Policy Brief

A GLOBAL PLANT-BY-PLANT COAL PHASE-OUT STRATEGY

Reducing global greenhouse gas emissions requires structured coal phase-out strategies for all countries with large coal fleets. This brief presents global plant-by-plant retirement pathways that balance multiple national development priorities and societal objectives while also supporting national net-zero targets and a global 1.5°C warming goal. We find that:

1. **A feasible 2030 phase-out for OECD countries and a 2045 phase-out for the rest of the world will, by itself, reduce global energy CO_2 emissions by 15% in 2030 and by one-third in 2045.**
2. **Among the 10 countries with the largest coal fleets—accounting for over 90% of global capacity—retirements would be driven by unfavorable technical attributes (primarily for the U.S. and E.U. countries) and significant environmental benefits, such as improved air quality and water security (primarily for China and India).**
3. **Globally, we identify 817 GW of coal retirement potential through 2030 out of a current total of 2,070 GW in operation, including 222 GW of small, old, inefficient, and dirty plants and an additional 595 GW of plants older than 30 years in 2030. These retirements would reduce 40% of today's coal power emissions; remaining plants would need to lower utilization to keep a 1.5°C-compatible coal phaseout within reach.**

In 2020, global total coal consumption reached 7.98 billion tons[1], and the majority is consumed for electricity generation[2]. Unabated coal power generation is the single largest emitting sector globally, accounting for 30% of all energy-related global carbon dioxide (CO_2) emissions.[3] As the world seeks to rapidly increase ambition to limit warming to 1.5°C, phasing out unabated coal power generation without carbon capture and storage (CCS) creates the largest potential for near-term, low-cost emission reductions.

An accelerated coal phase-out will generate large, immediate emission reductions for the top-emitting countries. The 10 countries with the largest existing coal power generation capacity—China, the United States (U.S.), India, the European Union (E.U.), Japan, Russia, South Africa, South Korea, Indonesia, and Australia—account for over 90% of global total coal power capacity and nearly 72% of total global GHG emissions. A majority of these countries have announced net-zero targets. Phasing out unabated coal power generation will lead to substantial emissions reductions and help meet these net-zero targets.

An accelerated coal phase-out will also generate broader societal benefits, for example, benefits in air quality and human health and water security. But without structured phase-out strategies that integrate economic, environmental, and social objectives, negative impacts such as employment losses and stranded assets will challenge the ability to move beyond coal. While each country has its own opportunities and challenges, many of these are shared. A consistent framework can help identify cross-country differences and inform specific strategies that help meet both emissions goals and national priorities.

This policy brief series explores near-term coal retirement potentials and develops plant-by-plant retirement pathways to achieve 1.5°C-compatible phaseouts for individual countries. To balance broader national development goals, we apply a five-dimensional framework that integrates technical, economic, environmental, security, and social criteria (Figure A1). This approach allows us to explore the shared and different opportunities and challenges of a rapid coal phase-out across countries. Three important findings emerge from our analysis:

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First, a rapid global coal phase-out would deliver large, immediate, low-cost emissions reductions. A 2030 phase-out for OECD countries and a 2045 phase-out for the rest of the world will, by itself, reduce emissions by 5.1 $GtCO_2$ in 2030 and by 10.1 $GtCO_2$ in 2045 (Figure 1), accounting for one-third of today's global energy CO_2 emissions.[4] Over 90% of these emission reductions will come from the 10 countries with the largest coal fleets. Our plant-level analysis shows that canceling new projects that have not started construction and retiring plants once they reach 30-years-old is in line with the 2°C temperature goal. A 1.5°C-compatible coal phase-out would require faster retirements with shorter lifetimes and lower utilization.

Second, our globally consistent assessment through the five-dimensional framework shows that coal retirement opportunities vary largely from country to country. Among the top 10 countries, coal fleets in the U.S., the E.U., Russia, South Africa, and Australia are much older compared to those in China, India, and Indonesia. Japan and South Korea are the only OECD regions that added large new capacity in recent years (Figure 2). Coal plants in Indonesia and Russia are generally smaller, while South Korean and South African coal plants are the largest on average (Figure 2). However, all countries have a considerable number of smaller plants that could be retired rapidly. There is a large regional variation in coal plants' environmental impacts (Figure 2). China and India in particular have a larger potential for benefits in air quality and health and water security through coal retirement.

