

**For Health and Climate:
Retiring Coal-Fired Electricity and
Promoting Sustainable Energy Transition
in Developing Countries**

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Abstract

- Coal fuels 38% of global electricity and there are plans to build over 1,000 new coal-fired power plants, mostly in the developing countries with growing energy needs.
- Carbon emissions from those current and planned power plants will prevent the world from achieving the 1.5°C climate scenarios that call for a reduction of coal-fired electricity from 38% to 9% of total generation by 2030 and to 0.6% by 2050.
- ESG initiatives are resulting in leading global financial institutions exiting and/or avoiding new investments in coal, but other buyers are stepping in; thus, many existing and planned coal assets are likely, without intervention, to continue to operate well beyond 2030-2050.
- Proposed solution: Coal Retirement Mechanisms (CRMs) financial facilities that purchase coal-fired power plants in developing countries from existing owners and retire the plants in 10-15 years vs. typical 30-40 years of operation. Funds paid to current owners of coal-fired power plants to be recycled into new greenfield sustainable power.
- The CRM's capital would come from developed countries, multilateral development banks, climate funds and/or blended finance. Those investors would be paid back from the power plants' operating revenues, but at a lower rate of return reflecting today's low costs of funds. Supplementary revenue from carbon credits, transfer of fossil fuel subsidies, or energy surcharges might be used to meet or accelerate the retirement date.
- Parallel to the CRM, a Sustainable Energy Transition Mechanism (SETM) will provide host countries with both financial and technical assistance to accelerate transition towards renewables (including storage, transmission, and distribution infrastructure).
- Rather than create a new global financial institution/bureaucracy, an existing global or regional multilateral bank could act as lead shareholder and operator of the CRM/SETM in each host country.
- Both the CRM and SETM must be aligned with the host country's agreed national emission reduction targets with hard limits / moratoria on new builds; adherence to targets would be achieved through relevant agreements and default provisions in the financing arrangements.
- The 10-15-year transition period allows host nations, with SETM assistance, sufficient time to manage the energy transition without sacrificing energy security and to provide economic and other assistance to ensure a just transition for affected workers, communities, and businesses.
- Such an arrangement would be consistent with the Paris Agreement and previous climate summits, including promised funding by developed countries to help developing countries achieve less carbon-intensive growth; it could be promoted at COP26 as a means to accelerate emission reductions versus current trends.

Key words

Coal-fired electricity, carbon emissions, climate change, sustainable energy transition, financing

Introduction

2020 will be remembered as the year that the world's two biggest crises wreaked havoc with lives and economies. The climate crisis took center stage at the start of the year with record bushfires in Australia and a rising chorus for climate action in national capitals and at the Annual World Economic Forum Meeting in Davos, only to be overtaken by the COVID-19 crisis, the greatest global health and economic challenge since the Great Depression. As multi-billion-dollar COVID-19 rescue packages are debated and dispensed in Europe and the U.S., and as leaders of the United Nations² and IMF³ call for the world to invest in a green recovery, perhaps the most accessible and high impact initiative would be funding the retirement and replacement of coal-fired electricity. Creating a public mechanism to acquire and replace coal-fired electricity on an accelerated scale and recycle funds into renewable energy would be a productive use of massive global liquidity available to governments at record low interest rates. Such an initiative would create a triple win: it will create millions of jobs, make huge contributions to public health, and arrest climate change.

The health costs and climate math of coal

Coal-fired power generation is one of the largest sources of greenhouse gases — about 10 billion⁴ of the 55.3 billion tonnes⁵ of CO₂e annually. Coal power on average has more than 1.2 times the CO₂ emission intensity of oil and double that of gas.⁶ It is also a major source of air pollution and health impacts. Globally, around 3.4 million people die every year because of outdoor air pollution – more than AIDS, tuberculosis and road traffic accidents combined.⁷ Between 200,000 – 550,000 deaths have been attributed annually to coal-fired electricity in China, India, U.S., and Europe⁸, the upper range of which is almost twice the deaths that have

² Guterres, A. (April 28, 2020). “A time to save the sick and rescue the planet”. *New York Times*.

<https://www.nytimes.com/2020/04/28/opinion/coronavirus-climate-antonio-guterres.html>

³ Georgieva, K. (April 29, 2020). *Managing Director's opening remarks at the Petersberg Climate Dialogue XI: Opening remarks by Kristalina Georgieva*. IMF.

<https://www.imf.org/en/News/Articles/2020/04/29/sp042920-md-opening-remarks-at-petersberg-event>

⁴ International Energy Agency's report “CO₂ Emissions from Fuel Combustion 2019 edition”

(<https://www.iea.org/reports/co2-emissions-from-fuel-combustion-2019>) reported 10 GtCO₂e emissions from coal in electricity and heat generation and other energy industry own use. Endcoal's report “Boom and Bust 2020”

(<https://endcoal.org/global-coal-plant-tracker/reports/boom-and-bust-2020/>) reported that the coal fleet grew in 2019.

Though total 2019 global emissions are not available yet, a growing global fleet indicates that carbon emissions from coal-fired electricity for the year may have grown

CO₂e refers to “carbon dioxide equivalent”, which equates the warming potential of different greenhouse gases to equivalent measures of carbon dioxide (CO₂). For example, methane has 28-36 times the warming intensity of CO₂ over 100 years. See United States Environmental Protection Agency. (n.d.). *Understanding global warming potentials*. EPA.

<https://www.epa.gov/ghgemissions/understanding-global-warming-potentials>

⁵ United Nations Environment Program. (2019). *Emissions Gap Report 2019*. Page XIII Foreword. Nairobi: UNEP.

<https://www.unenvironment.org/interactive/emissions-gap-report/2019/>

⁶ Foster, V. and Bedroysan, D. (2015). Understanding CO₂ emissions from the global energy sector (English). *Live wire knowledge note series*, 2014(5). Figure 4. World Bank Group. CO₂ reported to be 879 gCO₂e/kWh for coal, 713 gCO₂e/kWh for oil and 391 gCO₂e/kWh for gas.

<http://documents.worldbank.org/curated/en/873091468155720710/Understanding-CO2-emissions-from-the-global-energy-sector>

⁷ Global Burden of Disease Collaborative Network. (2018). *Global burden of disease study 2017 (GBD 2017) results*.

Seattle, United States: Institute for Health Metrics and Evaluation (IHME). <http://ghdx.healthdata.org/gbd-results-tool>

⁸ Annually, coal-fired electricity causes 86,500-434,000 premature deaths in China, 83,000 in India, 7,500 in the U.S. and 23,300 in Europe.

China: Health Effects Institute. (2016). *Burden of disease attributable to coal-burning and other major sources of air pollution in China*. <https://www.healtheffects.org/system/files/GBDMAPS-ExecSummEnglishFinal.pdf>

Hausfather, Z. (November 18, 2016). “Coal in China: Estimating deaths per GW-year”. *Berkeley Earth*.

