SCHOOL OF PUBLIC POLICY
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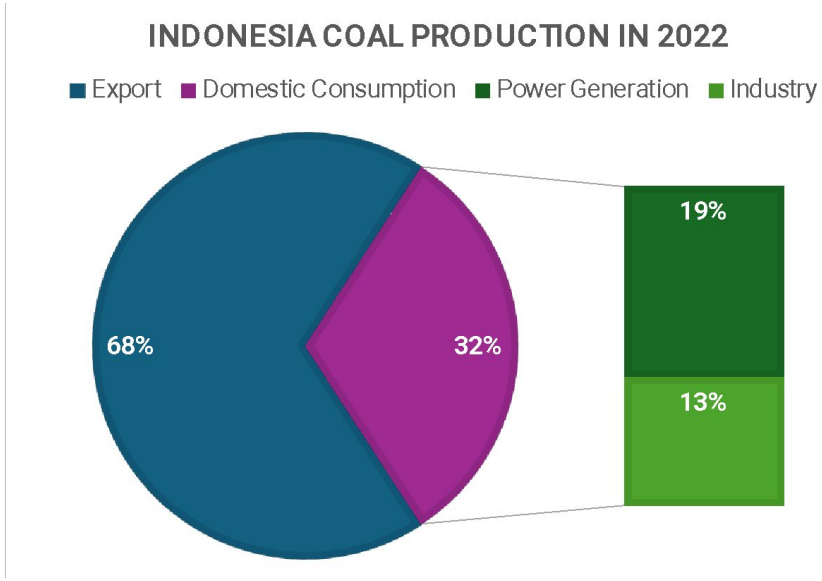
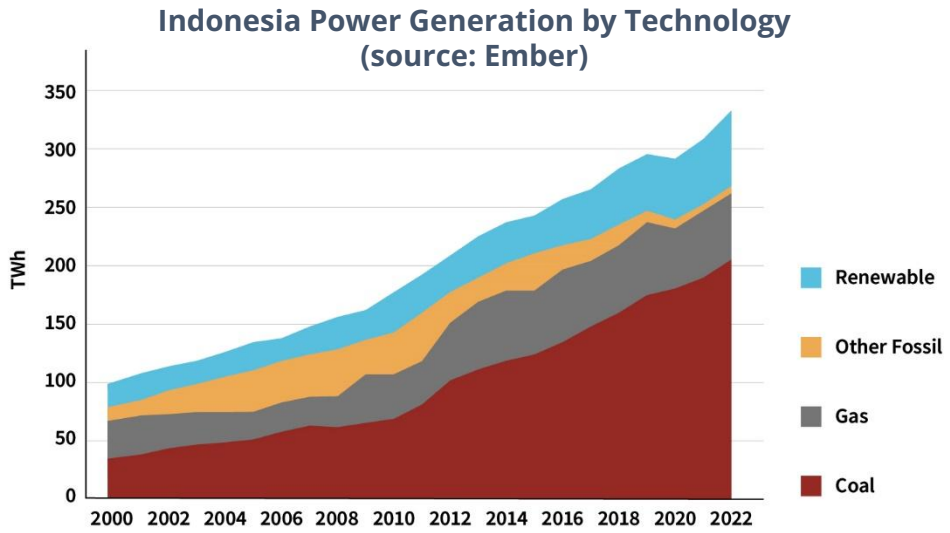
1.5°C-aligned coal power transition pathways in Indonesia:
Additional Strategies beyond the Comprehensive Investment and Policy Plan (CIPP)

