is critical in creating an attractive investment environment through regulations, policy supports, and/or market-based mechanisms.

# Key findings

1. The pathways in line with 2050 net-zero emissions and global 1.5ºC show Indonesia's coal power generation decreases by 11% in 2030, by over 90% in 2040, and is completely phased out by 2045.
2. Immediate retirement of 4.5 GW of "low-hanging fruit" plants which are older, dirtier, and more inefficient, can reduce emissions by 28.8 MtCO2 per year and help improve air quality, public health, water security, etc.
3. According to the detailed retirement schedule presented here, 18 plants (9.2 GW, 8 PLN & 10 IPP plants) retire by 2030, 39 plants (21.7 GW, 18 PLN & 21 IPP plants) retire in 2031–2040, and the remaining 15 plants (12.5 GW, 5 PLN & 10 IPP plants) continue to operate beyond 2040 at a low utilization level and retire before 2045.
4. The accelerated coal phaseout is feasible and beneficial from the economic and social perspectives – the positive and broadly shared benefits from avoided coal power subsidies and health impacts are 2-4 times larger than the costs on stranded assets, decommissioning, employment transition, and state coal revenue losses.
5. Retirement costs are estimated to be 4.6 billion USD through 2030 and 27.5 billion USD through 2050. About 2/3 of the costs are associated with IPP plants and 1/3 with PLN plants. The large upfront costs for retirement necessitate substantial international support, despite the larger benefits gained in the long run.
6. Cancelling pipeline projects under PPA or construction may save up to 18.7 billion USD that can be alternatively invested in renewable energy.
7. The accelerated coal phaseout can reduce cumulative CO2 by 341 MtCO2 through 2030 and 2,297 MtCO2 through 2050, making the retirement costs equivalent to approximately $12-13/tCO2 removed.
8. As coal power is replaced by renewable energy, primarily solar, to meet increasing demand, the investment required to scale up renewables and transmission is estimated at 1.2 trillion USD through 2050, where international financing can help fill in the gap.

# Policy recommendations

- Given that the process of coal phase-out will take more than 25 years, there should be strong and cohesive political will through the creation of no-regret policy and strong regulatory framework to phasing out CFPP.
- Both the Energy Law (no. 30/2007) and the government's Energy Plan (RUEN/Presidential Regulation 22/2017) that are currently under review and updates could be used to strengthen the policy framework supporting coal phase-out.
- CFPP retirement pathway must be considered in the planning of the next electricity supply business plan (RUPTL) of PLN and other utility.
- Government shall establish a national commission or task force across government agencies to plan a just energy transition by the end of this year, to address the multi-facets of retiring CFPPs, including facilitating the renegotiation with the IPP.
- Government of Indonesia needs to identify potential societal impact of coal phase-out on local community. Social protection and financial assistance packages shall be developed and implemented along with the retirement schedule, fitting into the national energy transition platform/mechanism that is currently being discussed.
- Scaling up renewable energy and energy storage should be integrated with the CFPP retirement plan. Indonesia needs to build up massive project pipeline and ready to deploy renewables projects.
- Early phase-out will require international support, in the form of grant and concessional loan, and carbon finance. There is a need to assess suitable financial mechanisms for retiring coal plants owned by IPP.

# Future research

- Continue to improve data and metric quantification, especially the operation data of individual plants.
- Explore different financing mechanisms and the role of public and private finance, and national and international stakeholders.
- Explore potential mechanism and financing need to cancel projects that have not started construction.
- Assess financing need at the subnational level.

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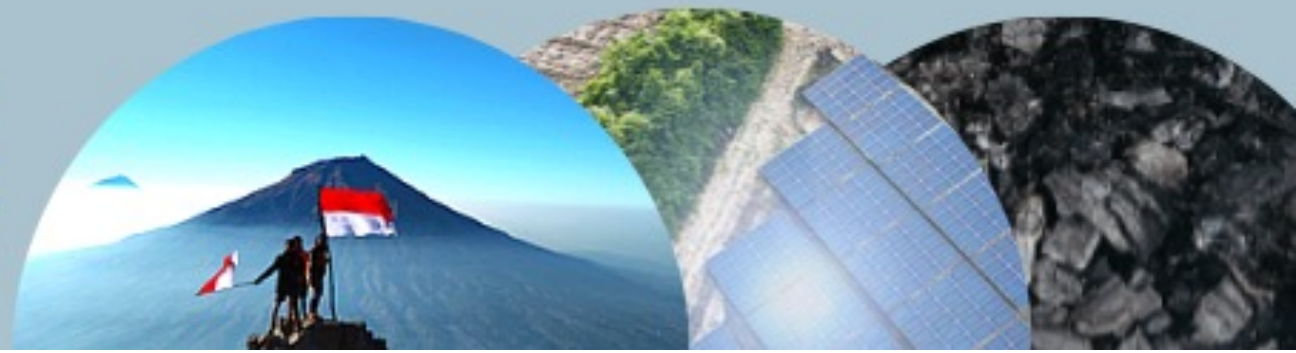

# Thank you!


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