



ICMGP 2024  
CAPE TOWN • SOUTH AFRICA • 21 - 26 JULY

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Navigating Mercury Emission Reduction  
in Coal-Powered Economies

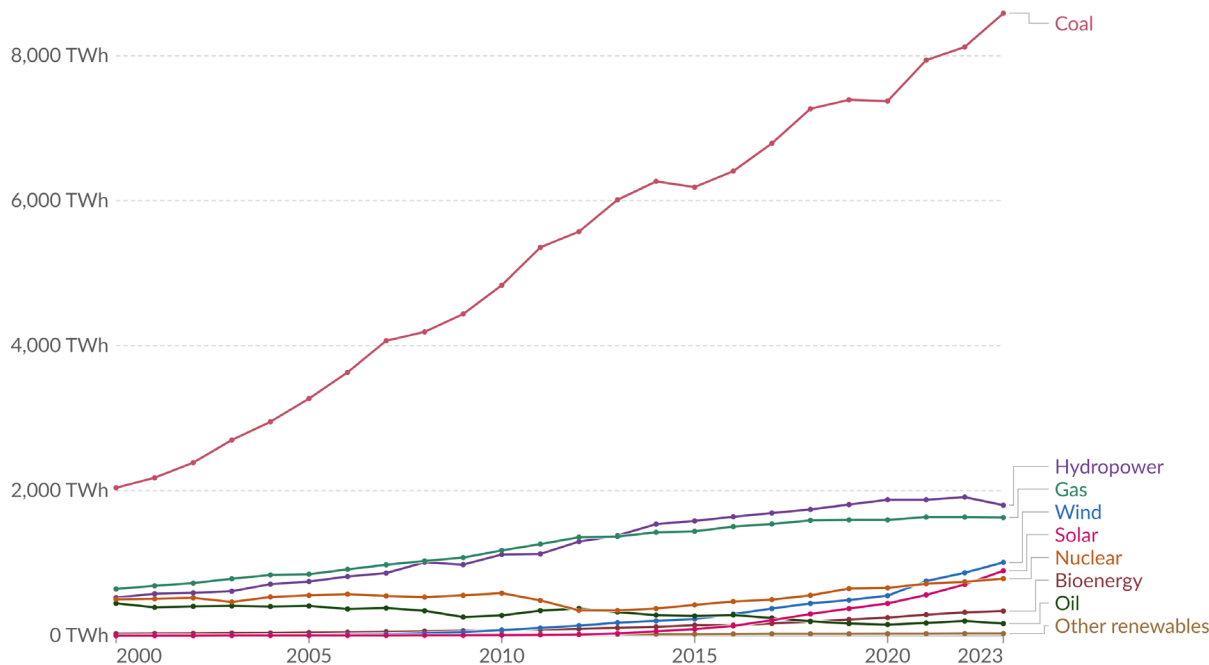


# A Continued Reliance on Coal

## Electricity production by source, Asia (Ember)

Measured in terawatt-hours<sup>1</sup>.

Our World in Data



Data source: Ember (2024); Energy Institute - Statistical Review of World Energy (2023)

OurWorldInData.org/energy | CC BY

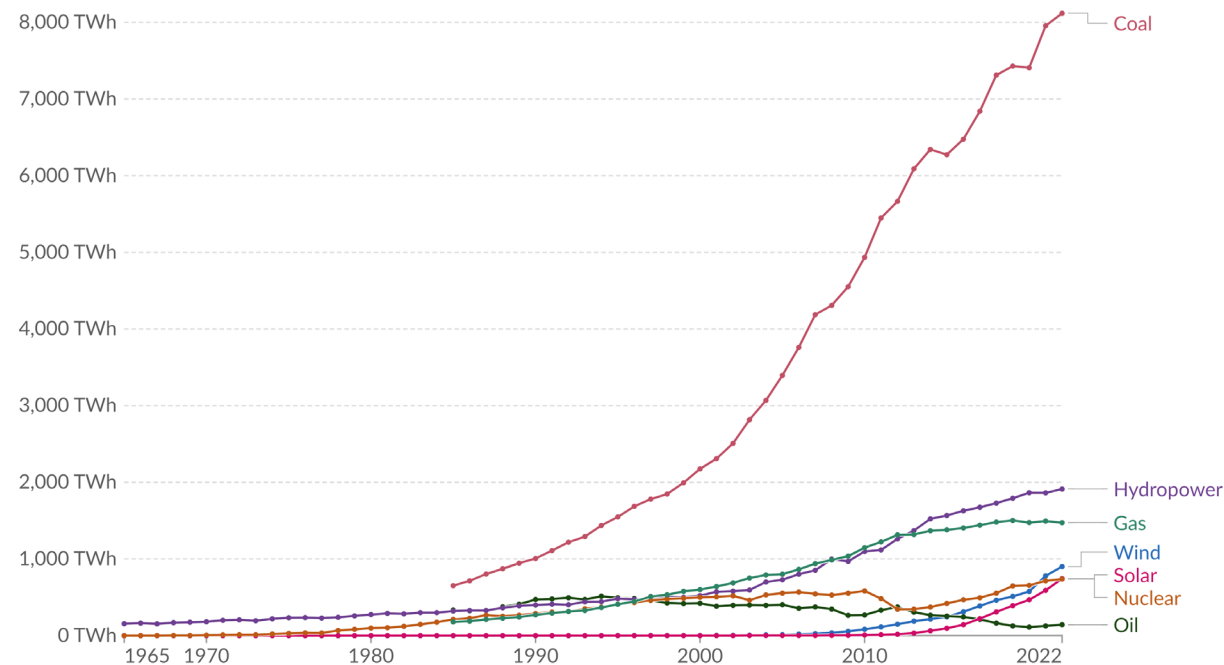
Note: Other renewables include waste, geothermal and wave and tidal energy.

1. **Watt-hour:** A watt-hour is the energy delivered by one watt of power for one hour. Since one watt is equivalent to one joule per second, a watt-hour is equivalent to 3600 joules of energy. Metric prefixes are used for multiples of the unit, usually: - kilowatt-hours (kWh), or a thousand watt-hours. - Megawatt-hours (MWh), or a million watt-hours. - Gigawatt-hours (GWh), or a billion watt-hours. - Terawatt-hours (TWh), or a trillion watt-hours.

## Electricity production by source, Asia Pacific (EI)

Measured in terawatt-hours<sup>1</sup>.

Our World in Data



Data source: Ember (2024); Energy Institute - Statistical Review of World Energy (2023)

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Note: Other renewables include waste, geothermal and wave and tidal energy.