June 4, 2024 • Indonesia

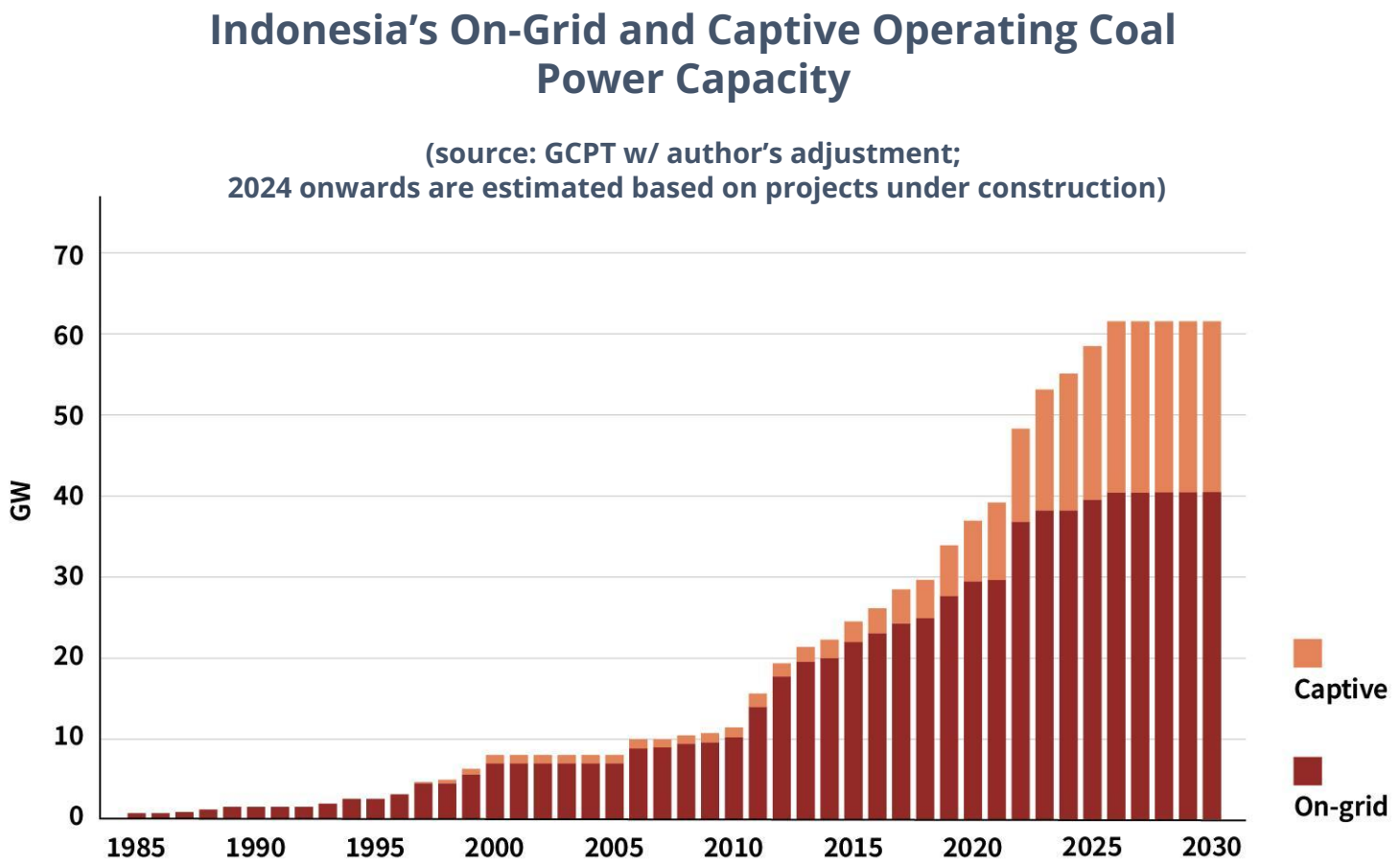
International financial mechanisms were set up to help Indonesia deliver an ambitious and just power system transition

- Indonesia is one of world's largest coal producers, with rapidly growing domestic demand.
- Indonesia has indicated its desire to move away from coal towards renewable energy and to achieve net-zero emissions by 2060.
- Indonesia's **Just Energy Transition Partnership (JETP)** was launched with G7 in 2022, including power sector targets and a finance deal:
  - Peak power sector emissions at 290 MtCO2 in 2030,
  - 34% RE in total generation in 2030,
  - net zero power sector emissions by 2050,
  - an initial $20 billion in public and private financing (3-5 years).
- The Government of Indonesia published the first version of **Comprehensive Investment and Policy Plan (CIPP)** in late 2023, outlining the roadmap for power sector decarbonization to support JETP implementation.





