

1 Appendix

2 Post-COVID Coal Power Capacity Scenarios

3 This Appendix describes the methodology employed to extrapolate historical country-level coal power
4 capacity data to generate bottom-up scenarios for 2025, the REMIND model period immediately
5 following the COVID-19 crisis. The intention is to estimate an uncertainty range – not a projection – of
6 the aggregate effect of national COVID recovery programs on near-term trajectories for the global coal
7 power sector. REMIND takes these stylized scenarios – *neutral*, *green*, and *brown* recoveries – as
8 various starting points for the energy system. Our analysis aims to determine the sensitivity – or path-
9 dependency – of long-term scenario results to these initial conditions.

10 Data Procurement

11 The Global Energy Monitor’s Global Coal Plant Tracker¹ (GCPT) is an open source database with
12 coverage of effectively all coal power plants larger than 30 MW, currently operating or not, dating back
13 to 1927. The data used for this study is from the January 2021 release. The publicly disseminated
14 [‘Summary Statistics’](#) report existing and planned capacity by country, categorized by status into
15 ‘Operating’, ‘Announced’, ‘Pre-permit’, ‘Permitted’, ‘Under Construction’, ‘Shelved’, ‘Mothballed’,
16 ‘Cancelled’ and ‘Retired’ assets. Additional datasets, distributed to mailing list subscribers and freely
17 available upon request, contain information at the individual plant level, such as plant age, year of
18 retirement or planned retirement, conversion efficiency and lifetime emissions. A separate plant-level
19 datasheet which provides semi-annual updates to plant status since 2014 was received upon request.

20 Data Manipulation

21 All GCPT data is read into R using the [readGCPT](#) function, part of the [mrremind](#)² package developed by
22 the Potsdam Institute for Climate Impact Research. The function is used to consolidate historical
23 capacity data into specialized array format ([magclass](#)³ objects) and to calculate national mean plant
24 lifespans, project completion rate of each pipeline phase, and scenarios for future capacity and
25 associated emissions. National plant lifespans are calculated as the mean age at which power plants in
26 each country are retired, weighted by the megawatt-capacity of the plant. The GCPT plant-level
27 datasheet provides 100% coverage of the retirement age of retired plants and 99.9% coverage of their
28 capacities.

29 The calculation of phase-specific national project completion rates is – to our knowledge – a novelty
30 of this study. This consists of several steps. First, a plant-level datasheet tracking the lifecycle stage of
31 each asset is parsed to compile transition flows, i.e. the number of plants which changed from
32 announced to operating, from permitted to canceled or from construction to shelved to operating, for
33 example. In total, 36 flow permutations are tracked and aggregated to the country level. Second, these
34 flows are used to compute the rates with which projects in each phase have been cancelled or shelved
35 in each country. Importantly, since shelved construction projects are much more likely to eventually
36 reach completion than shelved pre-permit projects, we derive the cancellation rates of shelved
37 projects specific to each previous stage of development.

38 Third, a significant fraction of the coal pipeline can be found in developing nations with a nascent coal
39 power industry, hence their historical project data are either unreliable or nonexistent. Thus, we
40 calculate the weighted mean cancellation and shelving rates of each of REMIND’s 12 world regions
41 (Figure M1), and any nation with over 50% of its entire coal history in the planning phases are assigned
42 their region’s value. Finally, national completion rates are calculated by subtracting the phase-specific
43 cancellation and shelving rates from 100%.