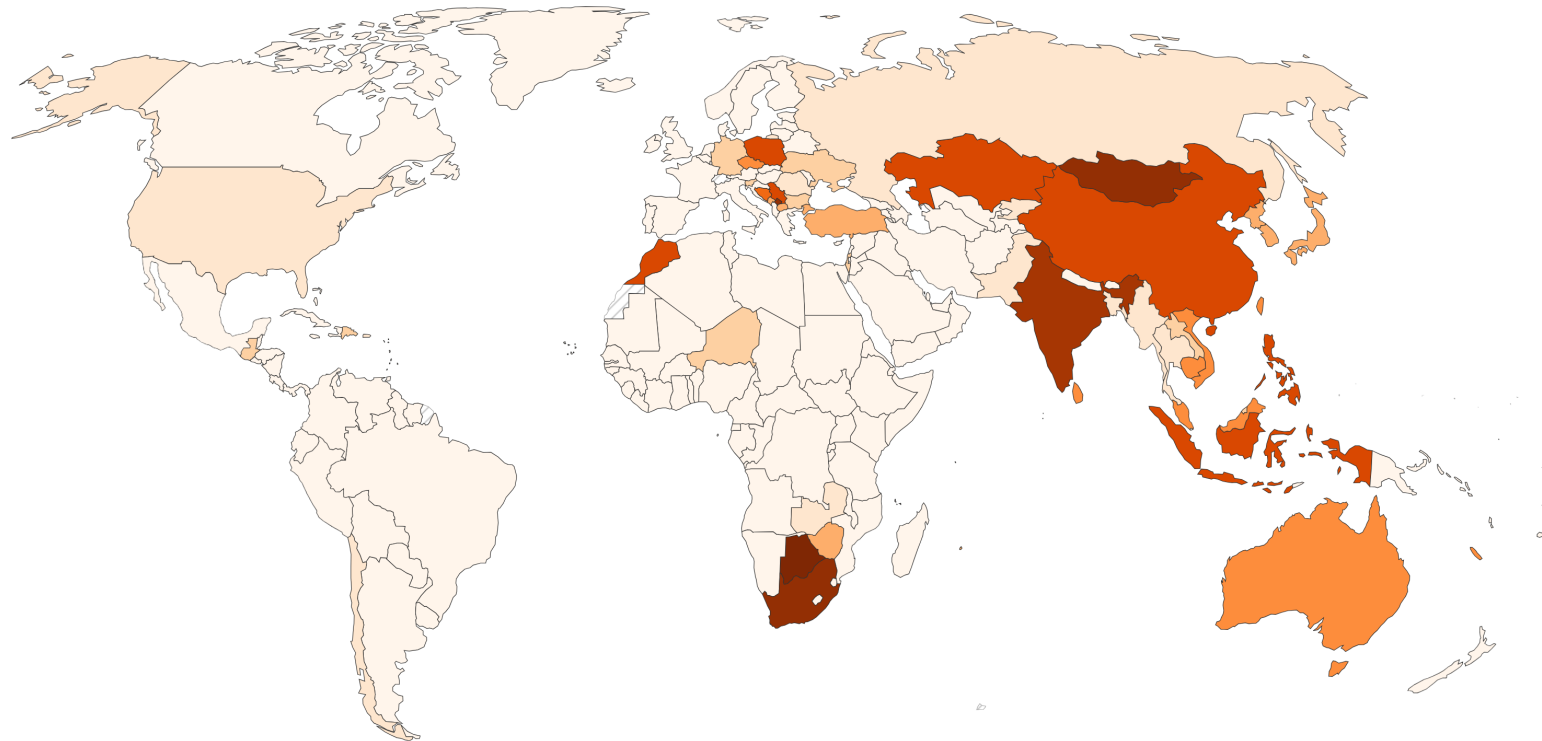
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# A Continued Reliance on Coal

## Share of electricity production from coal, 2023

Measured as a percentage of total electricity.

Our World in Data



# Towards Climate Action:

## Options & considerations:

### A. Accelerated phase-out of coal

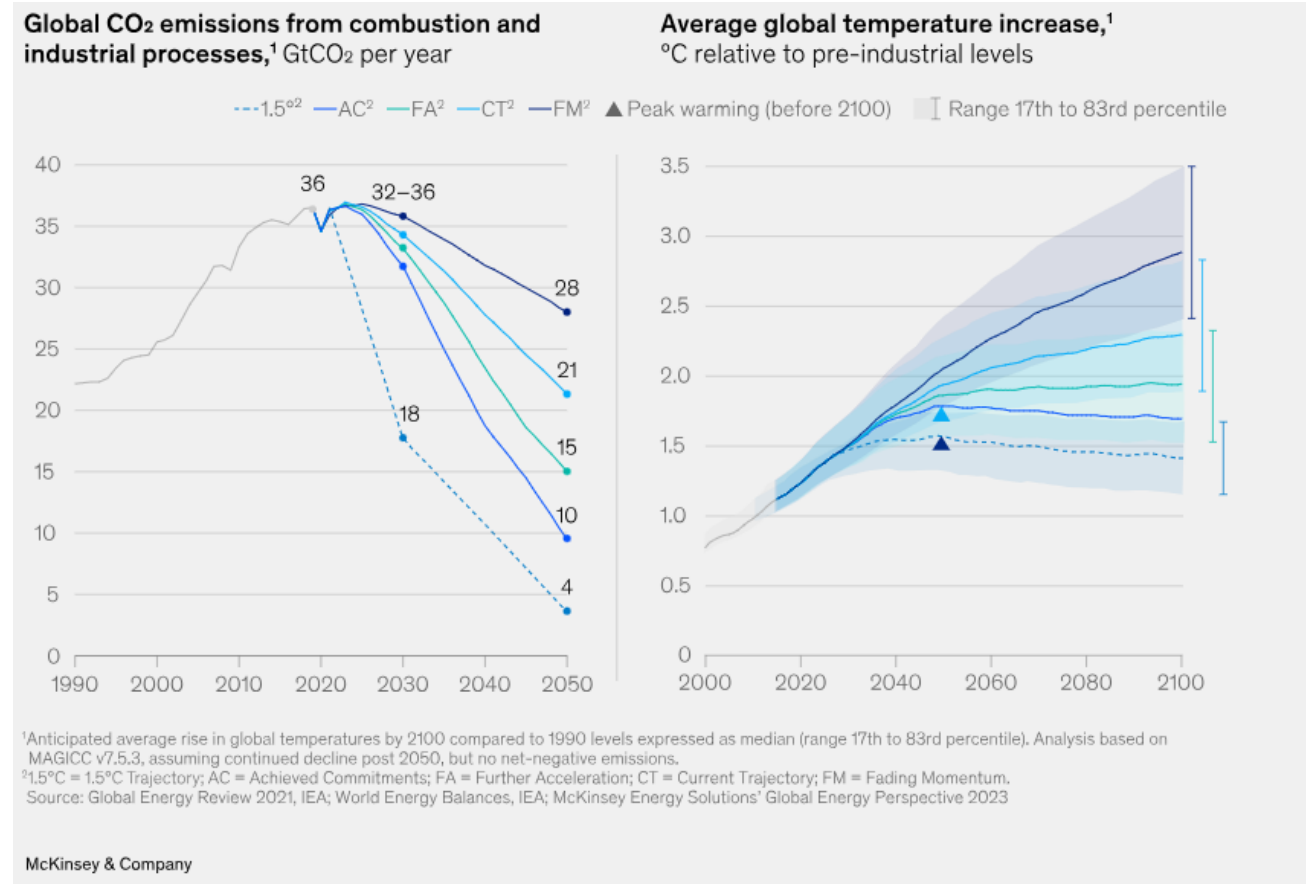
- Dependent on alternative energy resources and infrastructure over the long term
  - i.e., renewables, battery storage, transmission infrastructure, nuclear
- Social, economic & financial considerations – including secure energy provision over the short term

### B. Improvement of air pollution control for new and existing resources

- Social, economic & financial considerations

“In all scenarios, the average warming caused by cumulative CO<sub>2</sub> emissions would reach 1.5°C above pre-industrial levels by 2035, even if all climate commitments are achieved, as modeled in the Achieved Commitments scenario.” – McKinsey & Co., Global Energy Perspective 2023: CO<sub>2</sub> emissions outlook

<https://www.mckinsey.com/industries/oil-and-gas/our-insights/global-energy-perspective-2023-co2-emissions-outlook>





## **OUTCOME 1: Comprehensive coal sectoral analysis**

### Activities

- Review scientific data on mercury emissions from CFPPs
- Evaluate the impact of commitments and targets by UN Conventions on Hg/GHG/POP emissions from the coal sector
- Potential mercury reduction figures & scenarios from CFPPs produced
  - Expand to Coal-Fired Industrial Boilers (CFIB)

# Project Outcomes

## Activities

- Synthesis of results from completed & ongoing CFPP projects
- Selection criteria: Future projects based on highest impact potential
  - Guidance on where to support large scale projects – Training/Capacity-Building
- Assist public and private sectors in their decision-making processes




## **OUTCOME 2:**

**STRATEGY FOR THE COAL  
SECTOR'S EMISSIONS  
REDUCTION CONTRIBUTION  
TO STOCKHOLM AND  
MINAMATA CONVENTIONS**


# The Global Energy Monitor – Global Coal Plant Tracker Database

<https://globalenergymonitor.org/projects/global-coal-plant-tracker/>



Global Energy Monitor

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## Global Coal Plant Tracker

The Global Coal Plant Tracker (GCPT) provides information on coal-fired power units from around the world generating 30 megawatts and above. The GCPT catalogues every operating coal-fired generating unit, every new unit proposed since 2010, and every unit retired since 2000. Units often consist of a boiler and turbine, and several units may make up one coal-fired power station. The map and underlying data is updated bi-annually, around January and July. Around April and October, partial supplemental releases also cover updates to proposed coal units outside of China. Each plant included in the tracker is linked to a wiki page on [GEM.wiki](#), which provides additional details.