Third, we identify a total of 222 GW of low-hanging fruit (LHF) plants globally (11% of current capacity) that are suitable for rapid shutdown in the near term largely in service of other societal goals. These plants perform poorly across all technical, economic, and environmental criteria evaluated. Retiring plants 30 years and older by 2030, in addition to the LHF plants, will increase total retirement to 817 GW. However, this is insufficient to achieve a 2030 phase-out in the OECD countries. An additional 98 GW of existing capacity needs to be retired in the five OECD countries, and Japan and South Korea would need to cancel new builds. Among the five non-OECD countries, retiring the LHF plants and plants older than 30 years by 2030 will reduce existing coal power capacity by a small share in China, India, and Indonesia, but by a large share in Russia and South Africa (Figure 1). Moreover, with many new projects currently under construction, it is uncertain whether these retirements will offset new capacity additions in China, India, and Indonesia. For these countries, it is critical to cancel new projects. The remaining 2030 emissions gap to the 1.5°C compatible pathway[1] can be filled by lowering coal plants' utilizations.

Global CO_2 Emissions from Coal Power Generation

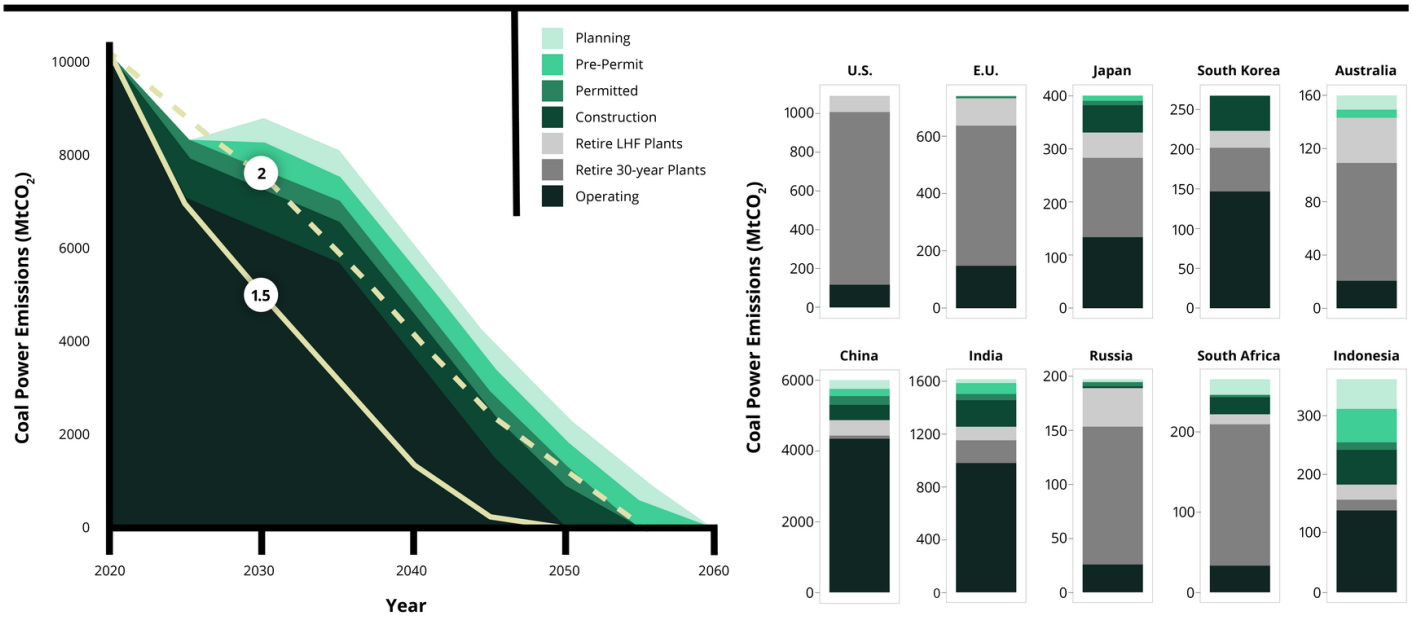

Figure 1. Global CO_2 Emissions from Existing and Proposed Coal Power Capacity over time and the Snapshot of Coal Power Emissions in the Top 10 Countries in 2030. Areas show the emissions shadow from coal capacity in operation, under construction, permitted, permitting, and planning over time, assuming a 30-year lifetime for all plants and constant utilization at today's levels. The solid line shows a 1.5°C pathway with a 2030 phase-out for OECD countries and a 2045 phase-out for the rest of the world, and the dashed line shows a 2°C pathway with a 2055 global coal phase-out. Bars show emissions from potential new builds through 2030 and the remaining operating plants in 2030 for each country. It also shows emission reductions from potential retirements through 2030, including retirements of plants considered to be low-hanging fruit (see Appendix for method) and plants 30 years and older by 2030.