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Region	Announced		Pre-permit		Permitted		Construction		Shelved	
	Capacity (GW)	Comp. Rate								
Canada, AUS, New Zealand	2.0	70.9%	1.0	0.0%	0.0	7.2%	0.0	7.2%	2.2	0.0%
China	57.4	28.1%	48.2	51.4%	53.2	72.0%	88.1	91.6%	38.8	5.9%
EU-28	0.0	26.3%	0.5	24.1%	0.1	76.9%	1.2	95.3%	0.0	4.7%
Former Soviet Union	0.8	44.9%	1.0	73.5%	0.0	32.5%	1.0	94.4%	2.8	6.4%
India	6.0	20.0%	13.9	26.0%	9.4	37.5%	36.6	83.9%	36.8	10.6%
Japan	0.0	49.2%	1.2	65.0%	1.3	70.1%	7.3	100.0%	0.0	7.2%
Latin America	1.4	36.4%	0.7	0.0%	2.0	25.2%	0.0	96.9%	1.0	15.2%
MENA	0.0	37.1%	0.0	0.0%	0.0	81.6%	2.4	91.5%	17.5	0.0%
Non-EU Europe	6.0	44.8%	11.6	35.0%	6.0	49.8%	2.0	100.0%	3.9	0.9%
Other Asian States	34.4	33.3%	37.2	70.8%	14.5	92.3%	36.0	99.6%	32.8	4.1%
Sub-Saharan Africa	8.3	35.7%	2.5	22.3%	3.0	47.6%	4.9	98.8%	16.2	0.0%
USA	0.0	7.2%	0.0	0.0%	0.0	0.0%	0.0	6.0%	0.0	0.0%
World	116.3	31.6%	117.8	51.7%	89.4	68.3%	179.7	92.3%	151.9	5.2%

45 **Table A1. Size of the coal pipeline by project cycle phase and the historical completion rates of each phase,**
46 **aggregated to the REMIND regional level.** Completion rates are calculated based on projects that were
47 constructed, canceled, or shelved between 2014 and 2020.

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Region	Shelving Rates			
	Announced	Pre-permit	Permitted	Construction
Canada, AUS, New Zealand	0%	44%	15%	5%
China	12%	16%	20%	7%
EU-28	34%	25%	0%	0%
Former Soviet Union	18%	0%	0%	5%
India	28%	25%	12%	3%
Japan	2%	0%	0%	0%
Latin America	11%	12%	33%	3%
MENA	36%	0%	0%	13%
Non-EU Europe	10%	11%	2%	0%
Other Asian States	21%	14%	4%	0%
Sub-Saharan Africa	41%	53%	37%	1%
USA	18%	0%	0%	0%
World	16%	18%	13%	3%

49 **Table A2. Shelving rates of projects in each pipeline phase.** Any country that did not shelve any projects in a
50 particular phase is assigned its region's value, and any region without shelved projects in a certain phase is
51 assigned the global weighted average.

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53 [Post-COVID Capacity Scenarios](#)

54 A set of assumptions, summarized in Table A3, are overlaid on the historical values computed above
55 to extrapolate 2025 capacity scenarios. In short, the MW capacity in each of the pipeline phases are
56 multiplied by the country's phase-specific completion rate and added to the operating capacity in
57 2020. Meanwhile, all plants which reach its nation's historical mean lifespan will be subtracted from
58 the 2020 operating capacity. Additionally, any plants with a planned retirement date of 2027 or
59 earlier will also be considered retired¹.

	Project Phase Affected	BAU Recovery	Green Recovery	Brown Recovery
Pipeline Phase Completion Rates	Announced, Pre-permit, Permitted, Construction	2016-2020 phase-specific rates (BAU)	50% of BAU completion rates	50% of BAU cancellation rates
Shelved Project Completion Rate	Shelved	BAU	Cancel all shelved projects not yet under construction	50% of BAU cancellation rates
Plant Lifespan	Operating	Historical mean (2000-2020)	Historical mean	Historical mean + 5 yrs
Mothballed plants	Mothballed	50% retire	100% retire	50% retire
Exceptions	OECD PPCA	Non-OECD PPCA	'Greening' nations	Nascent coal consumers
	0% completion	Half the completion rate of respective scenario	Half the completion rate of respective scenario	Regional (or global) completion rates and lifespans

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61 **Table A3. Assumptions used for the extrapolation of historical coal power plant and project data to post-COVID**
62 **scenarios.**

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64 *Neutral Recovery*

65 The *neutral* scenario represents a case in which governments on aggregate do not reconsider their
66 national energy plans in their COVID recovery stimulus packages. In terms of coal-fired power plants,
67 this corresponds to a perfect continuation of national historical mean plant lifespans, and of pre-
68 pandemic completion, cancellation, and shelving rates of the project pipeline in each country (Tables
69 A1-2). The future shelving of projects, and the ultimate completion of these plants, is modeled by first
70 applying the shelving rates in Table A2 to each pipeline phase and then multiplying by the completion
71 rate of shelved plants from Table A1. Furthermore, half of the currently mothballed plants are assumed
72 to retireⁱⁱ.