<http://berkeleyearth.org/deaths-per-gigawatt-year/>

been attributed to COVID-19 as of June 30, 2020⁹. Coal-fired electricity is also responsible for 13.1% of mercury emissions globally, exposures to which may have adverse effects on the nervous system, kidneys, and brain development.¹⁰

There have been encouraging developments in phasing out coal in some countries. In Europe and the U.S., regulation and the decreasing costs of gas and renewables are rendering coal-fired power uncompetitive, retiring it on a massive scale¹¹. Coal-fired electricity generation in the EU and the U.S. is now at approximately half the level of 2007 in both regions¹². China, which is by far the largest user and biggest builder of coal-fired electricity, is planning to reduce its total coal-fired power generation and has both the technical and financial capability to accelerate the shift towards renewable energy. There are also recent reports that Japan, one of the major funders of coal, is considering stepping away.¹³

Despite the reductions in some places, however, coal-fired electricity globally still accounts for 38%¹⁴ of electrical generation globally and about 10 billion tonnes of CO₂ emissions. This exceeds the maximum allowable emissions from all sources that the International Panel on Climate Change (IPCC) says the world must stay within by 2050 to keep warming to within 1.5°C (8.4 billion tonnes)¹⁵. Thus, IPCC's targets call for coal-fired electricity to fall rapidly, from 38% to 9% of global generation by 2030 and to 0.6% by 2050¹⁶. Despite the urgency to

United States: Health Effects Institute. (2018). *Air pollution from many sources creates significant health burden in India*. <https://www.healtheffects.org/system/files/GBD-MAPS-SpecRep21-India-press-release.pdf>

Sierra Club. (11 October 2017). "Bloomberg announces \$64 million in new funding to move America beyond coal as Trump EPA tries to prop up dead end fuel source". <https://www.sierraclub.org/press-releases/2018/02/bloomberg-announces-64-million-new-funding-move-america-beyond-coal-trump-epa>

Europe: Huscher, J. and Smith, D. (2013). *The unpaid health bill: How coal power plants make us sick*. In Jensen, G.K. (Ed.) HEAL. Page 5. https://www.env-health.org/IMG/pdf/heal_report_the_unpaid_health_bill_how_coal_power_plants_make_us_sick_final.pdf

⁹ World Health Organization. (2020). *Coronavirus disease (COVID-19) situation report – 162*.

https://www.who.int/docs/default-source/coronaviruse/20200630-covid-19-sitrep-162.pdf?sfvrsn=e00a5466_2

¹⁰ UN Environment. (2019). *Global Mercury Assessment 2018*. Geneva, Switzerland: UN Environment Program, Chemicals and Health Branch.

<https://wedocs.unep.org/bitstream/handle/20.500.11822/27579/GMA2018.pdf?sequence=1&isAllowed=y>

¹¹ The Carbon Tracker Initiative's report "Apocalypse Now" and Energy Innovation and Vibrant Clean Energy's report "The Coal Cost Crossover: Economic Viability of Existing Coal Compared to New Local Wind and Solar Resources" (<https://energyinnovation.org/publication/the-coal-cost-crossover/>) illustrate the unprofitable economics of coal-fired power plants in selected European countries and the U.S. respectively. Endcoal's report "Boom and Bust 2020" (<https://endcoal.org/global-coal-plant-tracker/reports/boom-and-bust-2020/>) also notes that 2019 was the second highest year for coal-fired power plant retirements in the U.S. and the fourth highest in the EU.

¹² U.S. Energy Information Administration. (February 25, 2020). *Monthly Energy Review*, Table 7.2a. Retrieved March 12, 2020, from <https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf>

Eurostat. (n.d.). *Electricity and heat statistics 2019*. Retrieved March 12, 2020, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_and_heat_statistics&oldid=463985

Agora Energiewende and Sandbag. (2020). *The European Power Sector in 2019*. Page 7 Table 2. <https://ember-climate.org/wp-content/uploads/2020/02/Sandbag-European-Power-Sector-Review-2019.pdf>

¹³ Smee, B. (March 31, 2019). "Japan to oppose new or expanded coal-fired power plant in blow to Australian exports". *The Guardian*. <https://www.theguardian.com/environment/2019/mar/31/japans-environment-minister-to-oppose-any-new-or-expanded-coal-fired-power-plants> Obayashi, Y. (February 25, 2020). "Japan to tighten export policy on coal-fired power plants: minister". *Reuters*. <https://www.reuters.com/article/us-climate-change-japan/japan-to-tighten-export-policy-on-coal-fired-power-plants-minister-idUSKCN20J0D2>

The Japan Times. (16 April 2020). "Sumitomo Mitsui and Mizuho to end lending for new coal-fired plants".

<https://www.japantimes.co.jp/news/2020/04/16/business/smf-mizuho-end-lending-coal-plants/>

¹⁴ BP. (2019). *Statistical Review of World Energy 2019 (68th edition)*. <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf>

¹⁵ The Intergovernmental Panel on Climate Change (IPCC). (2018). *Special report on global warming of 1.5°C*, Table 2.4 based on 1.5°C-high-OS scenario. <https://www.ipcc.ch/sr15/>

¹⁶ The Intergovernmental Panel on Climate Change (IPCC). (2018). *Special report on global warming of 1.5°C*, Table 2.7 based on 1.5°C-high-OS scenario <https://www.ipcc.ch/sr15/>

reduce, however, reality paints a different picture. Over 1,000 new coal-fired power plants are planned or under construction globally.¹⁷ Furthermore, existing coal-fired facilities in Asia – which have average lifespans of 40 years or more — are only 12-years-old on average¹⁸. This means that global emission reduction targets for 2030 and 2050 cannot be reached unless there is large-scaled action to accelerate the retirement of existing coal-fired power plants and halt the construction of new ones. Current ESG investment initiatives leading global financial institutions to divest coal assets are not sufficient to solve the problem as, in many cases, those assets are acquired by less sustainability-minded owners, who plan to continue to operate the plants for full lifetimes.

Breakdown of current and future plants

Figure 1 shows the breakdown of existing and planned coal-fired electricity capacity. The U.S., the EU27 + UK, and the next ten high-income countries with large capacities together account for about one-fourth of current, but only 7% of planned coal-fired capacity. Over 70% of existing and 90% of planned coal-fired capacity is in China, India, and 26 other developing countries.

Figure 1: Current and planned coal-fired electricity capacity

Country classification	Country	Current coal-fired capacity (% total)	Planned additional coal-fired capacity (% total)
High	United States	12%	0%
	EU27 + UK	7%	2%
	Next 10 largest current capacity high-income countries	7%	5%
Upper middle	China	49%	41%
	Next 10 largest current capacity upper middle-income countries	8%	12%
Lower middle and low	India	11%	13%
	Next 16 largest current and planned capacity lower middle- and low-income countries	5%	26%
Rest of world		1%	2%
World total		100% (adds up to 2,045 GW)	100% (adds up to 499 GW)

Source: Global Energy Monitor Global coal plant tracker (January 2020 version), World Bank country classification

Note 1: Planned capacity refers to specific projects that have been announced / obtained permits / under construction, and will be smaller than the total projected capacity required calculated on a macro forecast basis

Note 2: The “next 16 largest current capacity lower-middle and low-income countries” include Indonesia, Ukraine, Vietnam, the Philippines, Pakistan, Morocco, Uzbekistan, Lao PDR, Moldova, Zimbabwe, Bangladesh, Mongolia, Egypt, Nigeria, Kenya, and Cambodia

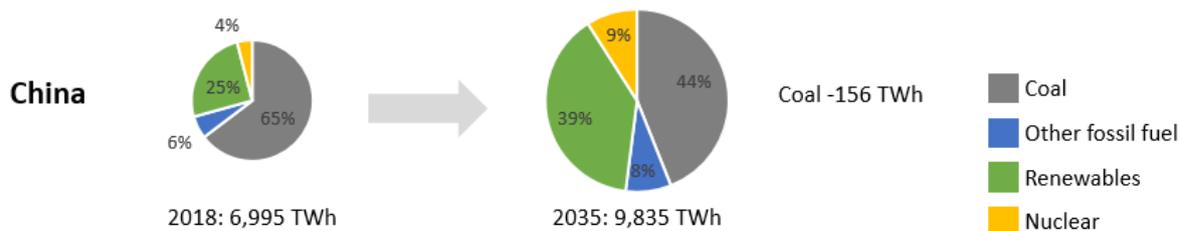
Note 3: North Korea has been excluded from the analysis

¹⁷ Global Energy Monitor. (n.d.). *Global coal finance tracker (February 2020 version)*. Retrieved May 8, 2020, from <https://endcoal.org/global-coal-finance-tracker/>

¹⁸ International Energy Agency. (2019). “Global Energy & CO2 Status Report 2019”. <https://www.iea.org/reports/global-energy-co2-status-report-2019/emissions>

Although China still represents more than 40% of planned capacity, experts project China's total coal-fired electrical generation will decrease both in percentage and in absolute terms (Figure 2). Such decreases are in line with China's continued push towards renewable energy. China's National Energy Administration in April 2020 released a draft energy law that prioritizes the use of renewable energy power sources¹⁹. This supports China's commitment to increasing renewable energy's share of generation.

