# Assessment of existing and future emissions reduction from the coal sector toward the implementation of the Minamata and Stockholm Conventions

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GEF/UNEP Project Workshop
*Webinair 4th September 2025*

# Session 1

Welcome and Workshop Objectives

# Project Outcomes

**OUTCOME 1:**

**Comprehensive coal sectoral analysis**

**Activities**

- Scientific data on mercury/POPs/GHGs from coal-fired power plants (CFPPs) & industrial boilers (IBs) reviewed
- Demonstrate the effect of UN Conventions on implementing mercury/POPs emissions reduction strategies from coal combustion
- Potential mercury/POPs/GHG reduction figures and scenarios from CFPPs & IBs produced

**Outcomes**

- Estimated mercury/POPs/GHGs reductions and future scenarios for CFPPs & IBs
- Determine the load of mercury that can be reduced by the coal sector under various emission reduction approaches?

# Project Outcomes

**Activities**

- Synthesis of results from completed/ ongoing coal-fired power plant (CFPP) projects
- Selection criteria: Future projects based on highest impact potential
    - Guidance on where to support large scale projects
- Policy guidance: Assist public and private sectors in their decision-making processes
- Detailed reports and communication materials on project findings developed and disseminated through dedicated platform (UNEP & MQ)

**OUTCOME 2:**

**Strategy for the coal sector's emissions reduction contribution to Stockholm and Minamata Conventions**

# Session 2: Overview

Global coal use and emissions perspective

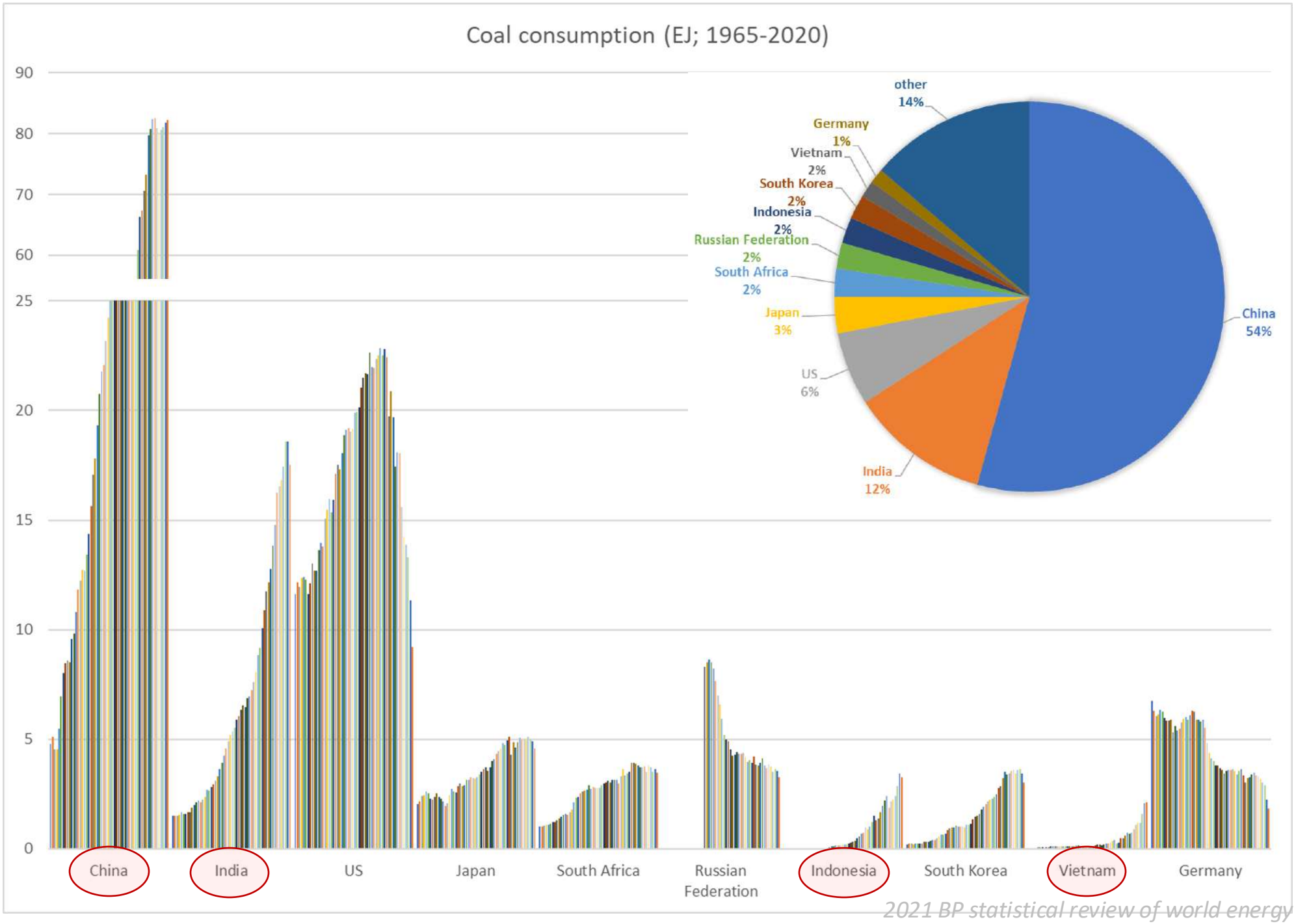
Focus countries

Short Break

# Background

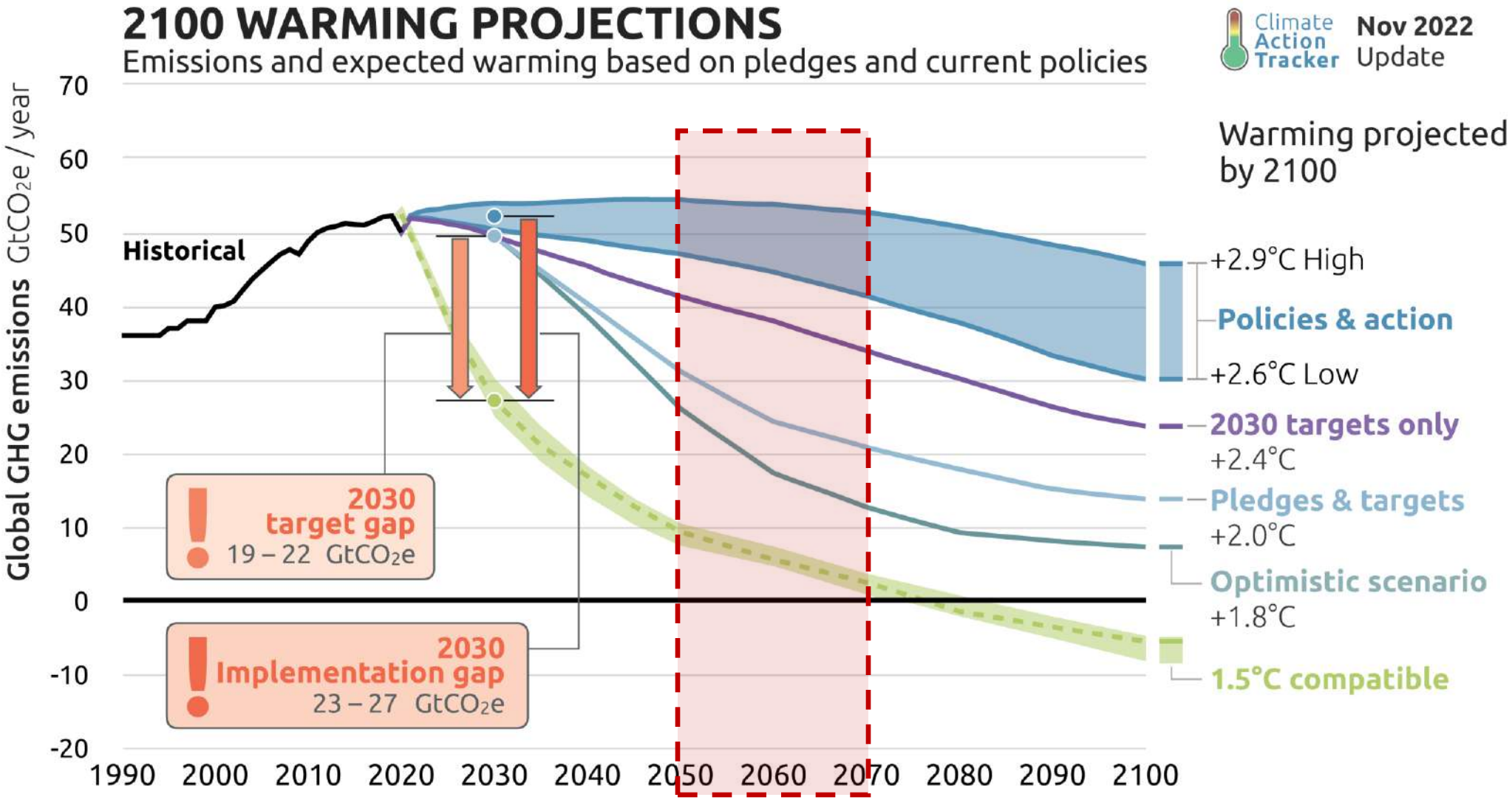
## UNDERSTANDING THE POSITION OF COAL IN GLOBAL ENERGY DEMAND

- **Global energy and electricity mix**
- **Climate change**
  - *UNFCCC - Paris Agreement*
  - *National determined contributions*
- **Global coal use**
  - *Contribution to GHG emissions*
  - *Existing GHG emission scenarios*
  - *Focus countries*
- **Mercury emissions from coal combustion**
  - *Minamata Convention on Mercury (MCM)*
- **POP emissions from coal combustion**
  - *Stockholm Convention*
- **Key targets and project outcomes/workplan**




*2021 BP statistical review of world energy*

# Nationally Determined Contributions (NDCs): Importance for Global Climate Action

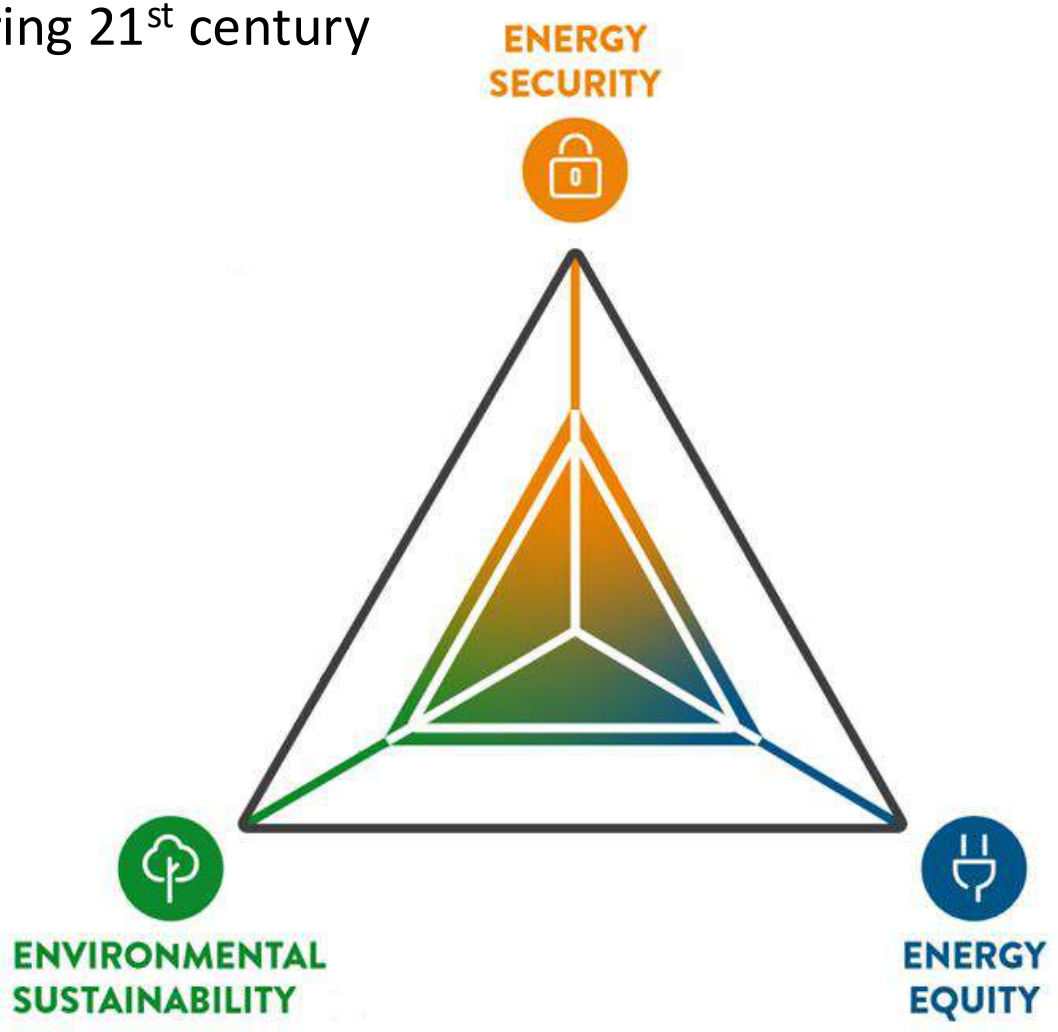


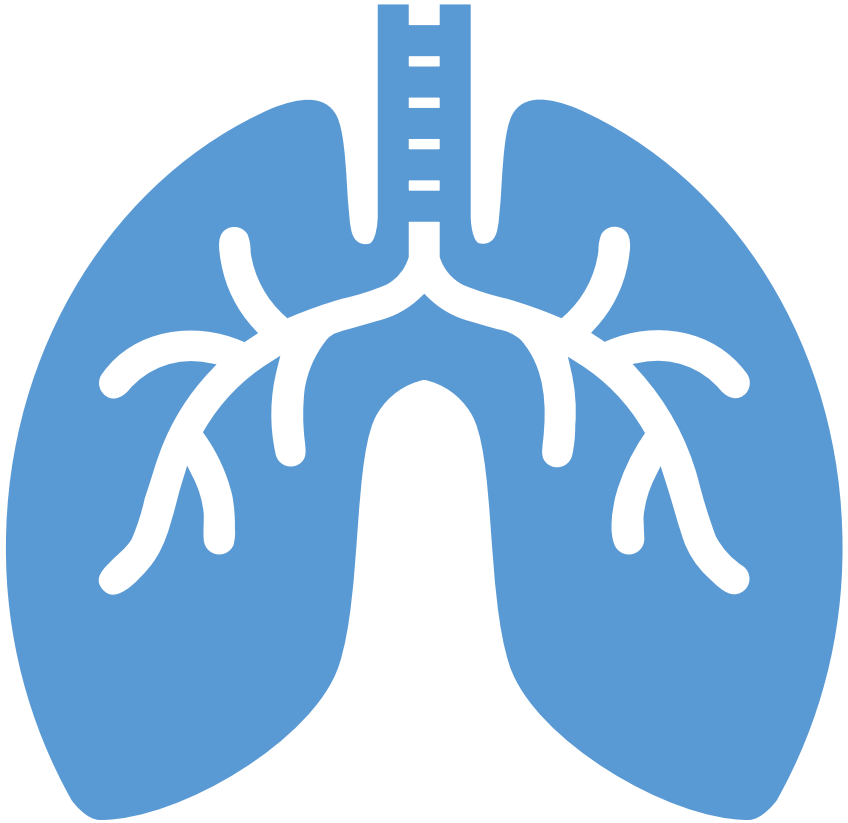
# Global Energy Trilemma – Moving Away from Fossil Fuels

- **Climate Action (Sustainability)**
  - Inadequate global action to avoid 1.5°C warming during 21st century
  - Achieving NDCs under the Paris Agreement
    - Success of JETP & ETM

- **Energy Equity (Affordability)**
  - Cost competitiveness of renewable energy
  - Stranded asset risks - coal-fired power generation
  - Improved energy efficiency

- **Energy security (Uninterrupted supply)**
  - Diversification of resources
  - Infrastructure – Battery storage & transmission
  - Diplomacy
  - Preparedness for energy supply disruptions



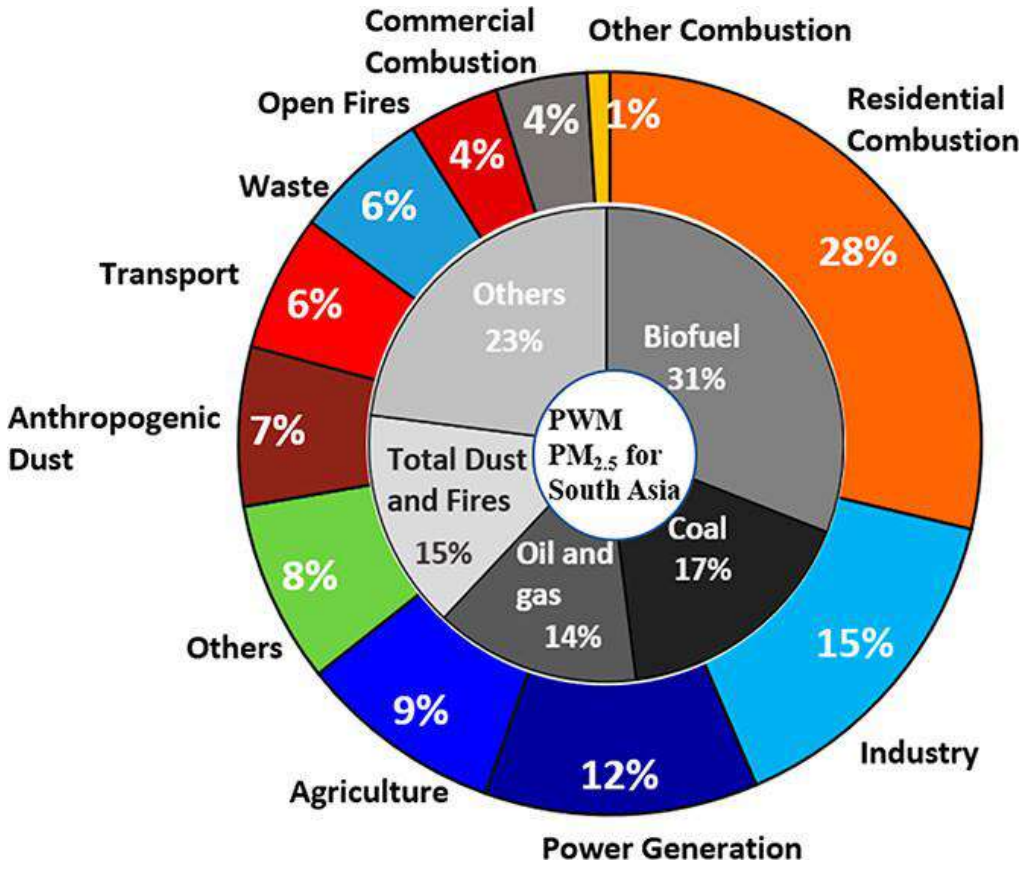


# Fine particles and the global burden of disease

- Exposure to ambient air pollution increases morbidity and mortality, and is a leading contributor to global disease burden
- Ambient $PM_{2·5}$ was the fifth-ranking mortality risk factor in 2015
- Exposure to $PM_{2·5}$ caused 4·2 million deaths and 103·1 million disability-adjusted life-years (DALYs) in 2015, representing 7·6% of total global deaths (Cohen et al, *Lancet* 2017)
- In India, 1·67 million deaths were attributable to air pollution in India in 2019, accounting for 17·8% of the total deaths. The majority of these deaths were from ambient particulate matter pollution (0·98 million) and household air pollution (0·61 million) (*Health and economic impact of air pollution in the states of India: the Global Burden of Disease Study 2019, Lancet Planetary Health)*

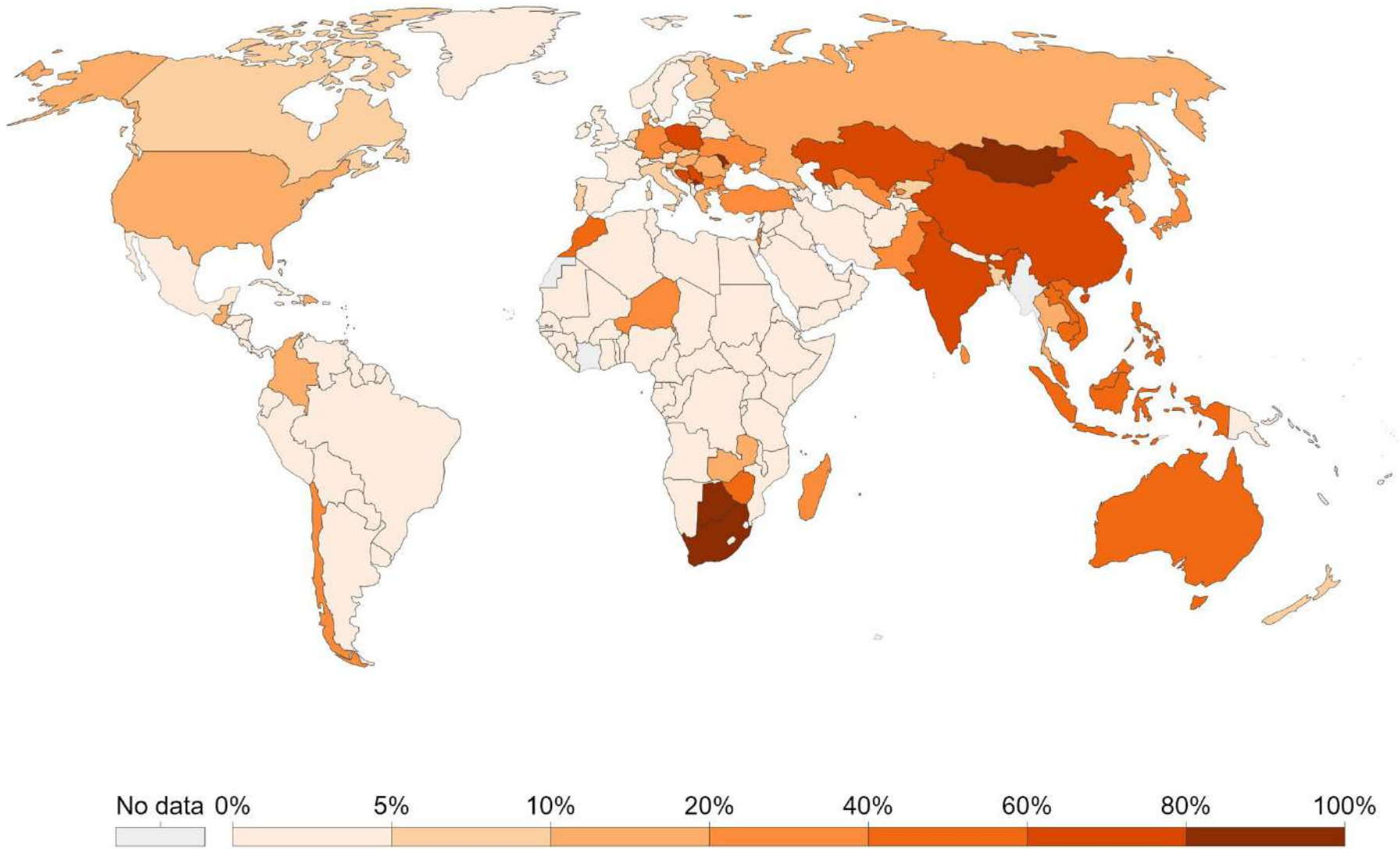
# **Source Contributions to Fine Particulate Matter and Attributable Mortality in India and the Surrounding Region** (Chatterjee *at al, Environmental Science & Technology,* 2023)

- **Key findings:**
  - 1.02 million deaths in South Asia attributable to ambient $PM_{2.5}$ in 2019 were primarily from three leading sectors: residential combustion (28%), industry (15%), and power generation (12%)
  - Solid biofuel is the leading combustible fuel contributing to the $PM_{2.5}$-attributable mortality (31%), followed by coal (17%), and oil and gas (14%)



# Share of electricity production from coal

Our World in Data




Source: Our World in Data based on BP Statistical Review of World Energy

OurWorldInData.org/energy • CC BY

# The Global Energy Monitor – Global Coal Plant Tracker Database

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

Global Energy Monitor

LANGUAGE | SUPPORT GEM

About | Projects | Download Data | News & Reports

Home › Projects › Global Coal Plant Tracker

## Global Coal Plant Tracker

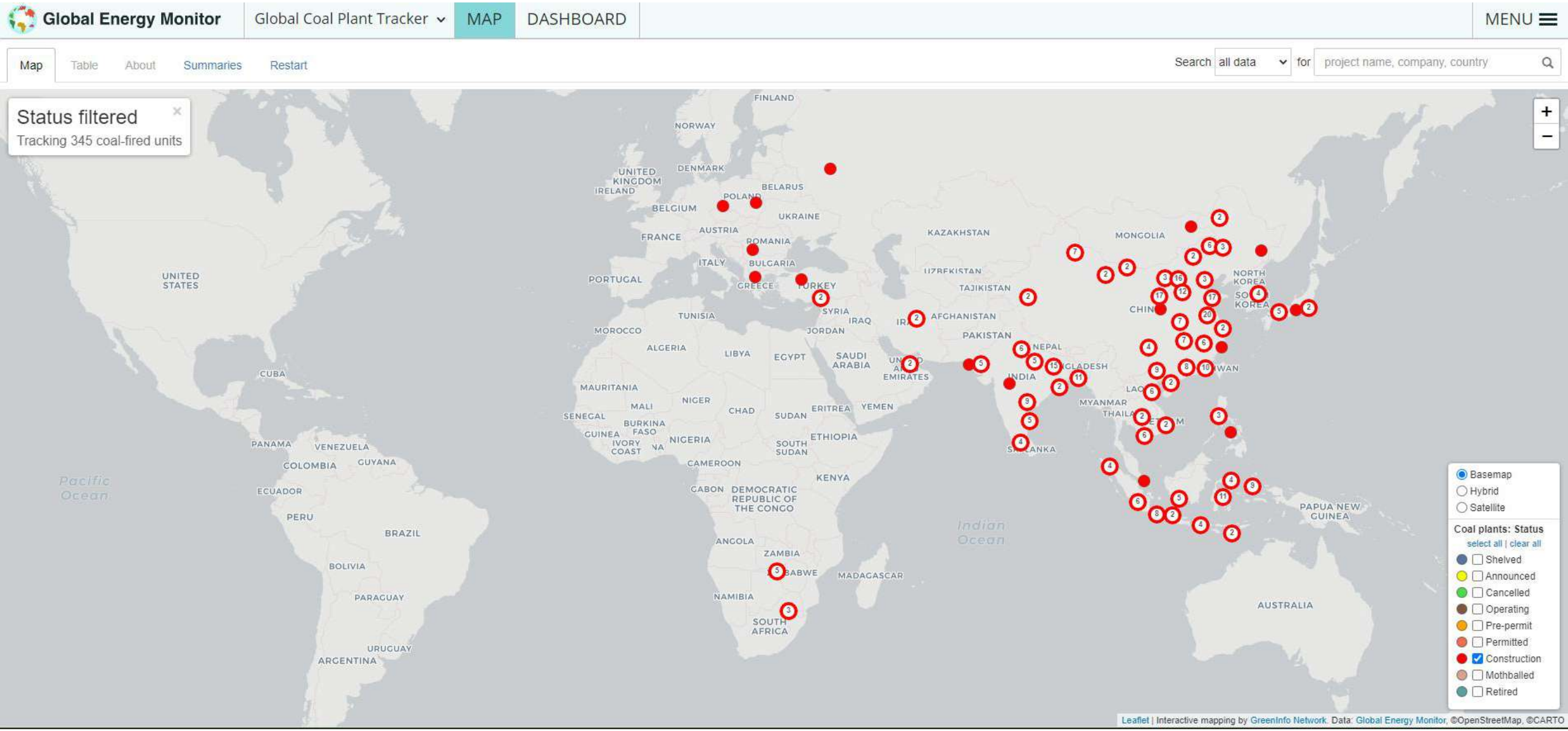
The Global Coal Plant Tracker (GCPT) provides information on coal-fired power units from around the world generating 30 megawatts and above. The GCPT catalogues every operating coal-fired generating unit, every new unit proposed since 2010, and every unit retired since 2000. Units often consist of a 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).

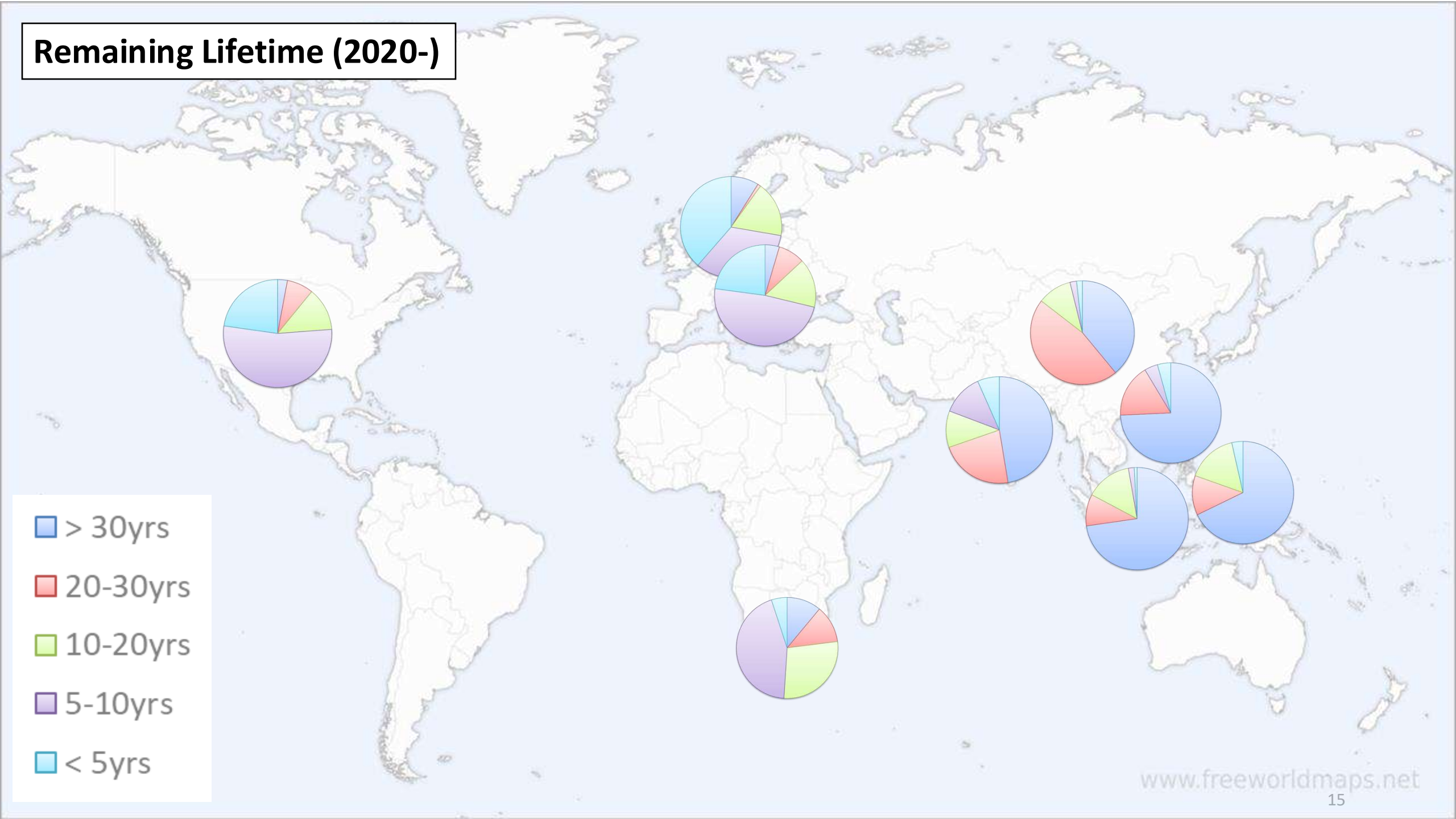
To receive notifications from this project, please sign up for our mailing list. If you have questions about this project, please contact the Project Manager, Christine Shearer.