73 There are some exceptions to this rule of thumb. In order to achieve their 2030 phase-out target, PPCA
74 members in the OECD and EU are assumed to complete 0% of their remaining pipelines. All other
75 current PPCA members are assumed to cut their historical completion rates in half and to cancel all
76 shelved plants. These assumptions also apply to countries which have already announced plans to
77 cancel large coal projects via press briefings. Specifically, these 'green-leaning nations' are the
78 Philippines, Spain, Bangladesh, Egypt, Pakistan, Australia, South Korea and Vietnam.

79 *Green Recovery*

80 The more optimistic *green* scenario envisions a world in which national governments account for the
81 detrimental long-term climate, financial, health, and/or environmental consequences of new coal
82 power plants in their COVID-recovery plans. Therefore, national project completion rates of all phases
83 fall to 50% of the historical (and *neutral* scenario) rates. Moreover, all mothballed plants are assumed
84 to retire, and shelved projects which have not yet entered the construction phase are assumed to be
85 cancelled. National plant retirement ages remain at the historical capacity-weighted mean, reflecting
86 the assertion that early retirements are politically more difficult than prospective project
87 cancellations⁴. OECD and EU members of the PPCA will again be assumed to cancel all projects, while
88 all other PPCA members and green-leaning nations will be assumed to cut their completion rates to
89 25% of historical rates.