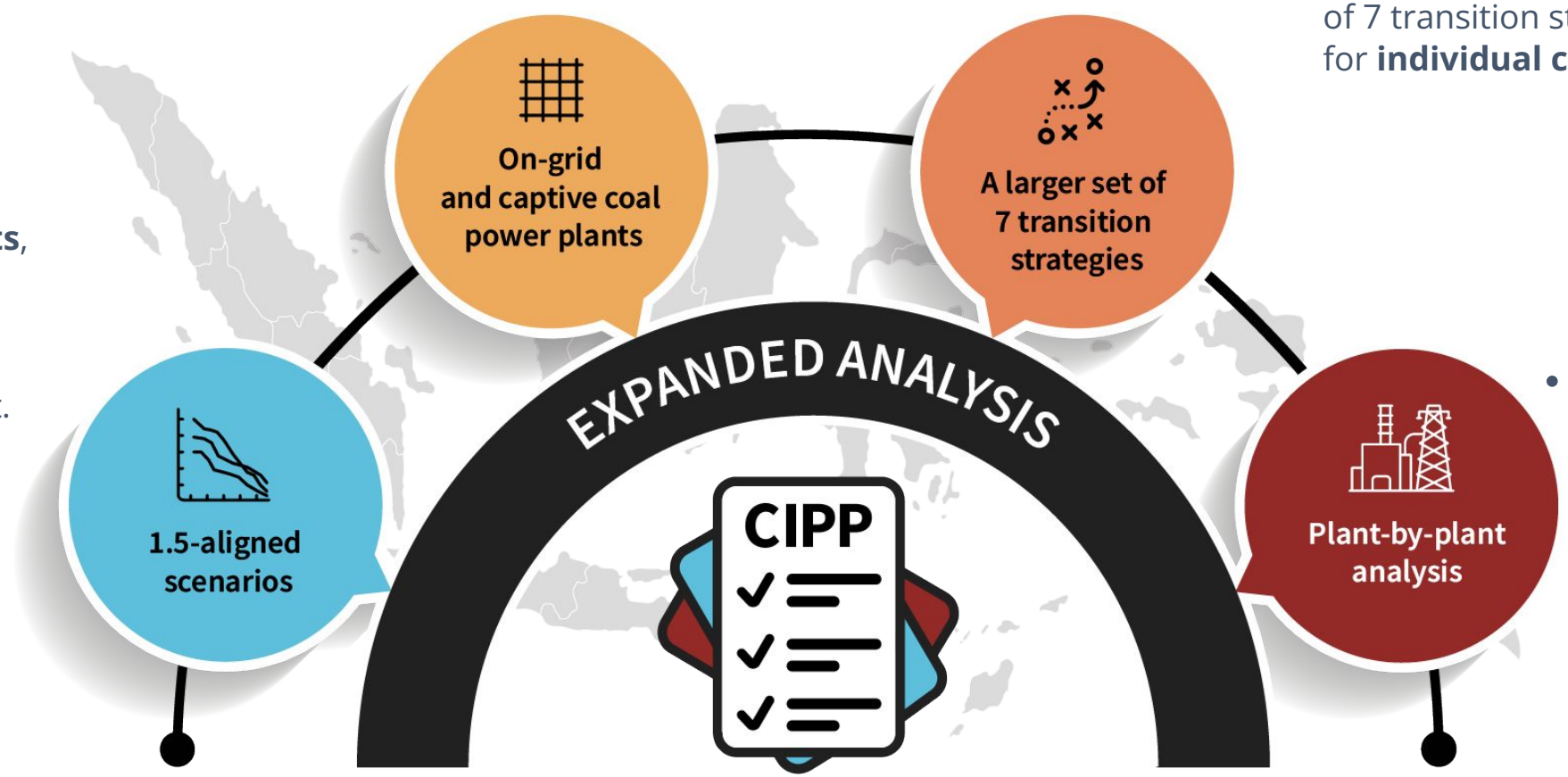
Rapid growth of captive coal has caught policy attention only recently and become a key challenge for Indonesia's coal transition



- While Indonesia has banned the development of new coal power plants (Presidential Regulation No. 112 of 2022), captive plants are exempt from this provision.
- As of 2023, Indonesia has 15 GW operating captive coal power plants, representing 28% of the total installed coal capacity.
- After 2025, with the 6 GW under construction projects coming online, captive coal will account for 35% of total installed coal capacity.
- Majority of captive coal capacity was built after 2016.

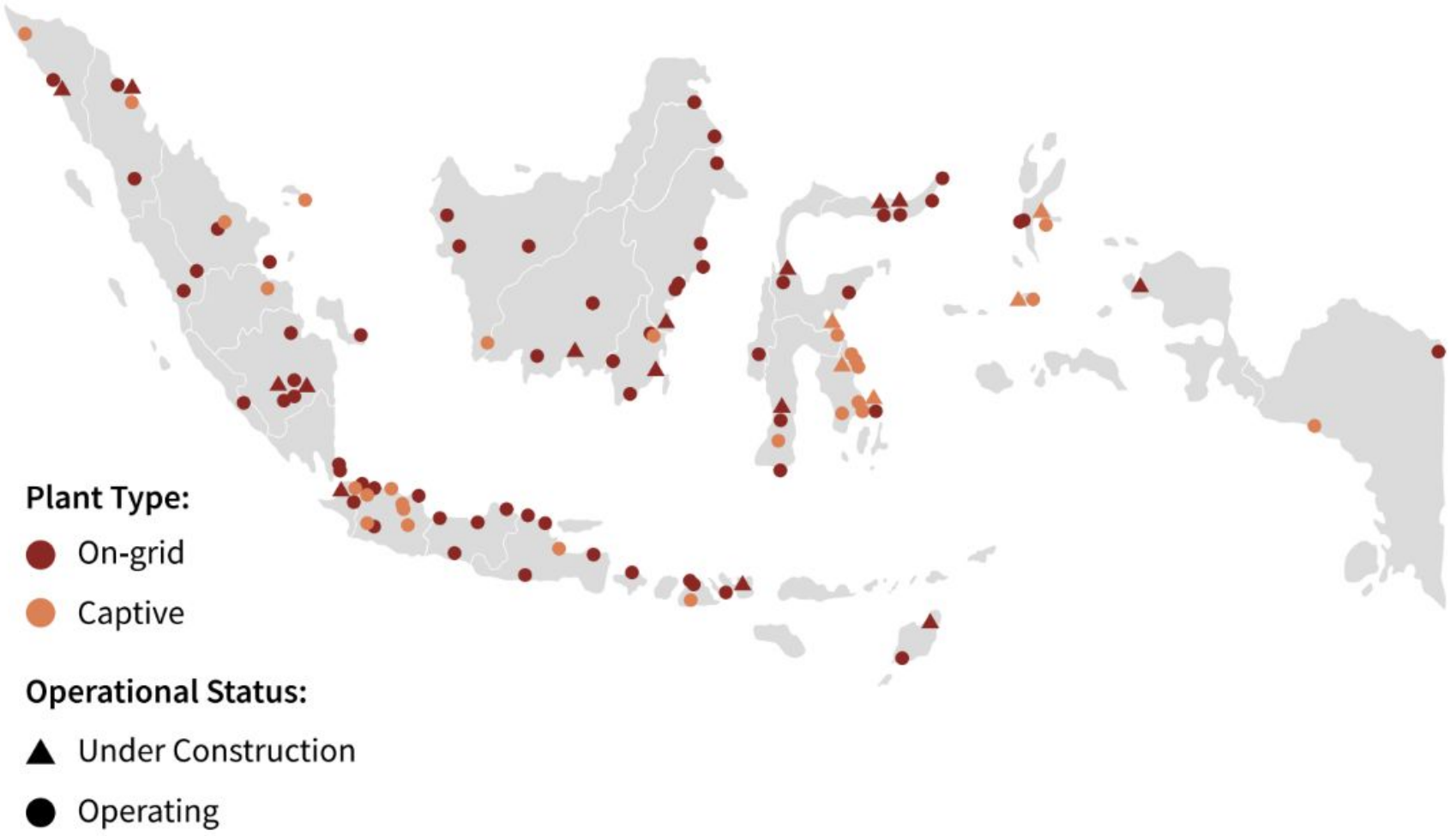
A comprehensive plan for 1.5C-aligned power sector transition beyond the CIPP