‹ PROJECTS

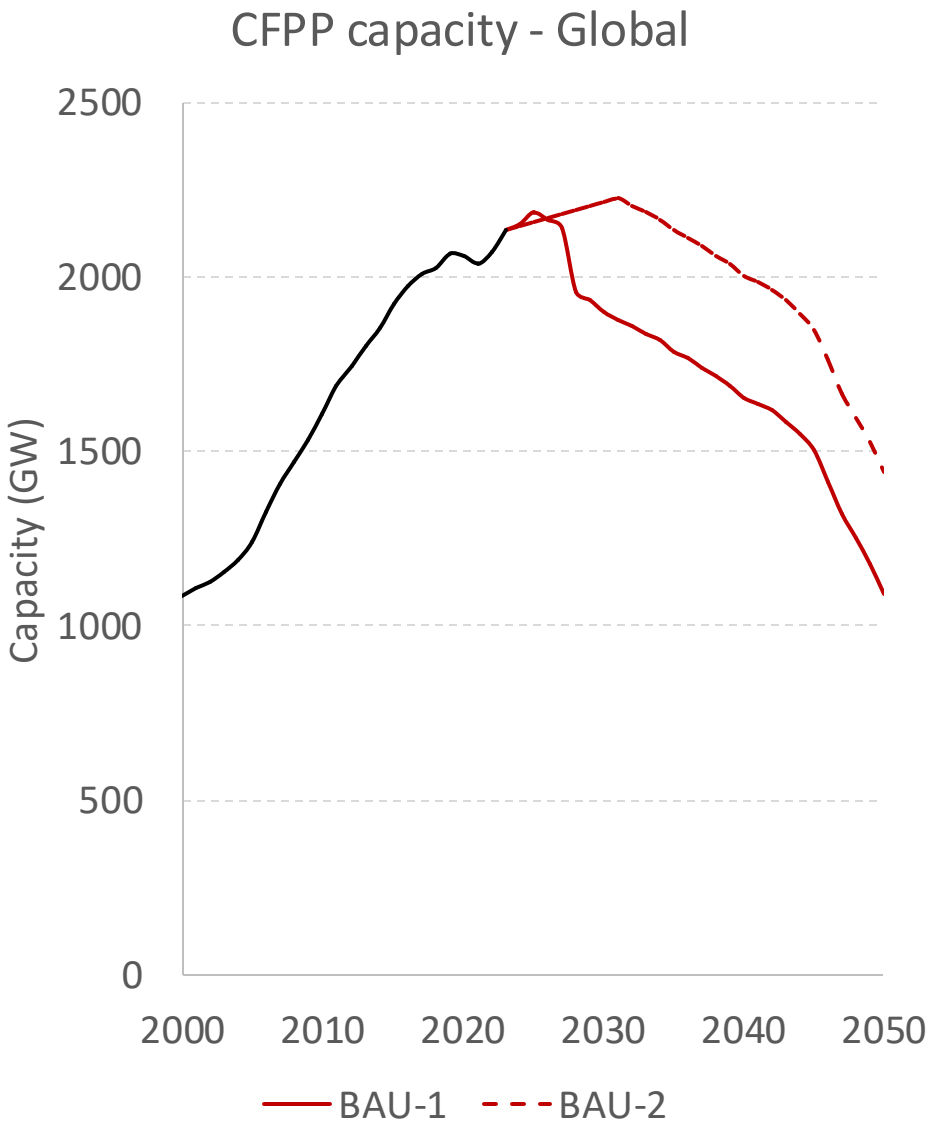
- **Global Coal Plant Tracker**
- Launch Tracker Map
- Summary Tables
- Launch Dashboard
- Download Data
- Reports & Briefings
- Tracker in the News
- Wiki Pages
- Global Coal Phaseout
- Methodology
- Frequently Asked Questions
- Subscribe

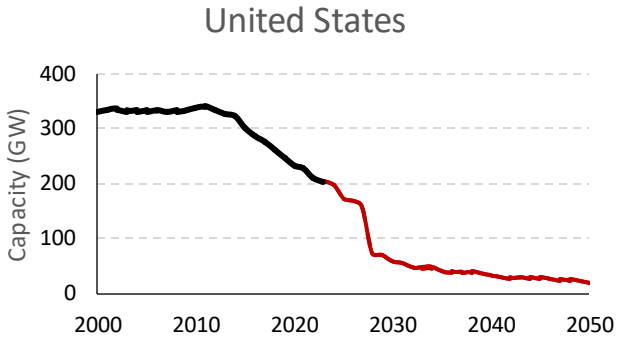

Global Energy Monitor
Global Coal Plant Tracker
MAP
DASHBOARD
MENU
Map
Table
About
Summaries
Restart
Search all data for project name, company, country
Status filtered
Tracking 345 coal-fired units
Basemap
Hybrid
Satellite
Coal plants: Status
select all | clear all
Shelved
Announced
Cancelled
Operating
Pre-permit
Permitted
Construction
Mothballed
Retired
Leaflet | Interactive mapping by GreenInfo Network. Data: Global Energy Monitor, ©OpenStreetMap, ©CARTO

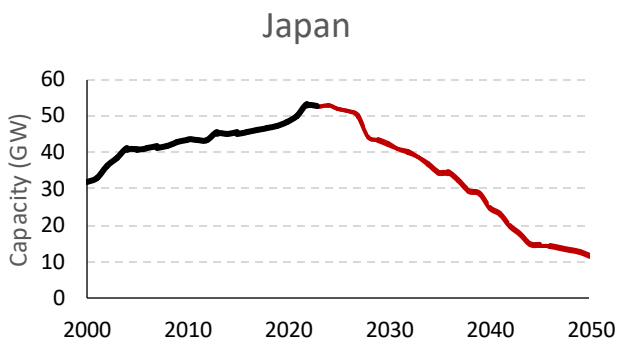
# Remaining Lifetime (2020-)

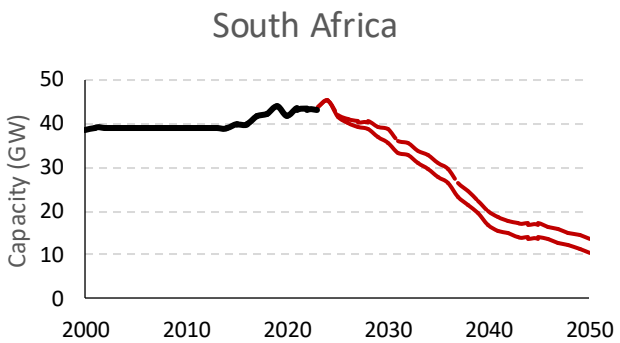


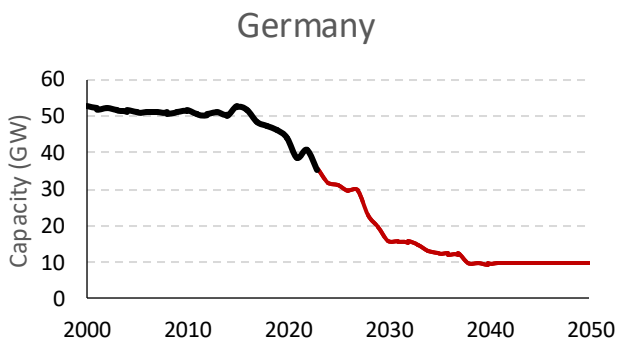
# Coal-Fired Power Plants (CFPP) - Capacity

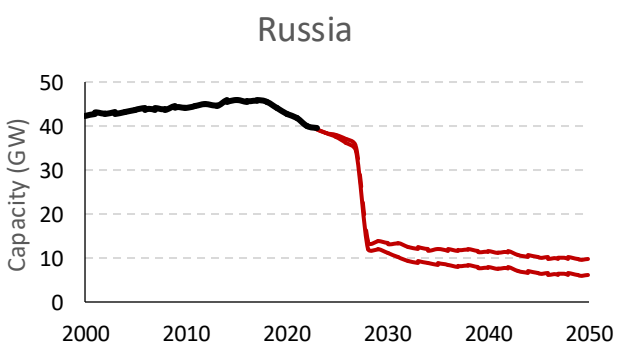


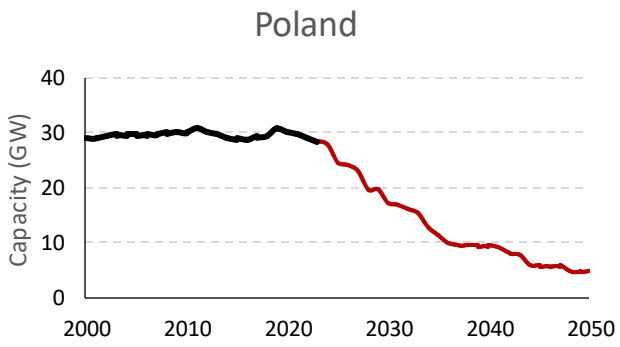



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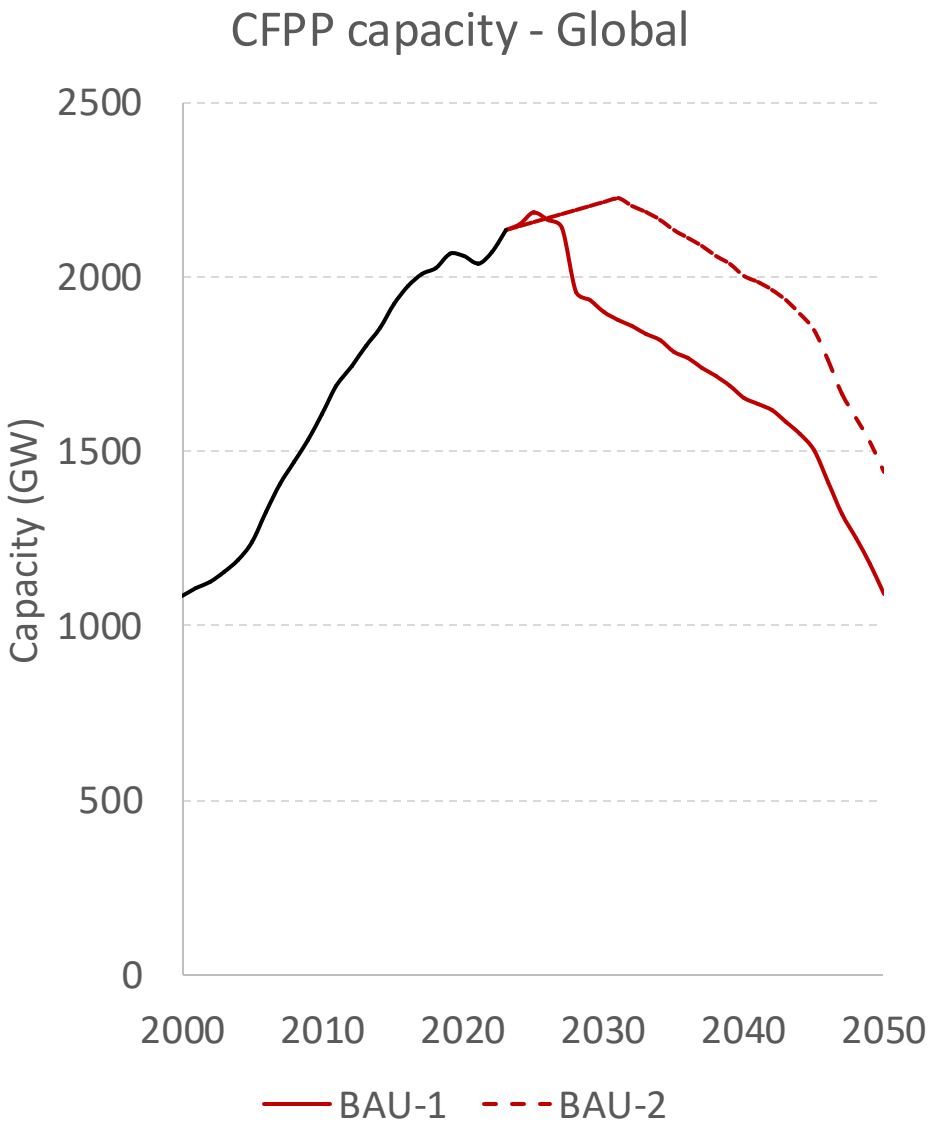
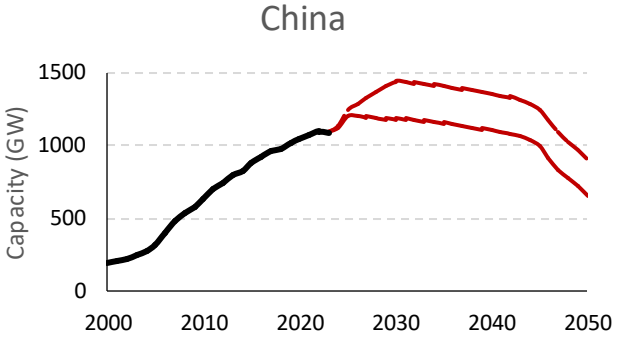
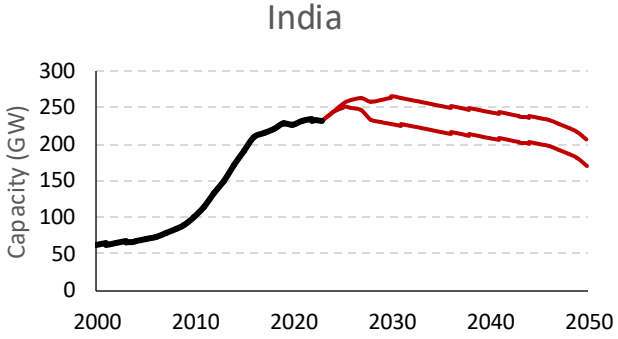
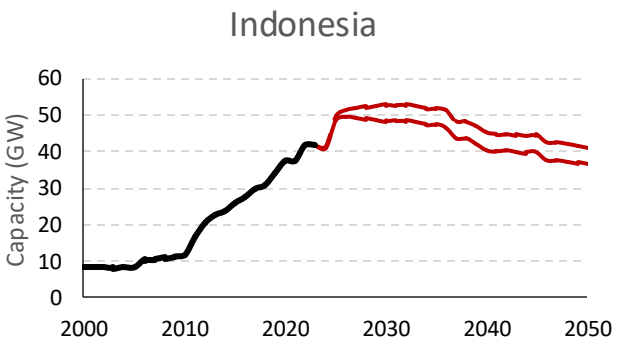
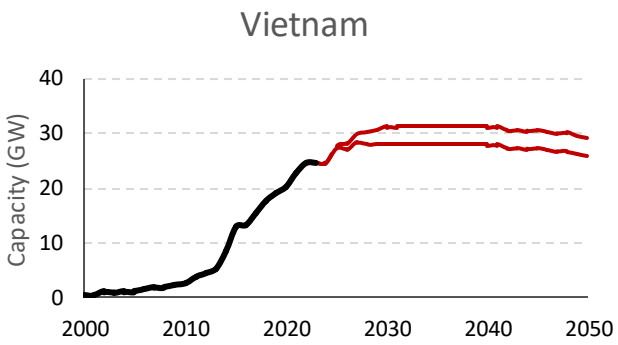
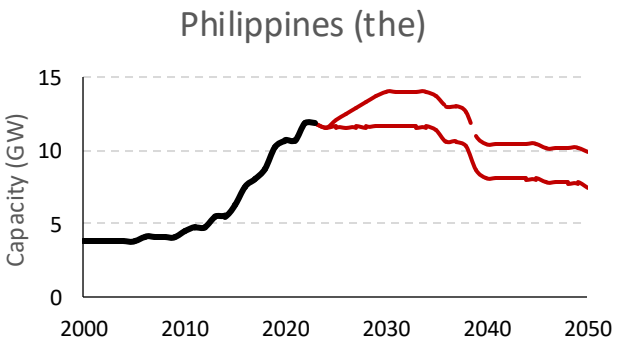


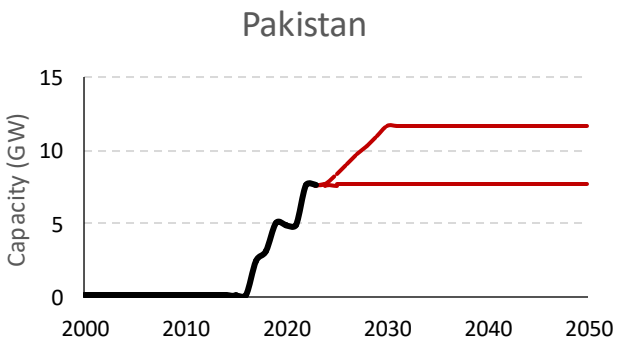



# Focus Countries

*China, India, Pakistan, Bangladesh, Indonesia, Vietnam, Malaysia, Thailand, Philippines, South Africa*

***2030***

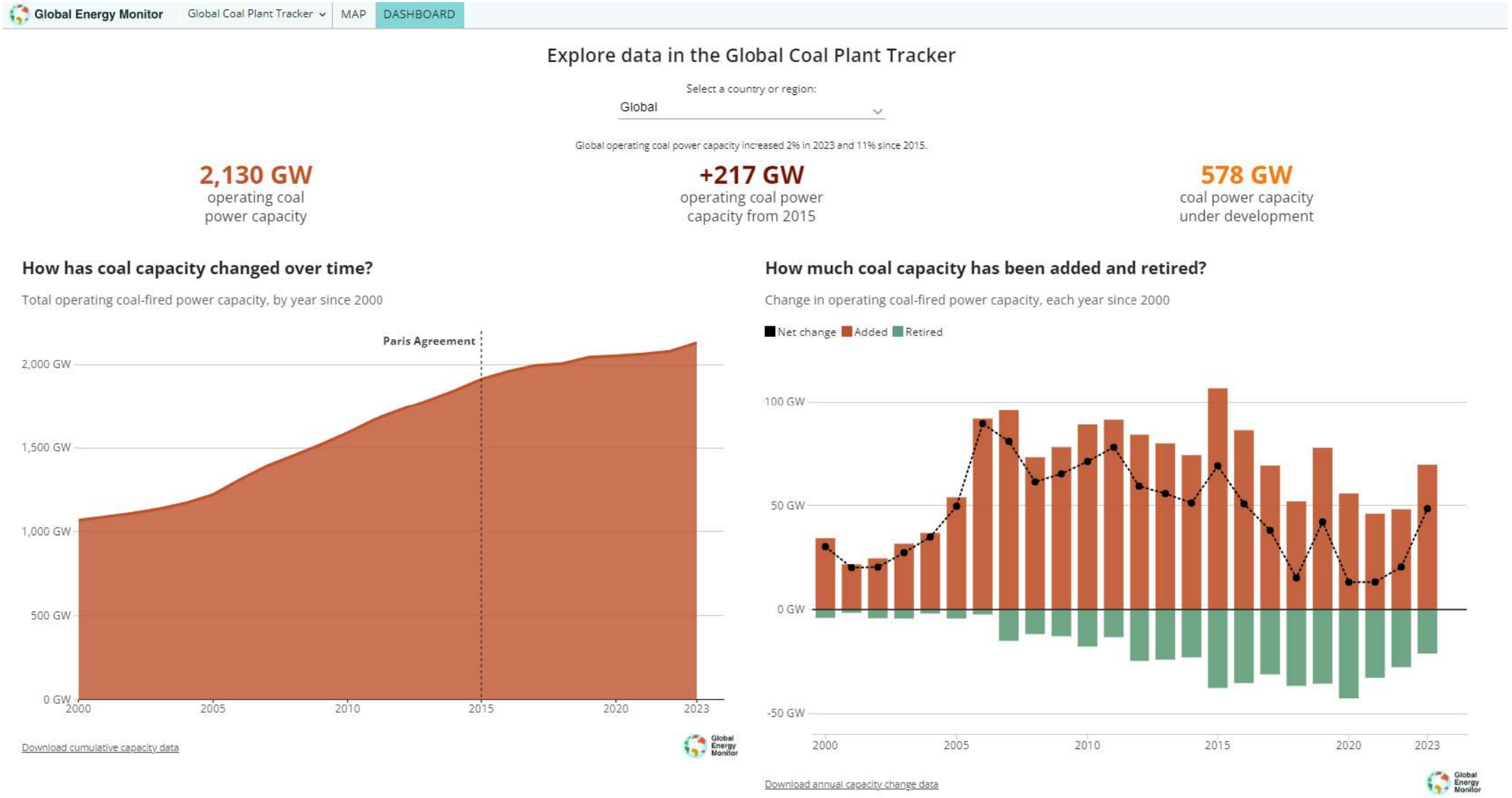
- 87% coverage (CFPP capacity)
- 86% coverage ($CO_2$ emissions - CFPPs)

***2050***

- 90% coverage (CFPP capacity)
- 89% coverage ($CO_2$ emissions - CFPPs)

# The Global Energy Monitor – Global Coal Plant Tracker Database

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



# Quantifying the regional stranded asset risks from new coal plants under 1.5°C

Edwards et al. (2022), *Environ. Res. Lett*. 17, 024029

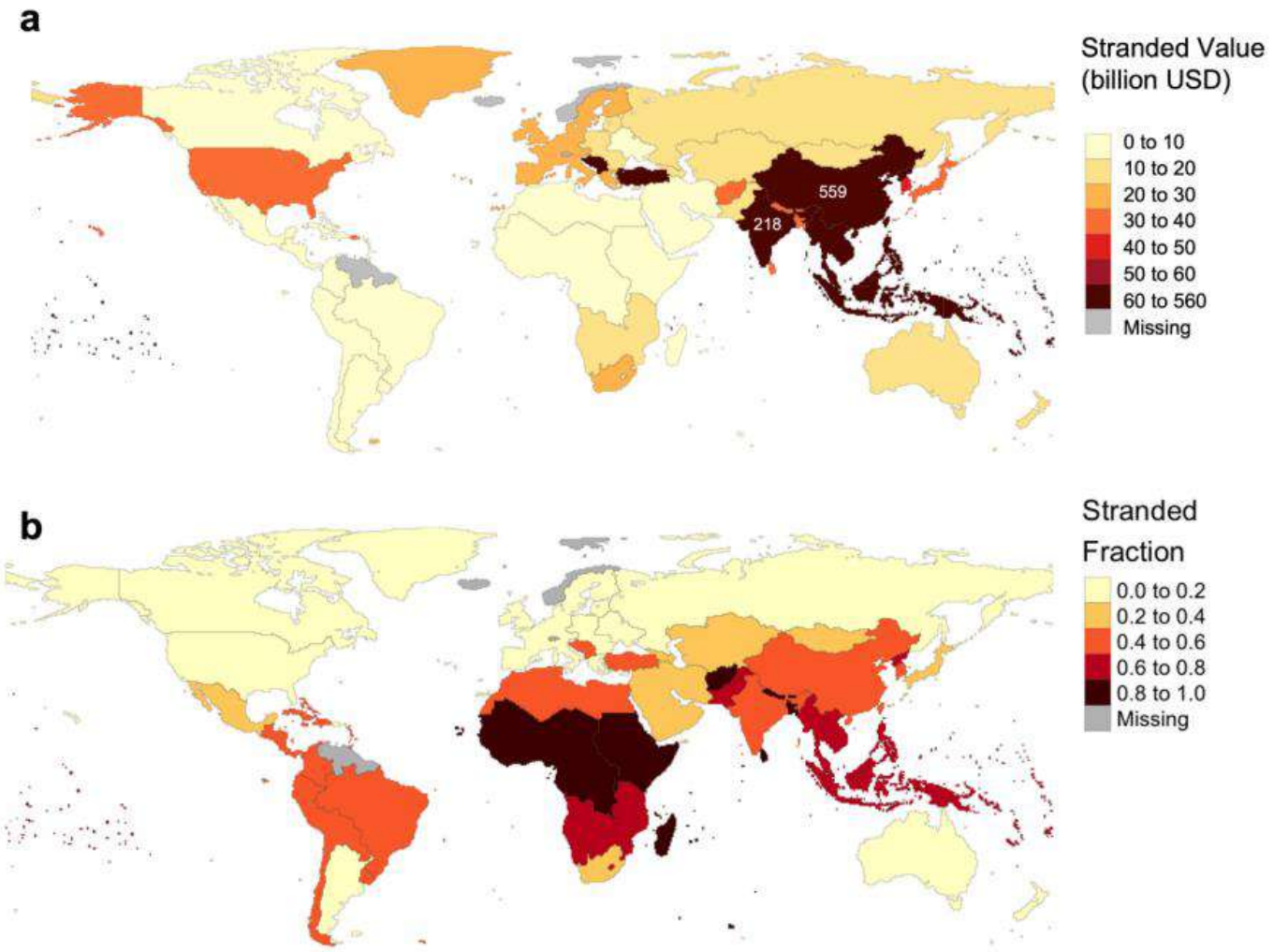
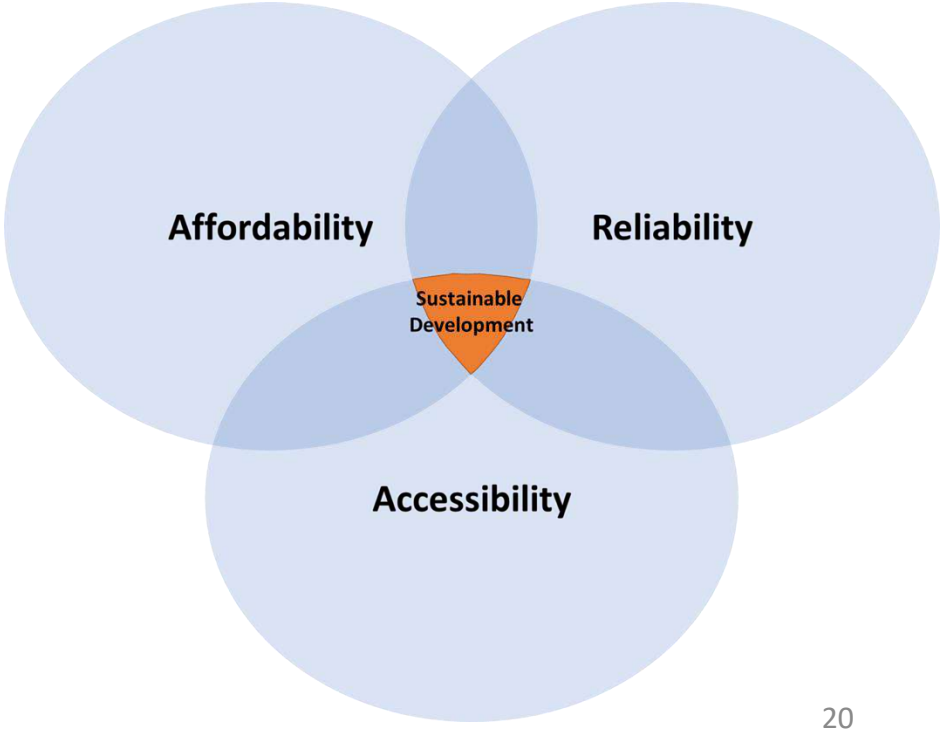



**Figure 5.** Coal plant stranded assets by region under a 1.5 °C policy if all plants currently in the pipeline are built: (a) absolute level of stranded assets and (b) fraction of assets stranded. Immediate action on no new coal reduces asset stranding, with the largest relative differences seen in parts of Asia, Africa, and Latin America (see supplementary figures S1–S2, S1–S3 and S1–S4 for a comparison of immediate and delayed action for 2 °C).

"If all proposed plants as of January 2021 are built, stranded assets can be significant even if plant lifetimes are limited to 20 years."



# Session 3

Emission methodologies, assumptions, scenarios

Dashboard demonstration (presented by Caroline Wood, UNEP)

# Future scenarios

## IEA WORLD ENERGY OUTLOOK 2021

| ***Scenarios*** | ***Reduction in unabated coal use (2030)*** |
| --- | --- |
| • Stated Policies | 5% |
| • Announced Pledges | 10% |
| • Sustainable Development | |
| • Net Zero Emissions 2050 | 55% |
| • Delayed recovery (Covid-19) | |

ENVIRONMENTAL Science & Technology
ARTICLE
pubs.acs.org/est

Global Source–Receptor Relationships for Mercury Deposition Under Present-Day and 2050 Emissions Scenarios

Elizabeth S. Corbitt,*[†] Daniel J. Jacob,[†,‡] Christopher D. Holmes,[§] David G. Streets,[∥] and Elsie M. Sunderland[†,⊥]

**Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES)**

(A1B) Worst-case scenario: Heavy use of coal with limited emission control technology

(B1) Best-case scenario: Aggressive transition away from fossil fuel energy sources and implementation (up to 70% mercury capture in developed countries)

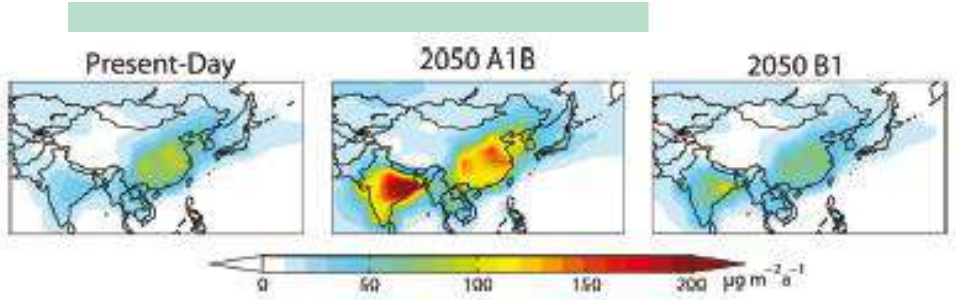



Figure 5. Annual mean net mercury deposition fluxes to Asia for the present-day and end-member IPCC 2050 scenarios.

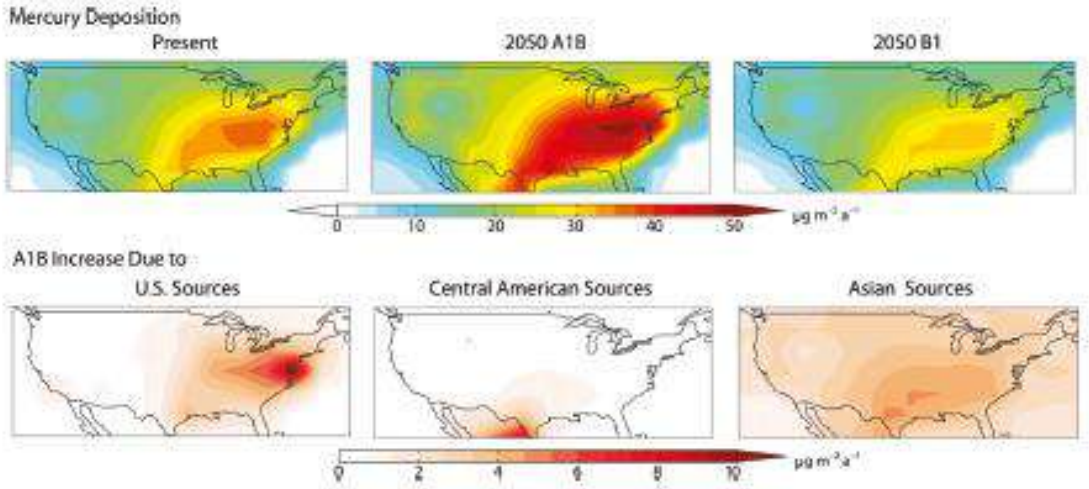
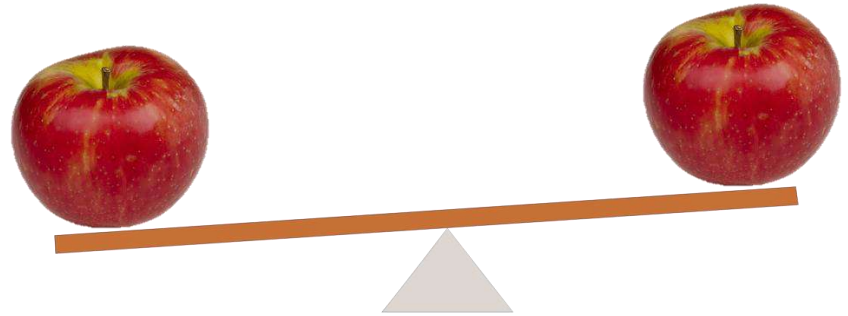



Figure 6. (Top panels) Annual mean net mercury deposition flux to the United States for present-day and 2050 A1B and B1 scenarios. (Bottom panels) Changes in the source contributions from anthropogenic emissions in the United States, Central America, and Asia in the A1B 2050 scenario relative to present day.