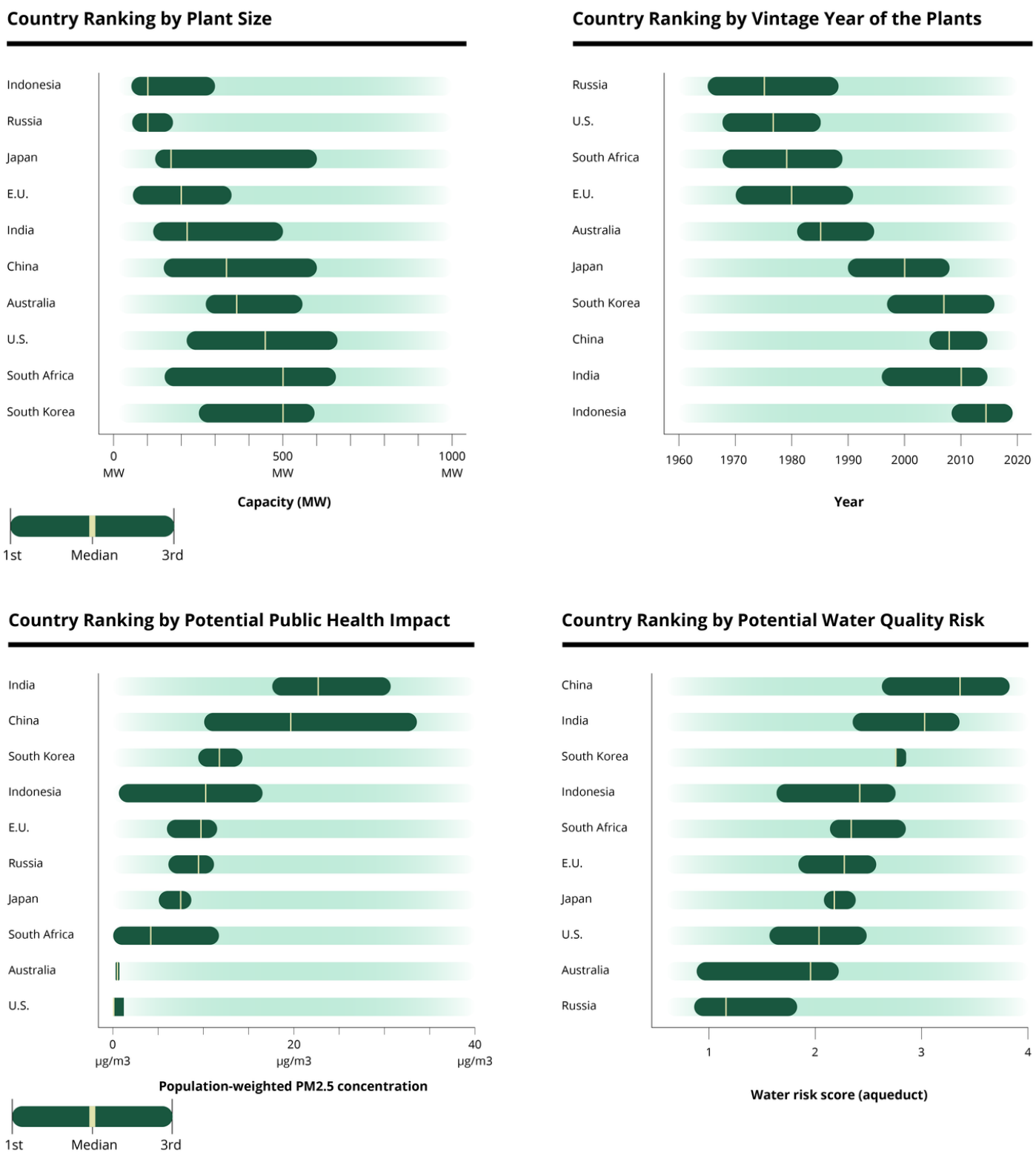

Figure 2. Ranking of Coal Plants of Selected Metrics across the Top 10 Countries. The distribution of each metric is based on the global ranking of all coal plants. Dark green bars show the 1st and 3rd quartile values of all plants in each country, and the yellow line shows the median value. Top panels show plant size and plant vintage; bottom panels show population-weighted PM2.5 concentration and the water risk score at the plant's location.