The most recent release of this data was in January 2024 (full) and April 2024 (partial; findings not reflected in map or dashboard).

To receive notifications from this project, please sign up for our [mailing list](#). If you have questions about this project, please [contact](#) the Project Manager, Christine Shearer.

< PROJECTS

### Global Coal Plant Tracker

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[Summary Tables](#)

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[Wiki Pages](#)

[Global Coal Phaseout](#)

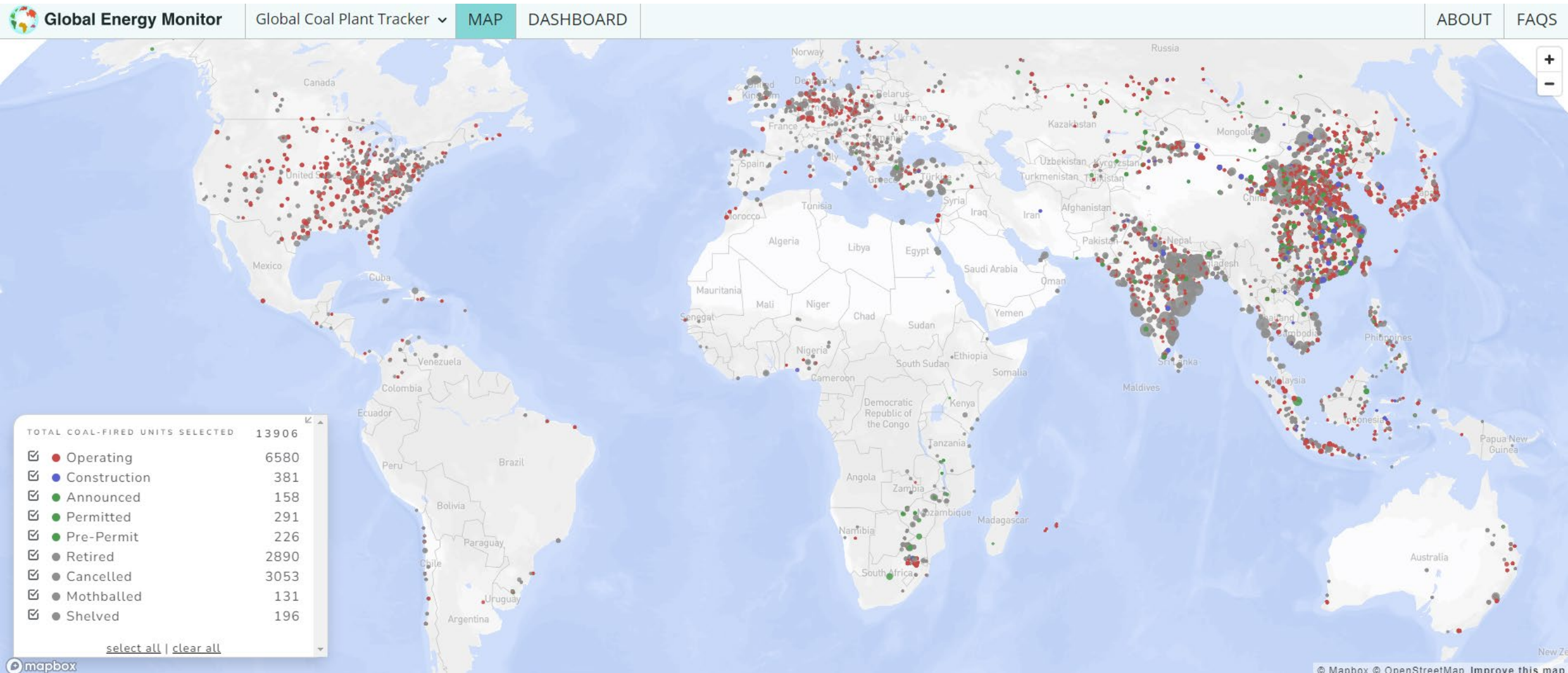
[Methodology](#)

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# The Global Energy Monitor – Global Coal Plant Tracker Database

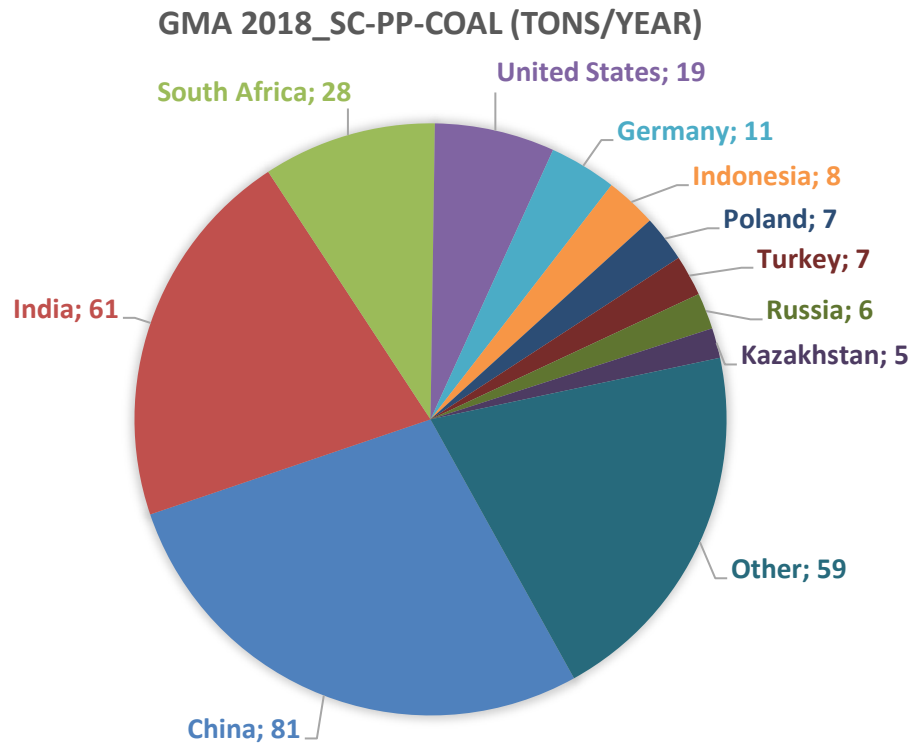
<https://globalenergymonitor.org/projects/global-coal-plant-tracker/>



# Global Mercury Assessment 2018

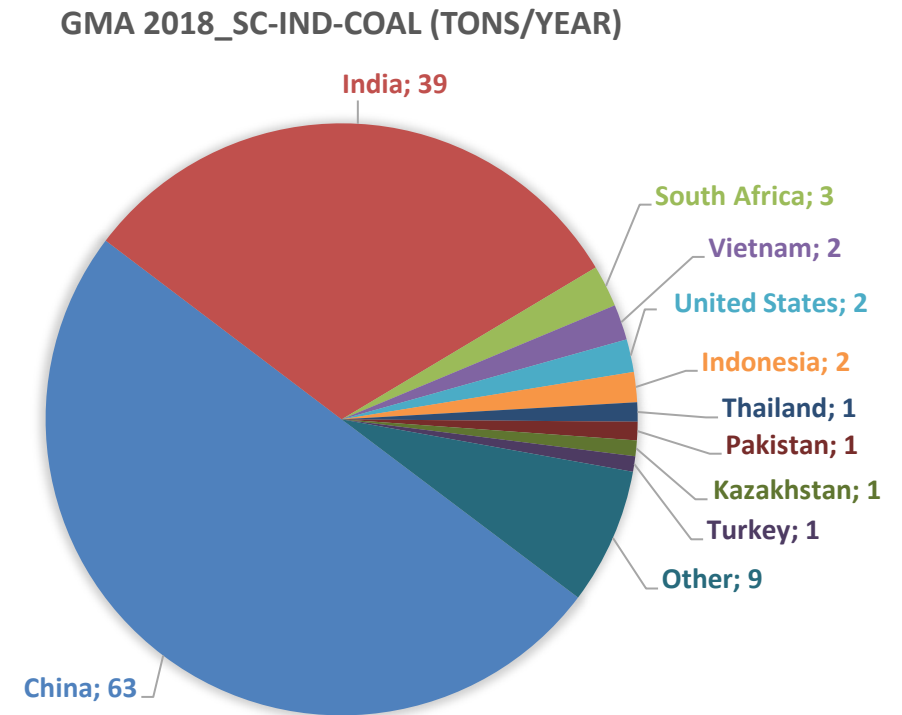
... But much has changed since then...