# Challenge: Finding a universal source of information

## LARGE RANGE OF UNCERTAINTIES & ASSUMPTIONS

- **Unit-specific data**
  - Coal consumption rate
  - Mercury content in feed coal
  - Air pollution control technologies (new plants)



- **Limited real measurements for some countries**
  - Compare with estimations
  - Limited countries with national inventories (e.g., NPI & MIA)

- **Large variation in metrics between locations/plants**
  - Coal consumption rate
  - “Capture” capability of technologies
  - Coal blending (i.e., different chemical content)
  - Plant maintenance, performance & age

# Project Overview

## METHODOLOGY

## Data sources:

- **Databases**
  - Global Energy Monitor – Global Coal Plant Tracker
  - BP Statistical Review of World Energy
  - IEA-coal & World Energy Outlook
  - EMBER - World Electricity and Energy Statistics

- Scientific **literature & reports**

- Government **statistical databases & reports**

# Project Overview

## SCENARIOS FOR FUTURE EMISSIONS PROJECTIONS

### Business-As-Usual (BAU)

- ***BAU-1*** – Existing plants and those under construction
- ***BAU-2*** – Existing plants & all new projects

### Early Retirement (AERS)

- Full modification possible on database
- E.g., >year< early retire by plant size/age

### Multi-Pollution Control (RETROFIT)

- Following UNEP Toolkit guidance

# Methodology – Mercury Emissions Estimate (UNEP toolkit)

Mercury emission (kg/year) = Coal consumption * IF * ((100-RF)/100)

Unit-specific information *or*
Default 3 300 ton / MW capacity

| 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 | https://link.springer.c |
| REMAINING WORLD | 0,15 | USGS |
| Australia | 0,08 | USGS |
| United States | 0,13 | https://pubs.usgs.gov |

**Mercury content in feed coal**

| | Hg retention rate (%) |
|---|---|
| FF | 50 |
| FF + FGD | 65 |
| FF + FGC | 50 |
| FF & ESP + FGC | 55 |
| ESP | 25 |
| ESP + FGD | 65 |
| ESP + FGD + SCR | 97 |
| ESP + FGC | 25 |
| ESP + LNB | 25 |

**Removal efficiency of installed technologies**

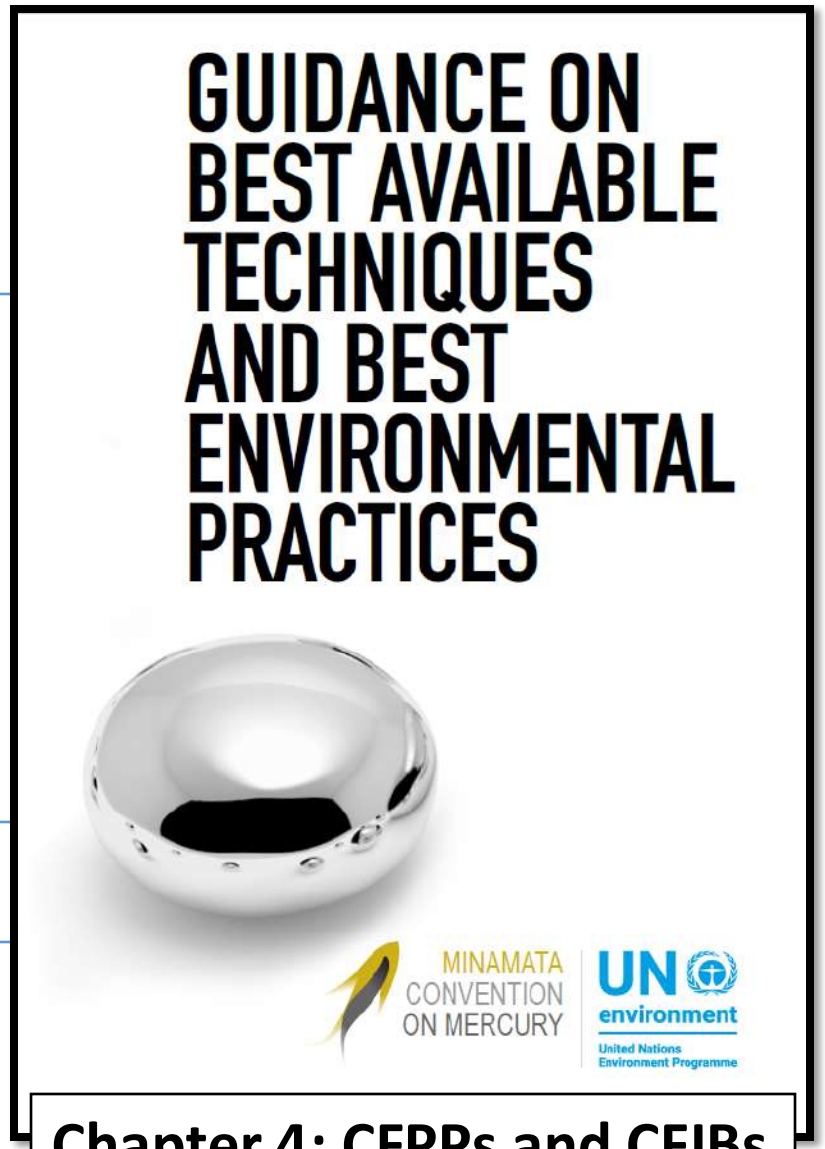
# Best Available Techniques (BAT)

## Primary

- **Fuel specification/monitoring**
  - Coal-washing / sorbent application
  - Co-combustion or blending
- **Combustion Conditions**

## Secondary

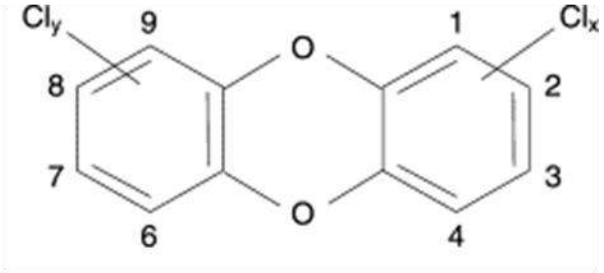
- **Multi-pollutant control technologies**
- **Dedicated mercury control**



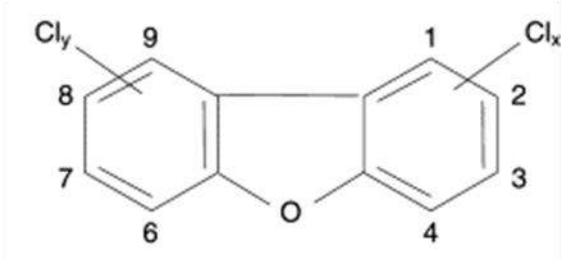

**Chapter 4: CFPPs and CFIBs**

# Persistent Organic Pollutants (POPs)

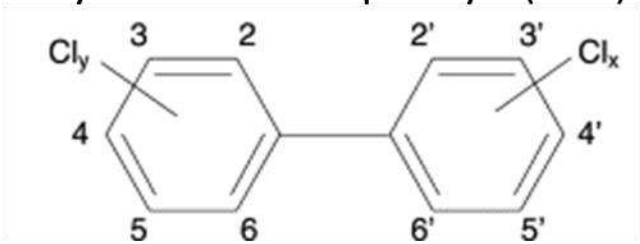
Polychlorinated dibenzo-p-dioxins (PCDD)



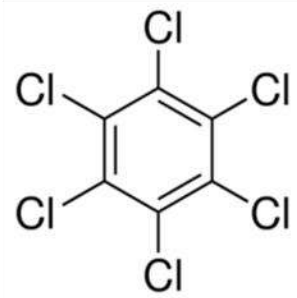

Polychlorinated dibenzofurans (PCDF)




Polychlorinated biphenyls (PCB)




Hexachlorobenzene (HCB)



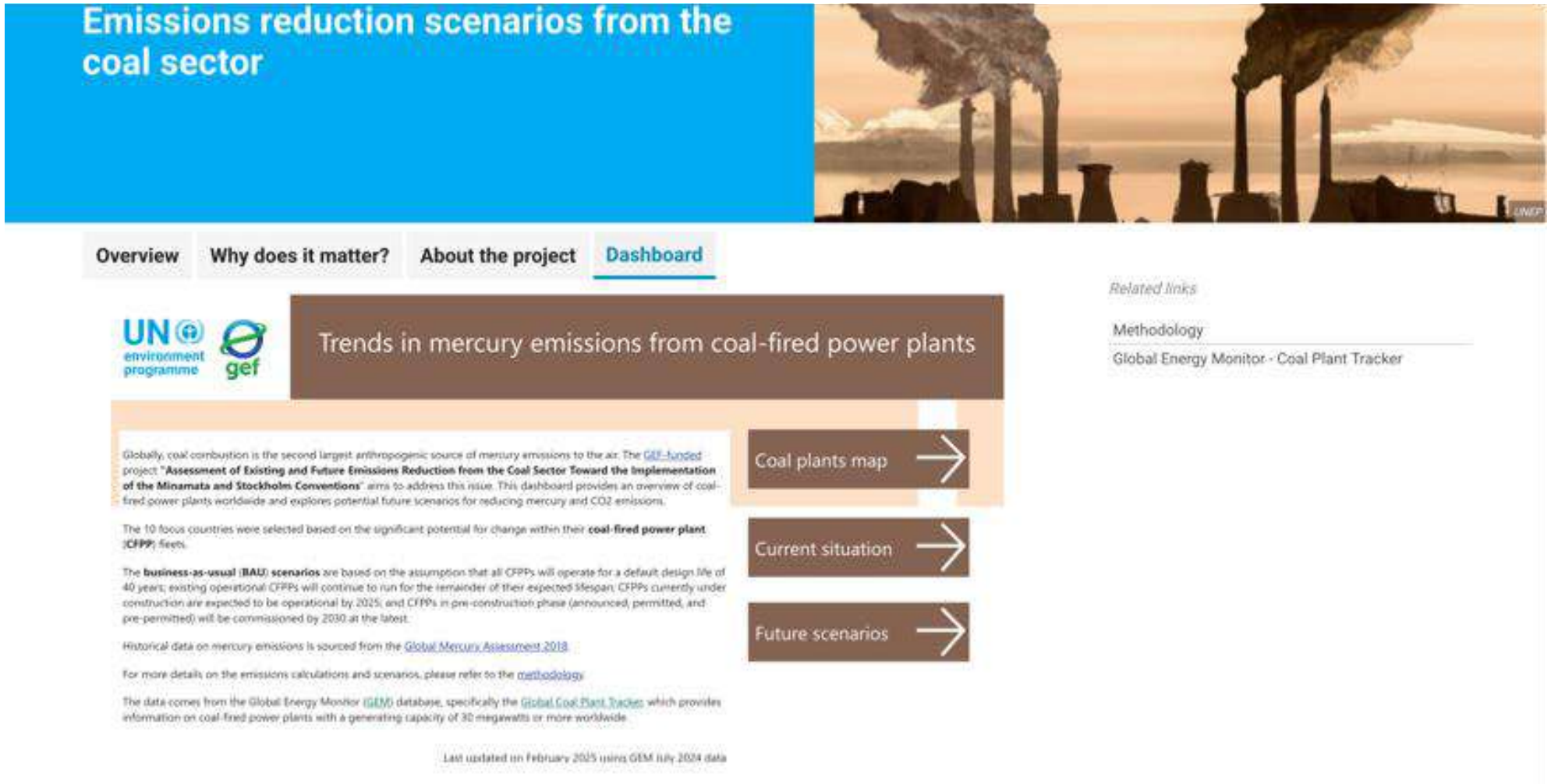

**ID main countries**

- Publications/reports on POP content in CFPPs
- Focus on locations with insufficient APCDs & combustion technologies
- Co-combustion with organic material

**Prove/disprove priority of POPs in CFB processes as health hazard**

- Referral to Stockholm Convention
  - Action Plan within 2yrs of the date of entry into force of the Convention
  - BAT/BEP guidance for new & existing sources
- UNEP toolkit (g-TEQ/TJ)
- Provide scientific evidence
- Forecasting under future CFB scenarios

**Ecological- & Human Health Risk Characterization with existing data**




https://www.unep.org/globalmercurypartnership/Emissions-reduction-scenarios-from-coal-sector

# Session 4

Project Results and Outcomes

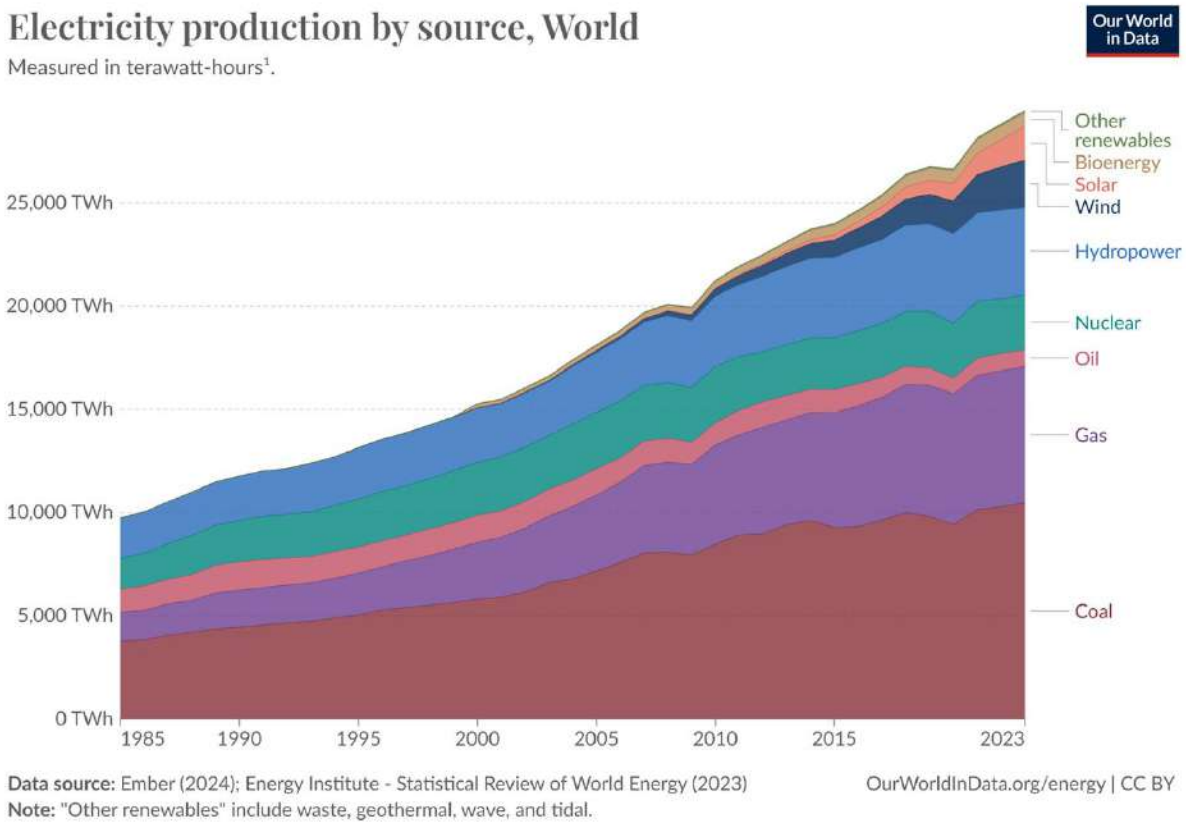
Trends: Coal use; power plant capacity

Global Emissions Trends

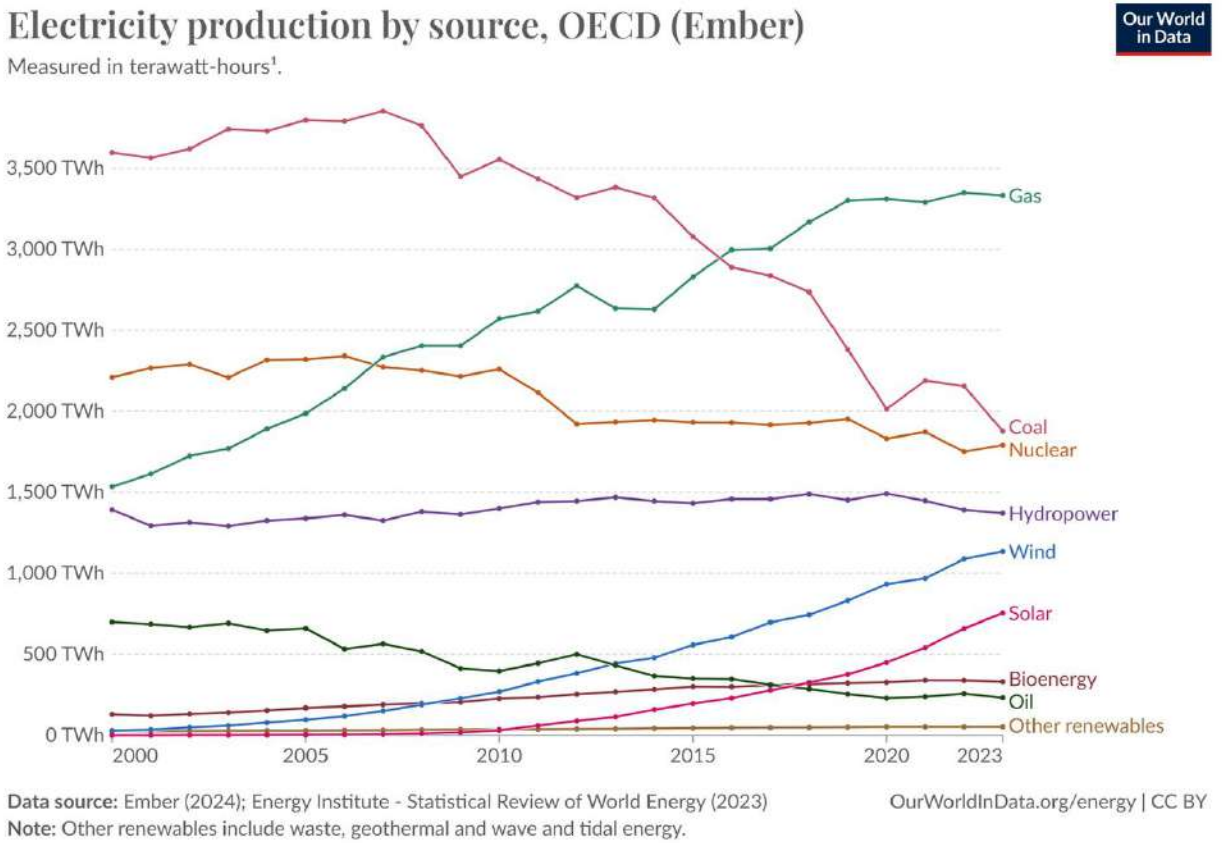
Gender responsive perspectives

Short Break

# A World with Rising Energy Demand and Climate Action Needs




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.

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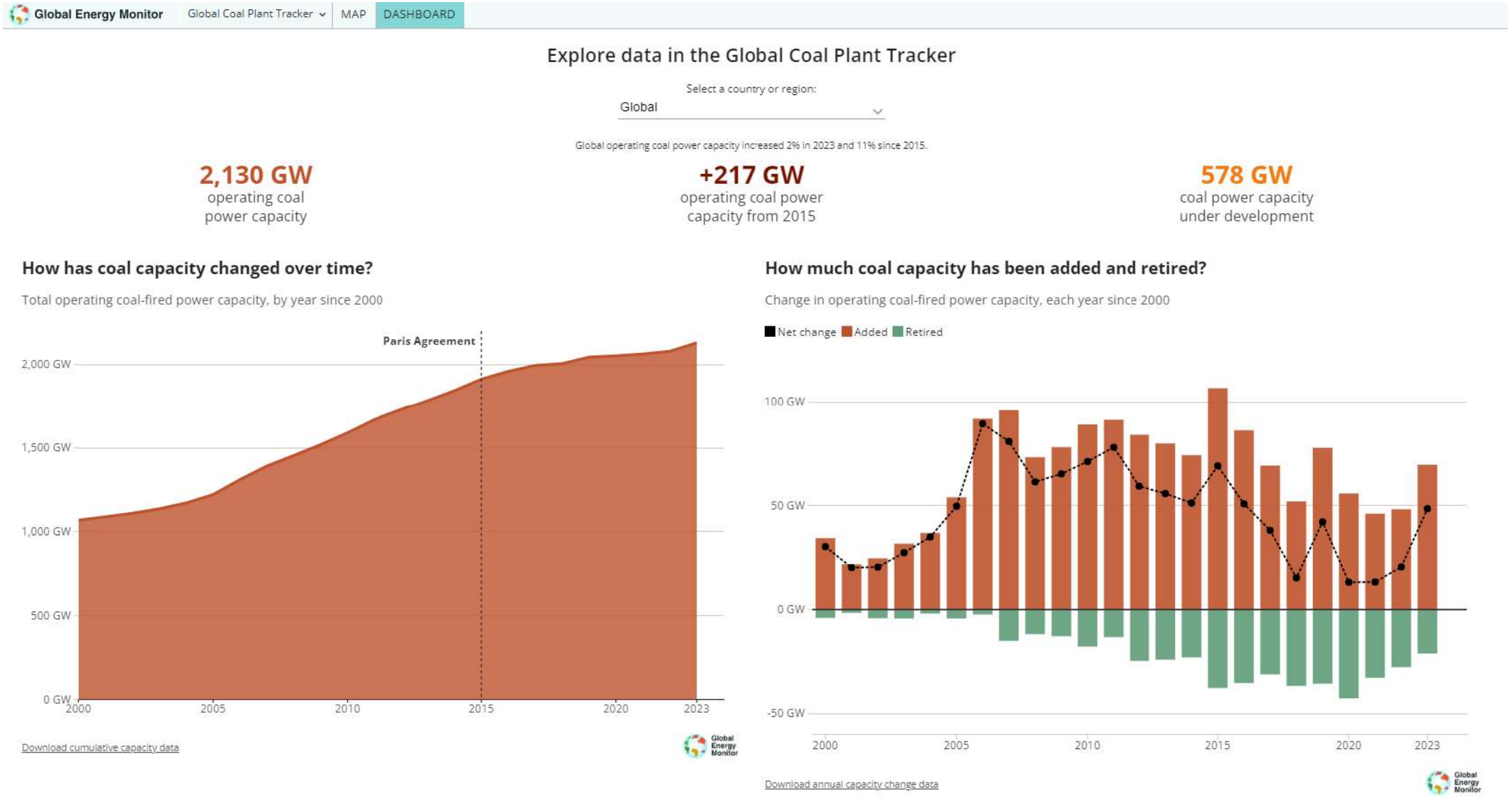
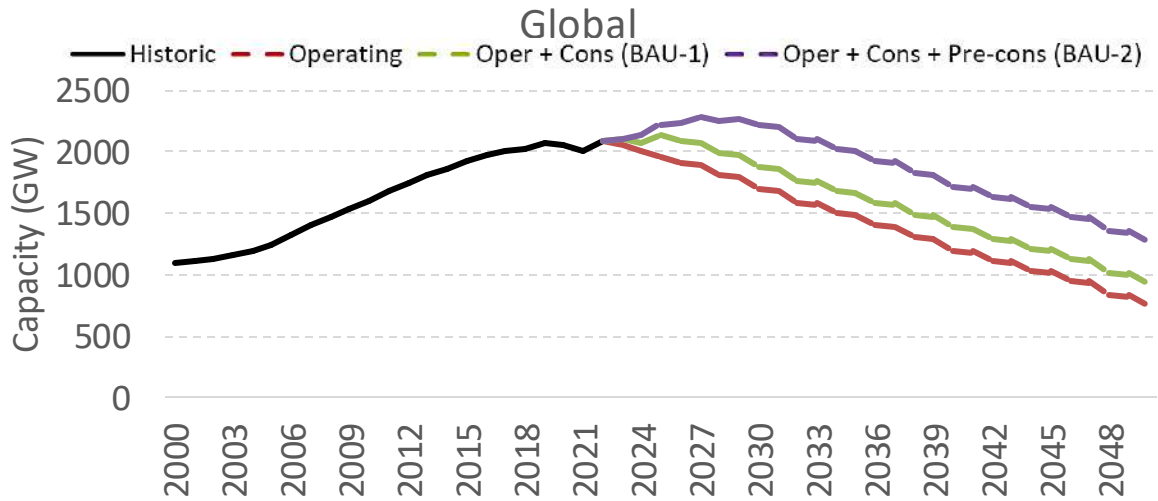
# The Global Energy Monitor – Global Coal Plant Tracker Database

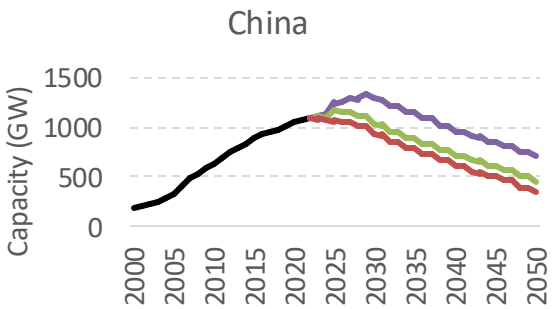
https://globalenergymonitor.org/projects/global-coal-plant-tracker/