Figure 2: Current and future electricity generation mix in China



Source: China Electricity Council; China Electric Power Planning & Engineering Institute "China Power System Transformation"

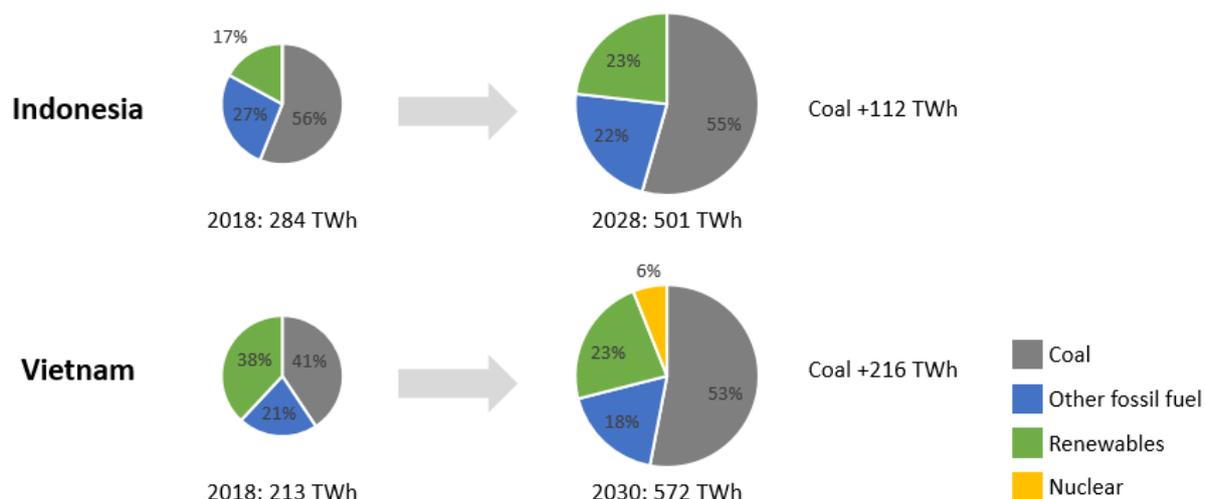
Note: Numbers do not directly tie with Figure 1 as those represent capacity, while those in Figure 2 represent generation

Even if China were willing to phase out coal more aggressively and other upper middle-income countries follow suit, there is still an enormous challenge in the lower middle- and low-income countries, which are host to almost 40% of planned coal-fired capacity, and which lack financial and technical capacity and/or incentives to replace coal. In countries such as India, Indonesia, and Vietnam, for example, coal may well provide half of electricity well beyond 2030 (Figure 3).

Figure 3: Current and future electricity generation mix in India, Indonesia, and Vietnam



¹⁹ Lin, Chunting (林春挺). (April 10, 2020). "历经三年中国首部能源法即将颁布，未来能源发展更市场化". *Yicai*. <https://www.yicai.com/news/100588022.html>



Source: India Central Electricity Authority “Annual report 2018-19”; Government of India Ministry of New and Renewable Energy “Annual report 2018-19”; India Central Electricity Authority “19th Electric Power Survey”; India Central Electricity Authority “Draft report on optimal generation capacity mix for 2029-2030”; Republic of Indonesia Ministry of Energy and Mineral Resources “2018 Handbook of energy & economic statistics of Indonesia (final edition)”; RUPTL 2019-2028; Government of Vietnam Ministry of Industry and Trade “Revised Power Development Master Plan VII”; BP “Statistical Review of World Energy 2019 (68th edition)”

Note: Numbers do not directly tie with Figure 1 as those represent capacity, while those in Figure 3 represent generation

India, Indonesia, and Vietnam are joined by eight low-middle- and low-income countries with over 1 GW of current coal-fired capacity, and six countries that have less than 1 GW of current capacity but have between 1.8 GW and 23 GW of planned capacity (Figure 4).

Figure 4: Breakdown of lower-middle and low-income countries included in Figure 1

Country	Current coal-fired capacity (MW)	Planned additional coal-fired capacity (MW)	Current + planned additional coal-fired capacity (MW)
India	228,964	66,025	294,989
Indonesia	32,373	31,200	63,573
Ukraine	22,265	660	22,925
Vietnam	18,432	30,942	49,374
Philippines	9,670	10,536	20,206
Pakistan	5,090	6,208	11,298
Morocco	4,317	0	4,317
Uzbekistan	2,522	150	2,672
Lao PDR	1,878	1,500	3,378
Moldova	1,610	0	1,610
Zimbabwe	950	2,160	3,110
Mongolia	781	6,965	7,746
Bangladesh	525	22,984	23,509
Cambodia	505	1,750	2,255

Egypt	0	6,600	6,600
Nigeria	0	2,400	2,400
Kenya	0	2,010	2,010
Total of above	329,882	192,090	521,972
World	2,044,831	499,181	2,544,012

Note: 1 GW = 1,000 MW

Source: Global Energy Monitor Global coal plant tracker (January 2020 version); author's calculation

Why coal-fired power retains a major role in developing economies

Despite recent remarkable advances in renewables, grid management, and energy storage, it is important to recognize the main reasons why coal-fired power remains part of existing and planned energy strategies in spite of its well-known health and environmental costs:

- Perceived reliability and security: Availability of coal reserves, technology, and proven technical capacity to deliver sufficient power;
- Perceived low costs to end users (often a misperception due to coal-related subsidies and exclusion of costs to health and environment); and
- Opposition from coal-power producers, coal-related industries, workers, and coal-dependent communities.

Perceived reliability and security: Availability of coal reserves, technology, and proven technical capacity to deliver

Supporters of coal-fired power point to high levels of energy security in terms of fuel supply, ease of transport, and ability to provide reliable, affordable energy to the country's businesses and citizens that is within their technical and financial capacity.²⁰ Many countries have large proven domestic coal reserves that can provide a secure source of power in times of economic crisis or geopolitical challenges, and also help a country's balance of payments and foreign exchange reserves. For example, India has enough coal to last 132 years at current rates of consumption, Indonesia 67 years, and Zimbabwe 165 years.²¹

Thus, any proposed alternative energy strategy that involves eliminating coal-fired power must be geopolitically secure. Where gas is available, it might be a source of fuel for transition, but large proven natural gas reserves are concentrated in a handful of countries.²² Also, using modern technologies to extract gas (e.g. fracking) has implications for water use and other environmental and climate consequences, so we do not envisage gas as a part of a sustainable solution for most countries.

²⁰ World Coal Association. (2012). *Coal – energy for sustainable development*.