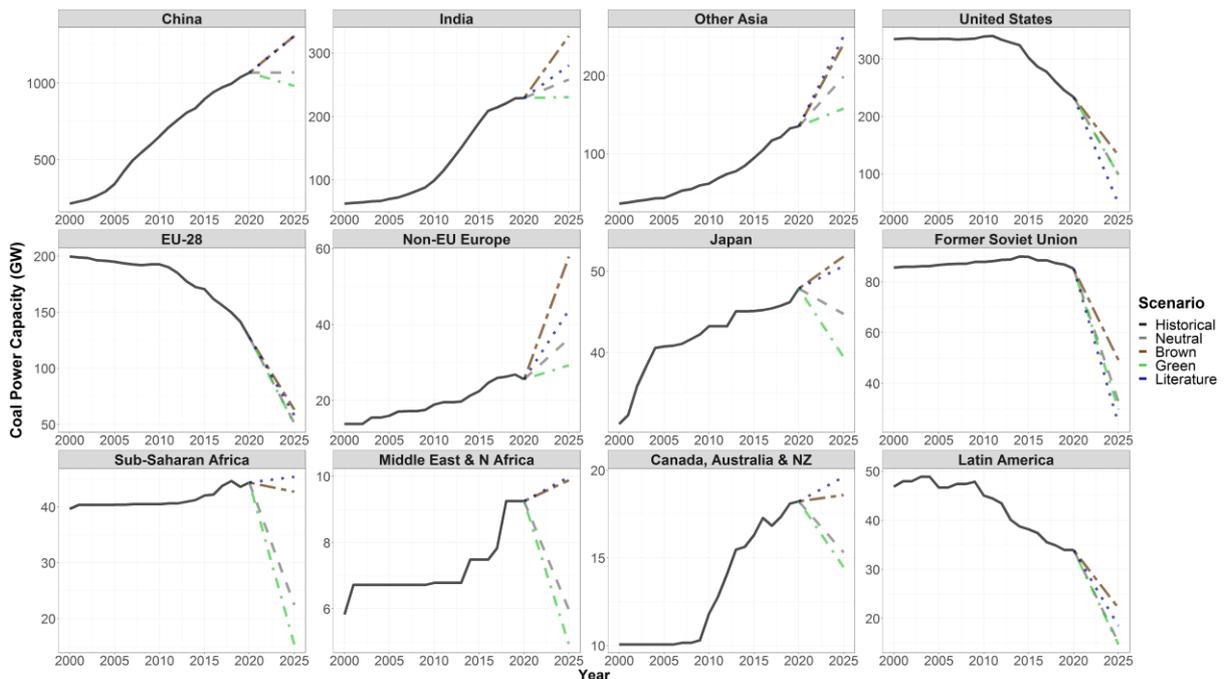
90 *Brown Recovery*

91 The *brown* scenario depicts a more cynical outlook in which national governments turn toward coal
92 power as seemingly 'safe and proven' energy investments to lift the economy out of crisis. The
93 recovery package thereby reduces the cancellation rate of all pipeline projects by 50% and increases
94 the lifespan of coal stations by five years above the national historical capacity-weighted mean. OECD
95 and EU PPCA members are unaffected by this global movement, while other PPCA members and green-
96 leaning nations are assumed to complete a larger share of their projects than in the *neutral* case but
97 still at half the rate of the rest of the world.

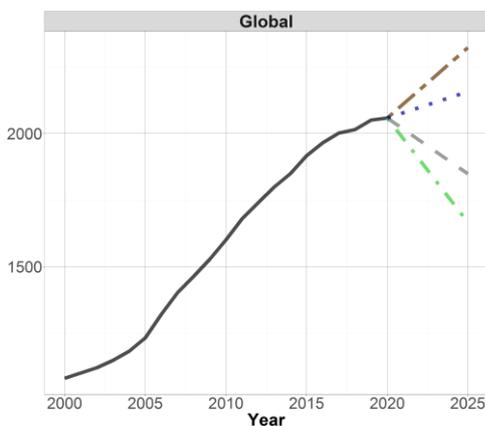
REMIND Region	Implied Emissions (GtCO ₂)		
	Green	Brown	Literature
Canada, AUS, NZ	1.9	2.9	2.5
China	68.7	107.0	184.2
EU-28	7.9	10.9	7.4
Former Soviet Union	4.3	6.4	3.2
India	31.5	45.6	46.3
Japan	5.0	7.0	6.6
Latin America	2.1	2.9	3.2
MENA	0.9	1.7	4.0
Non-EU Europe	4.7	8.8	7.4
Other Asian States	20.3	32.9	43.2
Sub-Saharan Africa	1.6	4.6	8.4
USA	13.9	19.4	6.3
World	163	250	323

98 **Table A4. The amount of CO₂ that would be emitted from coal power plants by REMIND region from varied**
99 **near-term trajectories.** Implied emissions are calculated using plant-level estimates of heat rates (technology-

100 **specific) and emissions factors (based on coal quality) given by the GCPT database¹. See Table 2 for implied**
101 **emissions from the *neutral* Covid recovery scenario. Literature = globally-uniform assumptions commonly used**
102 **in the literature, i.e. 40-year lifespans and 100% pipeline completion.**



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Region	Coal Power Capacity (GW)			
	Brown	Green	Neutral	Literature
Canada, AUS, NZ	22	15	15	18
China	1307	982	1069	1307
EU-28	63	50	51	58
Former Soviet Union	49	30	33	24
India	327	231	258	281
Japan	52	39	45	51
Latin America	19	14	15	20
MENA	10	5	6	10
Non-EU Europe	58	29	36	44
Other Asian States	241	158	199	251
Sub-Saharan Africa	43	15	22	45
USA	132	98	99	48
Global	2322	1666	1849	2157

Figure A1. Historical coal power capacity in GW from 2000-2020 and near-term scenarios extrapolated with varied assumptions, aggregated to REMIND regions and globally.

107 **Historical Capacity**

108 Historical values are derived from the GCPT at the country level by working backwards from the
109 January 2021 operating capacity. The GCPT summary statistics track annual capacity additions and
110 retirements from 2000 on. Plants added (retired) in each year were subtracted from (added to) the
111 previous year's capacity value.

112 Mothballings are only tracked from 2014 onward. Since there were no mothballed plants at the end-
113 of-year 2014 according to the GCPT, any currently mothballed plants are added to all years 2000-2014.
114 From 2015-2020, these plants were added to the 2020 value during operating years. Currently
115 operating and retired plants which were mothballed or operating in previous years were subtracted
116 and added accordingly.

117

118 **References**

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ⁱ The 2025 time-step in REMIND is a 5-year period representing the average of years 2023-2027.

ⁱⁱ Data on the fate of mothballed plants is too scarce and uncertain to derive historical rates.