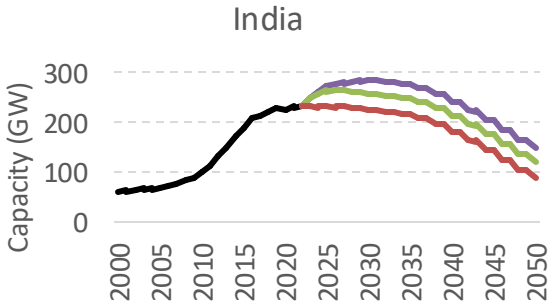


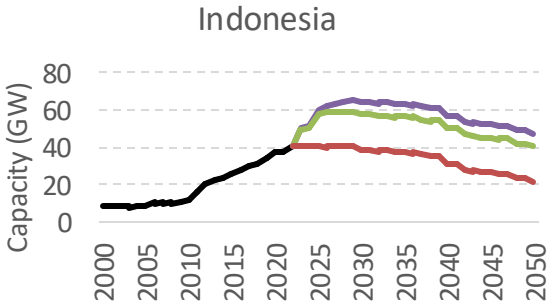
# Project Overview

## GLOBAL THERMAL COAL-FIRED POWER - CAPACITY



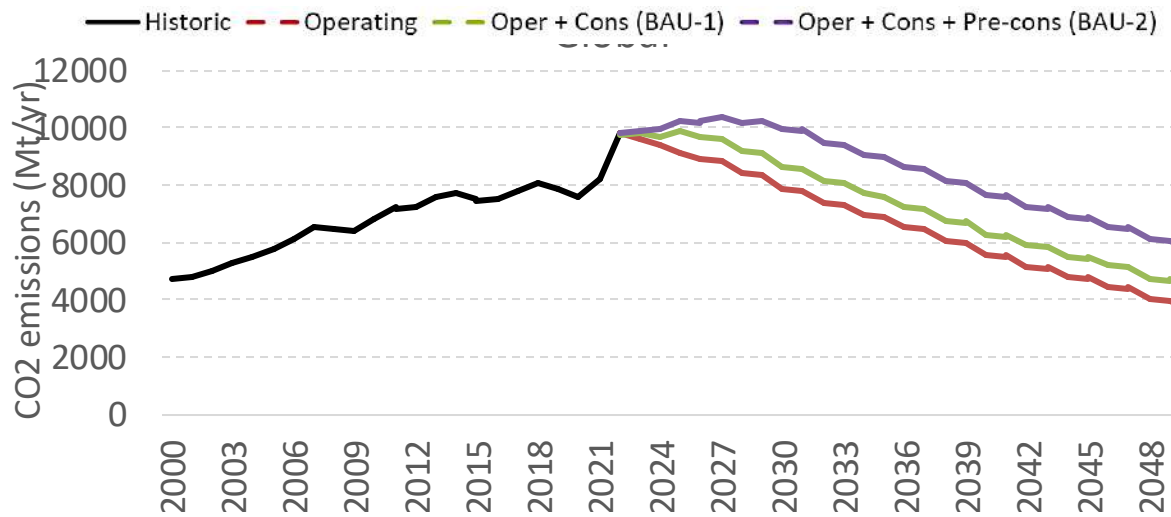



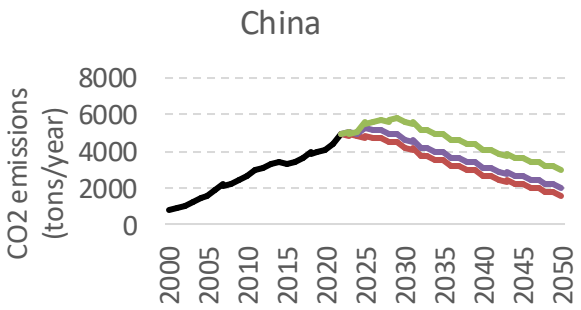



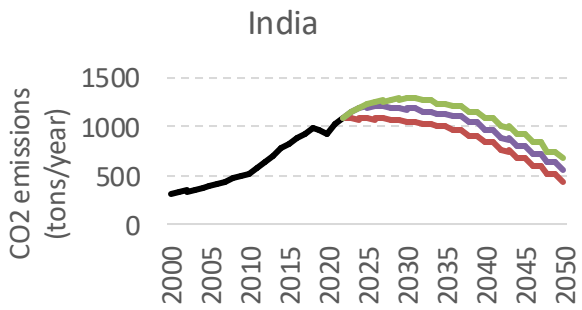



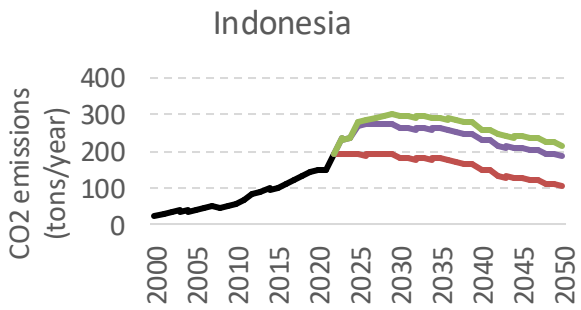
# Project Overview

## GLOBAL THERMAL COAL-FIRED POWER - CO2 EMISSIONS



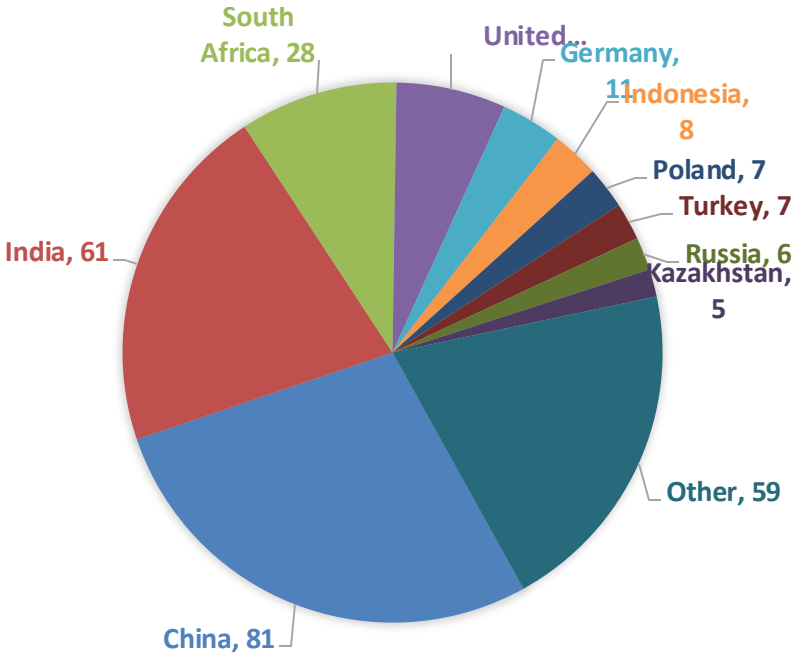



# Project Overview

## 2018 GLOBAL MERCURY ASSESSMENT

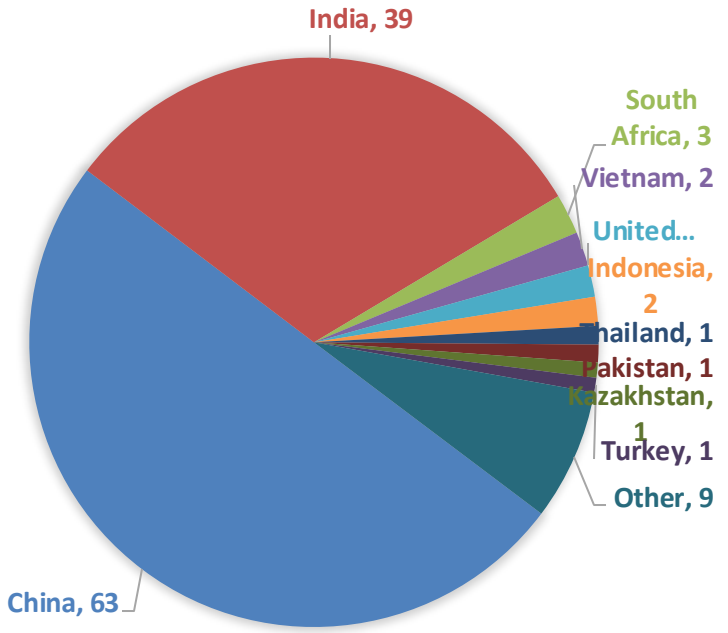
MACQUARIE University

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




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

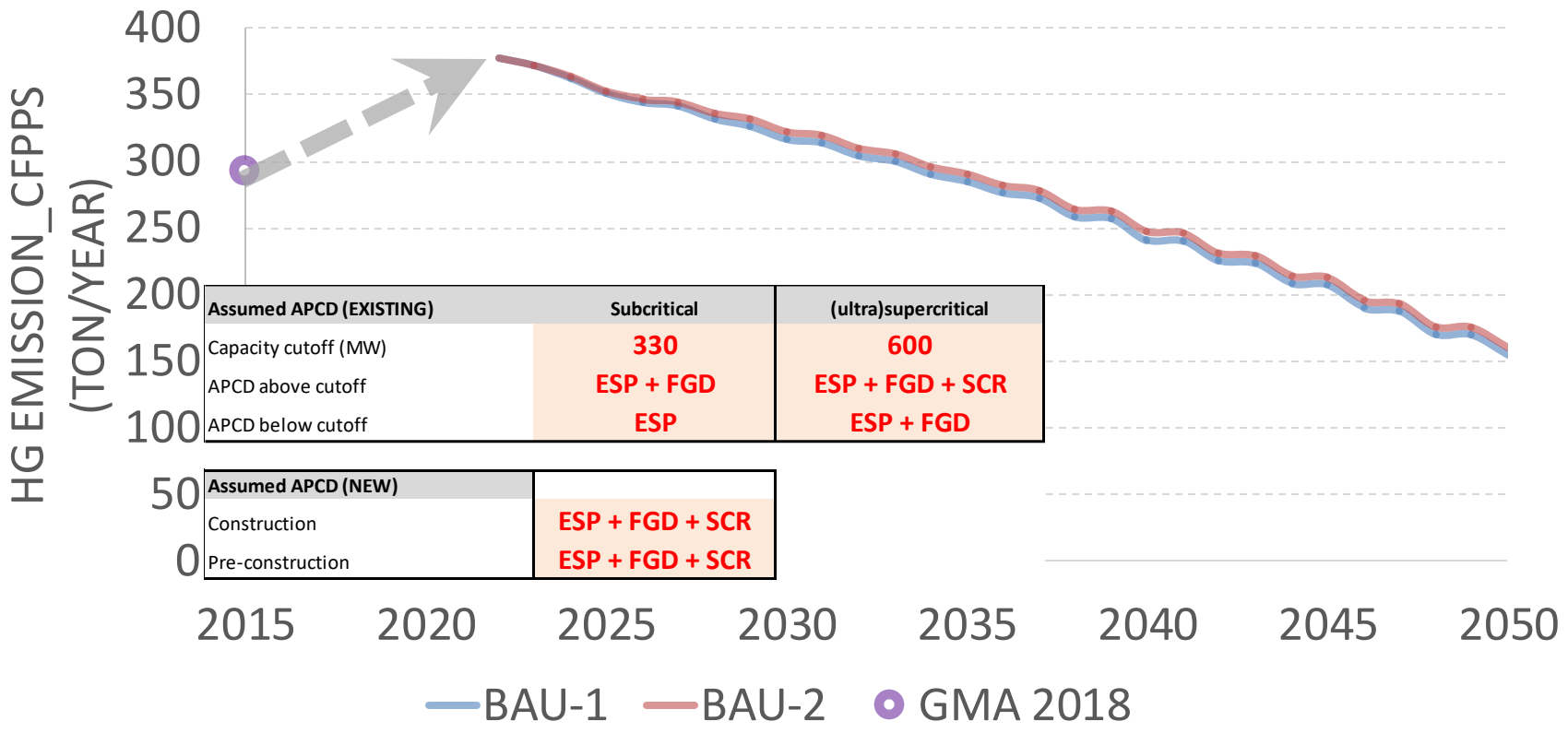
**Stationary Combustion of Coal at Industrial Boilers**
**126 tons/year**




China & India = 73% - 83% global coverage

# Project Overview

## GLOBAL THERMAL COAL-FIRED POWER EMISSIONS - MERCURY

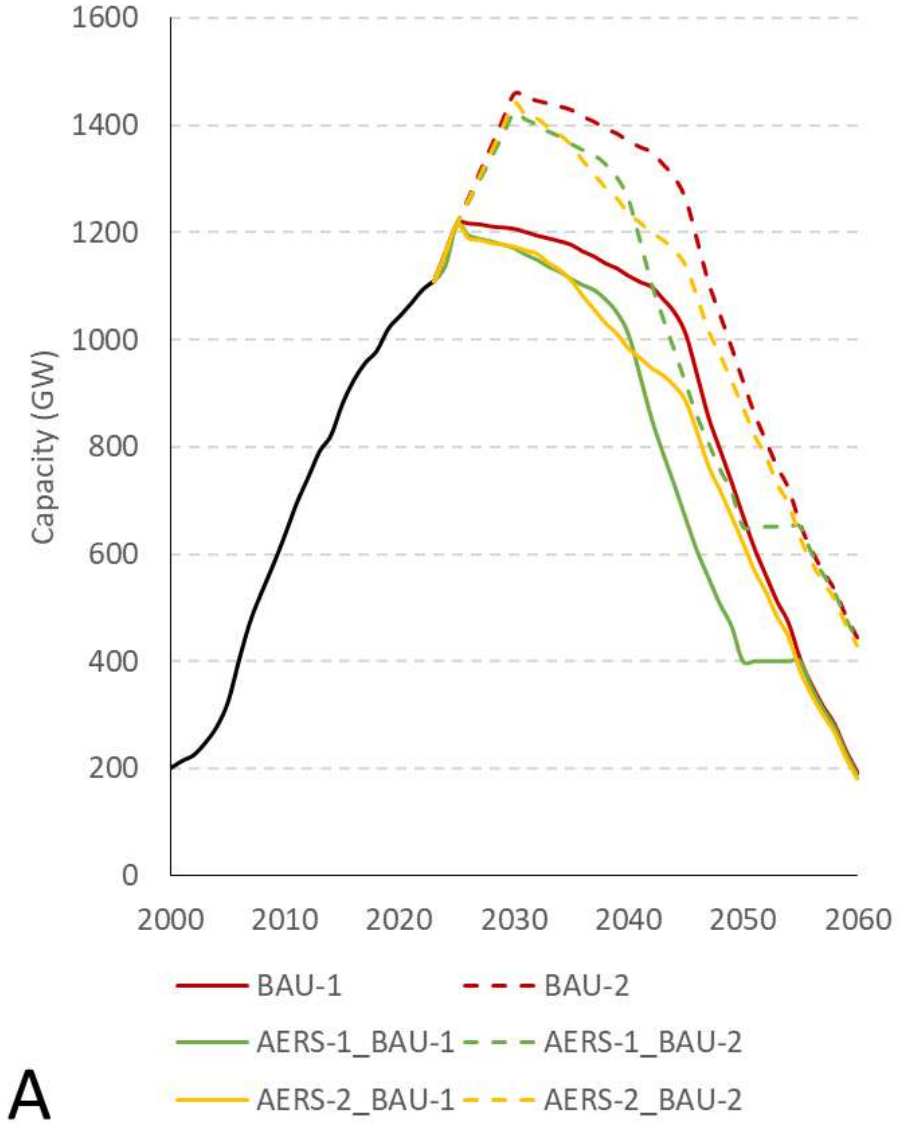


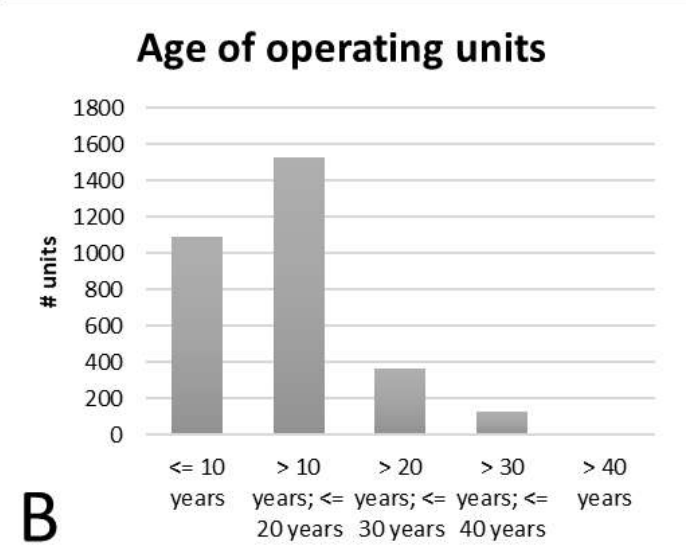

| Assumed APCD (EXISTING) | Subcritical | (ultra)supercritical |
|---|---|---|
| Capacity cutoff (MW) | 330 | 600 |
| APCD above cutoff | ESP + FGD | ESP + FGD + SCR |
| APCD below cutoff | ESP | ESP + FGD |

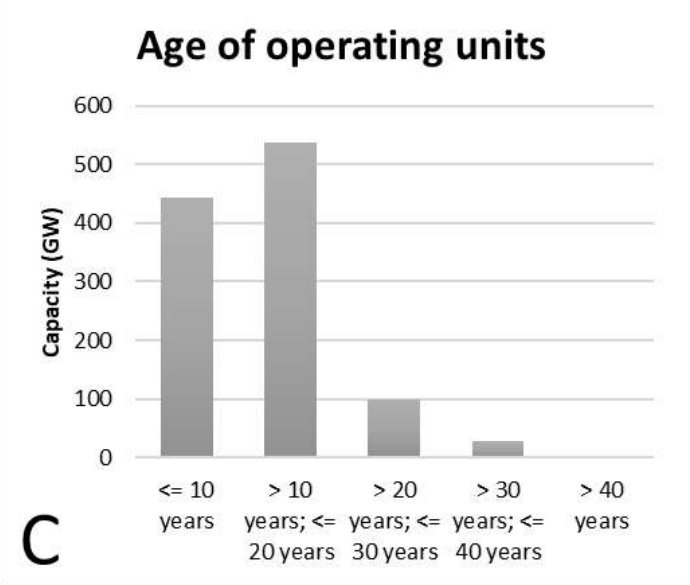
| Assumed APCD (NEW) | |
|---|---|
| Construction | ESP + FGD + SCR |
| Pre-construction | ESP + FGD + SCR |

# Focus Countries

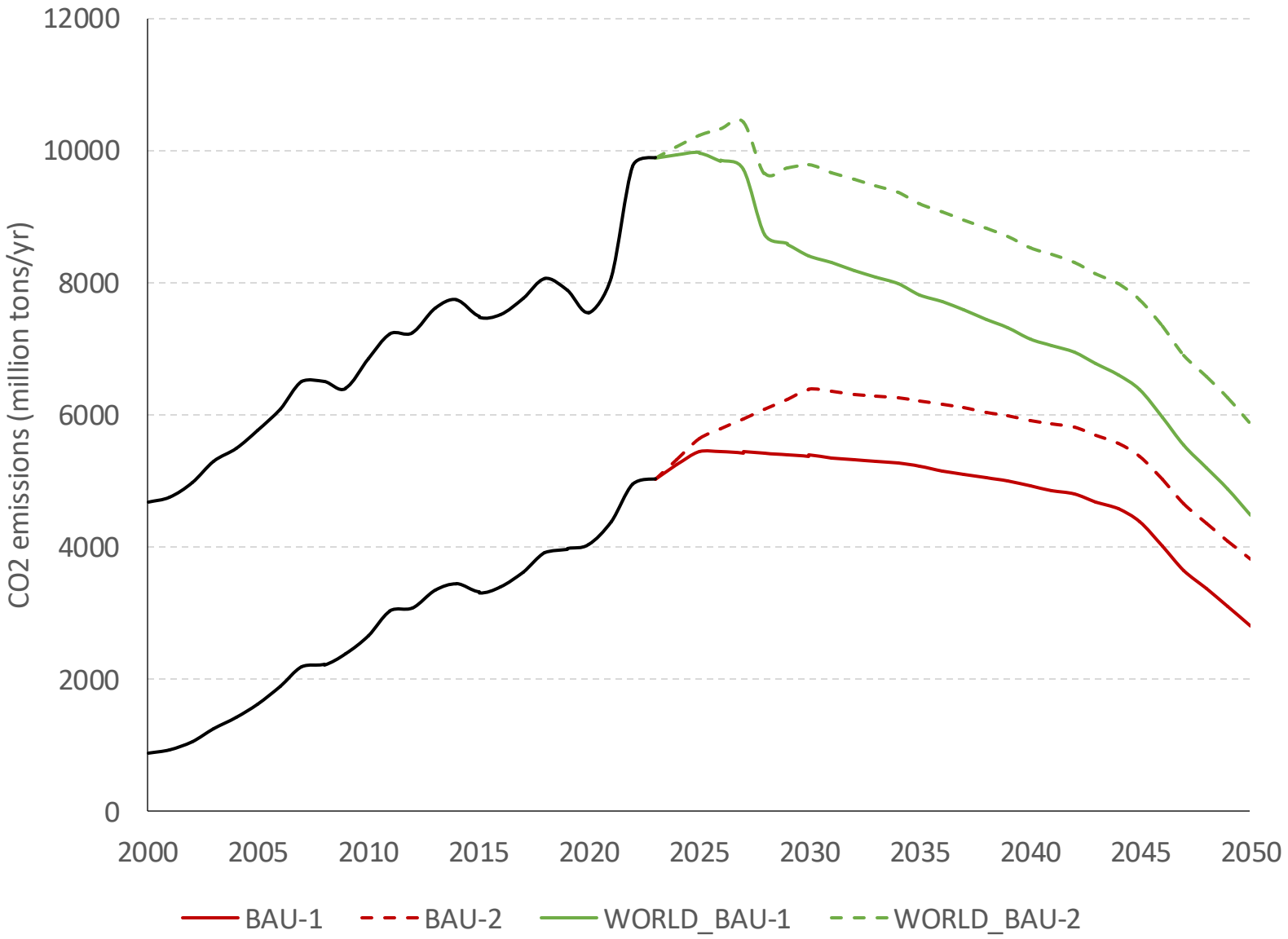
China




**The fate of coal-fired power plants in China up to 2060 under the business-as-usual (BAU) scenarios, and profiling of China's existing coal-fired power plant fleet according to the age and size of the operating units**




**Future $CO_2$ emissions estimate for China's CFPPs up to 2050 under the BAU scenarios, alongside the global projection for the same period and scenarios**

# Example 1: Coal consumption forecast - China

## (1) WEO2022 - Electricity generation from coal (TWh)

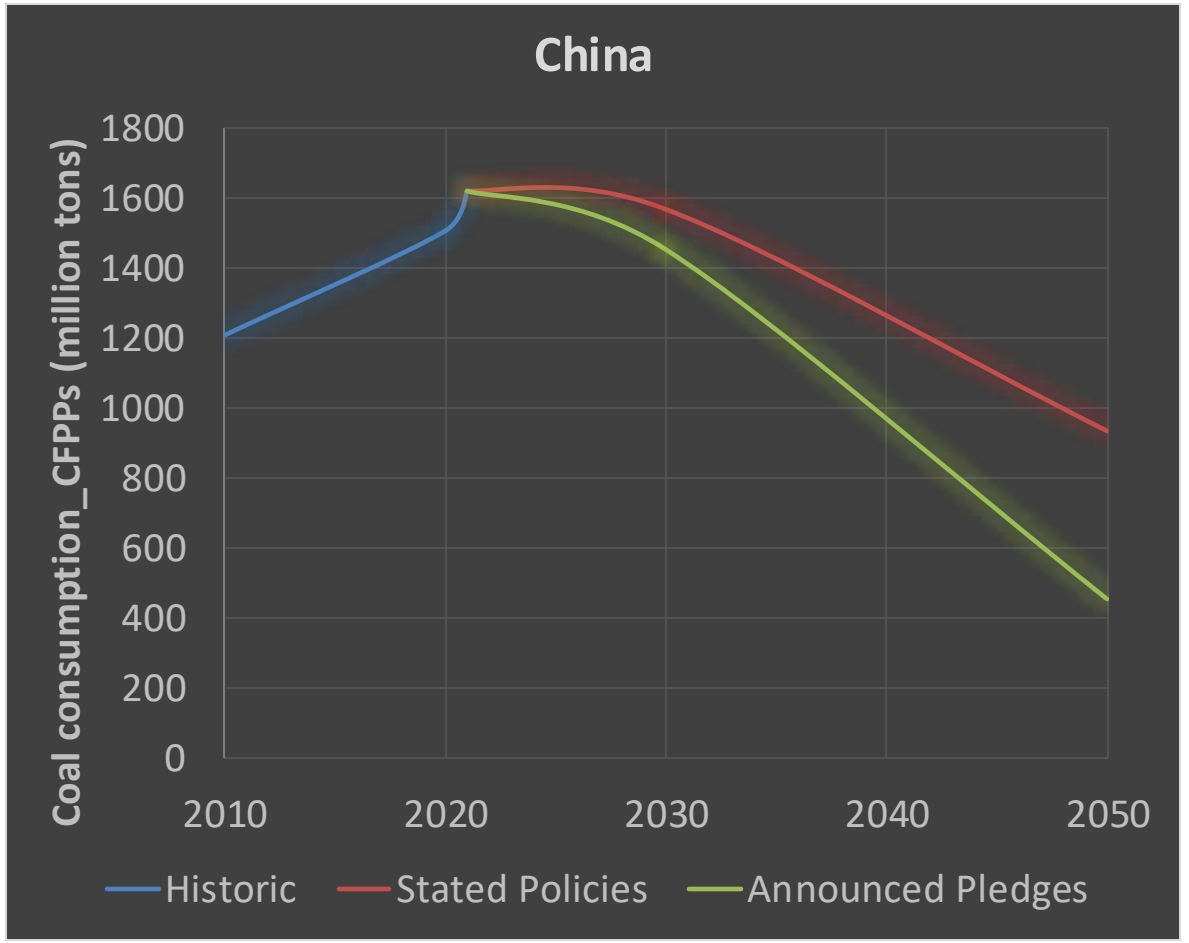
| | Historic | | | Scenarios | |
|---|---|---|---|---|---|
| | 2010 | 2020 | 2021 | 2030 | 2050 |
| China | 3263 | 4941 | 5363 | | |
| Stated Policies | | | 5363 | 5239 | 3118 |
| Announced Pledges | | | 5363 | 4855 | 1511 |

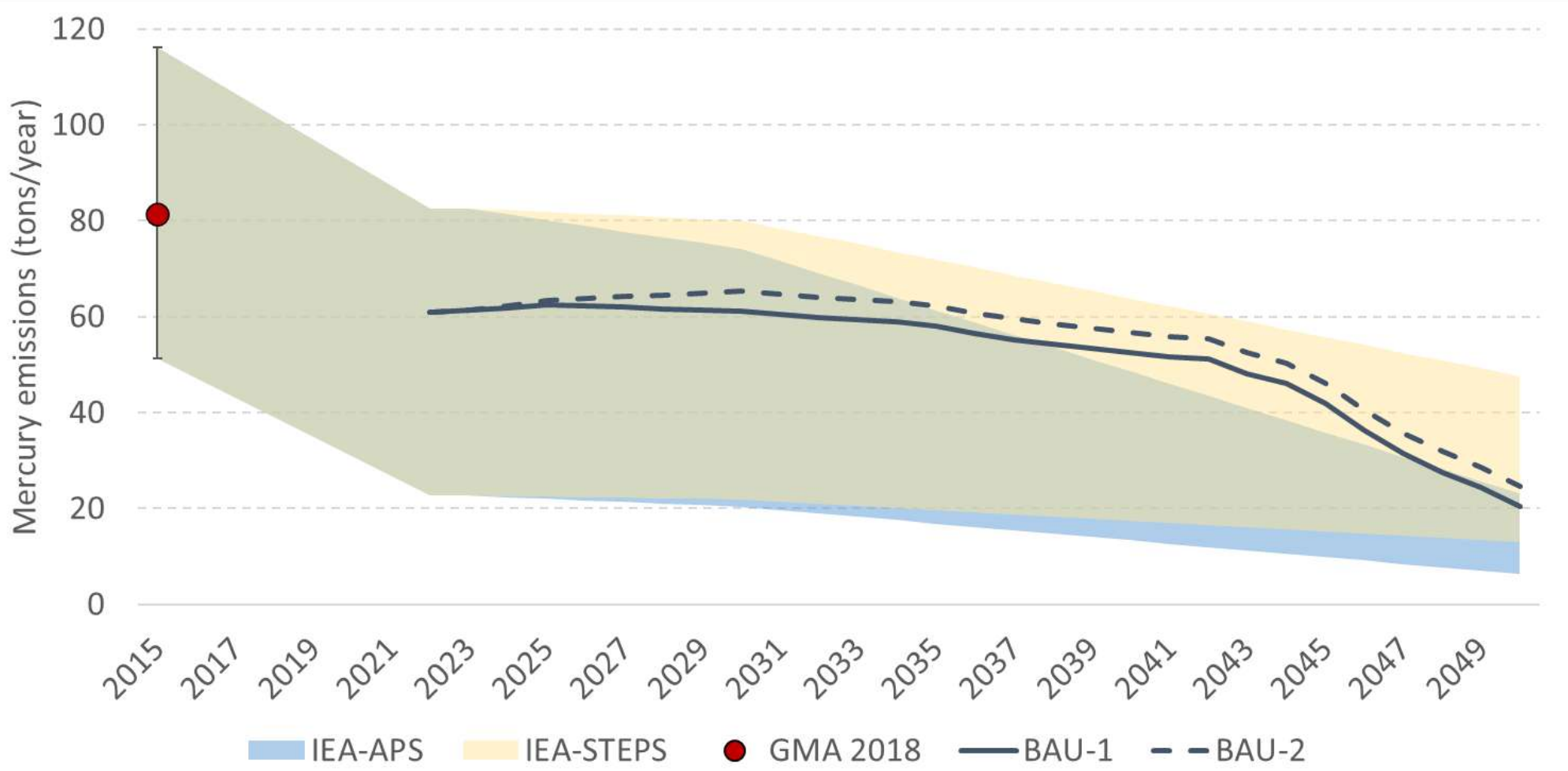
## (2) China Energy Portal - Coal consumption rate_CFPP (tons/TWh)

| | Historic | | | Scenarios | |
|---|---|---|---|---|---|
| | 2010 | 2020 | 2021 | 2030 | 2050 |
| China | 370000 | 304900 | 302500 | | |
| Stated Policies | | | | 300000 | 300000 |
| Announced Pledges | | | | 300000 | 300000 |

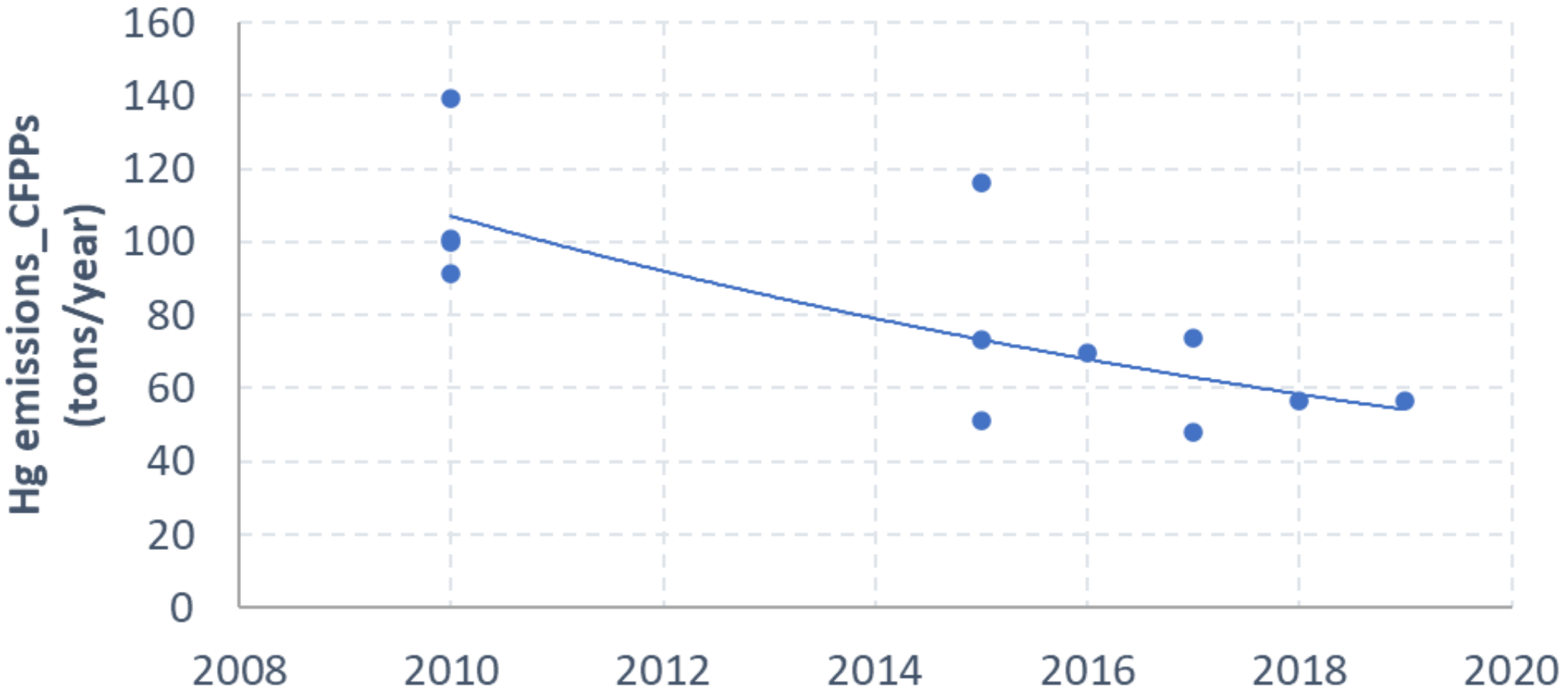
## Coal consumption (million tons) – (1)*(2)/10e6

| | Historic | | | Scenarios | |
|---|---|---|---|---|---|
| | 2010 | 2020 | 2021 | 2030 | 2050 |
| Historic | 1207.3 | 1506.5 | 1622.3 | | |
| Stated Policies | | | 1622.3 | 1571.7 | 935.4 |
| Announced Pledges | | | 1622.3 | 1456.5 | 453.4 |






Estimated mercury emissions from Chinese CFPPs, considering the unit-specific mercury emission calculations and remaining lifetime for existing CFPPs and those listed under construction (BAU-1; solid line), and including CFPP projects that are listed as either announced, permitted or in the pre-permitted phase (pre-construction; BAU-2; dashed line)




**Summary of historical reports of China's atmospheric mercury emissions (tons/year) from coal-fired power plants (CFPPs)**

Data is derived from the following sources: Wu et al., 2016; Zhang et al., 2015; Tian et al., 2015; Wu et al., 2020; Liu et al., 2018; AMAP, 2018; Habuer et al., 2022

# Uncertainties from the CFIB sector

Environmental Science & Technology

Article

Cite This: Environ. Sci. Technol. 2019, 53, 8938−8946

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**Measure-Specific Effectiveness of Air Pollution Control on China's Atmospheric Mercury Concentration and Deposition during 2013–2017**

Kaiyun Liu,[†] Qingru Wu,[†] Long Wang,[‡] Shuxiao Wang,[*,†,§] Tonghao Liu,[∥] Dian Ding,[†] Yi Tang,[†] Guoliang Li,[†] Hezhong Tian,[⊥] Lei Duan,[†,§] Xun Wang,[▽] Xuewu Fu,[▽] Xinbin Feng,[▽] and Jiming Hao[†,§]

[†]State Key Joint Laboratory of Environment Simulation and Pollution Control, School of Environment, Tsinghua University, Beijing 100084, China

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[∥]China National Environmental Monitoring Centre, Beijing 100012, China

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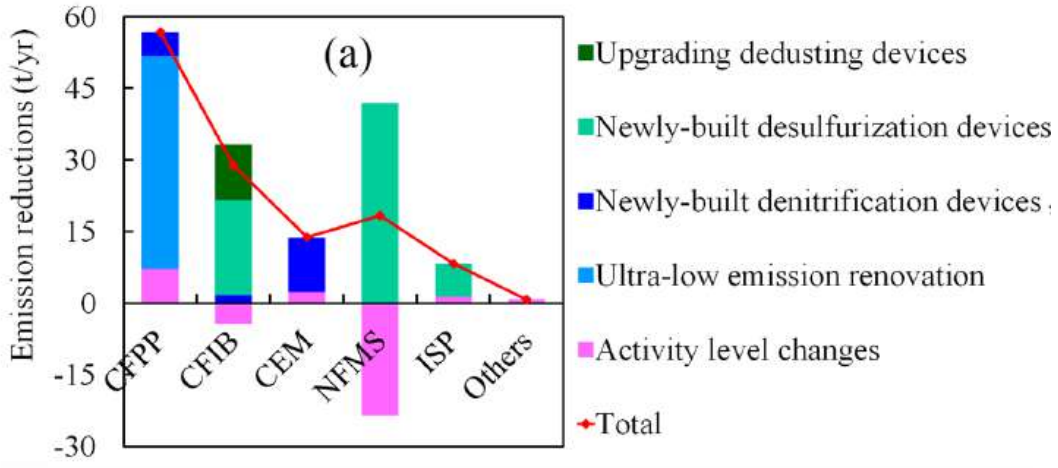
[▽]State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, China