<https://sustainabledevelopment.un.org/getWSDoc.php?id=996>

²¹ BP. (2019). *Statistical Review of World Energy 2019 (68th edition)*. <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf>

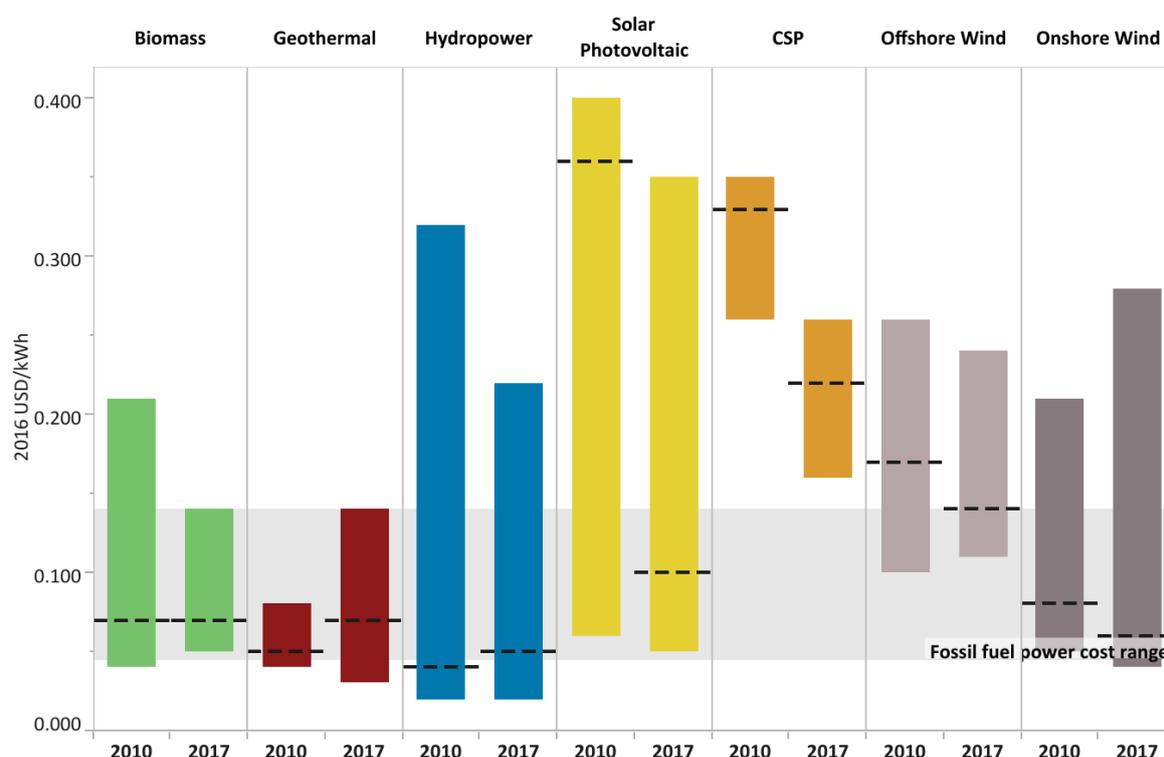
²² Ibid. Russia has 20% of the global natural gas reserves, Iran 16%, Qatar 13%, and Turkmenistan 10%.

Many countries still see coal as vital to load balancing.²³ Historically, renewables (particularly wind and solar) have been challenged as a reliable source of affordable base load and peak power. Despite advances in renewables, storage, and smart grids, the adequacy of these solutions remains to be demonstrated at scale in most developed countries.²⁴ Therefore, any plan to retire coal must come with accompanying financing and technical assistance and a sufficient transition period to allow demonstration of security, reliability, and affordability.

Perceived low costs to end users (often a misperception due to coal-related subsidies and exclusion of costs to health and environment)

Renewable energy's levelized cost of electricity (LCOE) has declined swiftly and is now recognized as being on par with fossil fuel power (Figure 5).

Figure 5: Global levelized cost of electricity from utility-scale renewable power generation technologies 2010-2017



Source: IRENA Renewable Energy Cost Database. Note: All costs are in 2016 USD. The dashed lines are the global weighted average LCOE value for plants commissioned in each year. Cost of Capital is 7.5% for OECD and China and 10% for Rest of World. The band represents the fossil fuel-fired power generation cost range.

© IRENA

²³ PennState Department of Energy and Mineral Engineering. (n.d.). *9.1 Base load energy sustainability*. <https://www.e-education.psu.edu/eme807/node/667>

²⁴ There are studies showing that the U.S. can run on 80-90% renewable energy, while Australia can run on 100%. Parts of Germany are already operating on 100% net renewable energy. See Diesendorf, M. (2015). Do we need base-load power stations? *EnergyScience Coalition briefing paper No.16 (revised)*. <http://www.energyscience.org.au/BP16%20BaseLoad.pdf> A recent study conducted by three Californian utilities also indicated that a solar power plant with four hours of storage in 2022 will have a 99.8% effective load carrying capability, which means it is almost completely able to reliably supply the grid with power. See Stern, G.A. (2020). *Southern California Edison Company, San Diego Gas & Electric Company, and Pacific Gas and Electric Company's ELCC Study Submission*. Southern California Edison. https://library.sce.com/content/dam/sce-doclub/public/regulatory/filings/pending/electric/ELECTRIC_4243-E.pdf

Even though renewables have achieved cost parity with fossil fuels, this fact is not recognized widely in society as fossil fuel power's perceived cost often benefits from government fuel subsidies. Prominent economists and climate advocates have often called for the elimination of subsidies for coal and other fossil fuels, and progress has been made in some countries. Yet, according to a report by the Overseas Development Institute (ODI)²⁵, G20 governments are spending over US\$60 billion per year in fiscal support for coal alone (Figure 6).

Figure 6: Total amounts of G20 government support identified to each stage of coal production or consumption

US\$ millions, 2016–2017 annual average

	Coal production (incl. infrastructure)	Coal-fired power production	Consumption	Transition support
Argentina	227	368	0.4	none identified
Australia	14	none identified	805	0.05
Brazil	none identified	281	none identified	none identified
Canada	14	none identified	17	none identified
China	1,975	16,870	68	2
France	0.5	1,129	78	none identified
Germany	103	24	185	2,106
India	1,246	16,673	none identified	3
Indonesia	154	1,013	2,320	none identified
Italy	none identified	33	870	none identified
Japan	1,088	4,132	none identified	none identified
Mexico	none identified	992	3	none identified
Russia	29	748	none identified	none identified
Saudi Arabia	none identified	none identified	none identified	none identified
South Africa	260	3,380	570	none identified
South Korea	140	1,076	none identified	49
Turkey	333	281	374	none identified
UK	15	161	682	975
US	1,068	173	718	none identified
Total	6,667	47,336	6,691	3,135

Source: ODI "G20 coal subsidies: Tracking government support to a fading industry". Table A2.

The second reason that coal is still perceived as cheap relative to renewables is that coal-fired electricity's cost does not reflect health and environmental impacts. IMF has estimated that coal prices were typically well below half of their true cost if global warming damages and local air pollution costs were taken into account, and that the cost of those unaccounted externalities amounted to US\$2.3 trillion in 2015.²⁶ Lord Nicholas Stern noted that IMF's estimates are conservative as they exclude other severe potential consequences, such as accelerated warming due to methane released from the oceans, sea level rise and large-scale migrations triggered by

²⁵ Gençsü, I., Whitley, S., Roberts, L., Beaton, C., Chen, H., Doukas, A., Geddes, A., Gerasimchuk, I., Sanchez, L., and Suharsono, A. (2019). *G20 coal subsidies: tracking government support to a fading industry*. Overseas Development Institute. <https://www.odi.org/publications/11355-g20-coal-subsidies-tracking-government-support-fading-industry>

²⁶ Coady, D., Parry, I., Le, N. P., and Shang, B. (2019). *Global fossil fuel subsidies remain large: An update based on country-level estimates*. IMF Fiscal Affairs Department Working Paper No. 19/89. Page 4-5. <https://www.imf.org/en/Publications/WP/Issues/2019/05/02/Global-Fossil-Fuel-Subsidies-Remain-Large-An-Update-Based-on-Country-Level-Estimates-46509>

extreme weather events. Stern concluded that the real price of coal should therefore be above US\$200 a tonne, rather than about US\$50 at his time of writing in 2015.²⁷

Opposition from coal-power producers, coal-related industries, workers, and coal-dependent communities

Even in wealthier countries, which possess the financial and technical capacity to make a transition, economic and political resistance to phasing out coal-fired power remains. This requires difficult decisions and deliberate and expensive interventions to help coal-related industries, workers, and communities. The importance of providing a just transition to affected communities was recognized in the 2015 Paris Agreement as a critical requirement of decarbonization.²⁸ Just transitions can include a range of support measures such as retraining, developing new business programs, relocation assistance, to adequate pensions and payouts.²⁹

Europe's experience shows that decarbonization cannot happen overnight and will require adequate timelines in order to ensure just transition for all stakeholders. Europe has been implementing transition mechanisms for coal-mining regions since the 1950s.³⁰ The recently released European Green Deal Investment Plan also includes a Just Transition Mechanism³¹.