## Stationary Combustion of Coal at Power Plants 292 tons/year



China, India & South Africa = 47% - 59% global coverage

## Stationary Combustion of Coal at Industrial Boilers 126 tons/year



China & India = 73% - 83% global coverage

# Focus Countries

## Global CFPP coverage

### ***CFPP capacity (global)***

2023: 2,211.7 GW

2030: 2,011.5 – 2,390.9 GW

2050: 1,255.8 – 1,635.1 GW

### ***CFPP capacity (focus countries)***

2023: 1,610.7

2030: 1,682.9 – 2,022.6

2050: 1,163.6 – 1,503.4

### ***CFPP capacity (China)***

2023: 1,182.6

2030: 1,259.8 – 1,527.7

2050: 843.1 – 1,111.0

### ***Global share (%)***

2023: 73%

2030: 84 - 85%

2050: 92 - 93%

### ***Global share (%)***

2023: 53%

2030: 63 - 64%

2050: 67 - 68%



# Methodology – Unit Coal Consumption (1000 tonnes / year)

$$\text{Heat Rate Value} / \text{Gross Calorific Value} * \text{Unit Capacity} * \text{Capacity Factor} * 9.24\text{E}03$$

## Features

### Heat Rate Value (Btu per kWh)

Global Energy Monitor, Global Coal Plant Tracker Database

[https://www.gem.wiki/Estimating\\_carbon\\_dioxide\\_emissions\\_from\\_coal\\_plants](https://www.gem.wiki/Estimating_carbon_dioxide_emissions_from_coal_plants)

1 Btu/kWh = 1,06 kJ/kWh

### Unit Capacity (MW)

Global Energy Monitor, Global Coal Plant Tracker Database

<https://globalenergymonitor.org/projects/global-coal-plant-tracker/>

1 MW = 8,760,000 kWh/year

### Gross Calorific Value (kJ/kg coal)

Average values from Stockholm Convention Annex 28

[https://toolkit.pops.int/Publish/Annexes/A\\_28\\_Annex28.html](https://toolkit.pops.int/Publish/Annexes/A_28_Annex28.html)

GCV(kJ/kg coal)	Av
Bituminous	29300
Subbituminous	14500
Anthracite	30667
Lignite	8583
Unknown	25000
Waste coal	25000

### Capacity Factor\*

Assumption

China	0.48	WEO23 - Table B.4; Zhang et al., 2022
India	0.65	WEO23 - Table B.4
Indonesia	0.78	CIPP report
Vietnam	0.70	Breu et al., 2019
Thailand	0.75	Energy Policy and Planning Office of Ministry of Energy, Energy Statistics
Malaysia	0.53	Global average - IEA2023 World Energy Outlook
Philippines	0.67	Philippines DOE report
South Africa	0.53	Global average - IEA2023 World Energy Outlook
Pakistan	0.53	Global average - IEA2023 World Energy Outlook
Bangladesh	0.39	Bangladesh Power Development Board, Annual Report 2015-16, 2016
United States	0.35	WEO23 - Table B.4
European Union	0.30	WEO23 - Table B.4
Rest of World	0.53	Global average - IEA2022 World Energy Outlook

# Methodology – Mercury Emissions

$$\text{Mercury emission (kg/year)} = \text{Coal consumption} * \text{IF} * ((100 - \text{RR}) / 100)$$

HRV / GCV \* CAP \* CF \* 9.24E03

**Vietnam CFPPs (2023) = 54.6 million tonnes / year**

Mercury input factor by country (mg/kg) - USGS default		
China	0,17	Liu et al., 2019
India	0,22	India country profile
Indonesia	0,06	BCRC-SEA, 2017
Vietnam	0,28	UNEP, 2017
Philippines	0,08	USGS
Thailand	0,14	USGS
Malaysia	0,08	USGS
South Africa	0,21	<a href="https://link.springer.com">https://link.springer.com</a>
REMAINING WORLD	0,15	<a href="https://pubs.usgs.gov">USGS</a>
Australia	0,08	<a href="https://pubs.usgs.gov">USGS</a>
United States	0,13	<a href="https://pubs.usgs.gov">https://pubs.usgs.gov</a>

Table 5-11 Mercury retention rates and application profile developed by UNEP/AMAP (2012).

	Intermediate mercury retention rates, %, by coal type		Degree of application (%) by country group *1				
	Hard coal (anthracite, bituminous)	Brown coal (sub-bituminous, lignite)	1	2	3	4	5
<b>Air pollution controls</b>							
<b>Industrial use (combustion):</b>							
Level 0: None	0.0	0.0			25	50	75
Level 1: Particulate matter simple APC: ESP/PS/CYC	25.0	5.0	25	25	50	50	25
Level 2: Particulate matter (FF)	50.0	50.0	25	50	25		
Level 3: Efficient APC: PM+SDA/wFGD	50.0	30.0	25	25			
Level 4: Very efficient APC: PM+FGD+SCR	90.0	20.0	25				
Level 5: Mercury specific	97.0	75.0					
<b>Other coal combustion:</b>							
Level 0: None	0.0	0.0	50	50	100	100	100
Level 1: Particulate matter simple APC: ESP/PS/CYC	25.0	5.0	50	50			