**Table S12 Atmospheric mercury pollution in 2017 and mitigation for 2013-2017**

| Sectors | Status in 2017 | | | Mitigation for 2013-2017 | |
|---|---|---|---|---|---|
| | EMIS (t) | Contributions to TGM (ng $m^{-3}$ ) | Contributions to FLX (μg $m^{-2}$ $yr^{-1}$) | ΔTGM/ΔEMIS (pg $m^{-3}$ $t^{-1}$) | ΔFLX/ΔEMIS (μg $m^{-2}$ $yr^{-1}$ $t^{-1}$) |
| CFPP | 48 | 0.07 | 4.11 | 2.38 | 0.10 |
| CFIB | 97 | 0.18 | 10.30 | 3.02 | 0.25 |
| CEM | 129 | 0.21 | 13.04 | 2.45 | 0.15 |
| NFMS | 68 | 0.05 | 2.82 | 0.93 | 0.04 |
| ISP | 32 | 0.05 | 2.74 | 2.07 | 0.09 |




For CFPPs

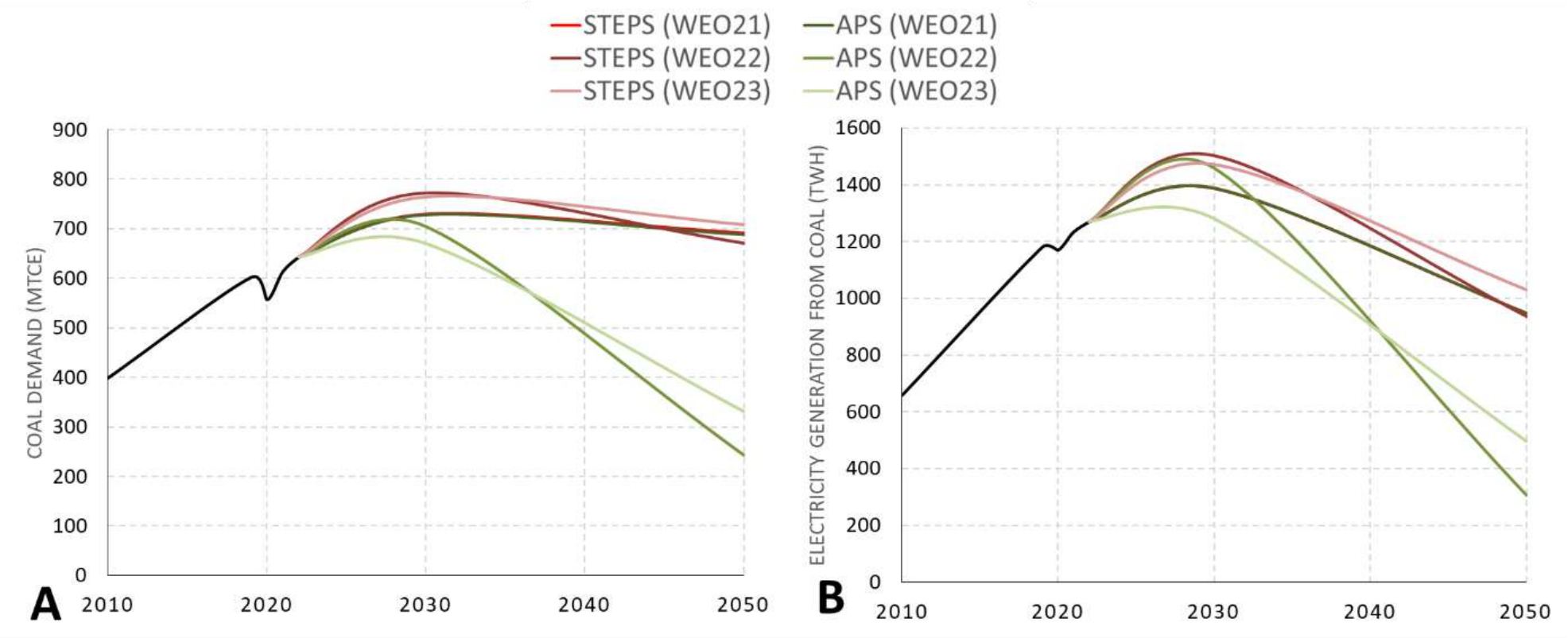
- Large decline due to almost 72% of all plants fitted with "ultralow" APCDs

For CFIBs

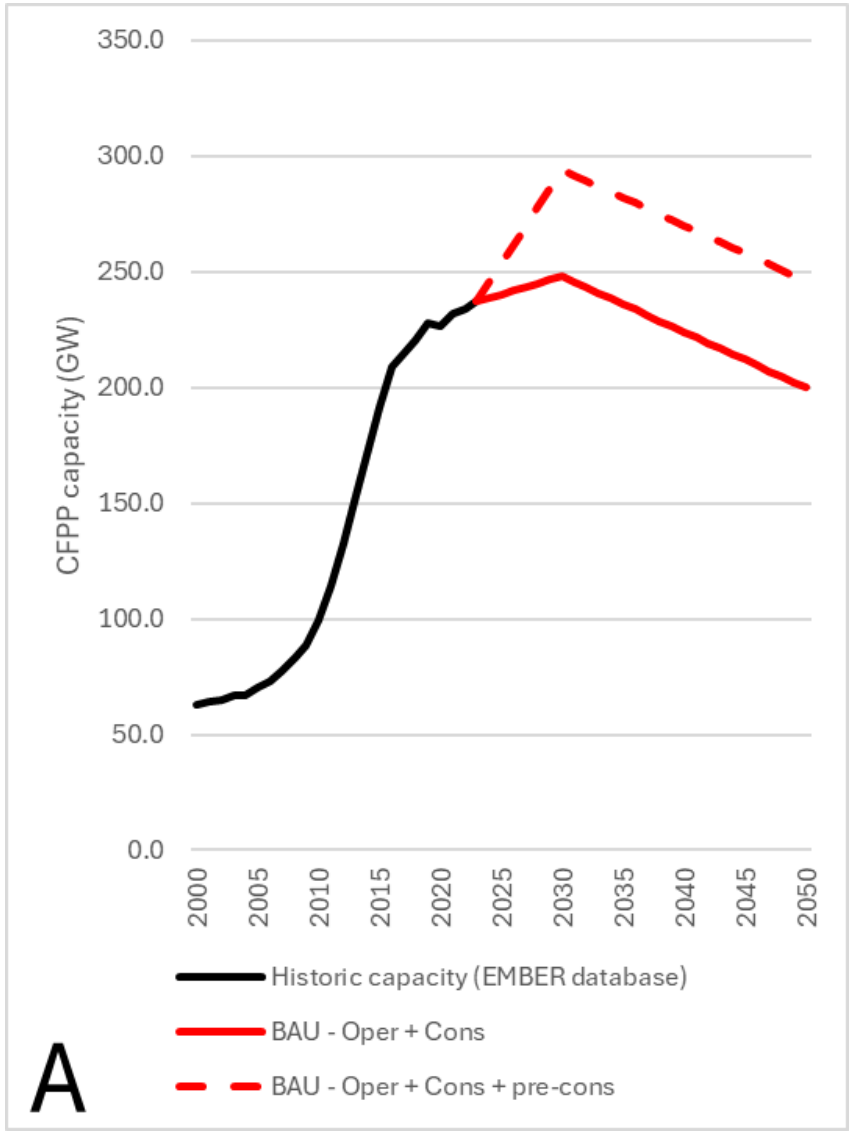
- Large need to reduce mercury deposition flux in the sector.
- Most reduction achieved by desulphurization processes
- Only 45% equipped with wFGD

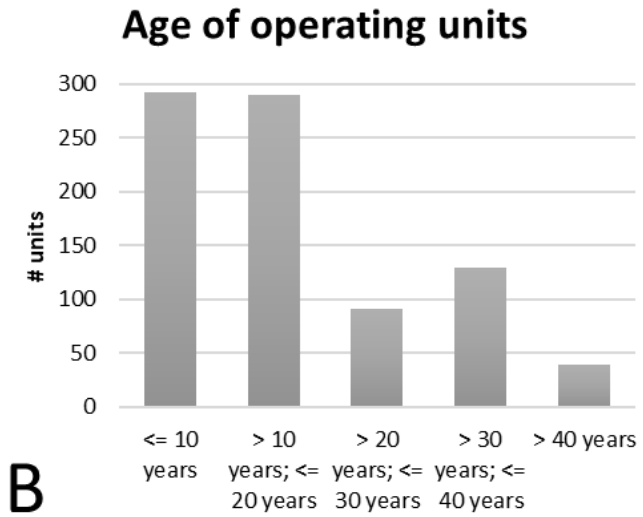
# Focus Countries

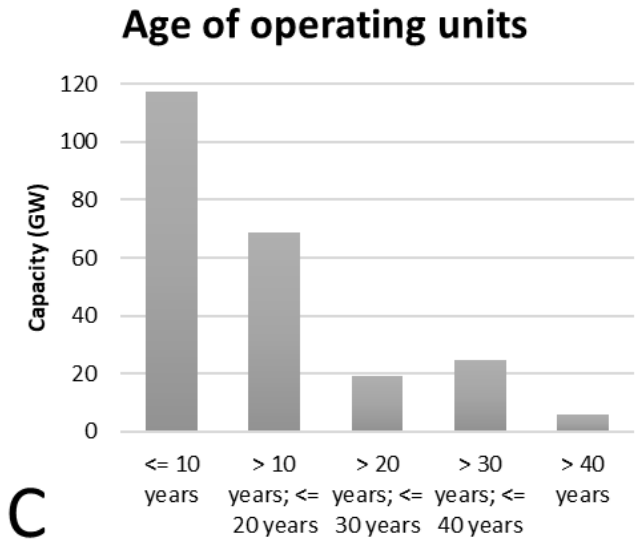
India




**Estimated coal demand (million tonnes; A) and electricity generated from coal-fired power plants (TWh; B) in India up to 2050 under the stated policies scenarios (STEPS) and announced pledges scenarios (APS)**




**The fate of coal-fired power plants in India up to 2050 under the business-as-usual (BAU) scenarios, and profiling of India's existing coal-fired power plant fleet according to the age and size of the operating units**

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journal homepage: www.journals.elsevier.com/environmental-science-and-ecotechnology/

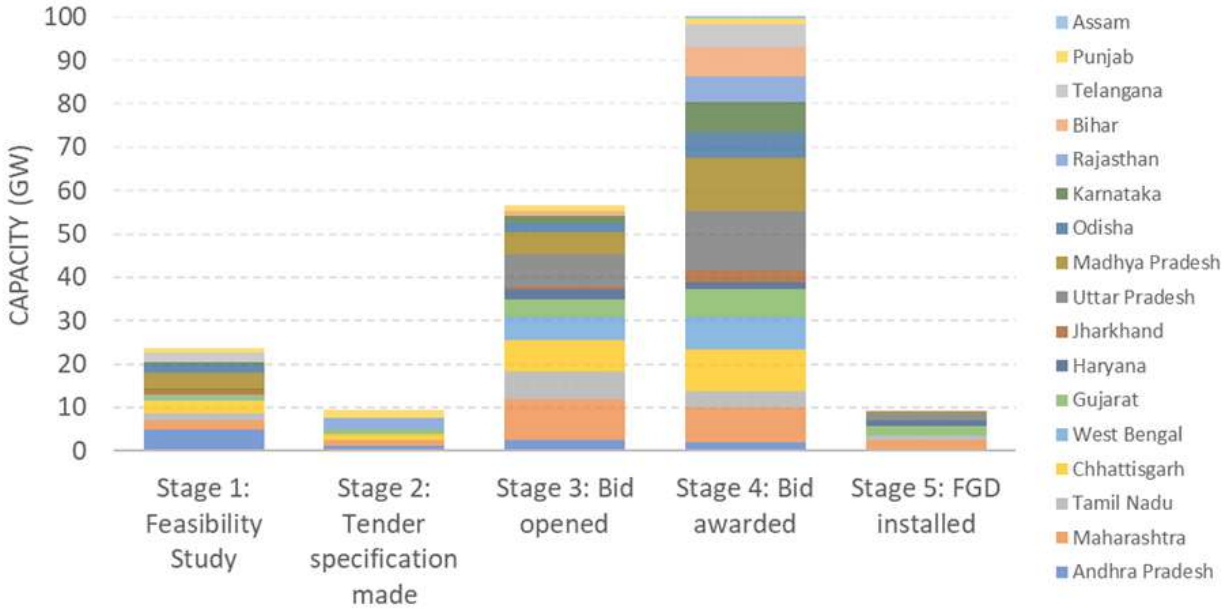
Original Research

# Overlooked $CO_2$ emissions induced by air pollution control devices in coal-fired power plants

Pengfei Zhang [a], Kuishuang Feng [a, b], Li Yan [c], Yaqin Guo [d], Bei Gao [e], Jiashuo Li [a, f, *]

[a] Institute of Blue and Green Development, Shandong University, Weihai, 264209, PR China
[b] Department of Geographical Sciences, University of Maryland, College Park, USA
[c] Chinese Academy of Environmental Planning, Beijing, 100012, PR China
[d] Department of Earth System Science, Tsinghua University, Beijing, 100084, PR China
[e] School of Business, Shandong University, Weihai, 264209, PR China
[f] Academy of Plateau Science and Sustainability, Qinghai Normal University, Xining, 810016, PR China

## Flue gas desulphurization (FGD) installations in India




*Source: Aggarwal, 2023. Compliance status of coal-based power plants: Tracking installation of SOx control measures, https://www.cseindia.org/compliance-status-of-coal-based-power-plants-11762*

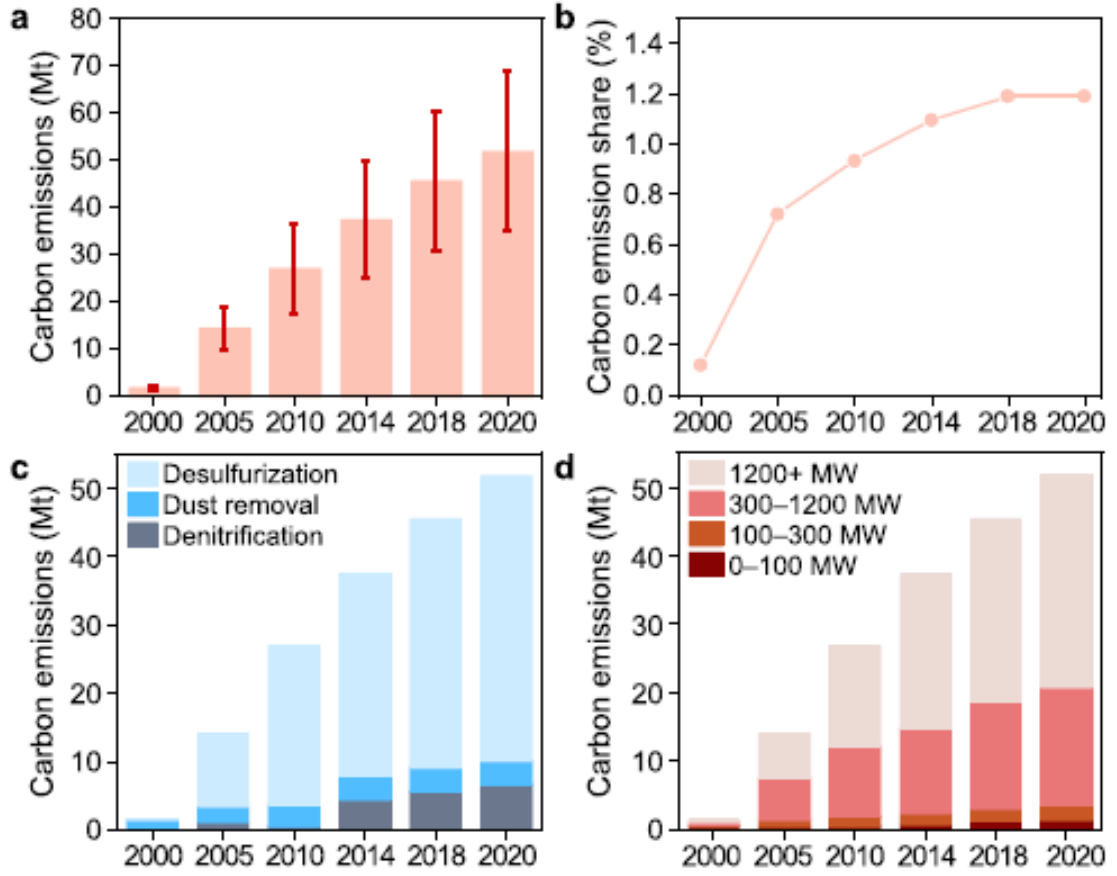
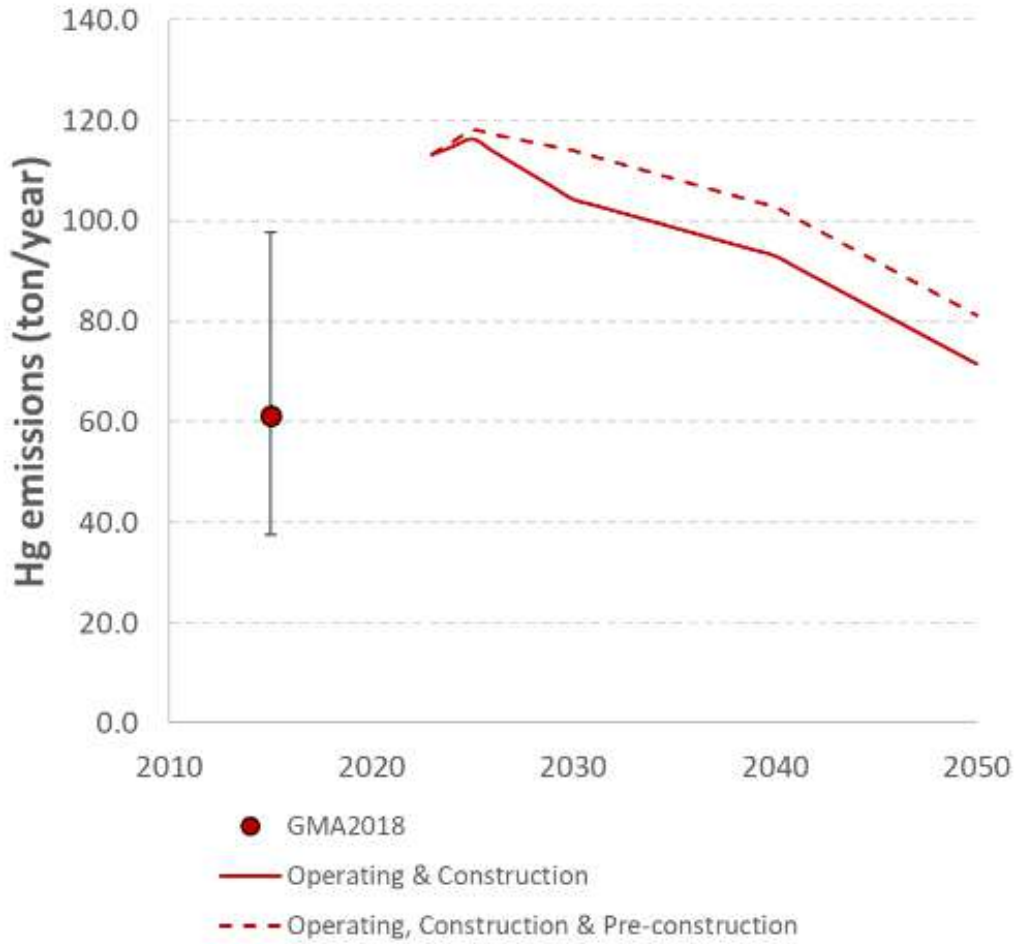
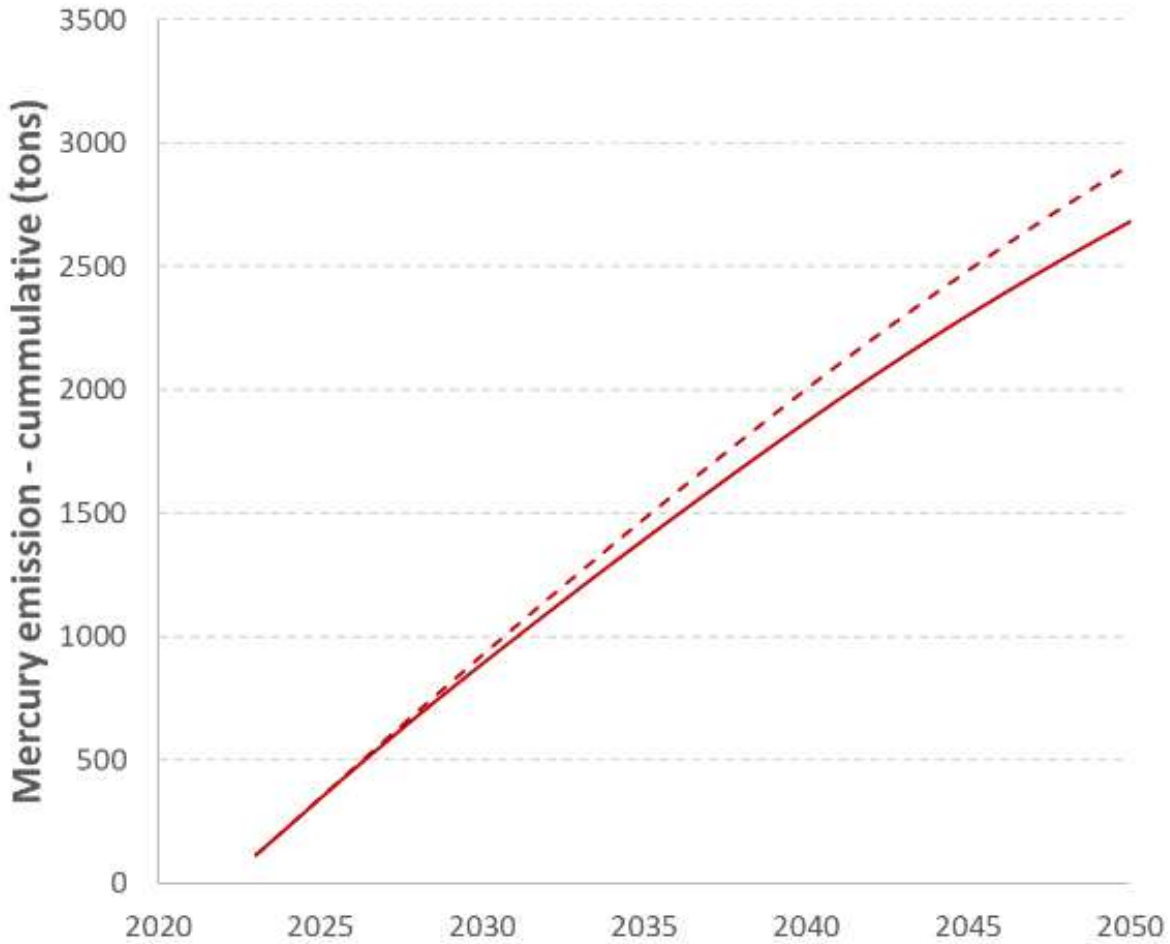
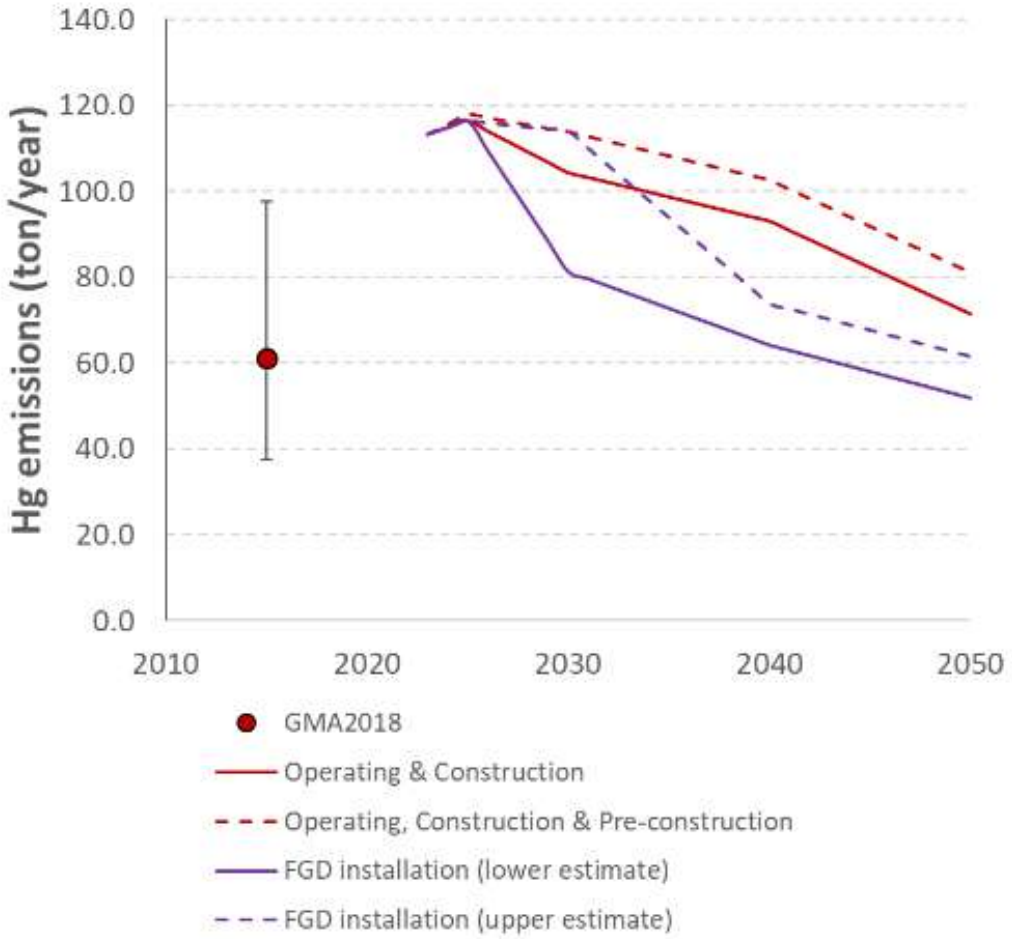


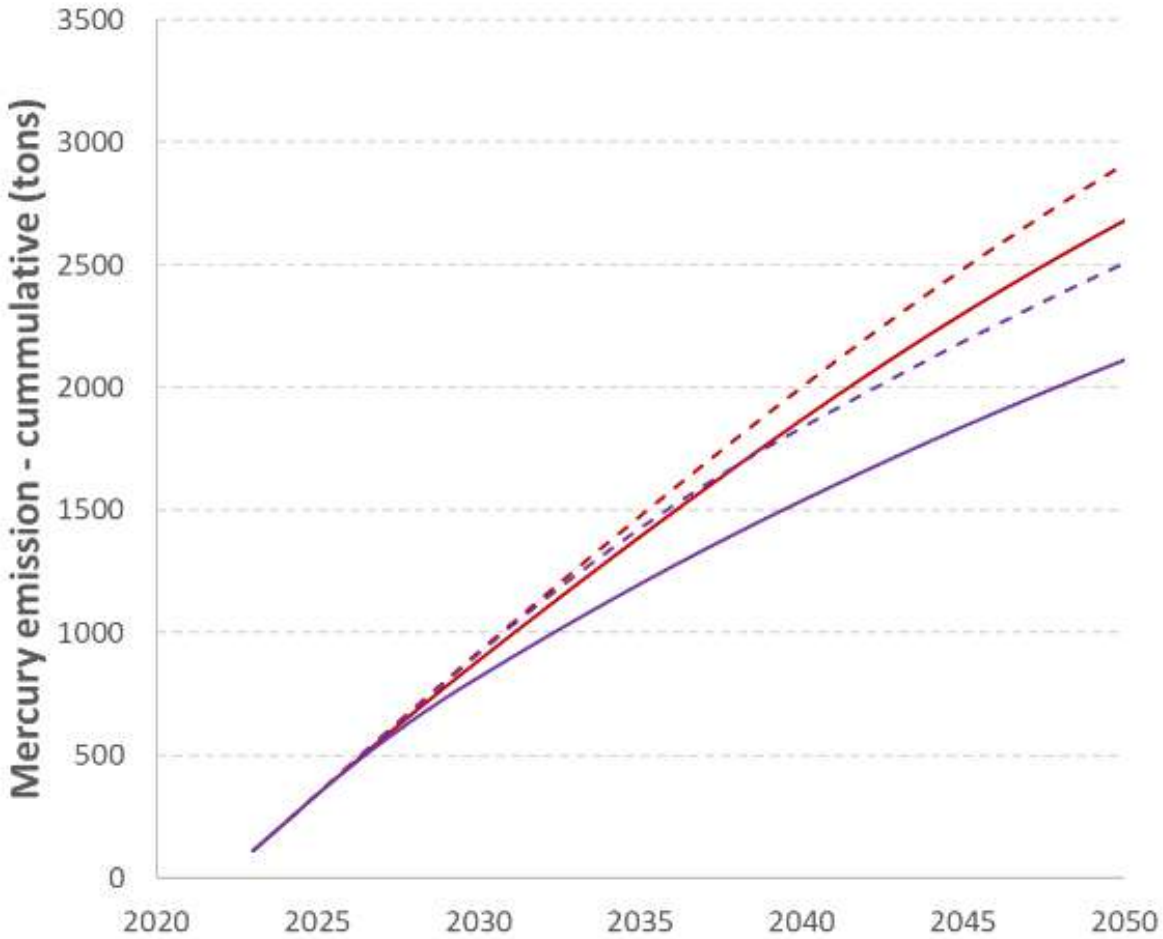

**Fig. 1.** National APCD $CO_2$ emissions 2000–2020 (**a**), their proportions to the total emissions from CFPPs (**b**), and emissions categorized by APCD type (**c**) and capacity size (**d**). (The error bars in panel **a** represent the 95% confidence interval.)