Developing countries face equal or greater challenges in transition. They often have larger populations working in mining and related jobs. They also have fewer fiscal resources and less capacity for transition. Coal mining directly employs more than 4 million workers across China, India, Indonesia, and South Africa, and benefits millions more through indirect jobs.³²

Developing countries will therefore need transition plans to retrain workers in coal-related industries to have the skills necessary to take advantage of the new jobs in the future. A study has shown that on average, US\$1 million spending creates only 2.65 full-time-equivalent (FTE) jobs in fossil fuels but would create 7.49 or 7.72 FTE jobs in renewables and energy efficiency

²⁷ Stern, N. (November 13, 2015). "Action on fossil fuel subsidies must be accelerated". *Financial Times*.

<https://www.ft.com/content/ff3e07e6-5485-33a0-a1eb-f121cb6becab>

For reference, Australia and South Africa coal prices were US\$52 and US\$57 per tonne in May 2020 respectively

Australia: <https://www.indexmundi.com/commodities/?commodity=coal-australian&months=60>

South Africa: <https://www.indexmundi.com/commodities/?commodity=coal-south-african&months=60>

²⁸ United Nations. (2015). *Paris Agreement*. Preamble on Page 2.

https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

²⁹ Robins, N. and Rydge, J. (2019). *Why a just transition is crucial for effective climate action*. UNPRI. Table 1.

https://www.unpri.org/inevitable-policy-response/why-a-just-transition-is-crucial-for-effective-climate-action/4785_article

³⁰ The European Coal and Steel Community (ECSC) Fund for the Retraining and Resettlement of Workers was created based on Article 56 of the ECSC Treaty to facilitate re-employment opportunities for those coal and steel workers who lost their jobs as a result of the introduction of new technical processes or new equipment.

Tagliapietra, S. Beyond coal: Facilitating the transition in Europe. *Bruegel Policy Brief*. Issue 5, November 2017. Page 5.

https://www.bruegel.org/wp-content/uploads/2017/11/PB-2017_05_SimoneTagliapietra-1.pdf

³¹ European Commission. (January 14, 2020). "Financing the green transition: The European Green Deal Investment Plan and Just Transition Mechanism". https://ec.europa.eu/regional_policy/en/newsroom/news/2020/01/14-01-2020-financing-the-green-transition-the-european-green-deal-investment-plan-and-just-transition-mechanism

³² Coal mining directly employs 3.7 million in China, 226,000 in India, 78,400 in Indonesia, and 82,000 in South Africa.

China, India, Indonesia: 李瑞峰, 任仰辉, 聂立功, 滕霄云, 邢相. (2017). 关于煤炭生产效率与去产能的思考. *煤炭工程*, 49(3). DOI: 10.11799/ce201703001 <http://www.coale.com.cn/CN/10.11799/ce201703001>

South Africa: Mining Review Africa. (November 2, 2018). "South Africa's coal sector headed for major job losses". <https://www.miningreview.com/news/coal-job-losses/>

respectively.³³ However, renewable energy, energy storage, and related supply chain jobs may not be provided in the affected regions. Moreover, a portion of jobs in the renewable supply chain may not be created in the countries that use the energy but be centered in countries that export solar cells, advanced wind turbines, software, etc. Therefore, it is critical that transition jobs be considered broadly, not just be in the renewable energy sector, but in the overall circular economy, and special efforts will be needed in the areas most severely impacted.

Low marginal costs of existing coal-fired operations due to industry structure in some countries

In addition to the three main reasons for coal-fired power's persistence, in some markets another factor might be contributing to the slow rate of adopting renewables, even though the total cost of renewables is now comparable to or less than coal.

In some markets, independent power producers (IPPs) are contracted to develop coal-fired power through long-term offtake power purchase agreements (PPAs) with a power purchaser, which in many cases may be a state-owned enterprise charged with the operation of the transmission and distribution network. These PPAs are typically 20-25 years in duration, and often contain fixed payments for providing available capacity, which are not related to the actual amount of electricity the power purchaser purchases. Together with fixed maintenance costs, these fixed availability payments may amount to more than half of the revenues that the power plant receives. The positive effect of this fixed payment scheme is that it gives certainty to power plant developers and their financiers that do not have appetite for the risk of fluctuating fuel prices or power demand. Variable operating costs are passed through to the power purchaser. A simplified example of this type of payment structure is shown in Figure 7.

Figure 7: Simplified example of the tariff structure of a coal-fired power plant in Southeast Asia

Tariff component	Description of component	% of tariff	Volume risk	FX risk	Cost escalation risk
A	Cost of capital recovery (equity and debt) and investor's profit which is calculated based on availability of contractual / available capacity (not generation)	45-50%	None	Pass through	Not applicable
B	Fixed operations and maintenance cost	5-10%	None	Pass through	Pass through
C	Cost of fuel to produce electricity	40-45%	None	Pass through	Pass through
D	Variable operations and maintenance cost	0-5%	None	Pass through	Pass through

Source: Author's interviews

³³ Peltier, H. (2016). Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model. *Economic Modelling*. DOI: 61. 10.1016/j.econmod.2016.11.012. <https://www.sciencedirect.com/science/article/abs/pii/S026499931630709X>

This highly fixed payment / revenue structure in some countries might be deterring a shift to renewables. A power purchaser must pay the fixed availability payments for the existing plant (i.e. components A and B) as long as it is available to run, whether the plant is producing at 0% or 100% of capacity. Therefore, that purchaser will compare the marginal cost of using the available capacity of the existing power plant (i.e. components C and D) to the full costs of building a new renewable energy installation. Although renewable energy's total levelized costs (LCOE) has declined swiftly and is now similar to coal-fired electricity's total cost in some countries, it is not likely to be cheaper than coal power's marginal cost, as long as the existing coal-fired power plant still has available capacity to deploy and the cost of coal's externalities is excluded. Furthermore, there are also additional integration costs and system costs to consider when calculating the total cost of renewable energy³⁴, which may act as a further incentive to rely on existing facilities.

Overcoming the reasons for resistance to change – The global sustainable investment movement is helpful but is it enough? Is there a risk of shortfall in the near term in developing countries?

One of the strongest counterforces that has the potential to limit the lifespan and growth of coal is the movement toward sustainable investing. A combination of positive developments in sustainable investment practices, regulation, and disclosure are resulting in an increasing number of investors and financial institutions reducing or eliminating investments in coal and coal-fired power. The UN-backed Principles for Responsible Investing (PRI), the Task Force on Climate-related Financial Disclosures (TCFD) and many others (see examples in Appendix 1) have galvanized the owners and managers of trillions of dollars of assets to make their investment portfolios more sustainable and encouraged the users of capital to operate their businesses more sustainably. Those actions are being matched by commitments of many multilateral institutions that are taking both positive initiatives to invest in renewable energy and in some cases pledging not to invest in or lend to projects that are related to coal (see Appendix 2). Finally, there are a growing number of public-private initiatives advocating policy and mobilizing finance for sustainable development and infrastructure, including the use of blended finance (see Appendix 3).