- **A 1.5-aligned** pathway covering both **on-grid and captive plants**, as well as specific pathways for each segment.



- Plant-by-plant assessment of 7 transition strategies for **individual coal plants**
- Couple IAM (GCAM) + Power System Model (Plexos) to assess the power system's operational performance under ambitious climate pathways, for 2030.

We assessed a larger set of transition strategies for individual on-grid and captive coal plants

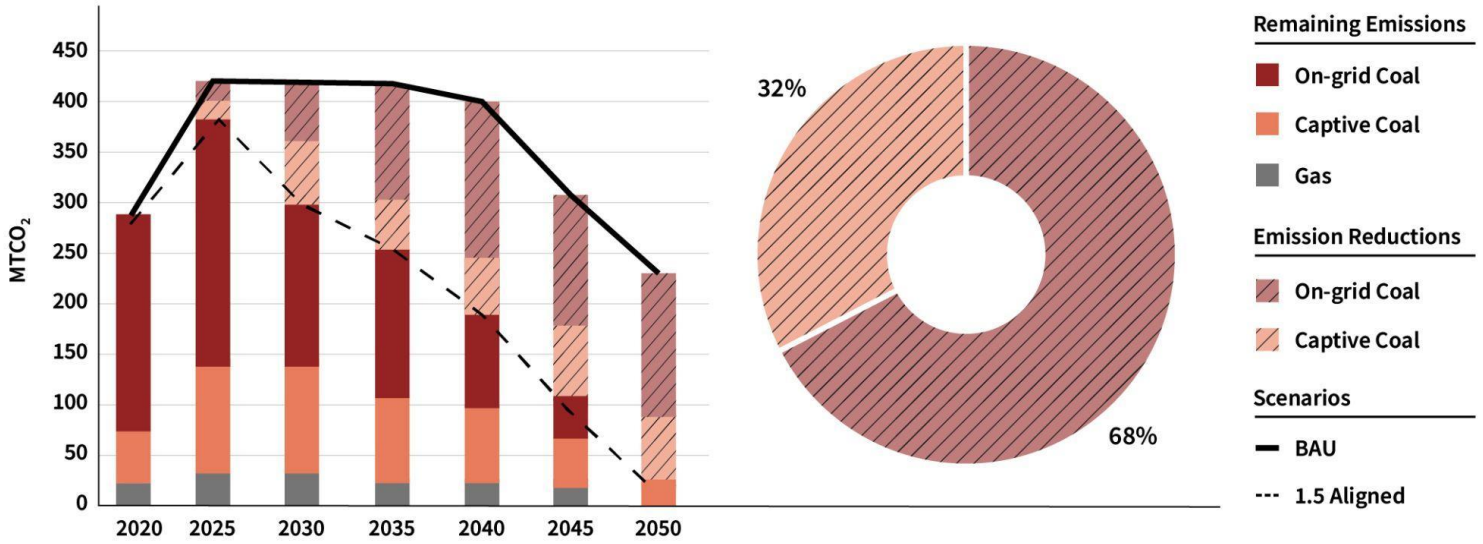


- Transitions Strategies for off-grid captive:
  - cancellation
  - biomass co-firing
  - onsite RE substitution
  - grid connection
  - CCS
- Transitions Strategies for on-grid:
  - lower utilization for dispatch
  - biomass co-firing
  - early retirement (before 30 years)
  - CCS