Annual mercury emissions estimate for India's CFPPs up to 2050 under the business-as-usual scenario, and cumulative mercury



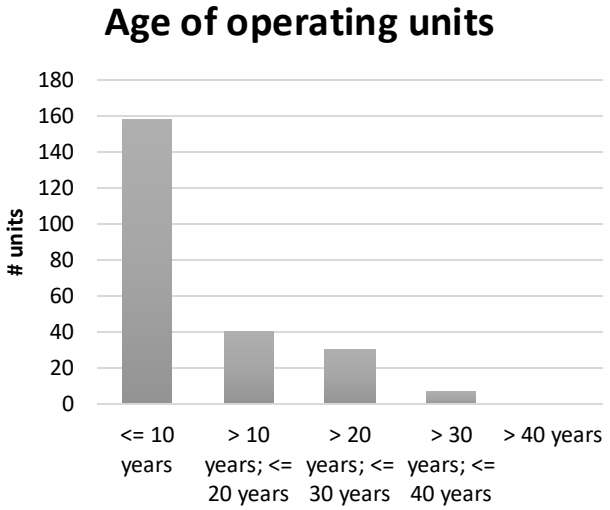

**Annual mercury emissions and cumulative emissions estimate for India's CFPPs up to 2050 under the business-as-usual (BAU) scenario compared to the FGD installation scenario**

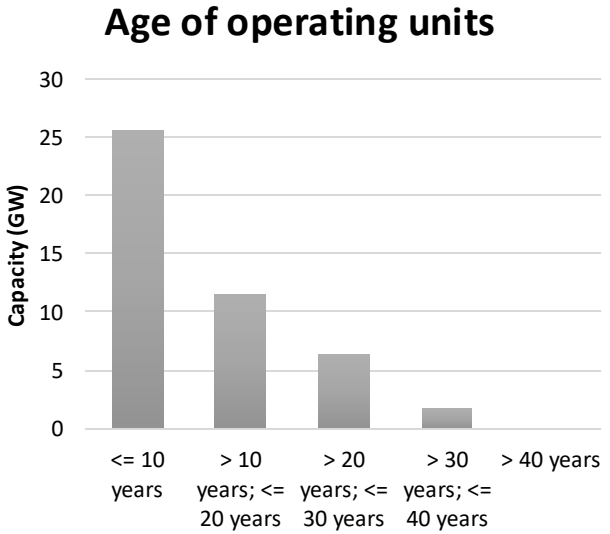
# Focus Countries

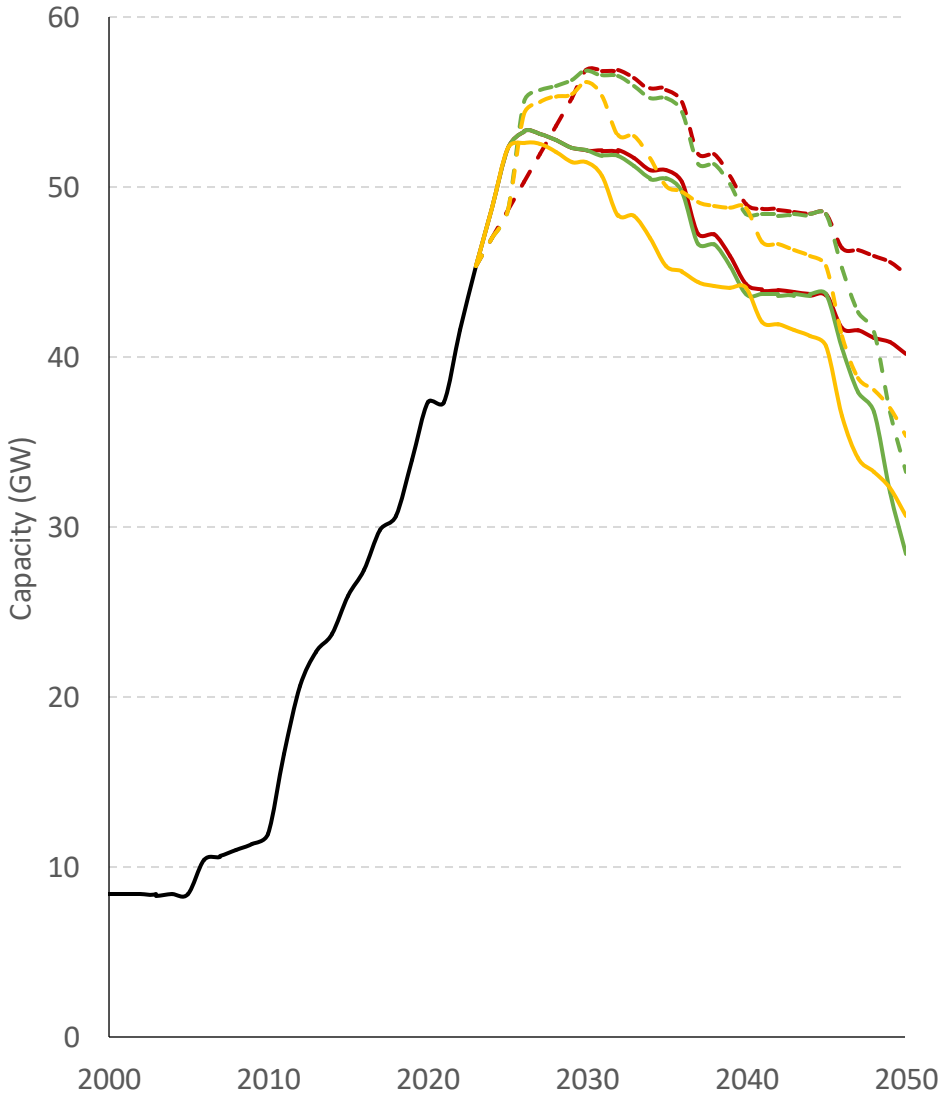
Indonesia

# CFPP profile – Indonesia

## CFPP capacity (GW)




**BAU**

- Retirement dates reported for existing units in GEM database
- Plants under construction and pre-construction with 40-year design lifetime

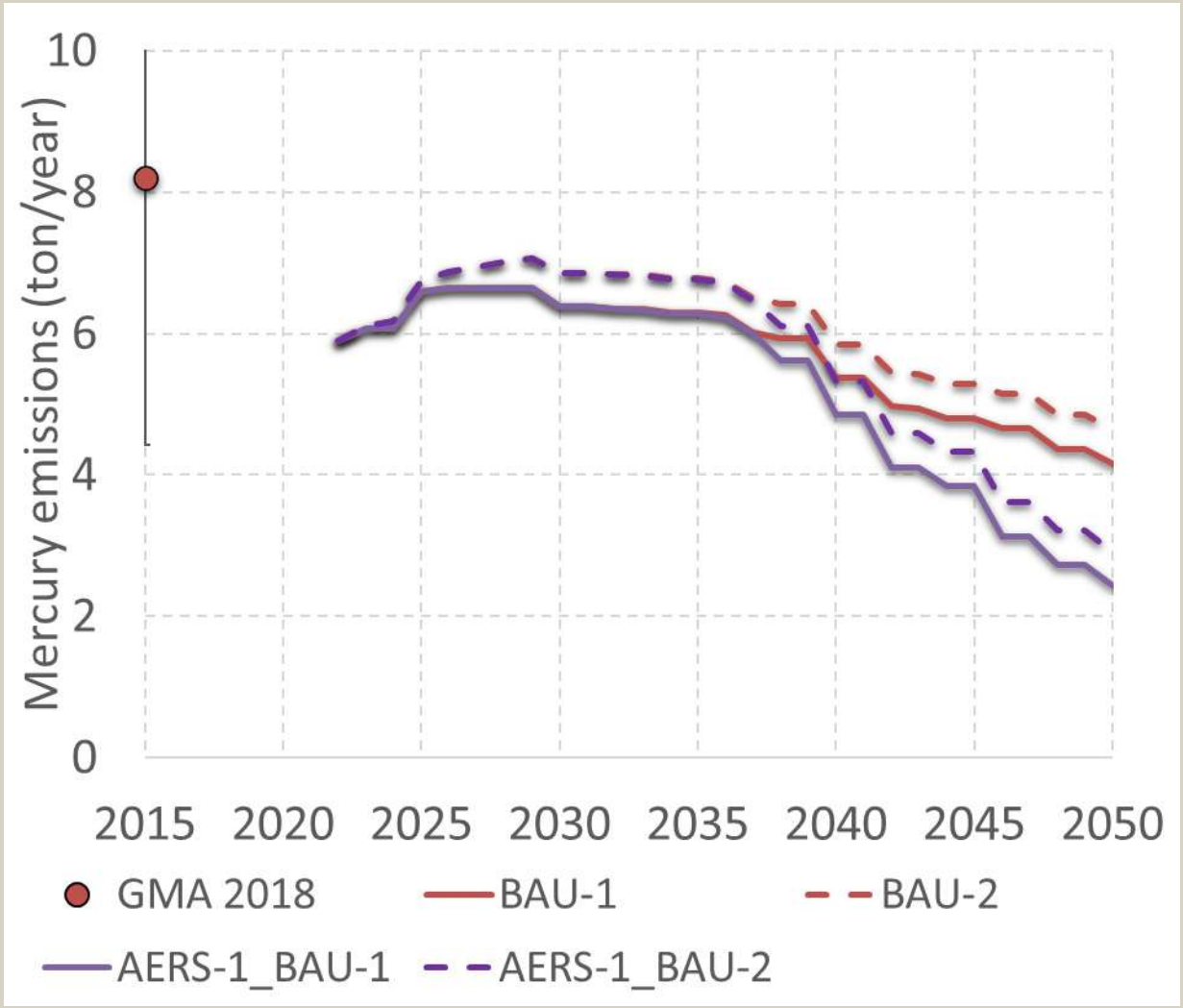
**AERS-1**

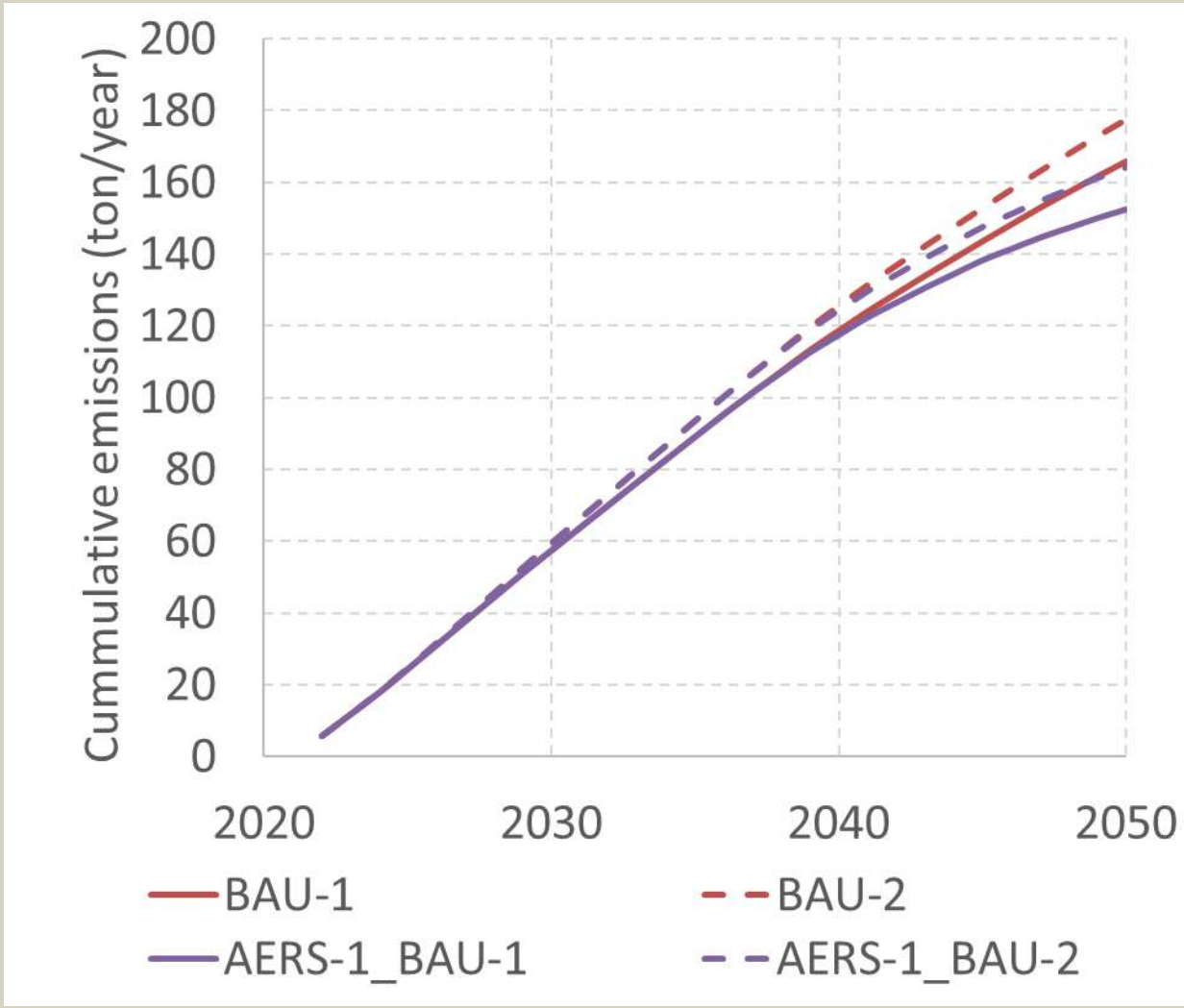
- 10-year early retirement for all units constructed after 2015

**AERS-2**

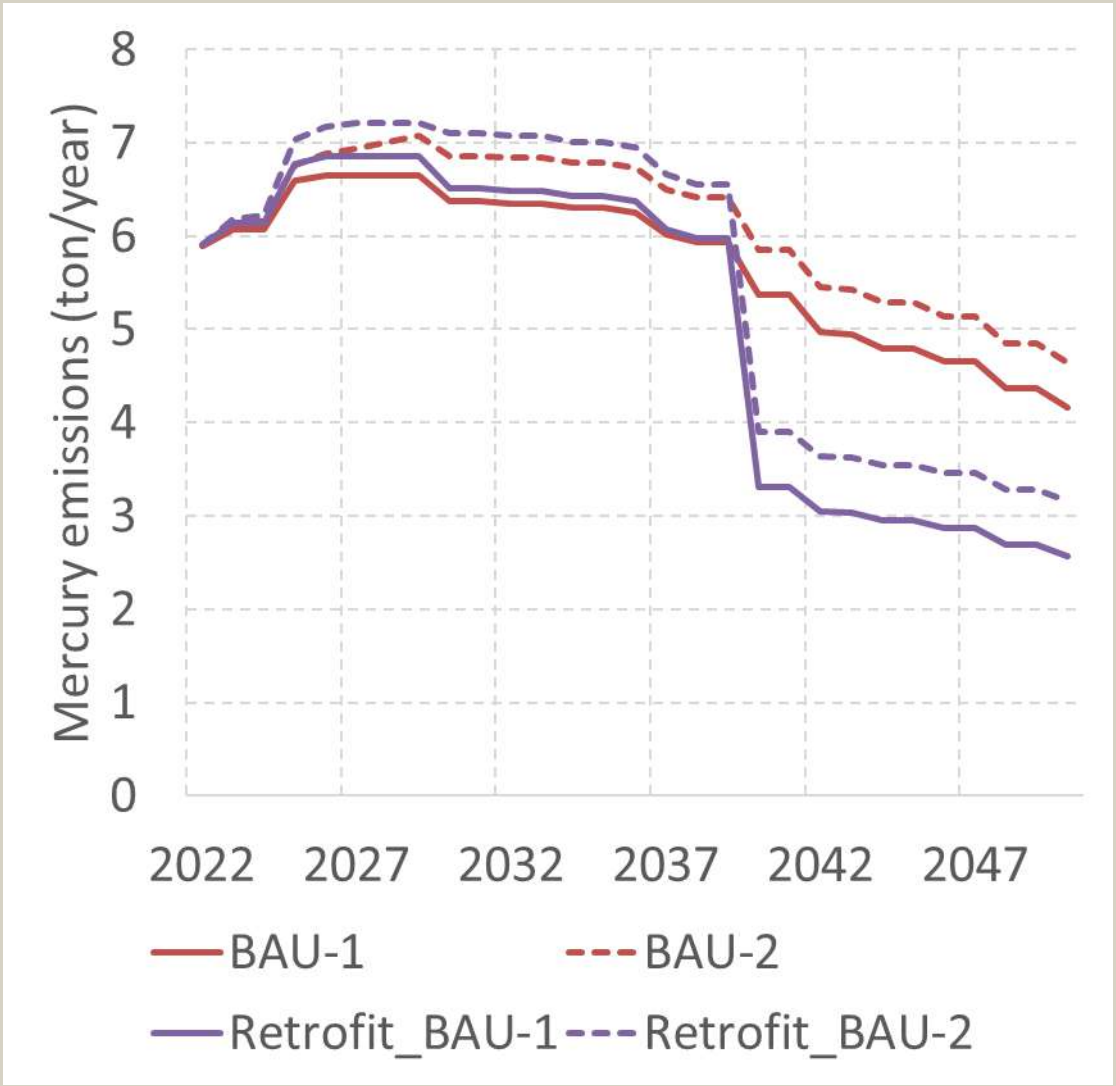
- 5-year early retirement of all subcritical combustion units

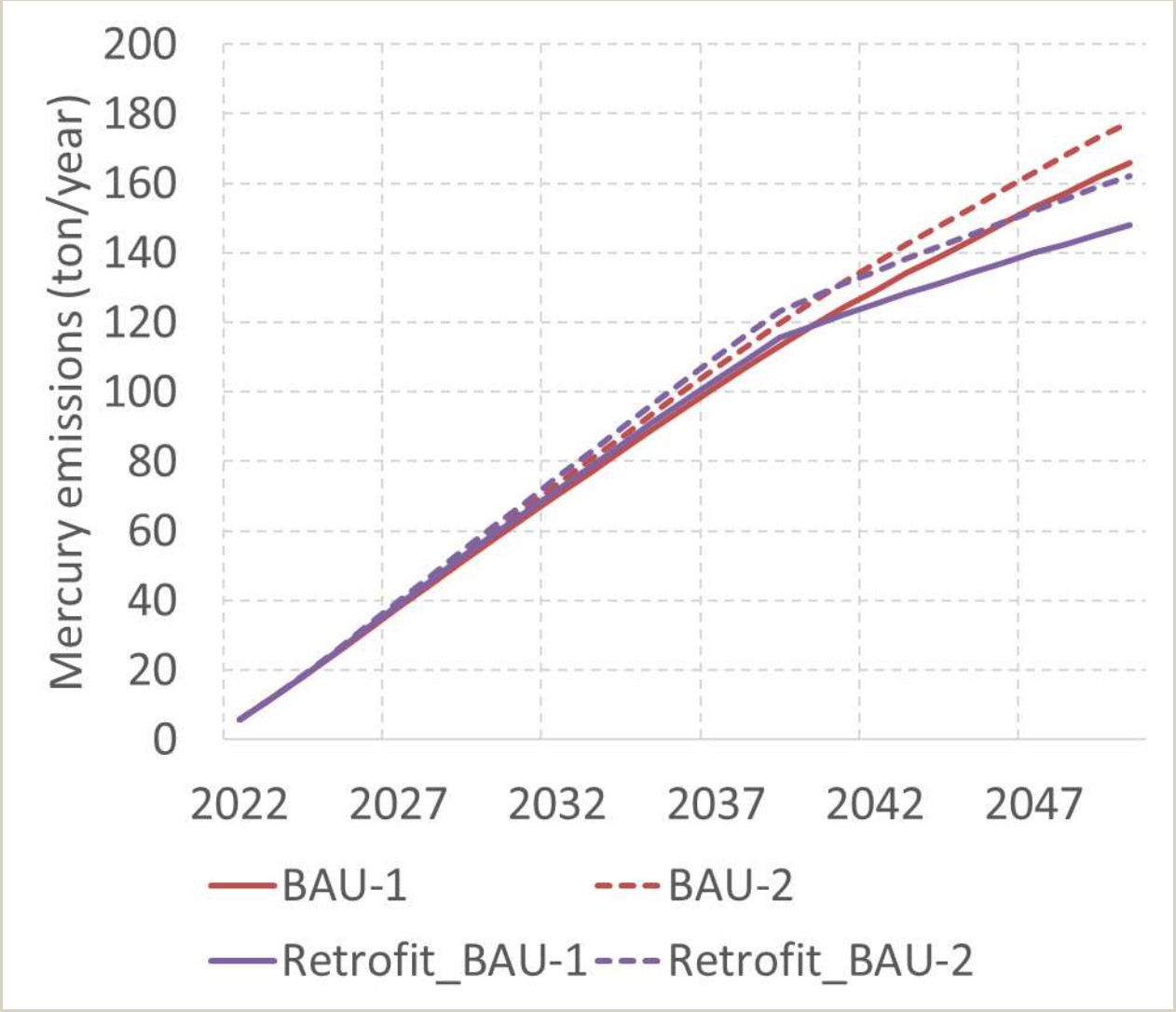
# Mercury emission estimates – Early Retirement



# Mercury emission estimates – APCD retrofit



# Conclusions

MACQUARIE University

1. <u>Plant-specific CFPP information in Indonesia is highly useful for emissions predictions</u>
   - Extrapolated to other SE Asian countries as well
   - Need for similar information from the CFIB sector

2. <u>Guidance</u>
   - Where should investment be prioritized towards mercury emissions abatement in the coal sector?
   - What forms of capacity development are desired?

3. <u>Considerations for CFPP modernization/decommissioning/repurposing</u>
   - Options for generation flexibility
   - Co-firing with biomass/ammonia
   - Cost of retirement compared to APCD retrofit
   - Role of BAT/BEP in energy transition mechanisms?

# Focus Countries

Vietnam

# Vietnam's Energy Future

## WITH REFERENCE THE PDP-VII

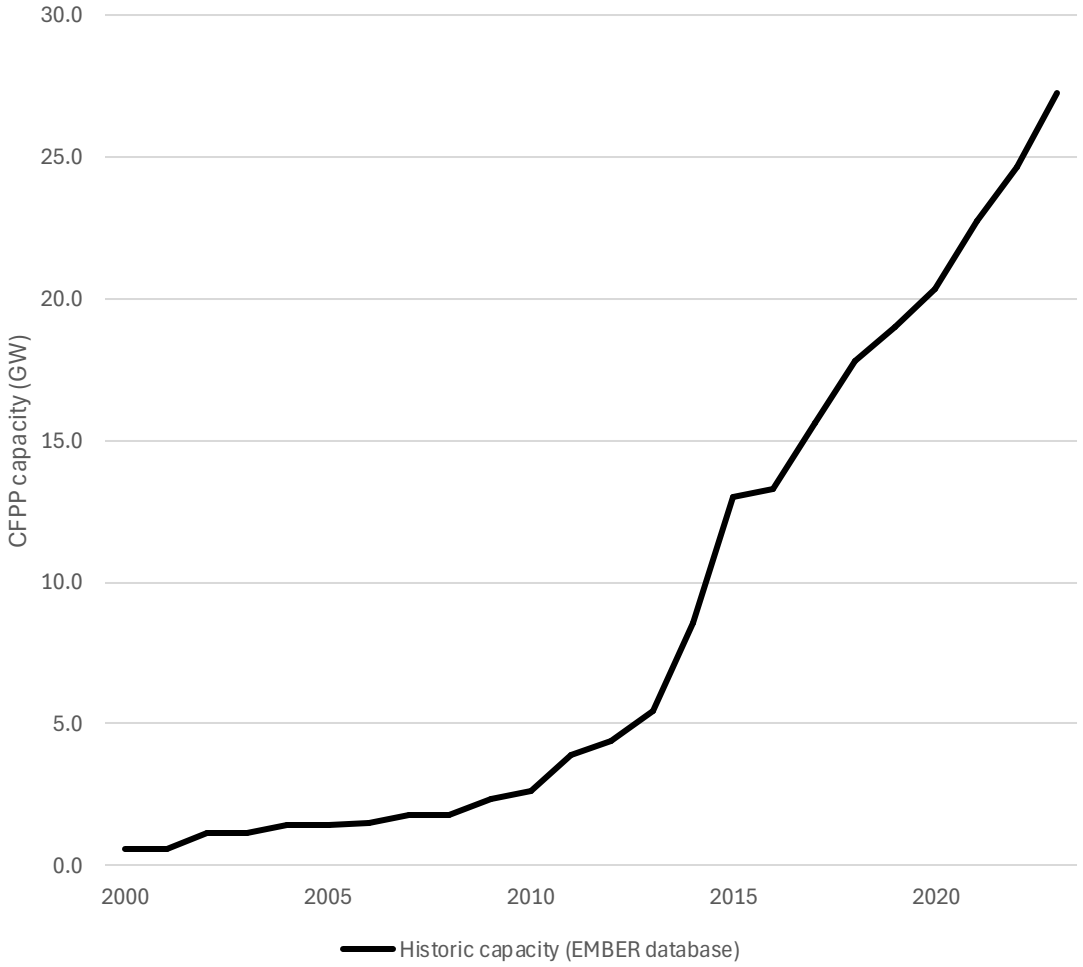
- In December 2022, Vietnam became the third country to agree on a JETP with its International Partners Group (IPG).
  - Initial USD 15.5 billion investment up to the period of 2026 to 2028 towards reaching energy transition targets.
  - Vietnam's reported annual investment needed - USD 8 to 14 billion per year up to 2030
    - Expansion of the national grid system & develop new power generation infrastructure.

- Eighth Power Development Plan (PDP-VIII) - released in May 2023
  - Total CFPP capacity of 30.1 GW is expected to be reached by 2030
  - Cessation of all CFPPs by 2050 through either retirement and/or repurposing with biomass and ammonia fuel sources.

- The application and feasibility of biomass/ammonia co-firing for Vietnam's CFPP fleet, along with the development of cost-effective battery storage and transmission improvements for renewable energy sources are thus priority areas to be explored for the country.

# Vietnam Coal-Fired Power Plants

## LARGE INCREASE SINCE 2015 – EST. 7.6 GW (2023)




**<u>CFPP capacity – 2023</u>**

27 GW operating

7.9 GW under development

**<u>Coal consumption in power plants (MIA 2016):</u>**

26.4 million tonnes / year

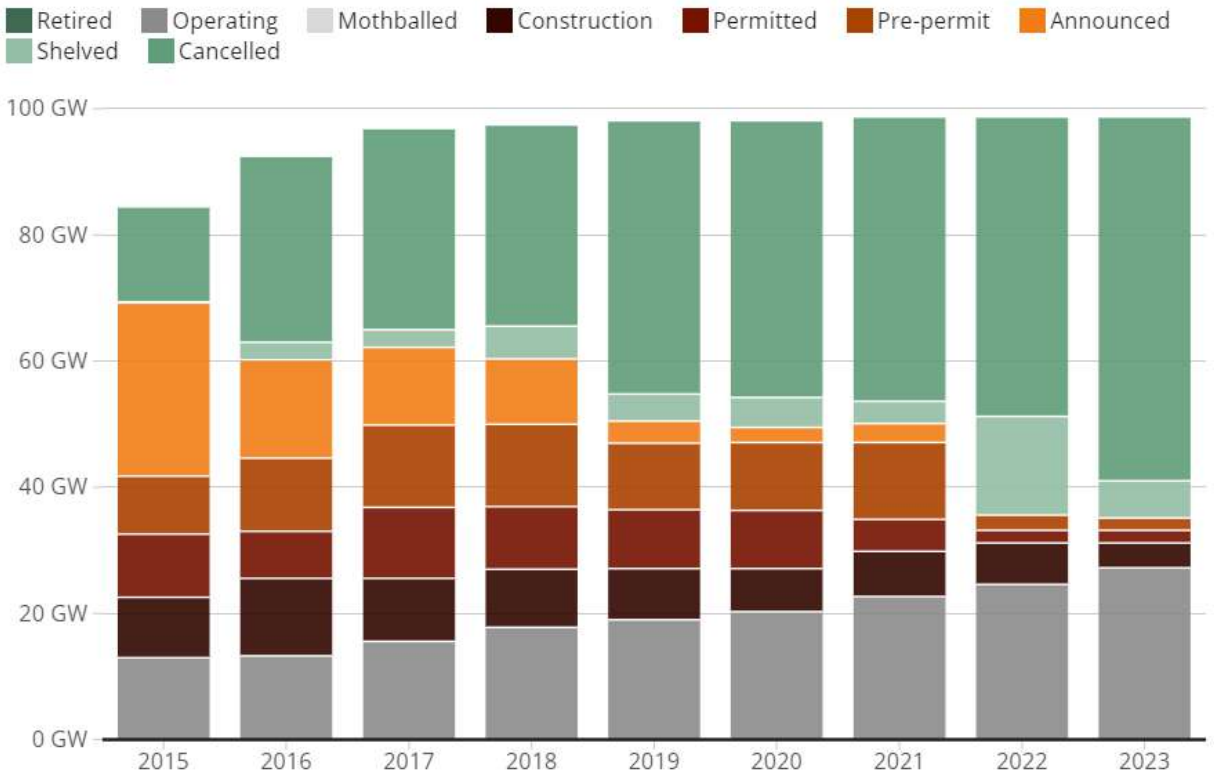
* Coal type influence mercury removal efficiency as mentioned in Minamata toolkit & POG

# Global Energy Monitor – Global Coal Plant Tracker database – Vietnam profile

HTTPS://GLOBALENERGYMONITOR.ORG/PROJECTS/GLOBAL-COAL-PLANT-TRACKER/

## How does coal capacity break down by status?

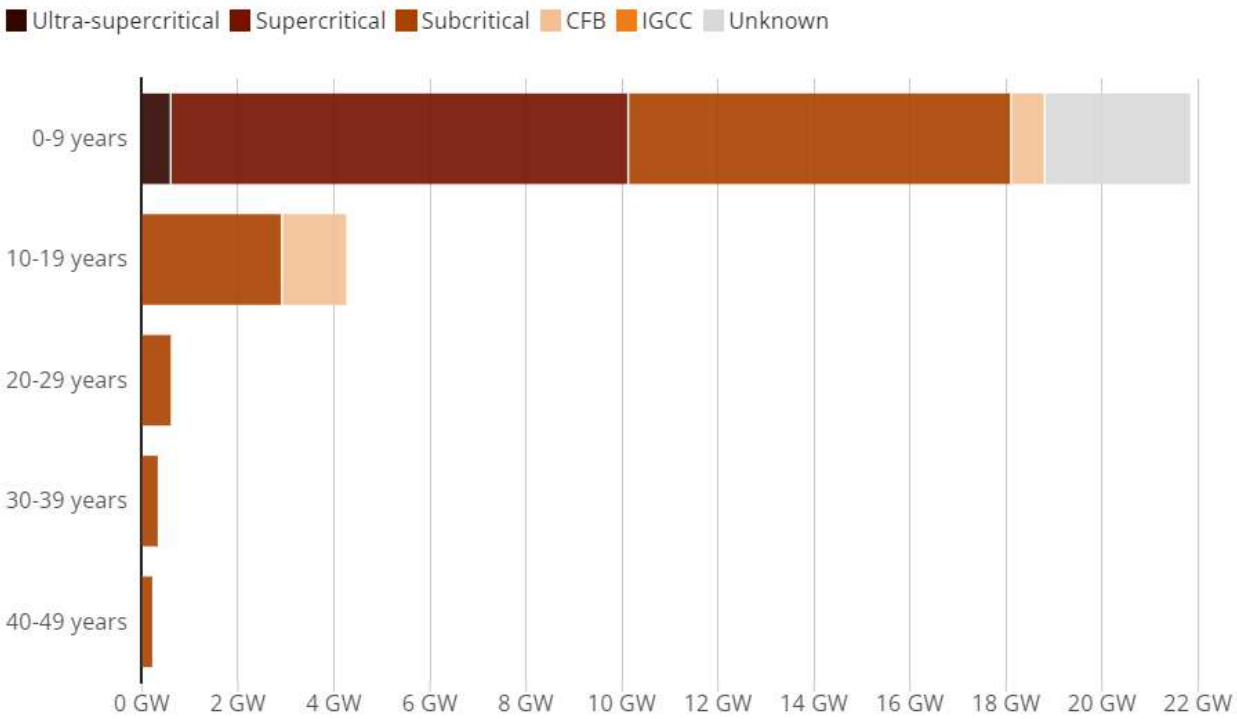
Coal-fired power capacity by status, each year since 2015