# Methodology – Outlook Scenarios

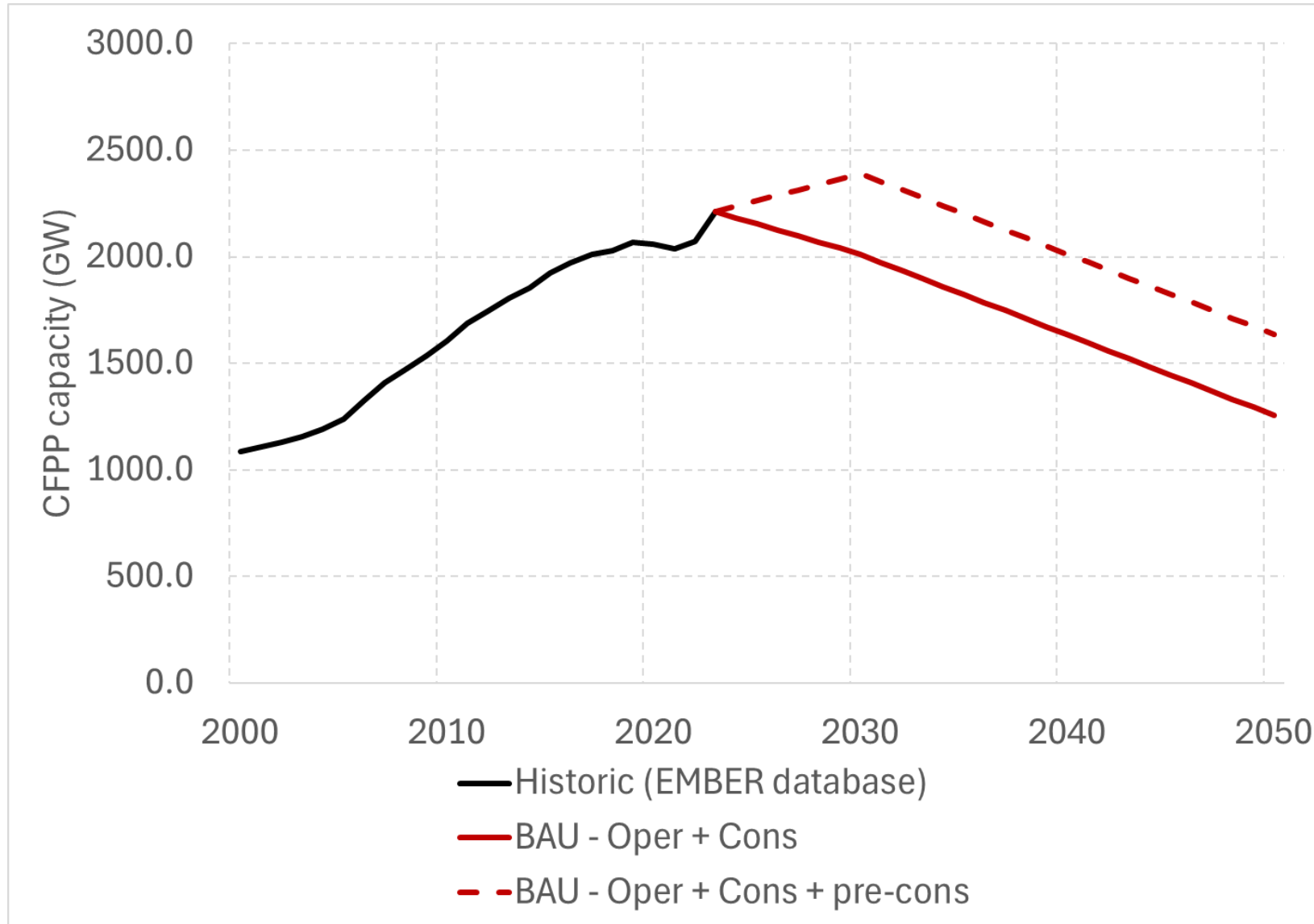
1. Business-As-Usual (BAU)
  - a) Operating and Construction
  - b) Operating, Construction & Pre-construction (Announced, Permitted, Pre-permitted)
  
2. Early Retirement
  
3. Change in Capacity Factor – i.e., annual operation time
  
4. Air Pollution Control installation\*
  - a) Retrofit of existing structures
  - b) Improved APCDs for new builds

\*where information is not available:

	APCD configuration							
	SUBCR (MW)	(ultra)SUPERC (MW)	SUBCR (↑)	SUBCR (↓)	(ULTRA)SUPERC (↑)	(ULTRA)SUPERC (↓)	NEW (CONS)	NEW (PRE-CONS)
Indonesia	300	600	ESP + FGD	ESP	ESP + FGD	ESP	ESP + FGD	ESP + FGD
Vietnam	300	600	ESP + FGD	ESP + FGD	ESP + FGD	ESP + FGD	ESP + FGD	ESP + FGD
Malaysia	300	600	ESP	ESP	ESP	ESP	ESP + FGD	ESP + FGD
Philippine	300	600	ESP	ESP	ESP	ESP	ESP + FGD	ESP + FGD
Thailand	300	600	ESP	ESP	ESP	ESP	ESP + FGD	ESP + FGD
South Africa	300	600	FF	FF	FF + FGD	FF	FF + FGD	FF + FGD
India	300	600	ESP	ESP	ESP + FGD	ESP	ESP + FGD	ESP + FGD
China	330	300	ESP + FGD	ESP	ESP + FGD + SCR	ESP + FGD	ESP + FGD + SCR	ESP + FGD + SCR
United States	100	300	ESP + FGD	ESP	ESP + FGD + SCR	ESP + FGD	ESP + FGD + SCR	ESP + FGD + SCR
Poland	300	600	ESP	ESP	ESP	ESP	ESP + FGD	ESP + FGD
Pakistan	300	600	ESP	ESP	ESP	ESP	ESP + FGD	ESP + FGD
Bangladesh	300	600	ESP	ESP	ESP	ESP	ESP + FGD	ESP + FGD
Russia	300	600	ESP + FGD	ESP	ESP + FGD	ESP	ESP + FGD	ESP + FGD
Other	300	300	ESP	ESP	ESP	ESP	ESP + FGD	ESP + FGD

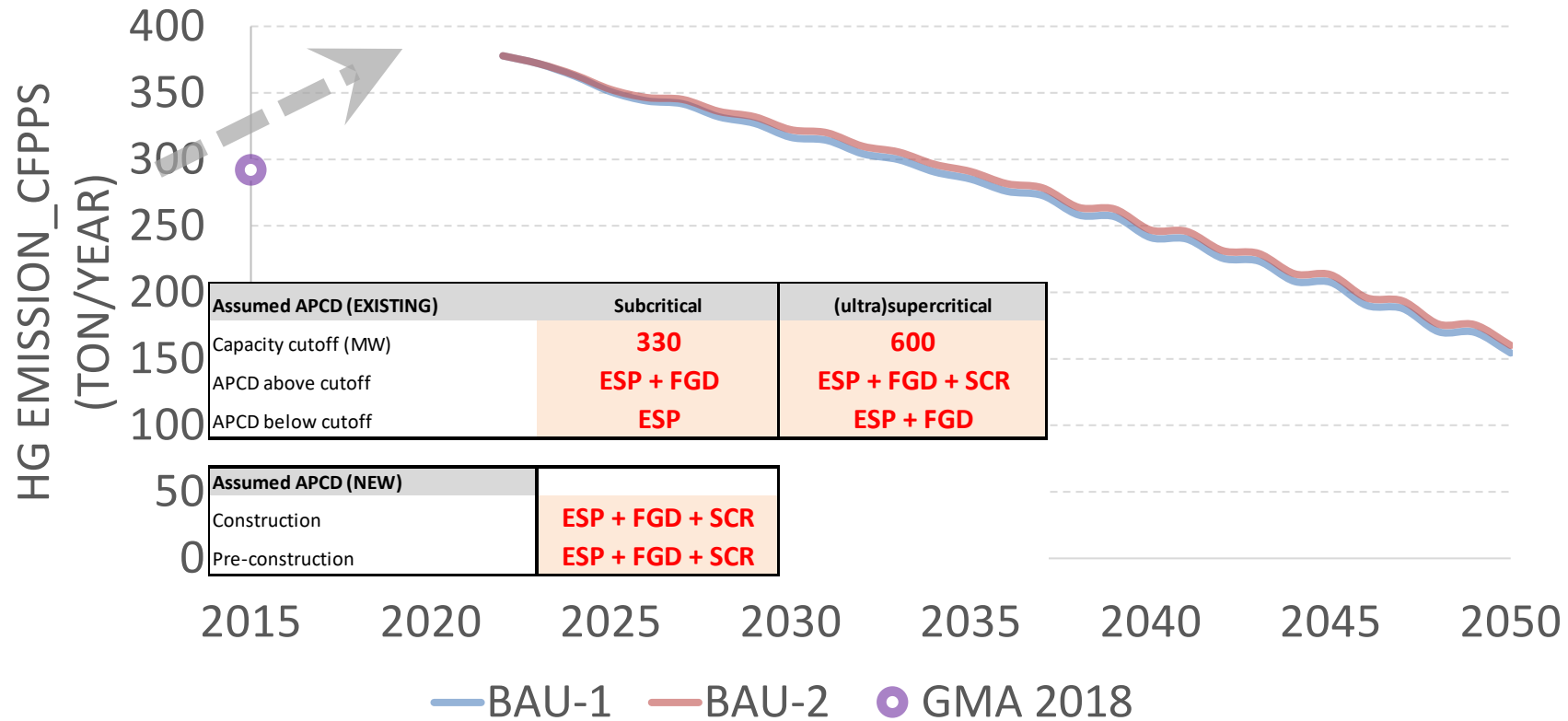
# Global Coal Plant Overview and Focus Countries