1.5°C aligned emission reduction pathway for both on-grid and captive coal power plants

- Under the 1.5°C aligned transition pathway that covers both on-grid and captive coal power plants, power emissions peak at 382 $MTCO_2$ by 2025, followed by a decrease of 13% by 2030, 50% by 2040, and close to zero by 2050.
- Emissions from captive coal power plants more than double between 2020 and 2025 due to projects already under construction, accounting for 30% of total coal power emissions in 2025.
- On-grid plants deliver more emissions reductions to offset growing captive coal emissions in the near term and contribute to 68% of the cumulative emissions reduction through 2050.

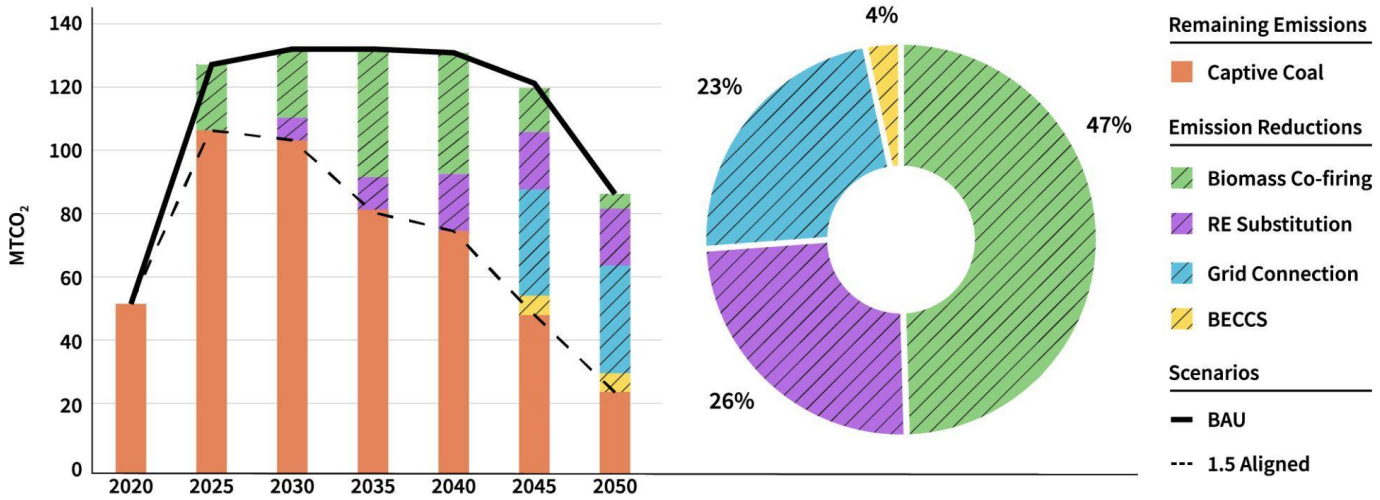
CO_2 emissions from power generation under BAU and 1.5°C -aligned pathways, including on-grid and captive power plants, reductions by plant type in each period (bar) and over 2025-2050 (pie)



Emissions reduction pathway for captive coal plants by transition strategy

- By canceling the 2.6 GW of projects at pre-construction stages, emissions from captive coal plants peak at 106 $MtCO_2$ in 2025 and achieve limited reductions (2% from peaking) by 2030.
- By 2030, 3/4 reduction comes from biomass co-firing and 1/4 from onsite renewable substitution. Grid connection in Sulawesi becomes critical to reduce emissions after 2040.
- Between 2025-2050, the adoption of biomass co-firing contributes to 47% of cumulative emissions reductions, onsite solar substitution contributes to 26%, and grid connection to 23% of total reductions.

CO2 emissions from captive power generation under BAU and 1.5C-aligned pathways, reductions by transition strategy in each period (bar) and over 2025-2050 (pie)



1.5°C -aligned Decarbonization Strategies for captive coal plants

- 156 captive units (Global Coal Plant Tracker, January 2024)
- **Biomass co-firing**: Scoring criteria included boiler type, distance from the nearest biomass processing plant, and the type of feedstock processed at the nearest processing plant. This includes all plants in the pulp, paper, and textiles industries.
- **Renewable substitution**: Renewable capacity publicly announced by industrial parks. Older coal units were retired.
- **Grid connection**: Plants located near grid investments expected in Sulawesi according to CIPP.
- **Carbon Capture and Storage**: Ranking based on capacity size, age of plant, availability of space near the plant, and distance from storage. We assumed the technology is capable of capturing 90% of the CO_2 released.