Download capacity status data

## What is the age and technology of operating coal capacity?

Operating coal-fired power capacity, by unit age group and technology type

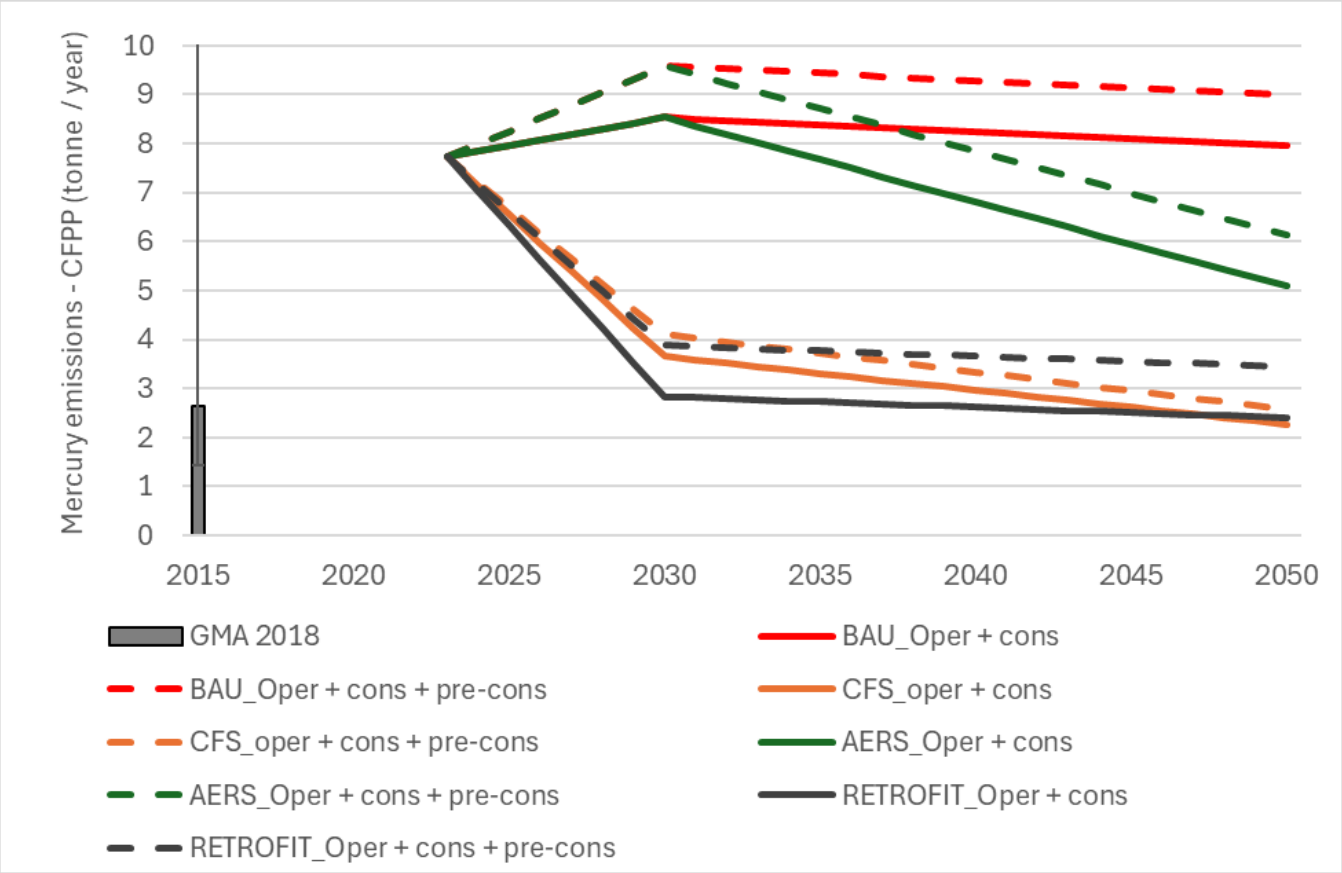



Download age and technology type data •

GEM wiki link for full definitions of coal plant technology type

# CFPP Mercury Emissions

2023 estimate – 7,7 tonnes / year




BAU – Business as Usual

AERS – Early Retirement

- All subcritical CFPPs retire 10 years earlier

CFS (Capacity factor scenario)

- 2024 – 0.53 (default global average)
- 2030 – 0.3
- 2050 – 0.2

} More alternative energy resources (e.g., RE, nuclear, etc)

RETROFIT scenario

| 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 |

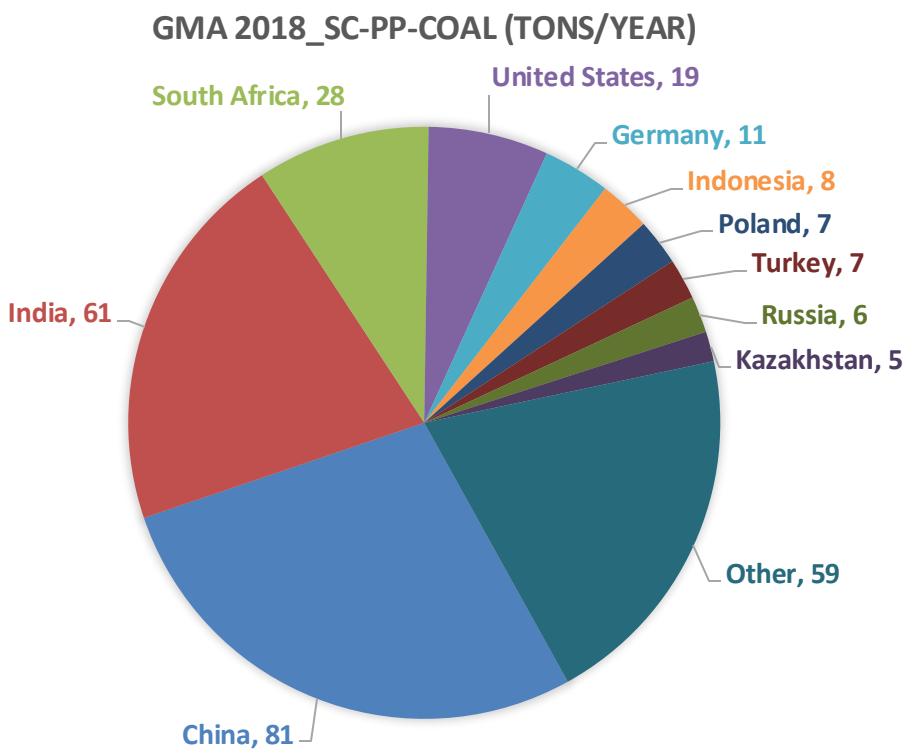
# Focus Countries

South Africa

# Global Mercury Assessment 2018

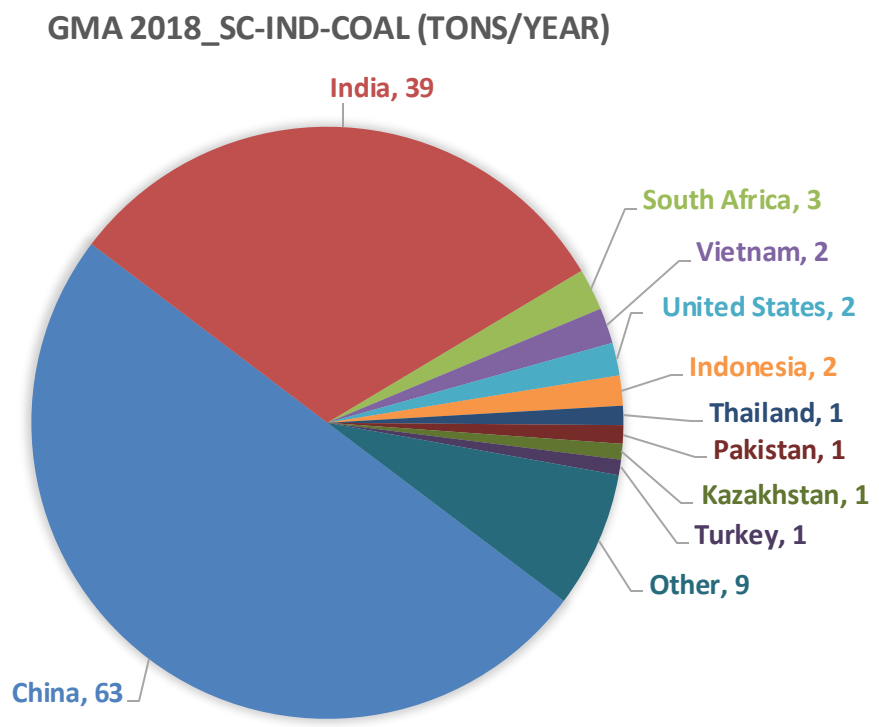
## SOUTH AFRICA IN THE GLOBAL CONTEXT

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



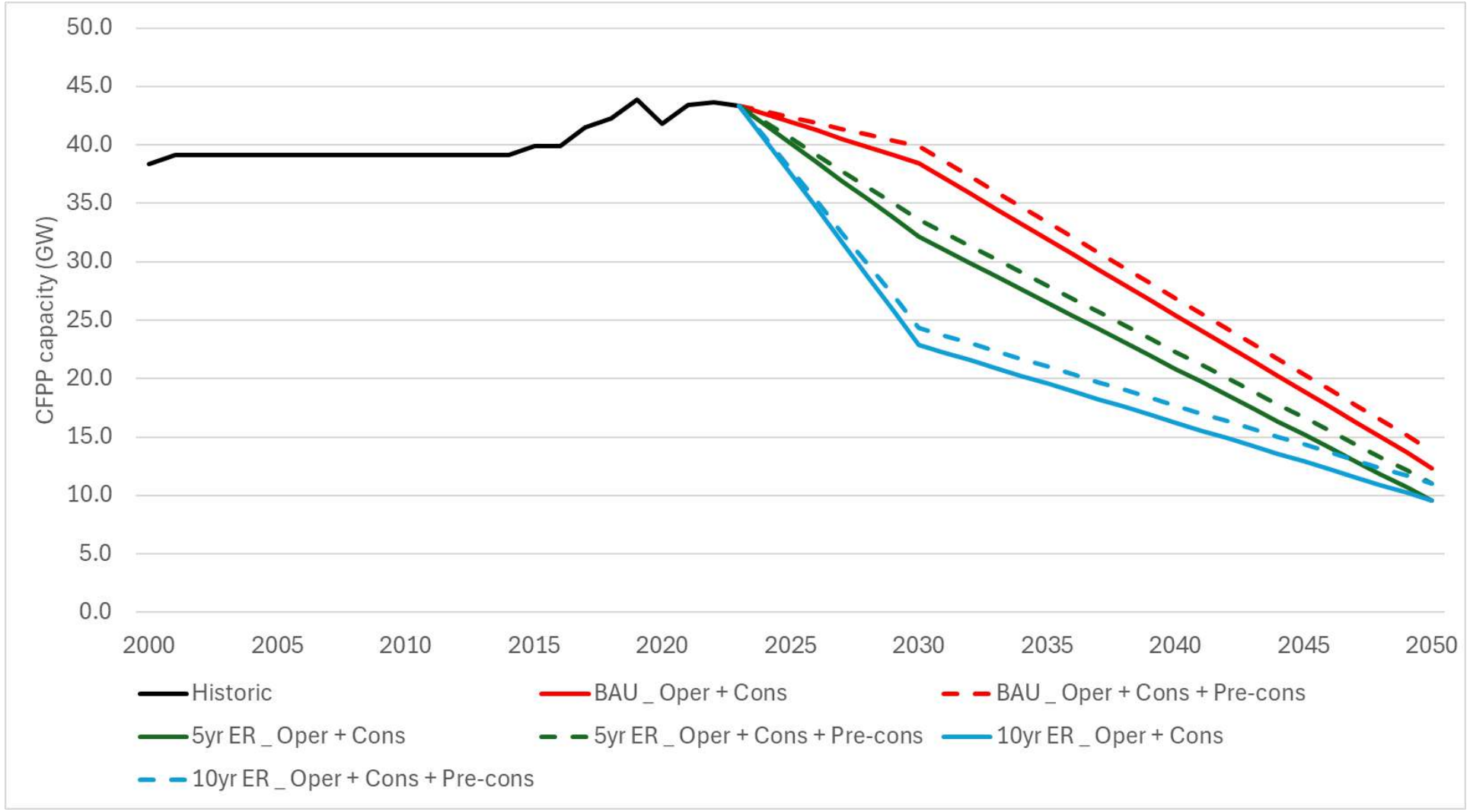

China, India & South Africa = 47% - 59% global coverage

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




China & India = 73% - 83% global coverage

# CFPP capacity outlook



# Energy Action Plan (2022)

Facilitated by the National Energy Crisis Committee (NECOM)

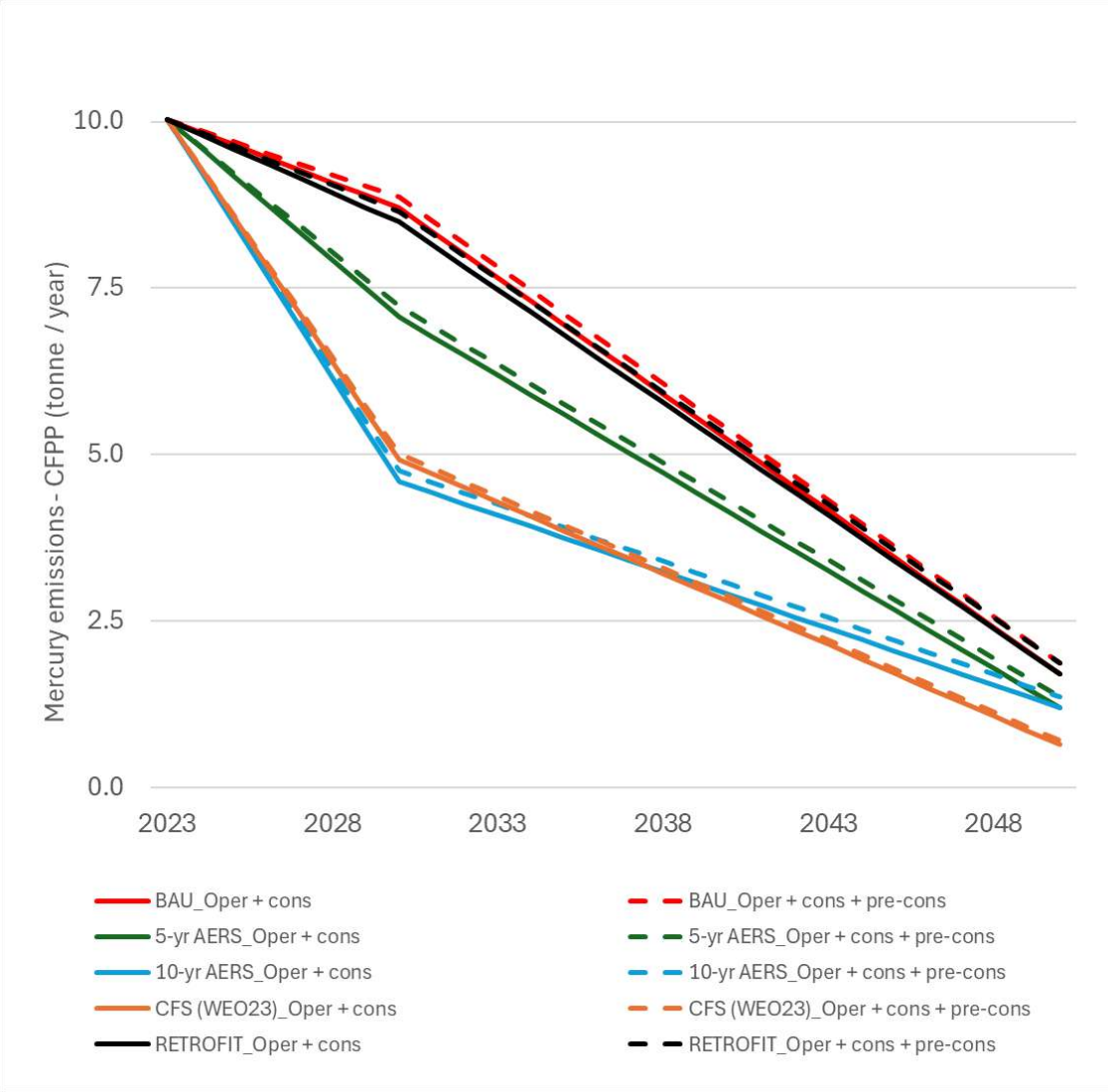
Actions:

1. ***Fast-tract procurement of new generation capacity from non-fossil fue***ls
    - 14 GW of new wind/solar/battery storage procurement
    - Three projects from the Risk Mitigation Programme in construction
    - Power Purchase Agreements for 19 projects & additional new capacity construction – 2,300 MW
    - Import power from neighboring countries, subject to transmission networks

2. ***Accelerate investment in rooftop solar (businesses & households)***
    - Special tax incentives for businesses & households installing solar
    - Bounce-back loan scheme for small businesses going solar
    - Progress in rooftop solar installments across the country

3. ***Fundamental transformation of electricity sector for long-term energy secur***ity
    - National Transmission Company of South Africa as independent entity for managing the national electricity grid (improved private sector participation)
    - New legislation for a competitive electricity market (i.e., Electricity Regulation Amendment Bill)

# CFPP Mercury Emissions




<u>BAU – Business as Usual</u>

<u>AERS – Early Retirement</u>

- Subcritical CFPPs
- 5-yr/10-yr early retirement

<u>CFS (Capacity factor scenario)</u>

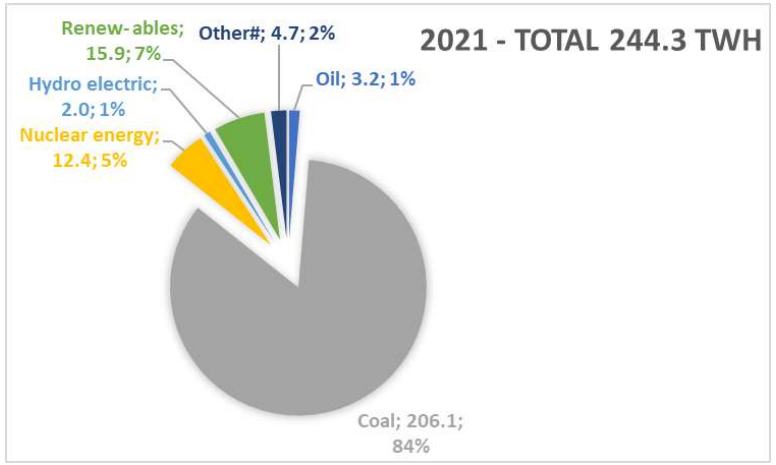
- 2024 – 0.53
- 2030 – 0.3
- 2050 – 0.2

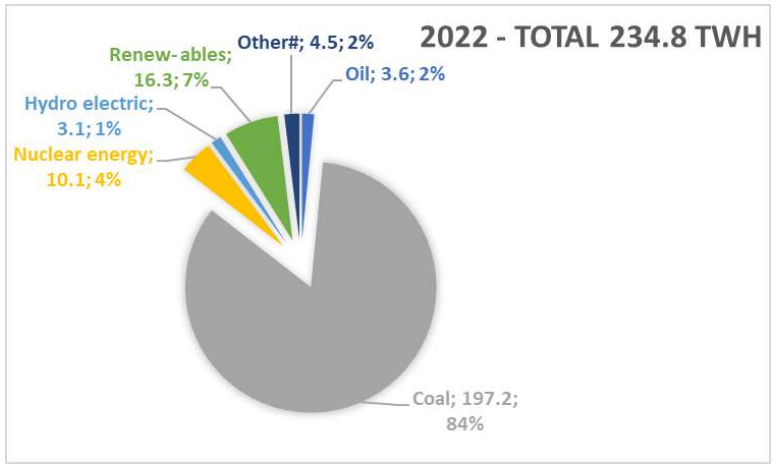
<u>RETROFIT scenario</u>

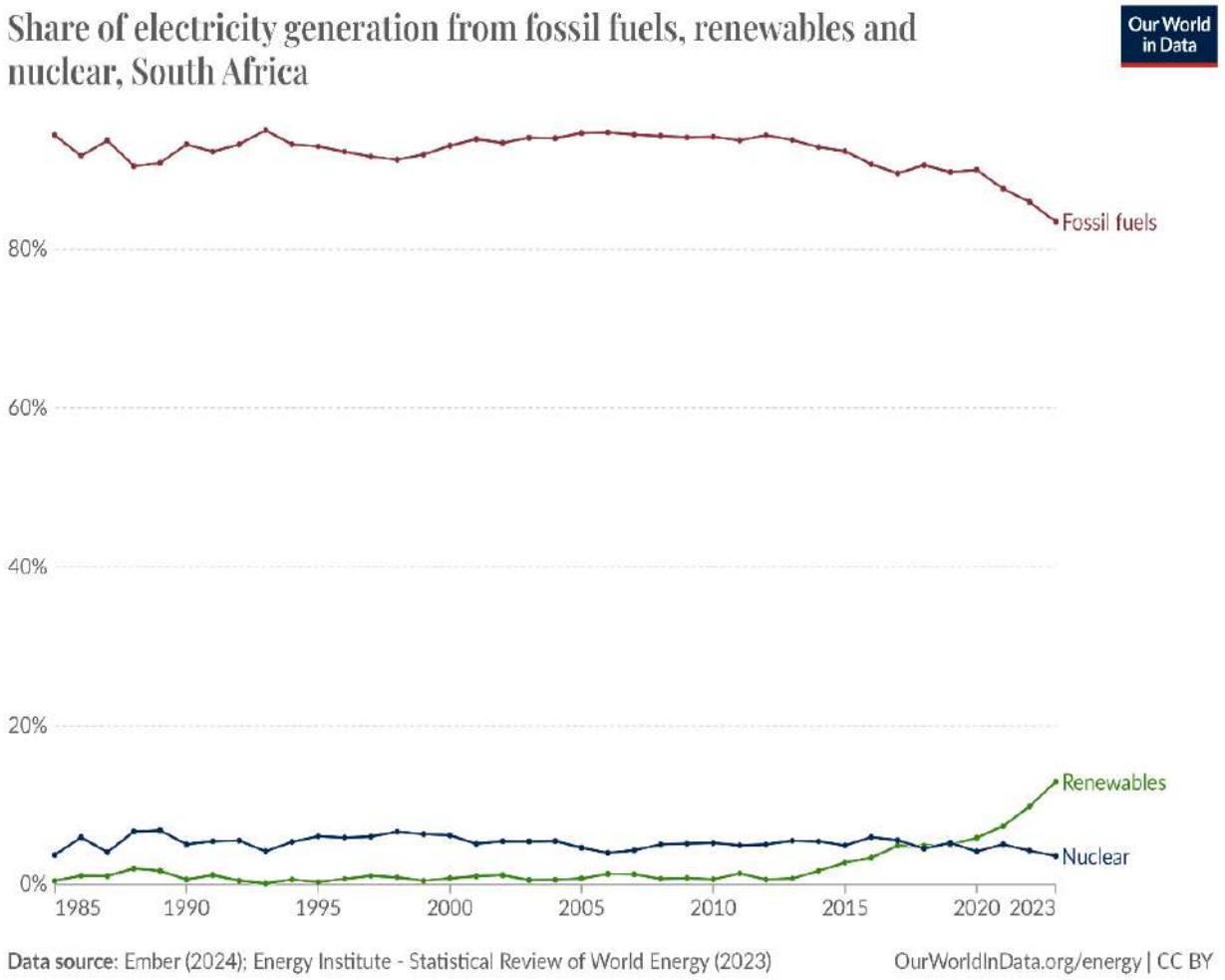
| RETROFIT scenario criteria | |
|---|---|
| Remaining lifetime | 20 |
| Original APCD configuration | FF |
| New APCD configuration | FF + FGD |
| Unit status to retrofit | Operating |
| Retrofit by | 2030 |

# Reduction in CFPP emissions reliant on alternative energy developments

Energy Institute – Statistical Review of World Energy



# Focus Countries

Pakistan

# Pakistan Coal-Fired Power Plants

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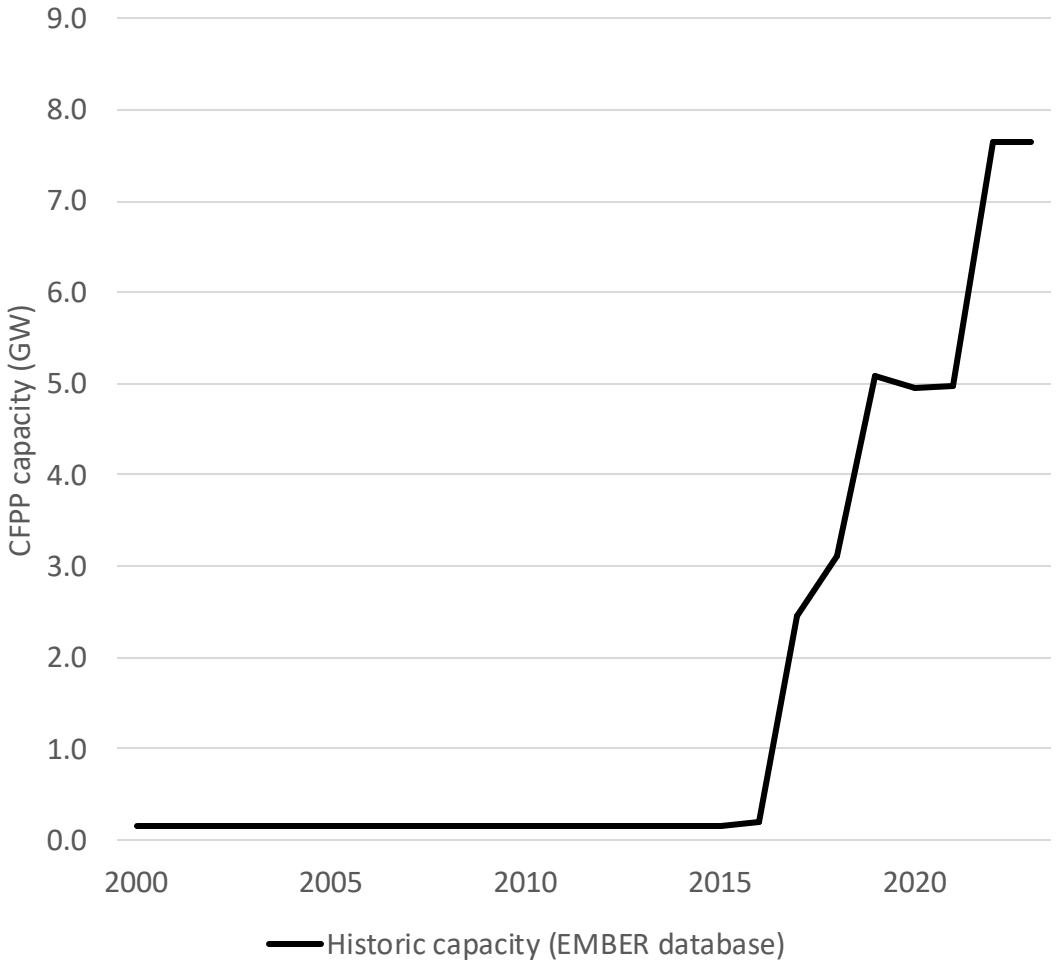


**Coal consumption in power plants (MIA 2021):**

4,436,100 tonnes / year (Economic Survey of Pakistan - 2016-2017).

- Sub-bituminous (brown) coal (2,825,000 t/y)
- Lignite (brown) coal (1,611,100 t/y)

* Coal type influence mercury removal efficiency as mentioned in Minamata toolkit & POG

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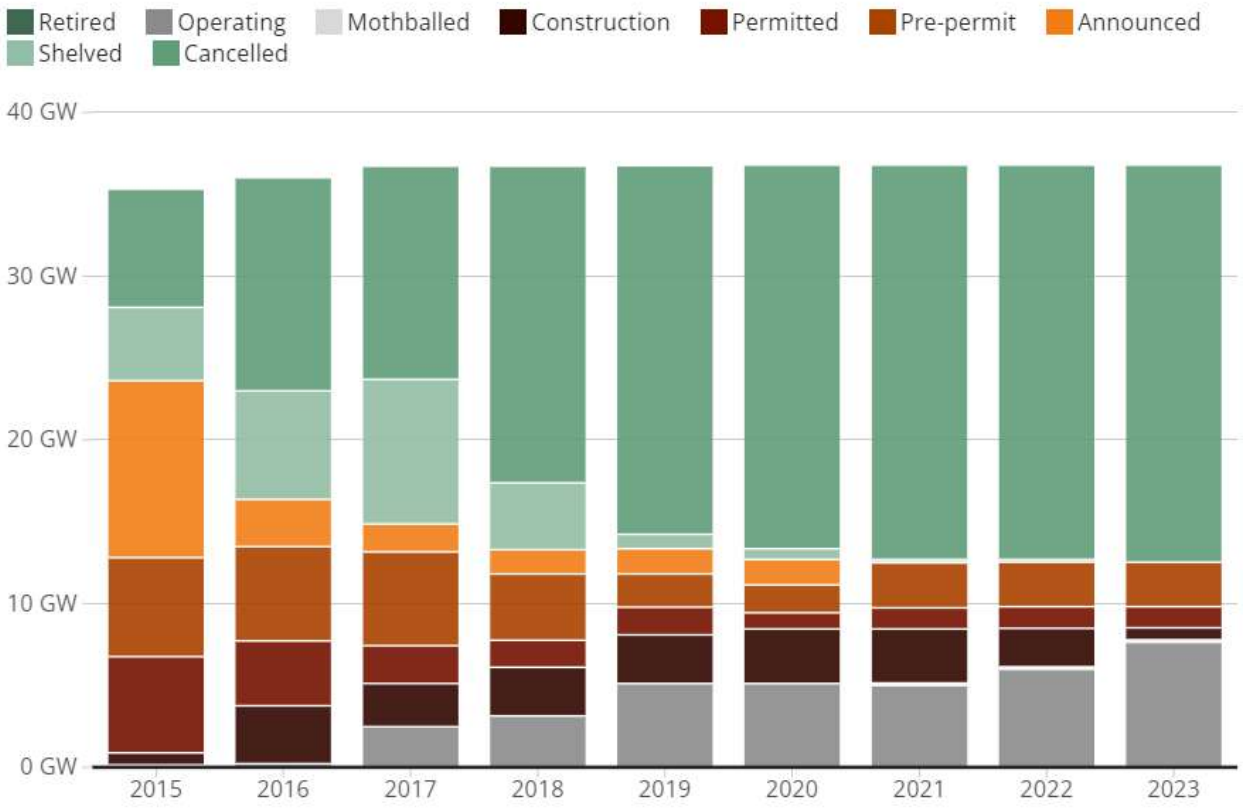


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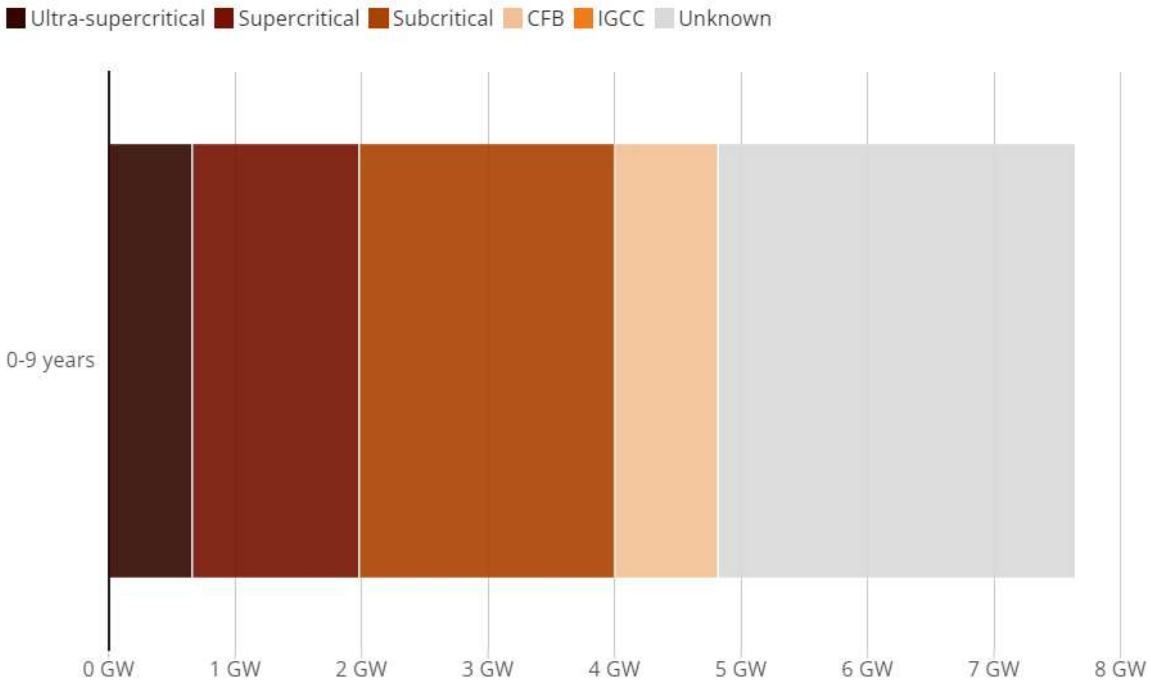