# Global CFPP capacity Outlook to 2030

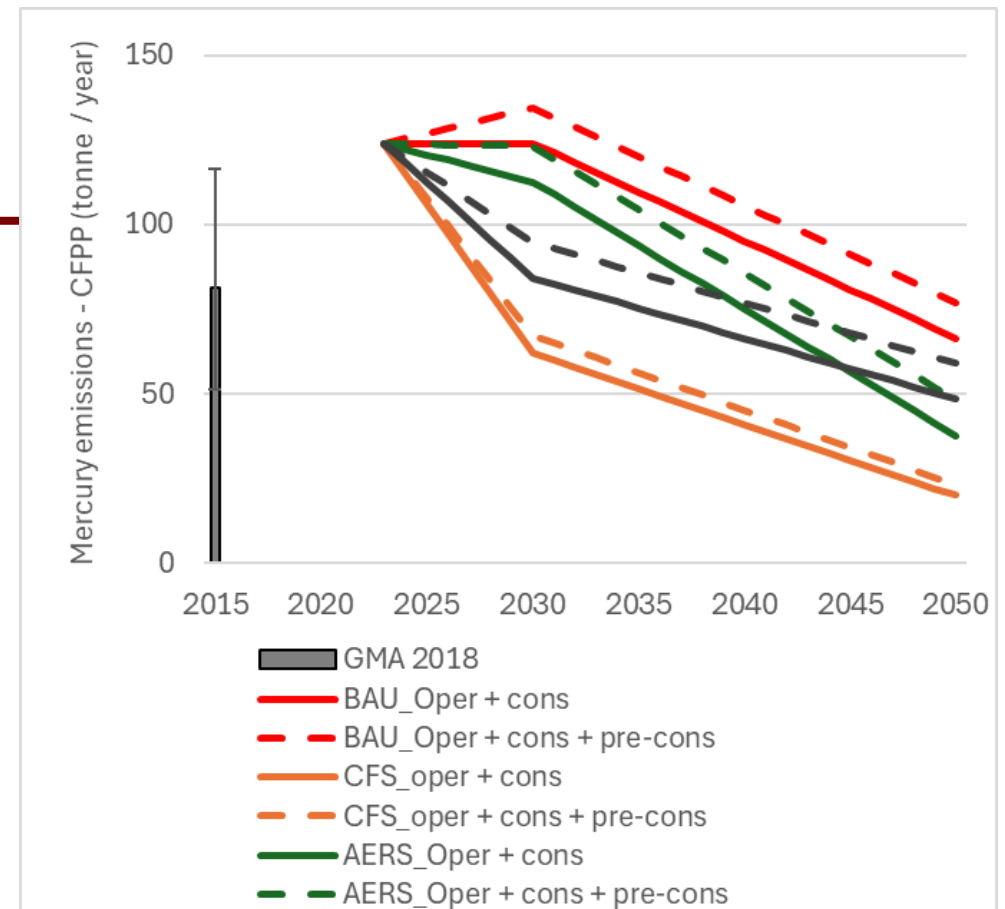
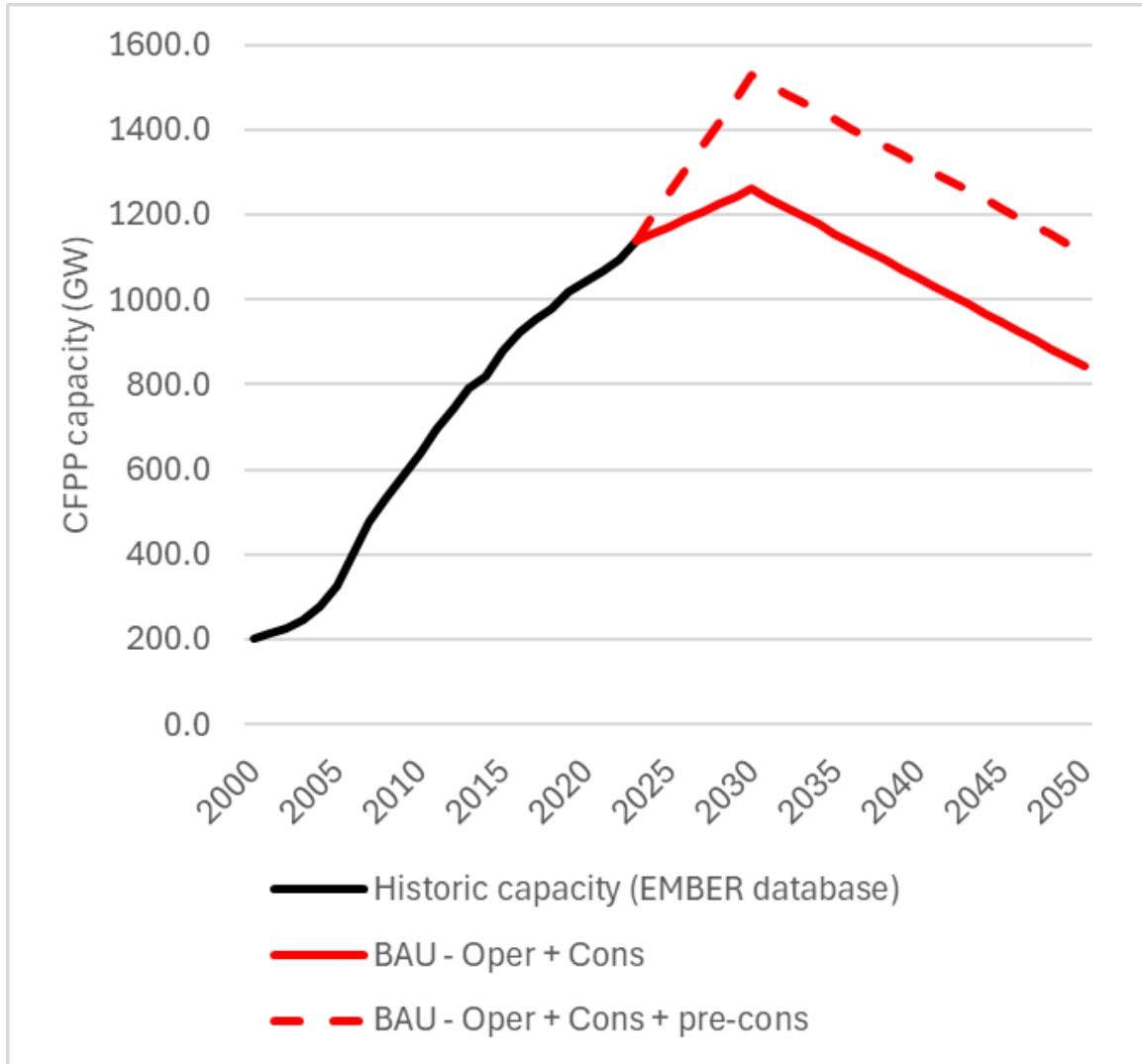