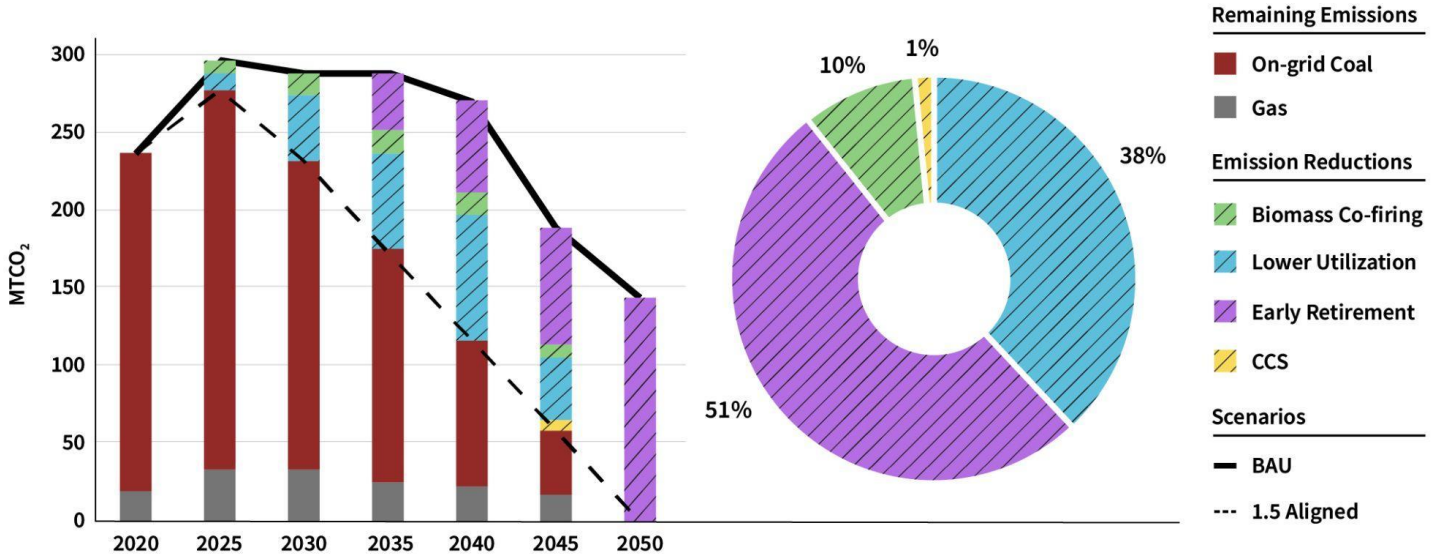
Summary of 1.5°C -aligned Decarbonization Strategies

	UNITS	CAPACITY (GW)	KEY PLANT-LEVEL RESULTS
Cancellation of Pre-Construction Projects	5	2.6	Cancellation of announced and pre-permit projects.
Biomass Co-firing	80	13	Substitution of 30% of coal used for electricity production with biomass in eligible plants.
Renewable Substitution	16	2.5	Incorporation of 11.2 GW of solar capacity by 2040 in eligible industrial parks.
Grid Connection	34	4.8	Connection to the transmission grid of captive coal power plants in Central, South, and Southeast Sulawesi.
Carbon capture and storage (CCS)	1	1.1	Adoption of CSS technology in biomass co-firing plant in North Kalimantan.

Emissions reduction pathway for on-grid coal plants by transition strategy

- Emissions peak at 276 MtCO2 in 2025 and follow roughly a linear pathway to zero emissions by 2050.
- By 2030, 3/4 of the reduction is attributed to lower utilization, and 1/4 to biomass cofiring. Early retirement (before 30 years) becomes increasingly important post-2035.
- Between 2025-2050, early retirement contributes to nearly half (51%) of cumulative emissions reductions, lower utilization contributes to 38%, and the adoption of biomass co-firing contributes to 10%.

CO2 emissions from on-grid power generation under BAU and 1.5C-aligned pathways, reductions by transition strategy in each period (bar) and over 2025-2050 (pie)



Emissions reduction pathway for on-grid coal plants by transition strategy

- 217 on-grid coal fired power (Global Coal Plant Tracker, January 2023)
- **Lower utilization:** Scoring criteria included age, size (proxy for the combustion technology), and coal type.
- **Early retirement**: Low-hanging fruit units (Cui, R., et al. (2022)) + plants that are not eligible for other strategies
- **Biomass co-firing**: Scoring criteria included boiler type, distance from the nearest biomass processing plant, and the type of feedstock processed at the nearest processing plant.
- **Carbon Capture and Storage**: Ranking based on capacity size, age of plant, availability of space near the plant, and distance from storage. We assumed the technology is capable of capturing 90% of the CO_2 released.