Those multi stakeholder initiatives collectively are driving change, including the exit from funding coal-fired power. On their own, however, both for existing and planned coal-fired power assets, they are unlikely to be sufficient to stimulate the required energy transition in developing countries that are currently committed to coal, at least not fast enough to meet the necessary timetable for emissions reductions to avoid dangerous climate change.

First, regarding existing assets, there is evidence that when sustainability-minded investors exit coal, new investors step in.³⁵ If those new investors plan to operate existing coal-fired power

³⁴ Fatmah, A. (August 29, 2018). "Going beyond LCOE: The real costs of variable renewable energy". *ASEAN Center for Energy*. <https://aseanenergy.org/going-beyond-lcoe-the-real-costs-of-variable-renewable-energy/>

³⁵ For example, see Cadman, E. (March 9, 2020). "Here's who's backing coal as some of the world's biggest banks get out". *Bloomberg*. <https://www.bloomberg.com/news/articles/2020-03-08/death-of-coal-financing-is-exaggerated-as-china-japan-step-up>

plants for their full remaining lifetime of 30 years or more, and lobby to protect their interests, a carbon-intensive energy future is virtually assured. To avoid this risk and to speed up the retirement of coal-fired power, consideration needs to be given not only to encourage the exit from investments in coal but also to place the ownership of those exited coal assets into the hands of parties that are committed to retire and replace them with more sustainable energy.

Second, regarding financing new energy assets, as large global investors and financial institutions seek to green their investment portfolios, it is likely that much of the new capital will continue to flow to investment opportunities in developed countries, rather than to low-income developing countries. This is because developed countries benefit from a combination of deep capital markets, availability of investable projects, reliable credit rating institutions, and established contractual and enforcement mechanisms. These conditions are less present in developing markets. Also, developed countries themselves will require trillions of dollars in energy and other infrastructure in the coming years, creating fierce competition with developing countries for sustainability-minded capital.³⁶

Thus, over the next few years, for both existing and new assets, many lower-income countries may find themselves “decoupled” to some extent from large portions of the global sustainable capital flow unless they can immediately generate more green, investable projects and create sufficient risk protection mechanisms to attract investment. Otherwise, in the absence of new and large-scale initiatives, they may face bottlenecks in financing sustainable energy. This in turn may sustain reliance on coal and other fossil fuels to generate electricity to support economic growth and job creation, which are critical to reducing poverty and achieving the other United Nations Sustainable Development Goals (SDGs) such as health, education, and improving the environment.

Against that backdrop, new financial mechanisms are needed for developing countries to replace and transition away from coal-fired power without compromising energy supply or security.

Coal Retirement Mechanism and Sustainable Energy Transition Mechanism

What if a developing country had an economically viable option to phase out existing coal-fired plants and the financial and technical resources to enable faster transition to a more sustainable long-term energy mix? This would require a large scale initiative of two parts³⁷: a “Coal

Sguazzin, A., Marawanyika, G. and Li, J. (May 7, 2020). “China risks further isolation in backing Africa’s coal projects”. *Bloomberg*. <https://news.bloomberglaw.com/environment-and-energy/china-is-virtually-alone-in-backing-africas-dirty-coal-projects>

Brock, J. (December 18, 2019). “StanChart exits three Southeast Asia coal plants worth estimated \$7 billion”, *Reuters*. <https://www.reuters.com/article/us-stanchart-coal/standard-chartered-exits-three-southeast-asia-coal-plants-worth-estimated-7-billion-idUSKBN1YM0KP>

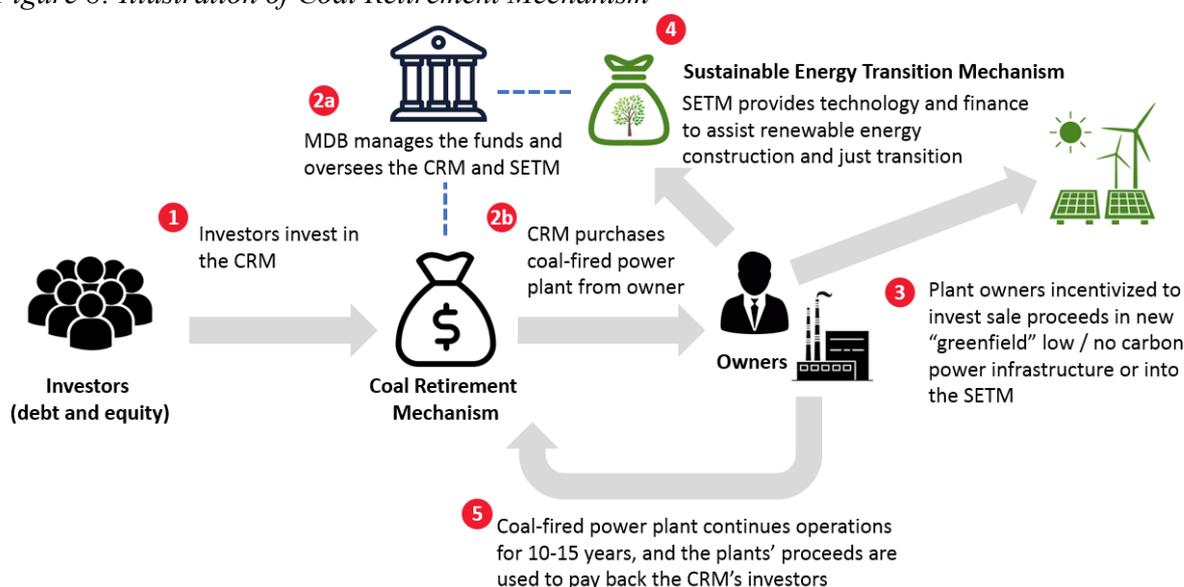
³⁶ For example, the European Commission announced on May 2020 a €1.85 trillion plan to recover from COVID-19. Part of the funds will be used to incentivize private investments to boost the resilience of strategic sectors, such as those related to green and digital transition.

European Commission. (May 27, 2020). “Europe’s moment: Repair and prepare for the next generation”. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_940

³⁷ The discussion here contemplates two distinct mechanisms, each with a focused mandate. In application, whether two separate mechanisms or one mechanism with two distinct parts might be more efficient needs to be tested with stakeholders. The CRM is envisaged as being funded with low cost (mainly public finance), and a focused objective of acquisition, operation and retirement of generation assets; the SETM would have a broader mission of technical assistance as well as finance and would offer opportunities for both public and private sector finance.

Retirement Mechanism” (CRM) to acquire and retire existing coal-fired power plants in 10-15 years instead of a current expected lifetime of 30-40 years; and a “Sustainable Energy Transition Mechanism” (SETM) to provide technical expertise and supplementary finance to replace the retired and planned coal plants with a combination of energy efficiency, renewable energy and storage, and possibly gas as a bridge fuel (Figure 8). Beyond the financial ownership, the CRM will be able to seek opportunities to improve the efficiency or reduce the pollution footprint of the plant during the remaining years of operation. Rather than create a new, expensive global financial institution / bureaucracy to oversee the CRM and SETM, an existing global or regional multilateral development bank (MDB) or several MDBs collaboratively could act as the lead shareholder(s) of both mechanisms in a country. In this way, existing MDBs could move quickly, divide the duties, and adapt the CRM in each country to its national circumstances.

Figure 8: Illustration of Coal Retirement Mechanism



Source: Author’s conceptual illustration

The CRM/SETM structure discussed above is a way to accelerate energy transition within the framework of the Paris Agreement climate regime. Under the Paris Agreement, the transfer of funds from developed countries to developing countries (discussed as a minimum of US\$100 billion annually³⁸) remains a vague promise, and thus not able to catalyze binding promises on the part of developing countries. In the absence of a binding global regime, the CRM/SETM structure creates the opportunity for bilateral commitments between a developing country government and the MDB overseeing the CRM/SETM for that country to channel developed country funds to a developing country to assist its energy transition. In return, the developing country (and/or its energy authorities) commit to agreed programs and emission reductions. As the Paris Agreement regime currently lacks large-scale compliance cross-border carbon markets, the CRM relies primarily on the plants’ own revenues to repay the CRM’s investors, with carbon or other potential revenue sources regarded as supplementary.