# Project Overview

## GLOBAL THERMAL COAL-FIRED POWER EMISSIONS - MERCURY



# China

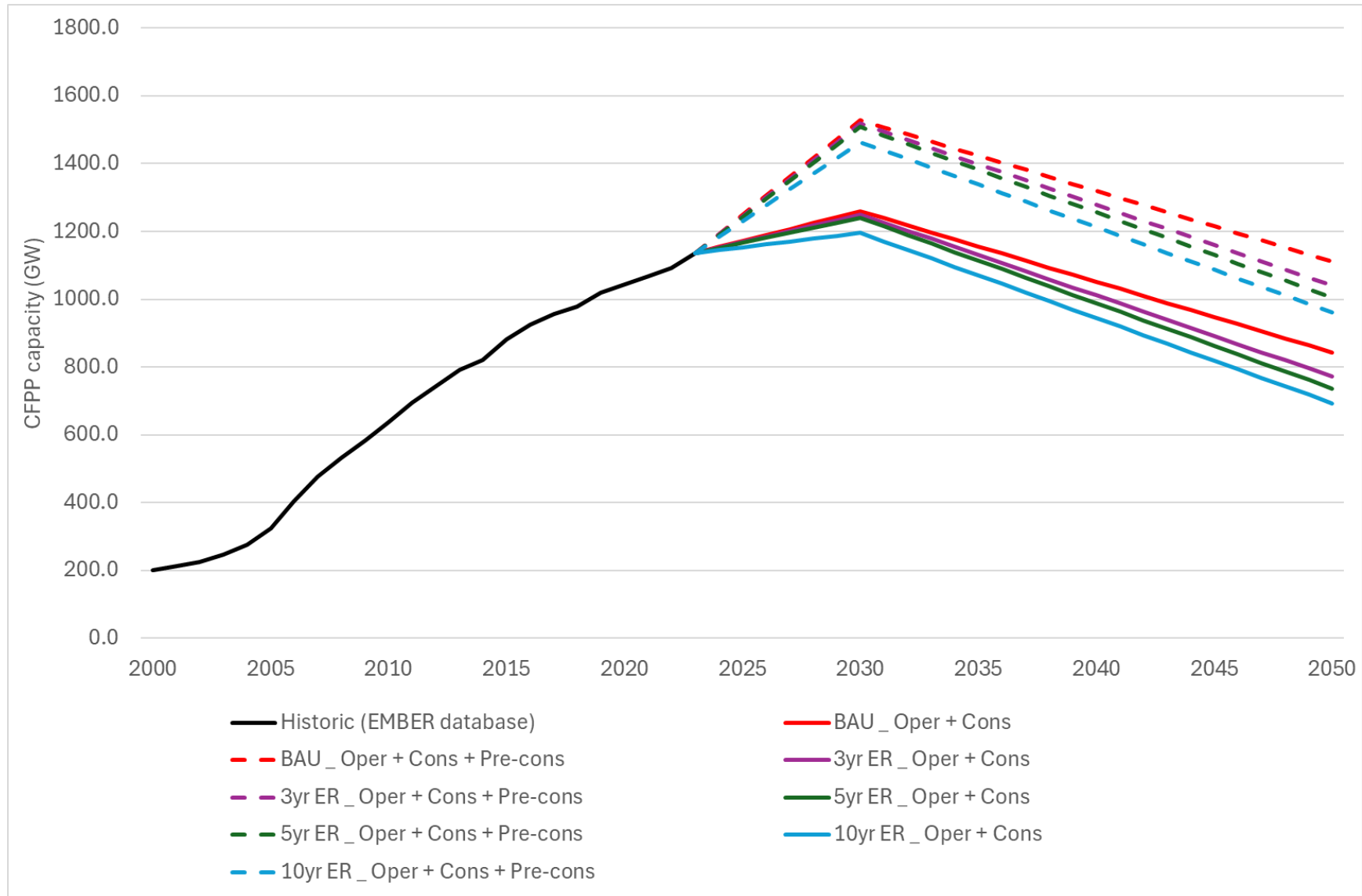


RETROFIT scenario criteria	
Unit remaining lifetime >=	20
Original APCD configuration	ESP + FGD
New APCD configuration	ESP + FGD + SCR
Unit status to retrofit	Operating
Retrofit by	2030

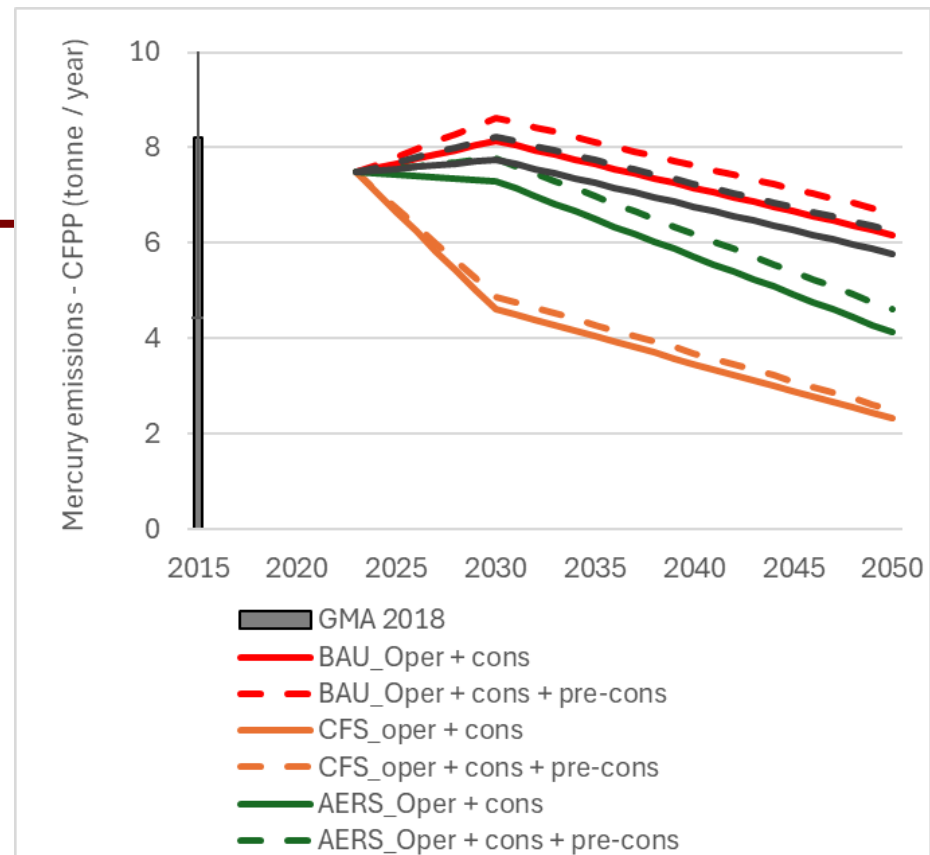
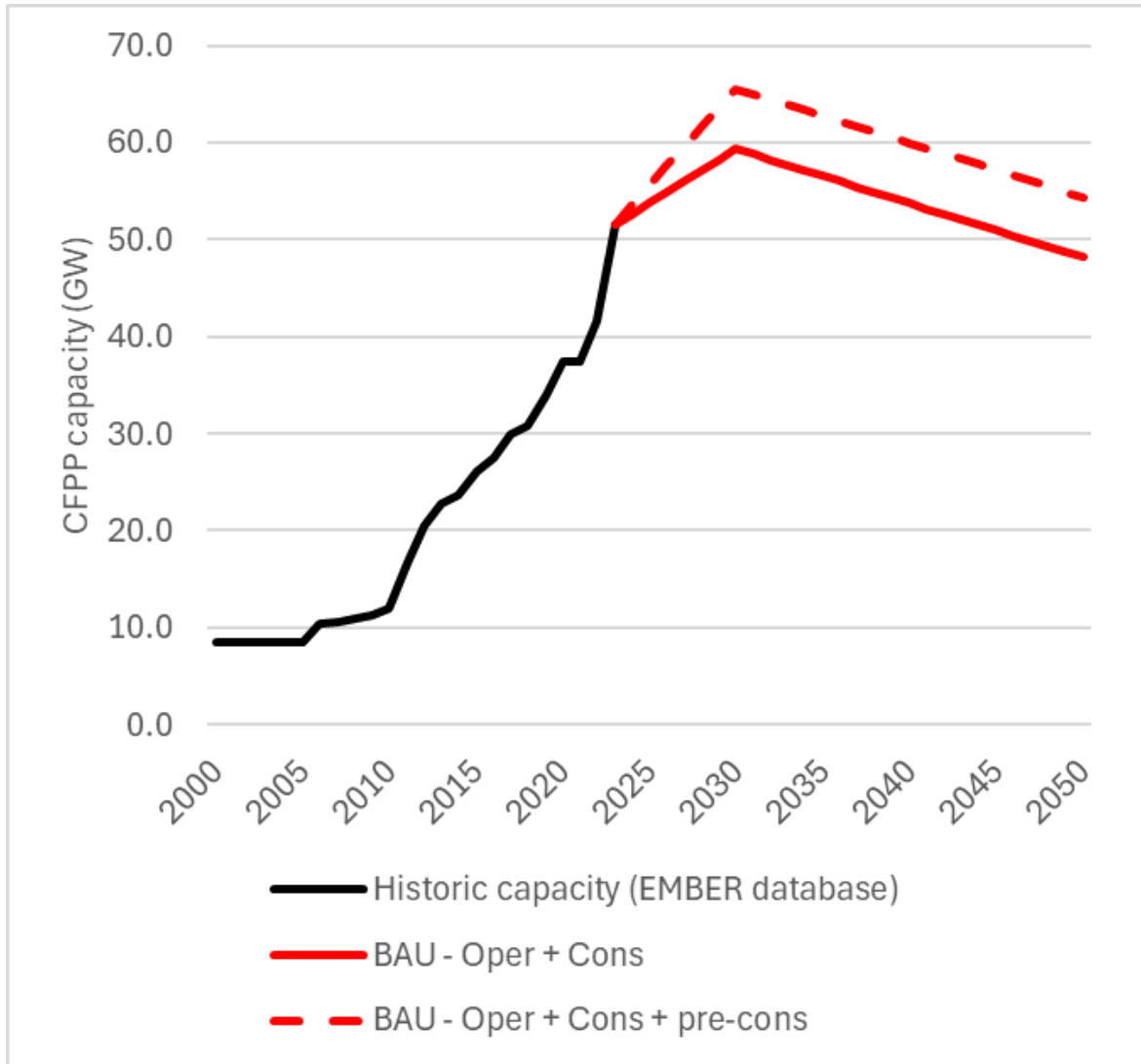
AERS scenario criteria	
Units to retire	Subcritical
Unit capacity ≤	1000
Years ER	10
If AERS < 2023, retirement year	2025