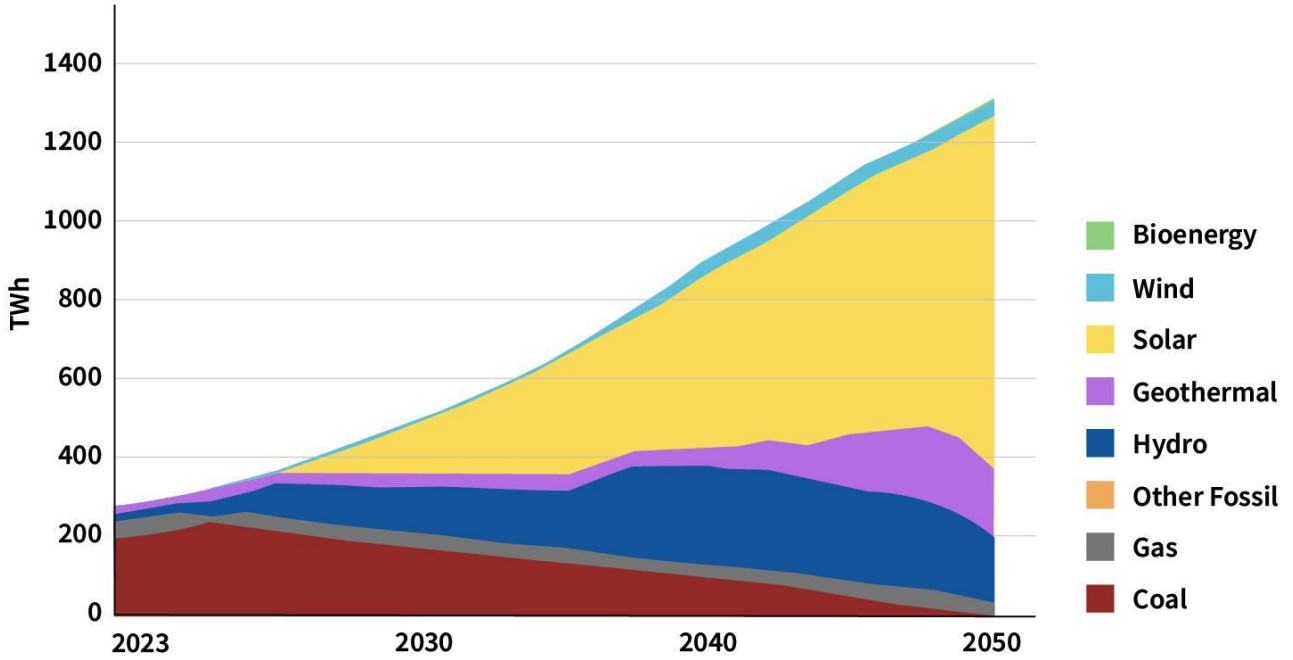
Summary of 1.5°C -aligned Decarbonization Strategies

	UNITS	CAPACITY (GW)	KEY PLANT-LEVEL RESULTS
Lower Utilization	53	8	Eligible flexible plants are expected to operate at 40% by 2030 and 2035, 35% by 2040, and 30% by 2045.
Early Retirement	105	25	3.8 GW of low-hanging fruit and 1.7 GW identified by the CIPP are expected to retire by 2035-2037. Additional 3.5 GW, 4.8 GW and 11 GW should retire by 2040, 2045, and 2050, to achieve climate targets.
Biomass co-firing	102	5	Biomass co-firing ratio should ramp from 5% in 2024 to 57% by 2030. Stoker plants (374 MW) are expected to complete the transition to full biomass conversion by 2035.
Carbon capture and storage (CCS)	4	1.8	Adoption of CSS technology in plants located in South Sumatra. CCS is expected to capture 90% of the CO_2 released.

Indonesia’s power generation mix under a 1.5°C-aligned scenario

- Under a 1.5°C-aligned scenario, Indonesia’s power system undergoes significant transformation.
- By 2030, renewables will displace unabated fossil fuels to comprise two-thirds of the total generation, with fossil fuels making up only a few percent by 2050.
- In the long term, utility-scale solar photovoltaics (PV) will be the most significant renewable contributor, supported by hydropower, bioenergy, onshore wind, and geothermal energy.
- The generation cost of the power system is expected to decrease by 21% by 2030 and by 75% by 2050.