³⁸ United Nations Framework Convention on Climate Change. (2016). *Report on the Conference of Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015. Addendum. Part two: Action taken by the Conference of the Parties at its twenty-first session.* Decision 1/CP.21 paragraph 53. <https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf>

It is crucial to note that rather than being “sunk capital”, the amounts paid by the CRM to existing coal-fired power plant owners should in most cases create large and immediate new cash available to recycle into the SETM or directly financing new greenfield renewable energy projects and related infrastructure, creating new jobs to aid in a post-COVID-19 recovery and accelerate energy transition. In fact, requirements and incentives to recycle the funds received from the CRM for new green energy could be built into the SETM.

A critical prerequisite for a CRM and a SETM to be established in a country would be robust agreements between the host government’s relevant national authorities and the lead MDB to a schedule of coal-fired power plants to be purchased and retired and a plan for sustainable energy development assisted by the SETM. This “road map” for energy transition would be linked to the country’s overall emissions reductions commitments. The agreements would include terms for deciding the method to purchase assets and set prices (for example, via a reverse auction), as well as terms for operation of the acquired power plants until retirement, and provisions for clean-up and restoration of the land after the plant is retired. To align interests for the long-term, an agreed method of enforcement with financial consequences of non-compliance or default by either side would be needed. The CRM agreements would also need to prevent the building of new coal-fired power plants merely to be purchased and retired.

The relative scales of the CRM and SETM for a given country would vary significantly based on its current and planned coal-fired capacity, and its energy needs over the coming decades. Figure 9 segments the 17 lower-middle and low-income countries listed in Figure 4 into three groups. The first group includes India and six other countries that have over 1 GW of existing coal-fired power and in total plan to build over 150 GW more in the coming years (Figure 9, brown bubbles). This group would be of high priority. The second group of four have over 1 GW of current coal-fired capacity but limited or no plans for new coal-fired capacity (brown/white bubbles). Some of these countries have significant expansion plans for renewable energy.^{39 40 41} Funds recycled from the CRM could potentially accelerate existing plans to develop renewables. The third group includes six countries that have relatively low coal-fired capacity today but plan to substantially increase (yellow bubbles). This segment could be most challenging as recycling of funds from the CRM would be small relative to the planned energy needed. The SETM would need to be relatively larger for those countries to assist the transition.

³⁹ For example, Ukraine plans to grow electricity generation by 31 TWh 2015-2035, of which 30 TWh will come from renewables.

Government of Ukraine Cabinet of Ministers. (2017). *Energy strategy of Ukraine for the period up to 2035 “Security, energy, efficiency, competitiveness”*. Annex 2 Table B.3.

http://razumkov.org.ua/uploads/article/2018_Energy_Strategy_2035.pdf

⁴⁰ Morocco announced plans at COP21 (2015) to increase installed renewable energy capacity from 34% of total capacity in 2015 to 52% by 2030.

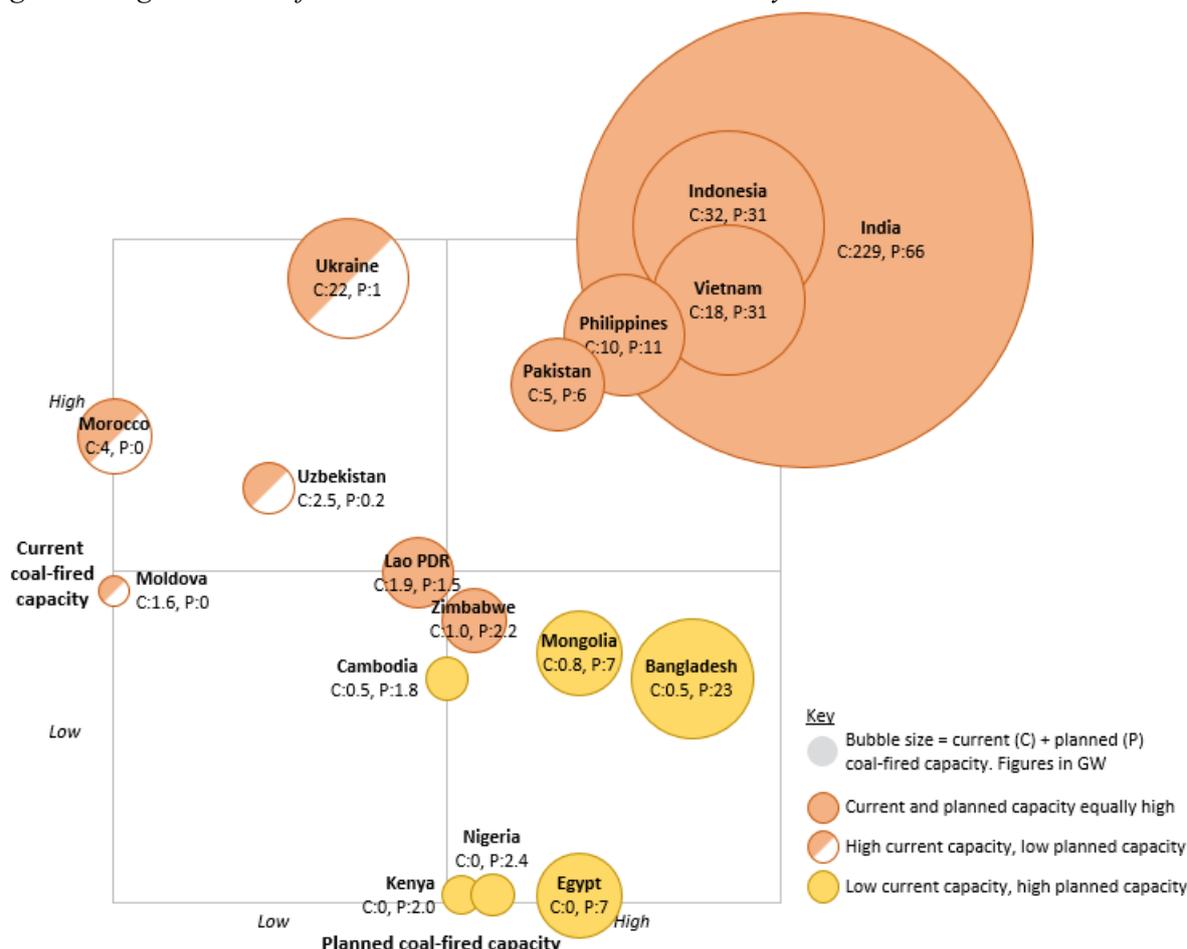
Oxford Business Group. (n.d.). “Morocco plans to add 10 GW of power from renewable energy sources by 2030”.

<https://oxfordbusinessgroup.com/analysis/viable-alternative-plans-add-10-gw-power-renewable-sources-2030>

⁴¹ Uzbekistan plans to increase electricity generation by 57 TWh 2020-2030, of which 25 TWh will come from renewables.

Ministry of Energy of the Republic of Uzbekistan. (2020). *Concept note for ensuring electricity supply in Uzbekistan in 2020-2030*. Figure 13. <https://minenergy.uz/en/lists/view/77>

Figure 9: Segmentation of lower-middle and low-income country CRM and SETM needs



Source: Global Energy Monitor Global coal plant tracker (January 2020 version); author’s calculation

Note: Not drawn to scale, for illustrative purposes only

Is it affordable? Who will pay for it?