# China – example of early retirement outlook

## 3- to 10-year early retirement of subcritical CFPP units



# Indonesia



RETROFIT scenario criteria	
Unit remaining lifetime $\geq$	20
Original APCD configuration	ESP
New APCD configuration	ESP + FGD
Unit status to retrofit	Operating
Retrofit by	2030

AERS scenario criteria	
Units to retire	Subcritical
Unit capacity $\leq$	1000
Years ER	10
If AERS < 2023, retirement year	2025

# A Rise in Captive Coal-Fired Power Generation

## An example from Indonesia

### Key findings

- Nearly 25% of operating coal capacity in Indonesia is for captive use, that is, generated by power stations that are operated and utilised off-grid by industrial actors. Despite this significant share, the government's efforts to transition away from coal are currently limited to the power sector.
- Operating captive power capacity has increased nearly eightfold from 2013 to 2023, from 1.4 gigawatts (GW) to 10.8 GW.
- Over half of proposed coal capacity additions (announced, pre-permit, and shelved) as of July 2023 is for captive use. Based on the latest dataset, 14.4 GW of captive coal capacity is proposed or in construction.
- Indonesia is a leading supplier of the critical metals needed for a renewable energy transition, but many operating and planned smelters are operated using coal power. The national industrial development plan for 2015-2035 considers metal processing to be "added value to natural resources", and developing coal plants is allowed when they will increase the "added value of natural resources". Smelters are currently located in 13 provinces.
- Coal capacity additions have been outpacing renewables additions, despite Indonesia's stated goal of peaking emissions by 2030 through the acceleration of renewable energy deployment.
- Future emissions from captive coal plants are a major threat that must be considered within the planned use of the USD 20 billion Just Energy Transition Partnership (JETP) funding. As the launch of the JETP investment plan has been delayed, Indonesia and international partners must negotiate commitments to clear, focused and ambitious targets.



**Emerging captive coal power: Dark clouds on Indonesia's clean energy horizon**

Jobit Parapat, Researcher  
Katherine Hasan, Analyst  
09/2023



# Outcome 2: Strategy for coal sector emissions reduction contribution to UN Conventions

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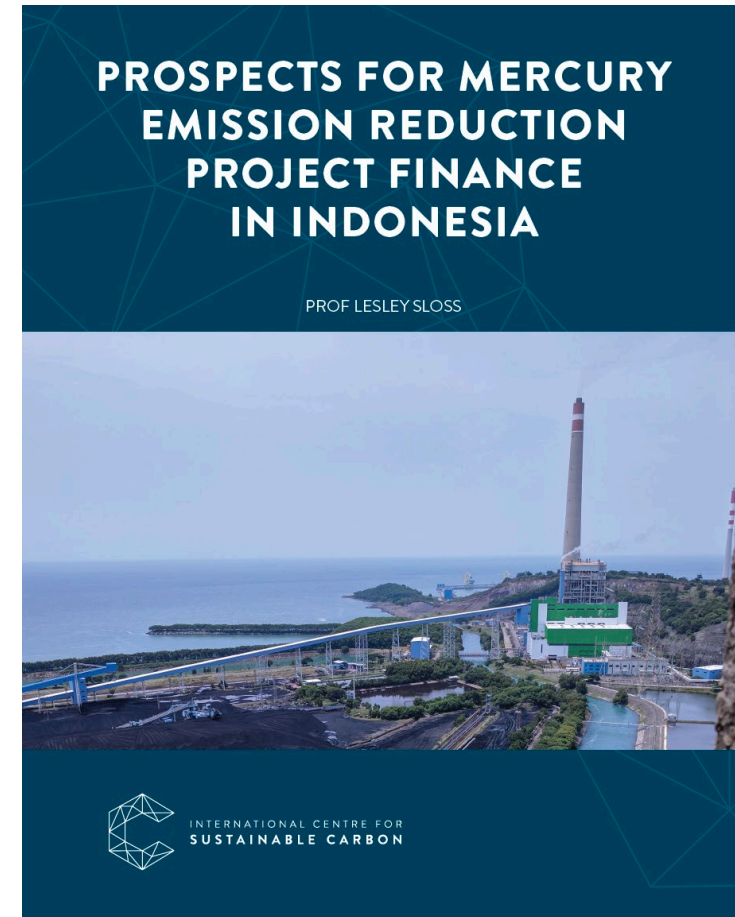


MACQUARIE  
University

- Initiatives
  - Powering Past Coal Alliance (PPCA)
  - Accelerating Coal Transition Program (ACT; Climate Investment Funds)
  - Energy Transition Mechanism (ETM; Asian Development Bank)
  - Just Energy Transition Partnership (JETP; World Bank)
- Considerations for CFPP early retirement
  - Available excess thermal capacity/flexibility
  - Plant-specific operation (consideration during ETM?)
  - Cost of retirement compared to APCD retrofit
  - BAP for retirement mechanism – RE transition

# Finance – the reality

- The Paris Climate Convention requires countries to phase down or even phase out coal by set deadlines
- Funding is only available for early coal plant closure or replacement
- Whilst this will accelerate the move to renewable energy, in many growing regions where gas and nuclear are not available, coal will remain an integral part of the baseload energy mix until reliable, dispatchable, and affordable alternatives are found



# Conclusions

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1. **Plant-specific CFPP information is highly useful for emissions predictions**
  - The continued reliance on fossil fuels (especially coal) is still an option for developing countries – Mostly in Asian countries and, for example, in South Africa
  - The social and economic implications of accelerated coal phase-out should be carefully evaluated
  - Need for similar information from the CFIB sector and the observed rise in captive CFPP developments in many countries
  
2. **Guidance**
  - Where should investment be prioritized towards mercury emissions abatement in the coal sector?
  - What forms of energy capacity development are desired?
  
3. **Considerations for CFPP modernization/decommissioning/repurposing**
  - Options for generation flexibility
  - Co-firing with biomass/ammonia
  - Cost of retirement compared to APCD improvements (stranded asset risks?)
  - Role of BAT/BEP in energy transition mechanisms?