Indonesia power generation by fuel in 1.5°C-aligned scenario, 2023-2050



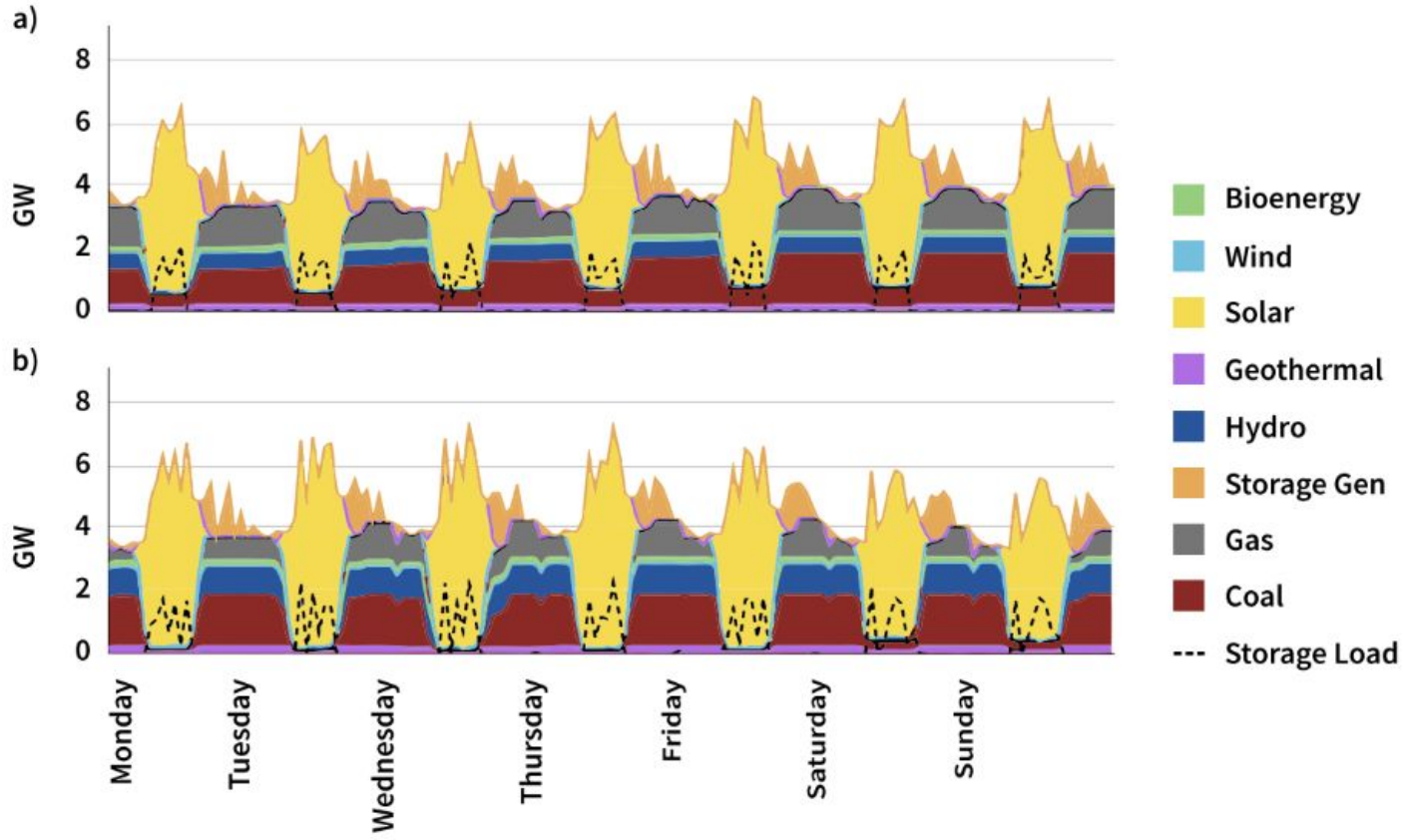
Coal plants role shift under a 1.5°C-Aligned Scenario

- The integration of increasing intermittent renewable energy sources requires deployment of new storage technologies, expanded and improved grid infrastructure, and stable and flexible operation.

- During the transition to the new system, coal plants shift the role from baseload generation to dispatch service with more flexible, reduced utilization, especially during dry seasons.

- In Sulawesi, by 2030 dry season coal and gas generation are projected to increase by 15% and 50%, respectively, to compensate for reduced hydro generation and to meet higher demand

Sulawesi production simulation in a 1.5°C-aligned scenario for a typical week during the dry season (a) and wet season (b), in 2030



Some concluding thoughts for discussion (I)

- This report presents a 1.5 aligned pathway that covers both on-grid and captive coal plants, and the strategies to achieve it.

- Next steps of JETP remain uncertain:
  - How to complete CIPP's financial gap
  - How to ensure real emissions reductions

- The key transition strategies proposed require deeper, granular, and holistic assessments:
  - Costs and technical feasibility of early retirement, retrofitting, and repurposing of coal plants
  - Current and future biomass pricing, availability, storage and transport, and sustainability for biomass co-firing
  - Onsite solar potential at captive plants locations
  - Potential grid connection of captive demand

Some concluding thoughts for discussion (II)

- Policy and regulatory initiatives can accelerate the transformation of the power sector:
  - National task force
  - Tax incentives to promote renewables in industrial parks
  - Prioritizing dispatch of biomass co-firing plants
  - Renegotiation of existing contracts between PLN and IPPs
  - Contract-based mechanism for flexibility service
  - Coal-to-renewable regulation

- Link domestic ambition, international support with broader national and global contexts:
  - Global stocktake energy targets: 3x RE, 2x EE
  - New cycle of national ambition enhancement – 2035 NDC + LTS
  - Green industry policies, supply chain, and economic development

Downloading link:

s.id/CoalTransition

https://cgs.umd.edu/research-impact/publications/15degc-aligned-coal-power-transition-pathways-indonesia-additional

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Thank you!

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