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APPENDIX: METHOD

In this policy brief series, we apply a multi-dimensional analytical framework (Figure A1) to structure 1.5°C-compatible coal phase-out strategies across countries. We combine plant-level data and analysis with long-term decarbonization scenarios from a globally integrated assessment model (the Global Change Analysis Model, GCAM, jgcri.github.io/gcam-doc/). The retirement pathways are developed based on the bottom-up plant-by-plant retirement priority scoring system and the top-down 1.5°C-compatible national pathways.

First, we develop the plant-by-plant retirement priority ranking based on multiple technical, economic, and environmental criteria to all the operating and under-construction coal-fired power plants up to January 2021 in each country.[5] A lower score indicates that the plant could be retired early due to poorer technical attributes, a worse economic performance, and/or higher environmental impacts, while a higher score closer to one indicates the plant could be the last to retire. Using the ranking system, we also identify the low-hanging fruit plants that are particularly suitable for rapid near-term retirement: those that are at the bottom 50% for all three dimensions evaluated.

Second, using an integrated assessment modeling framework in GCAM, we develop a global 1.5°C compatible emissions pathway scenario that includes national net-zero targets of the key countries. Starting in 2025, regional carbon prices are applied to reach net-zero GHG emissions by 2050 in the U.S., the E.U., Canada, Japan, and South Korea, and net-zero CO_2 emissions by 2050 in China and the rest of the world. We also develop a global 2°C scenario where the world achieves net-zero CO_2 by 2065. Carbon prices are applied to all sectors of the economy and emission reductions occur where it is most economical. Therefore, our results indicate the mitigation that would occur in the power sector if all sectors reduce emissions at the same marginal abatement costs. The 1.5°C compatible pathways suggest unabated coal power generation without CCS needs to decline immediately after 2020, if not earlier, in all countries. In our plant-by-plant analysis, we allow new plants already under construction to be implemented. As a result, countries with new capacity additions will result in faster retirements of existing capacity and/or larger reductions in coal plants' utilizations.

Finally, the national coal power generation constraint from GCAM is met in each country by retiring individual coal plants, including those in operation or under construction, one by one starting from the lowest to highest combined score and assuming all coal plants will continue to operate at today's utilization levels. Using this approach, we identify the retirement year and retirement age for each coal plant. We then apply a minimum guaranteed lifetime (20 years) to plants that are retired before that age, unless they are identified as low-hanging fruit. As some of the coal plants are retired later than they need to be to meet the national coal generation constraints from GCAM, coal plants' utilizations are reduced from today's levels.[7]