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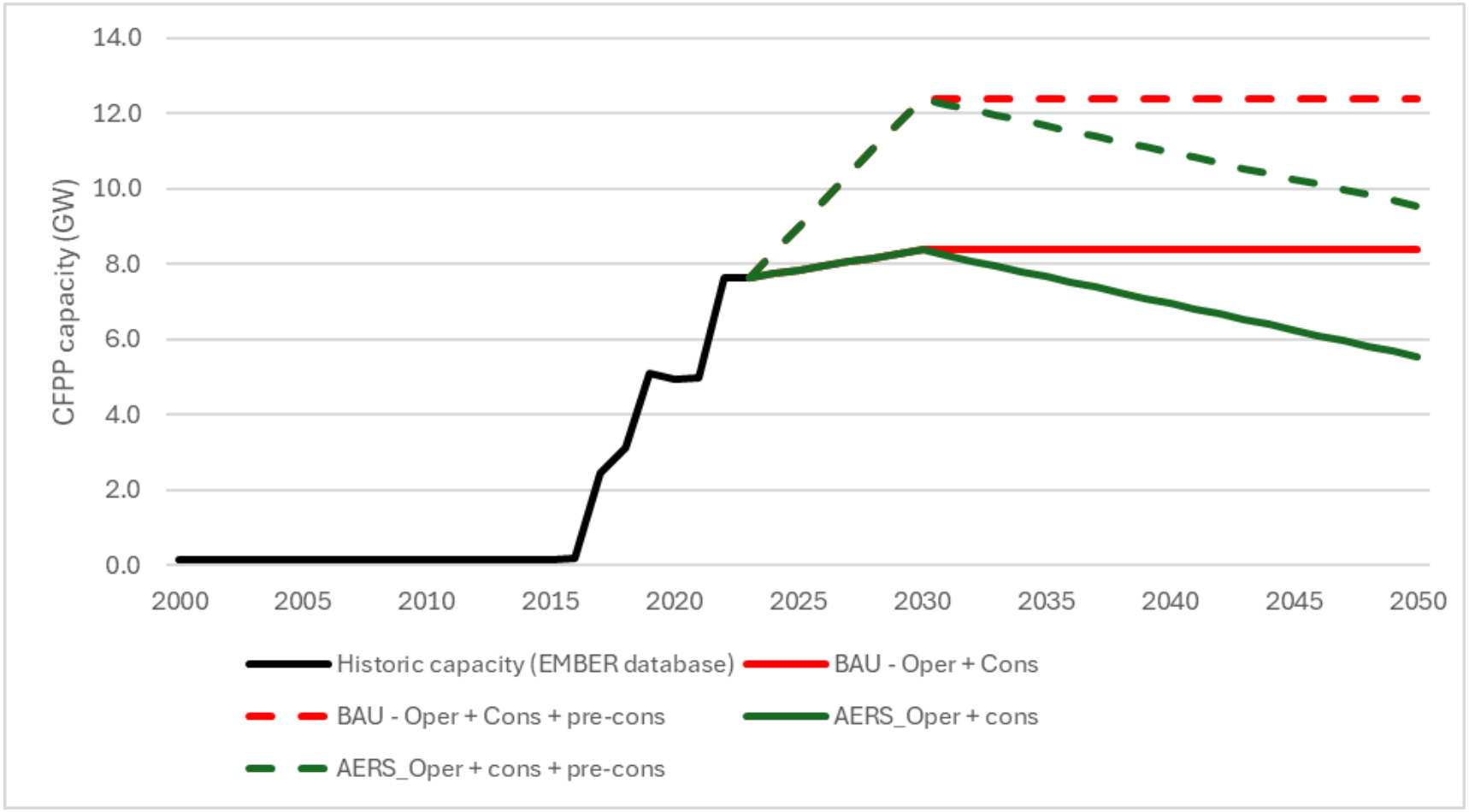
# CFPP capacity outlook - Pakistan



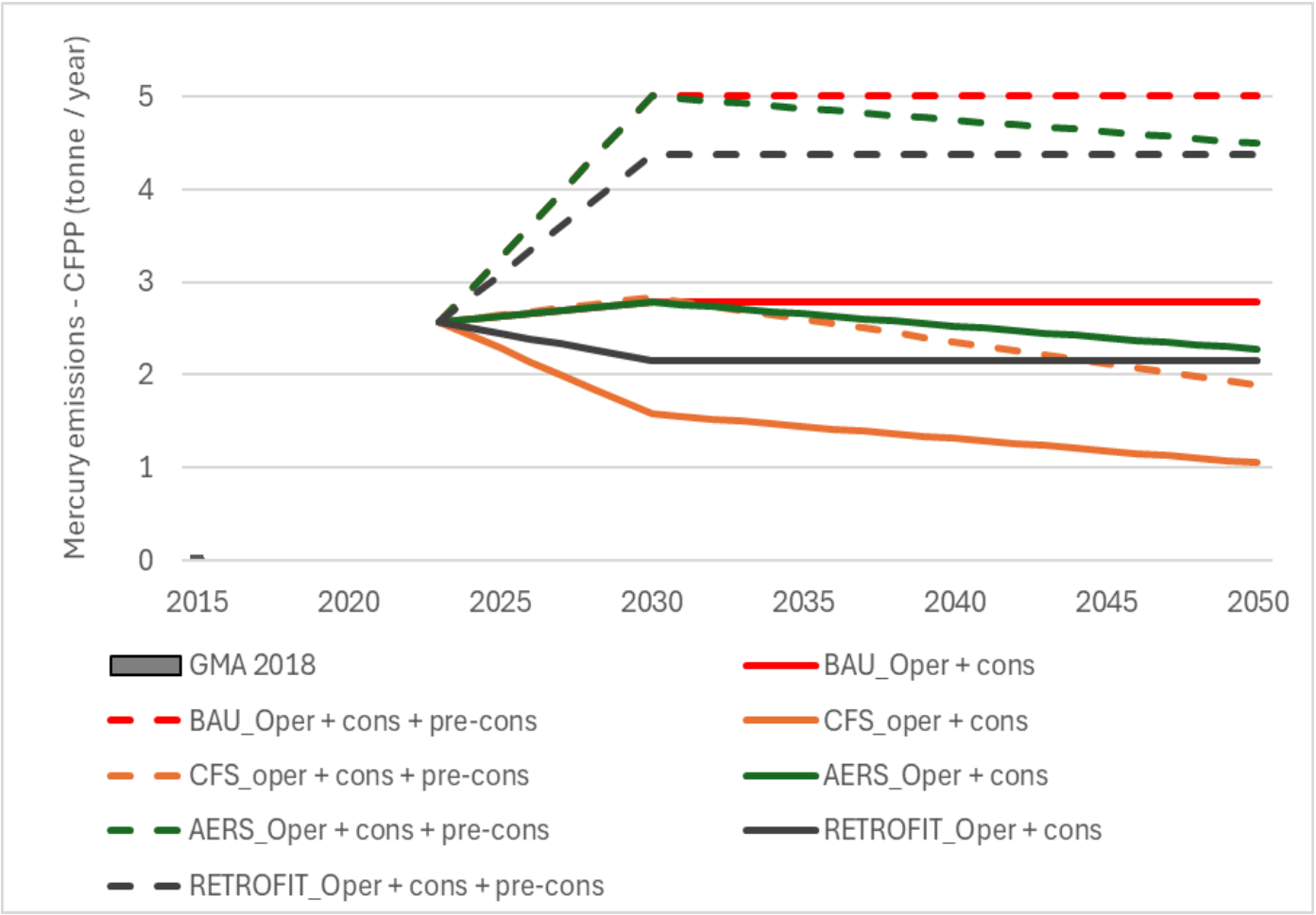

**Business-as-usual (BAU)**

2024: 7.6GW
2030: 8.4 - 12.4GW
2050: 8.4 -12.4GW

**10-year early retirement (AERS)**

2030: 8.4 - 12.4GW
2050: 5.5 - 9.5GW

# CFPP Mercury Emissions

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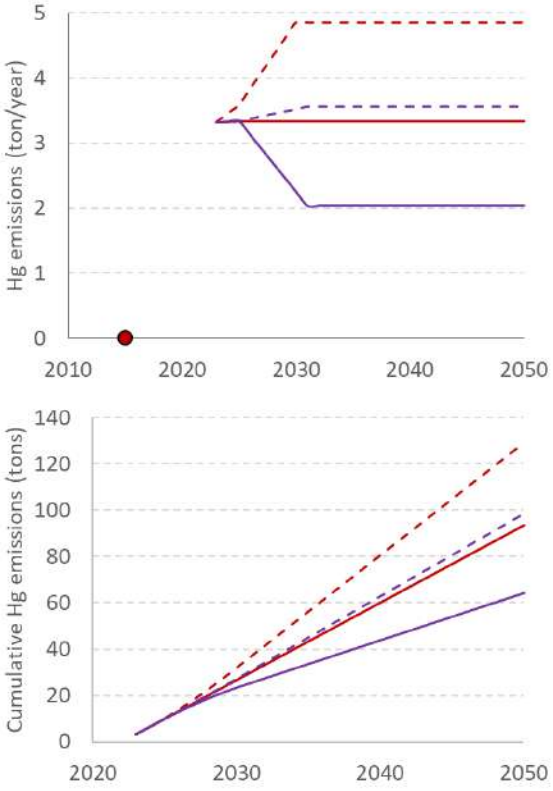
| Retrofit by | 2030 |

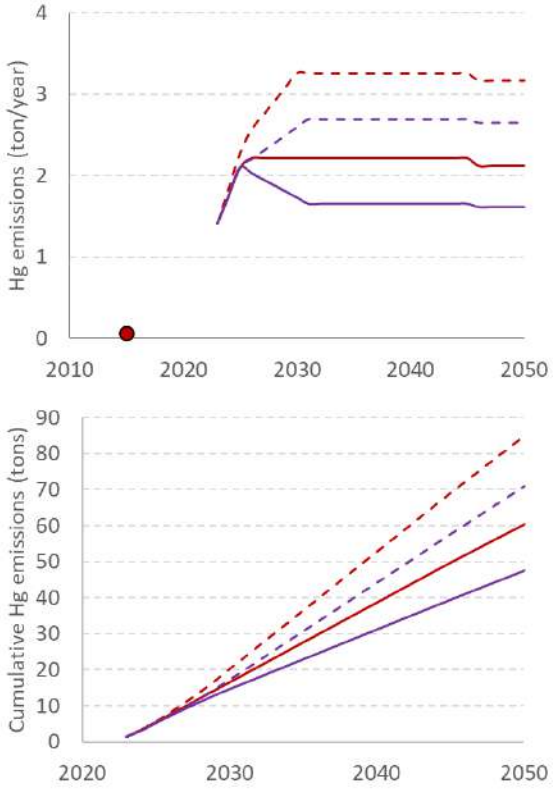
# Polarized coal dependence in Asia

*Growing CFPP dependence*

Pakistan

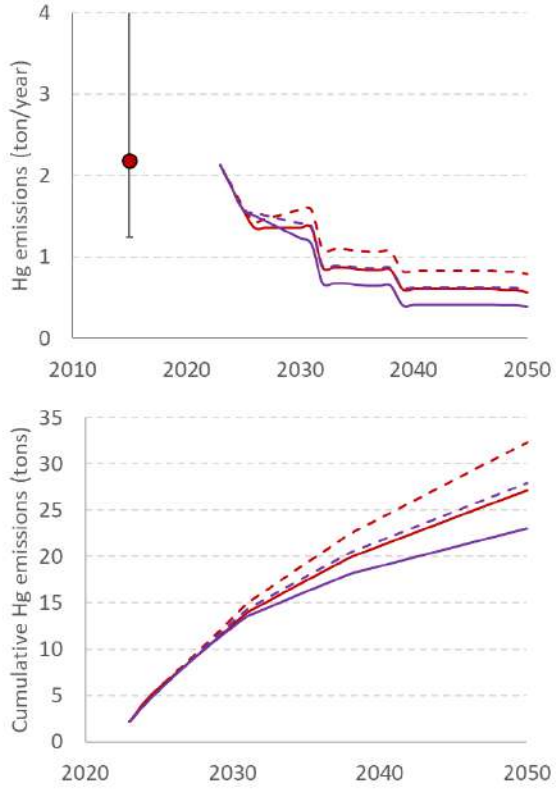



Bangladesh

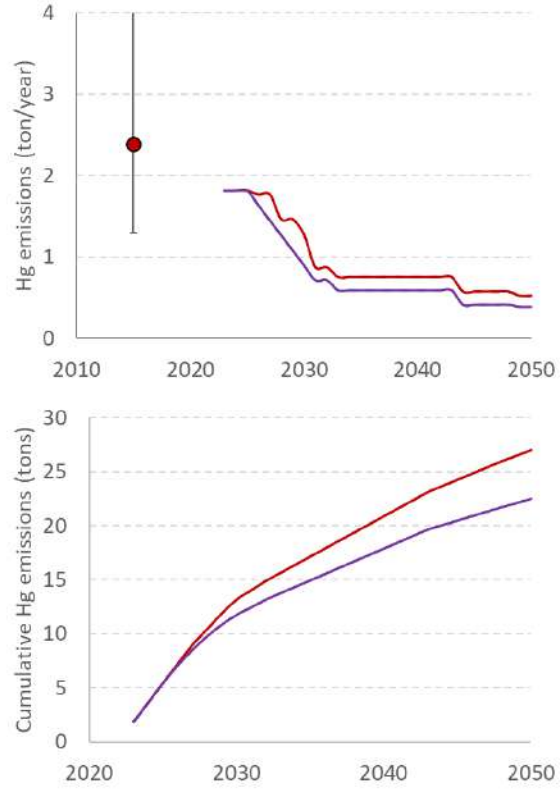



*Historic CFPP dependence*

Thailand



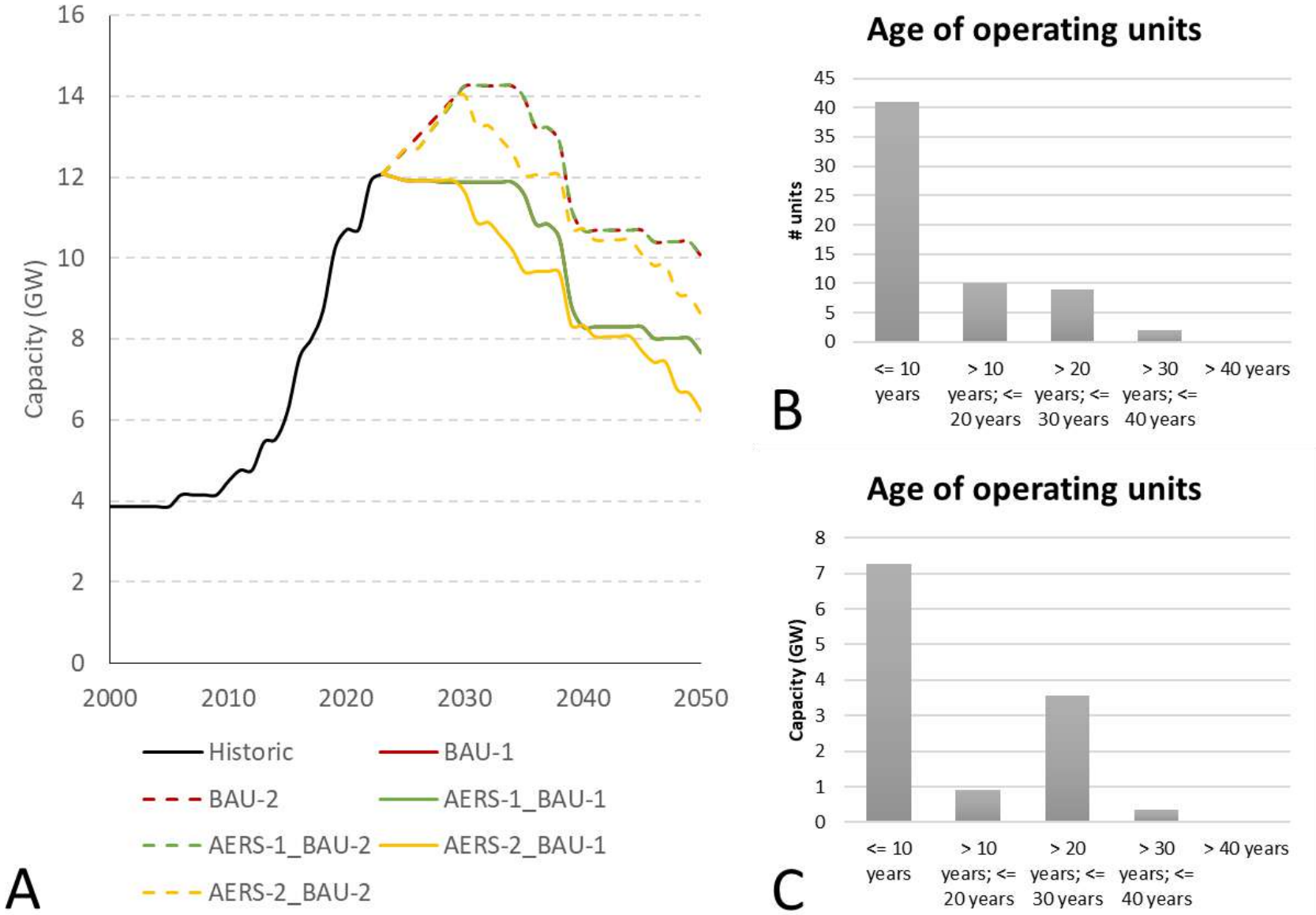

Malaysia



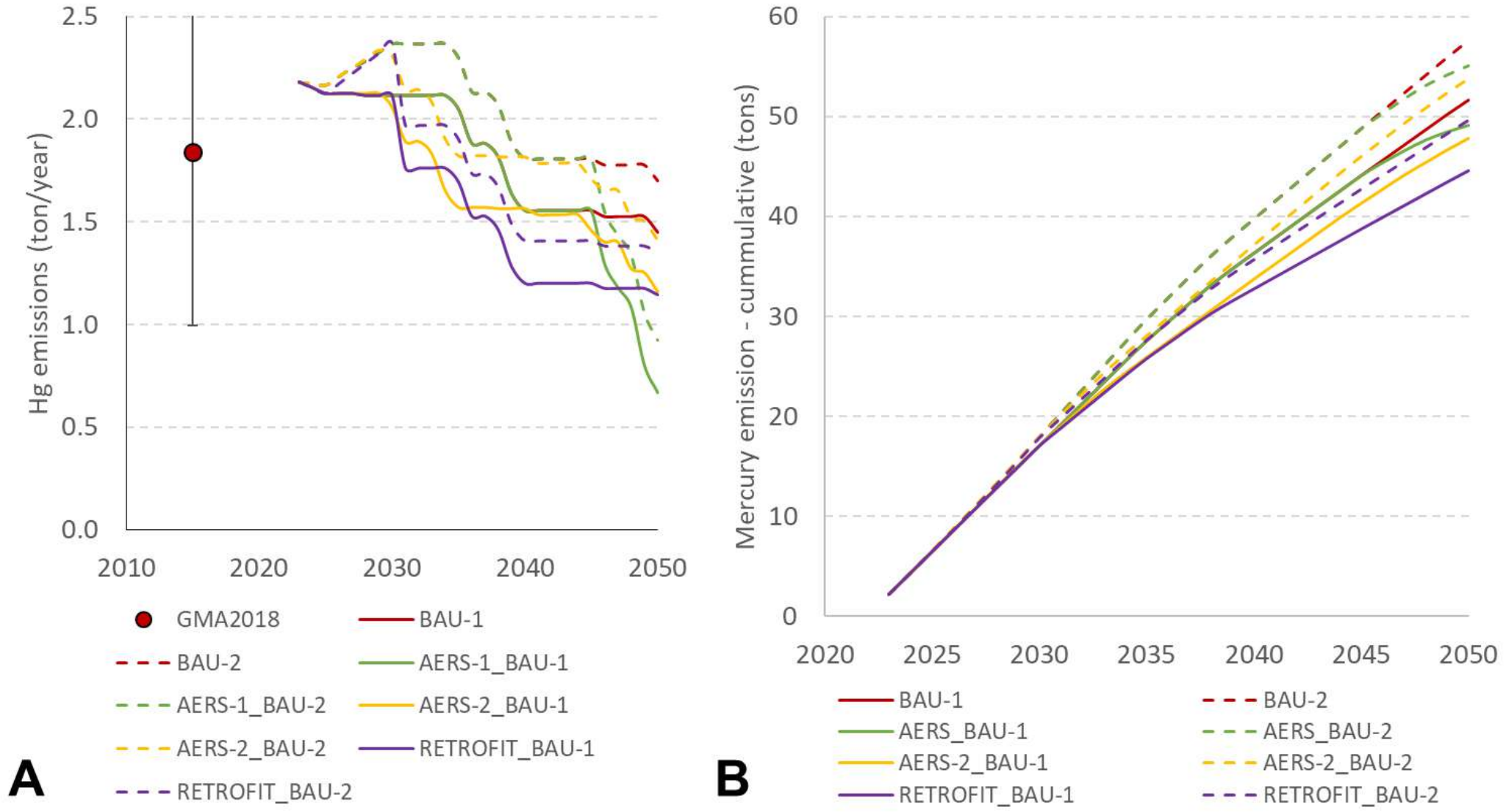
# Focus Countries

Philippines

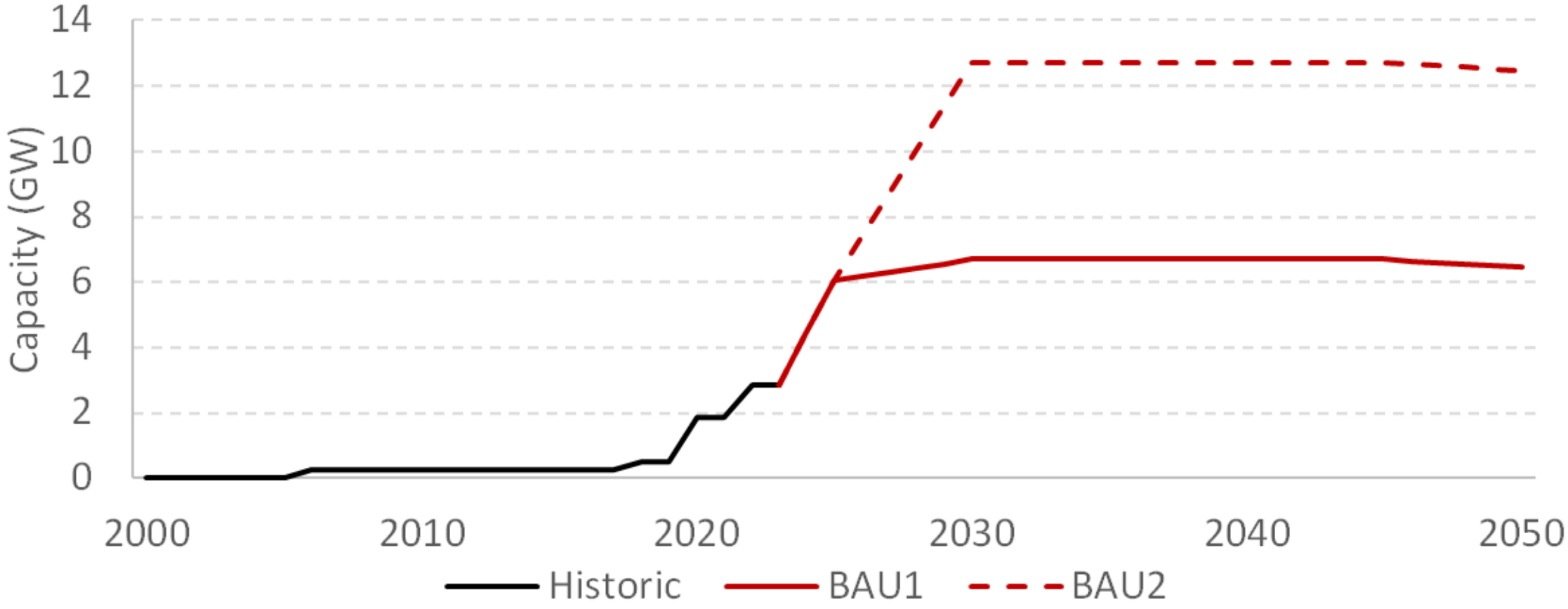
Bangladesh




**Projected CFPP capacity (GW) for the Philippines up to 2050 (A) under the business-as-usual scenario (BAU; red lines) and alternative early retirement scenarios (AERS; green and yellow lines)**




**Estimated mercury emissions (annual emissions – tons/year, A; cumulative emissions – tons, B) from the Philippines' coal-fired power plants under the business-as-usual scenario (BAU; red), alternative early retirement scenarios (AERS-1, green; AERS-2, orange) and RETROFIT scenario (purple)**




**Projected CFPP capacity (GW) for Bangladesh up to 2050 under the business-as-usual scenario (BAU; red lines)**

# Project Overview

## UNCERTAINTY FOR COUNTRY SPECIFIC ESTIMATIONS

MACQUARIE University

1. Plant/Unit-specific information on the **feed coal**
   - Variations in elemental composition of mercury, sulphur, chlorine
   - Variations in physico-chemical properties (calorific value, ash content, moisture content)
   - Proportion of coal washing
   - Blending rate with domestic/foreign coal types
   - Blending rate with biomass or municipal solid waste

2. Plant/Unit specific information on **plant performance**
   - Coal consumption and electricity generation (for consumption rate; g/kWh)
   - Nominal emissions measurement from stacks
   - Installed air pollution control devices (limited)
   - Application of dry sorbent/halogen/activated carbon injection

# Gender considerations

Gender considerations in mitigation actions for atmospheric emissions of greenhouse gas (GHG), mercury (Hg), and persistent organic pollutants (POP) coming from the combustion of coal for electricity production and other energy production practices.

Reduction of emissions of these pollutants in the coal sector are critical to **reducing health risks** associated with their exposure to humans and ecosystems

Although **gender considerations are embedded under each Convention**, the reality of diverse social- and economic status in countries worldwide provides a challenging platform to effectively address gender-related matters under a single action plan for all countries

Regardless, the **health impacts resulting from coal-fired emissions** are ubiquitous worldwide and rely on either the operation of improved air pollution control device (APCD) configurations or an outlook for an accelerated transition towards non-fossil fuel energy generation, from which the latter is the preferred pathway towards climate action and improved health in an ever-expanding global population

Gender considerations (health, norms, and roles) can potentially influence energy consumption patterns and usage behaviours, making gender-sensitive training and awareness campaigns essential for promoting sustainable energy practices

Associate Professor Maryam Khalid

Her research sits at the intersection global governance, human rights, race, gender, and sexuality in global politics and international relations

# Conclusions

MACQUARIE University

- Developing countries are unlikely to phase out coal in the next two decades due to energy security concerns and the intermittent nature of solar/wind power generation.
  - Global pressures to decarbonize the energy sector will impact future emissions.
  - The successful implementation of the Just Energy Partnership and Energy Transition Mechanisms for Southeast Asia requires careful evaluation.

- Global emissions and coal-fired power plant capacity are expected to peak between 2025 and 2030.

- If new plants operate for around 40 years and existing plants are decommissioned according to their design life, mercury emissions will significantly reduce by 2050.
  - China's coal-fired power plant sector is expected to see major emissions reductions, but less so in the industrial boiler sector (and possibly for other countries as well).

- Mercury and POPs emissions reduction will be improved through the co-benefit of NOx, SOx, PM pollution control devices in newly-constructed units and/or retrofitting to existing infrastructure.
  - India and Indonesia should promote FGD installation in both power plant and industrial boiler sectors

- Captive coal fired plants (eg for mineral processing in the non-ferrous sector) may have a large impact on prolonging coal use

# Session 5

Primary Strategies for Emissions Reduction and the way ahead

- Coal phase-out strategy
- Improved Air Pollution Control Strategy
- GlidePath to lower emissions (presented by Professor Lesley Sloss, EPRI)

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

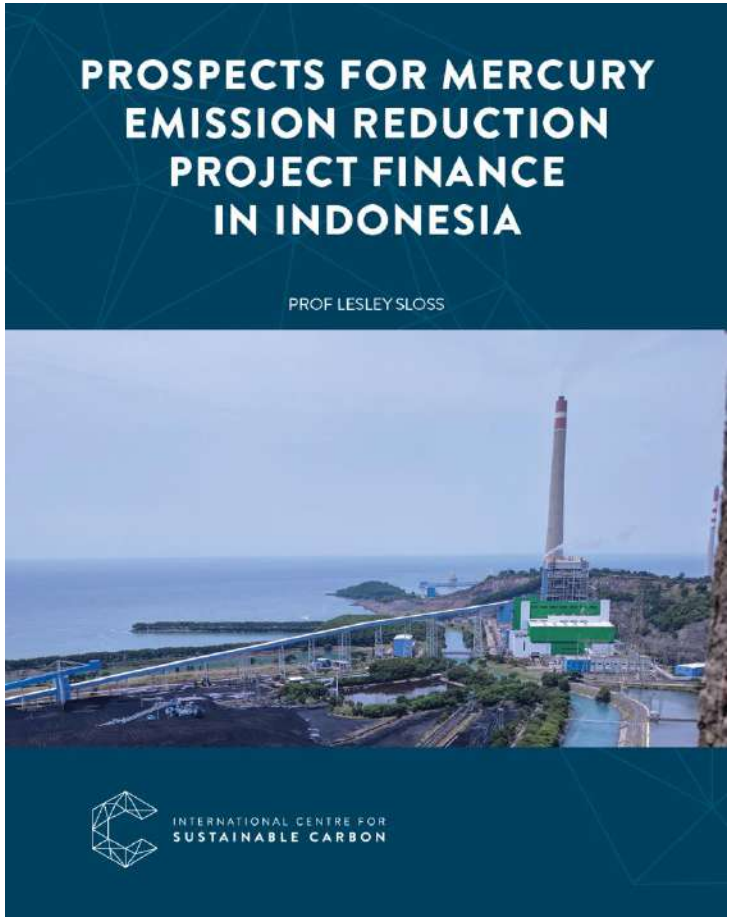
MACQUARIE University

- 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



# Project Outcome 2:

## Contribution to future GEF projects

MACQUARIE University

- **BAT/BEP** Co-benefit of emissions control from APCDs are well-known

- Options to meet climate action goals:
  - APCD retrofit, including deployment of CCUS in all units (high cost, stranded asset risk)
  - CFPP flexibility (reduced emissions to facilitate RE transition)
  - Early retirement of CFPPs (new projects will become stranded, risk to meet energy demand)

- For countries that will still rely on coal-fired power production
  - Plant/Unit-specific modifications in operation?
  - Coal choice & blending options?
  - Training on emissions monitoring & forecasting?

- For countries considering an accelerated transition to RE
  - Roadmap to energy transition mechanism
    - Facilitating the procedure
    - Refined selection criteria for the next phases of CFPPs in the mechanism

# Conclusions

**Global CFPP capacity & $CO_2$ emissions peak by 2027/30**

- Global mercury emissions likely already declining
- Subject to CFPP projects under pre-construction
- Global trajectory dominated by China
- SE Asia continuing with coal development - less multi-pollutant emissions control
- Uncertainties for CFIB sector: Limited country-wide information

**Climate action driven by…**

**Retiring plants earlier than planned**

- Pace of renewable energy development to meet rising energy demands and replace fossil fuel capacity
- International support for emerging economies
- Socio-economic considerations (e.g., unemployment - mining & utility sector)

**Multi-pollutant emissions control installations**

- Influenced by current & future policies on emission norms
- Consider stranded asset risk & additional carbon intensity
- Unit-specific cost-benefit analysis needed

**Health Impacts of air pollutants**

- Fine particle pollution role in the Global burden of disease
- Large impacts on mortality and morbidity
- Coal combustion are major contributor to exposure
- Key consideration for regulators
- Mercury control effected by co-benefit effects

# Thank you

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# QUESTIONS? OPEN DISCUSSION