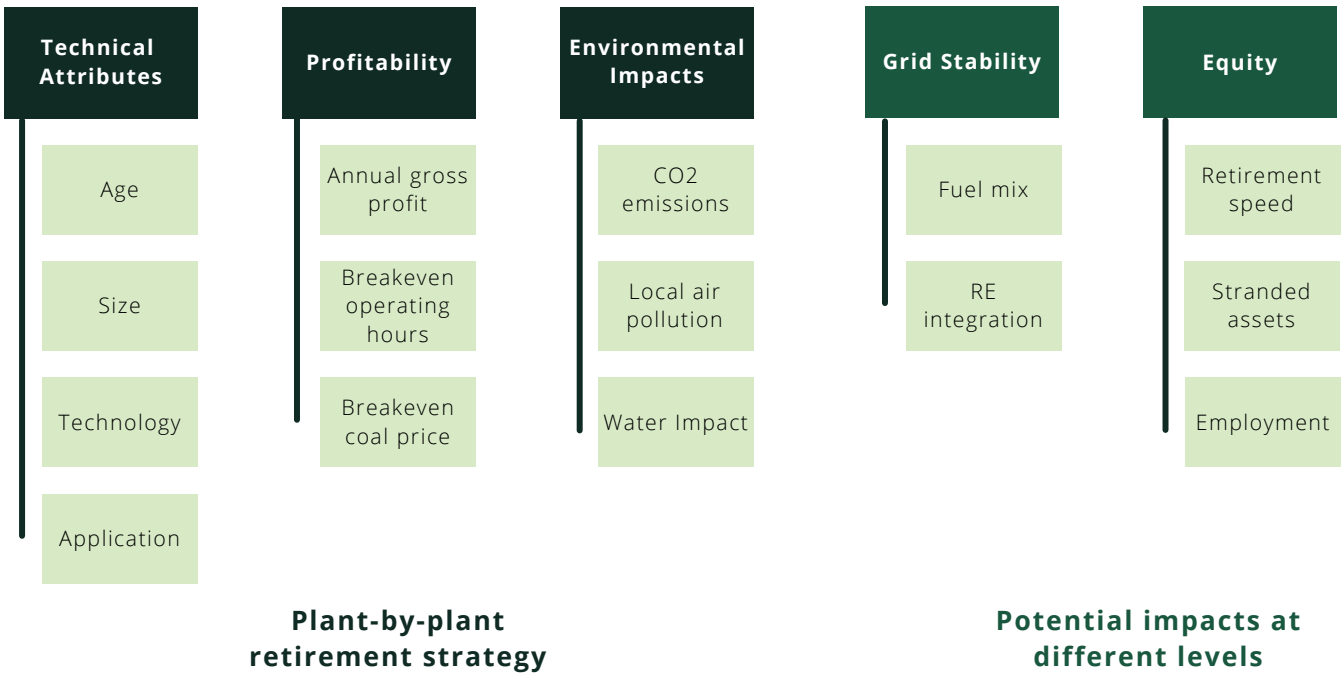

Figure A1. Five-Dimensional Analytical Framework of Coal Power Phase-Out. Each dimension is assessed through a set of metrics.

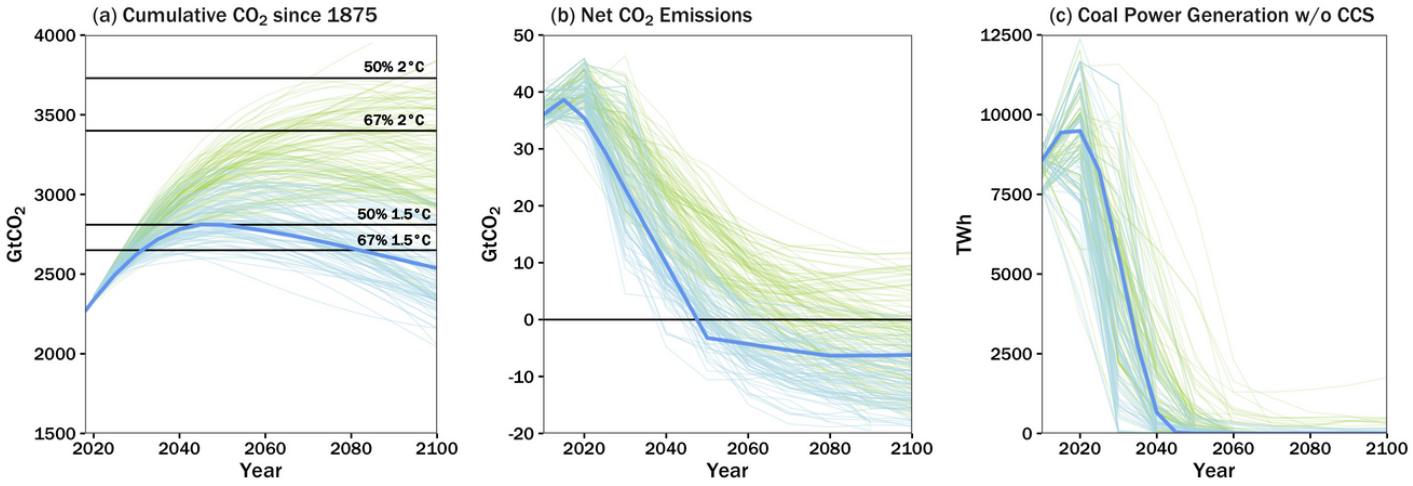

Figure A2. Comparison of the GCAM 1.5°C scenario applied in this analysis (thick blue line) to the set of scenarios from the integrated assessment modeling community in the IAMC 1.5°C Scenario Explorer[6] database: (a) the 1.5°C compatible scenario has better than a 50% probability of limiting warming to 1.5°C goal throughout the century; (b) global net CO_2 emissions reach net-zero by 2050 and to about -6.3 $GtCO_2$ at the end of the century; (c) global coal power generation without carbon capture and storage (CCS) is phased out between 2045 and 2050. The lighter lines are scenarios from the IAMC 1.5°C Scenario Explorer. The light blue lines indicate scenarios categorized as below 1.5°C and 1.5°C low overshoot, and the light green lines indicate scenarios categorized as lower 2°C in the database.

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