The funding for national CRMs for developing countries could come from a blend of sources: developed central governments, development finance institutions, and philanthropic or impact investment. Factors unique to each country will affect the amount of funds needed to acquire and retire half of the current coal-fired capacity. These factors include the structure and function of its electricity generation, transmission and distribution, and others. For approximation, using established valuation principles for power plants operating in jurisdictions heretofore favorable to coal-fired power, and applying a range of valuations of US\$1.0 million to 1.8 million per megawatt (MW) of capacity, it would appear that the CRM ought to be able to purchase and retire half of the coal-fired capacity in smaller lower-middle and low-income countries for US\$1-2 billion.

Figure 10: Current coal-fired capacity in the top 10 lower middle-income and low-income countries (ex-India)

Country	Current coal-fired capacity (GW)	Country	Current coal-fired capacity (GW)
Indonesia	32.4	Morocco	4.3

Ukraine	22.3	Uzbekistan	2.5
Vietnam	18.4	Lao PDR	1.9
Philippines	9.7	Moldova	1.6
Pakistan	5.1	Zimbabwe	1.0
Average	9.9		

Note: 1 GW = 1,000 MW

Source: Global Energy Monitor Global coal plant tracker (January 2020 version), World Bank country classification.

For a larger country such as Vietnam or Indonesia, the CRM would be on the order of US\$10-30 billion. Those are large sums but not in the overall context of national and regional infrastructure plans. For example, US\$30 billion is only 0.1% of the US\$26 trillion investment required for infrastructure in Asia in 2016-2030⁴², or less than 8% of the US\$412 billion that Indonesia plans to invest in national infrastructure in 2020-2024⁴³.

Having acquired existing plants, the CRM would operate those plants as efficiently as possible and use the revenue generated to repay the funds it received plus a modest return, and then retire the plant. Using a hypothetical country with 10 GW of coal-fired capacity (the average coal-fired capacity of countries listed in Figure 10) and assuming the CRM acquires half of that capacity, preliminary modeling based on input from experts in energy finance and development is summarized in Figure 11. The modeling suggests that with reasonable assumptions of plant efficiency, electricity pricing and utilization, the plants' operating earnings will produce most of the cash needed to repay the CRM in 15 years with a 5% return on investment (5% would likely be too low for private investors, but adequate assuming that the bulk of funding is from MDBs or developed country governments, which in the current environment have record low borrowing costs.)

Figure 11: CRM financial model assumptions and outputs for an "average" lower middle- and low-income country with 10 GW coal-fired capacity

Coal-fired capacity to retire	5 GW		
CO ₂ avoided annually by early retirement ⁴⁵	25 million tonnes on average		
Acquisition price multiple (US\$ / megawatt)	1.0 million	1.5 million	1.8 million
Total acquisition price (US\$)	5 billion	7.5 billion	9 billion
Average annual revenue required to meet 5% IRR (US\$)	1,849 mil	2,150 mil	2,331 mil
Average annual revenue from plant operations (US\$)	1,883 million		
Supplementary annual revenue required (US\$)	-	266 million	447 million
Carbon price in nominal terms to provide 50% of the supplementary revenue (US\$ / tonne) ⁴⁶	-	5.3	8.9
Average surcharge in nominal terms to provide 50% of the supplementary revenue (US\$ / kWh)	-	0.6 cents	1.0 cents

Source: Internal model based on published data, consultations, and analysis

⁴² Asian Development Bank. (2017). *Meeting Asia's Infrastructure Needs: Highlights*. Manila. <https://www.adb.org/sites/default/files/publication/227496/special-report-infrastructure.pdf>

⁴³ Suhartono, H. and Salna, K. (May 15, 2019). "Indonesia has a \$412 billion plan to rebuild the country". *Bloomberg*. <https://www.bloomberg.com/news/articles/2019-05-16/indonesia-has-a-412-billion-plan-to-rebuild-the-country>

Note: 5% returns presented here assume zero leverage. Assumes 25% tax rate on plant profits, supplementary carbon revenues and electricity surcharges. Assumes average plant age of 10 years.

At higher levels of acquisition prices, supplementary revenue would be needed for the CRM to repay principal and a 5% return to its investors and meet the retirement schedule. Supplementary revenue could come from a combination of several sources: energy surcharges, reallocation of coal and other fossil fuel subsidies, compensation for carbon reduction, or possibly negotiated performance payments or concessional terms from the CRM's investors for achieving specific environmental or social outcomes.⁴⁴

Current electricity-related carbon credit certification methodologies are mostly focused on generating electricity with a lower carbon footprint (e.g. renewable energy or energy efficiency), rather than avoiding carbon in the future and thereby changing the country's carbon baseline. Therefore, for the CRM to be eligible for offsets, a new certification methodology will be needed. Since the carbon emissions will only be terminated when the plants are retired, for supplemental carbon revenue to be realized, a mechanism will be needed to raise forward financing based on future carbon reductions.⁴⁵

Assuming that carbon reductions by the CRM (alone or in combination with the replacement renewables) are certified, the modeling suggests that carbon reduction revenue could provide half of the supplementary revenue for the US\$1.5 million per megawatt scenario at a carbon price of US\$5 per tonne on a present value basis for reductions to be produced at the time of retirement. That would equate to US\$11 per tonne beginning in Year 16.⁴⁶ Whether those prices could be achieved needs further research, as opinions among carbon market participants vary. Those prices are at the middle to high end for voluntary carbon offsets⁴⁷ but lower than the price range of the South Korean carbon market, which currently accepts qualified offshore emission reductions⁴⁸, and the European Union Emissions Trading System (ETS), which does not accept foreign project offsets.⁴⁹

⁴⁴ Environmental impact bonds, social impact bonds, and pay-for-success contracts are examples of instruments that give performance payments for achieving specific environmental or social outcomes. See Herrera, D. (July 14, 2017). "Environmental impact bonds: Next big thing for green investments?", *Environmental Defense Fund*. <https://www.edf.org/blog/2017/07/14/environmental-impact-bonds-next-big-thing-green-investments>
Rangan, V.K. and Chase, L.A. (2015). The payoff of pay-for-success. *Stanford Social Innovation Review*. https://ssir.org/up_for_debate/article/the_payoff_of_pay_for_success

⁴⁵ The modeling assumed average plant age of 10 years at acquisition, 15 years of operations after acquisition, and retirement at 40 years of operations. The plant was also modeled assuming decreasing capacity factor (i.e. lower utilization) and degrading heat rate (i.e. lower efficiency). 5 tonnes of carbon generated per GW of capacity is consistent with global averages calculated from the Global Energy Monitor's Global Coal Plant Tracker (January 2020 edition) (<https://globalenergymonitor.org/coal/global-coal-plant-tracker/>)

⁴⁶ Carbon prices expressed in nominal terms over plant operating period. Assumes forward carbon pricing for Years 16 to 30 of 25 million tonnes emissions reduction per year, discounted at 5% per annum. This would imply carbon prices of US\$11.0 and 18.5 per tonne in Years 16 to 30. 25 million tonnes of carbon emission reductions is not large relative to the total quantity covered in the EU Emissions Trading System, which is more than 1,700 million tonnes in 2018. European Environment Agency. (2019). *The EU Emissions Trading System in 2019: trends and projections*. Figure 1. DOI: 10.2800/256052 <https://www.eea.europa.eu/publications/the-eu-emissions-trading-system>

⁴⁷ As of July 3, 2020, a Gold Standard carbon credit can be purchased for US\$10-28 / tonne. Gold Standard. (n.d.). *Offset your emissions*. Retrieved July 3, 2020, from <https://www.goldstandard.org/take-action/offset-your-emissions>

⁴⁸ 1 Korean Allowance Unit (KAU) has been trading at KRW 23,000 – 41,000 a tonne (~ US\$19-33) in 2019, and is trading at around KRW 31,000 (~US\$ 26) in June 2020

Korean Exchange. (n.d.). [50101] *Daily / Closing price*. Retrieved June 15, 2020 from <http://global.krx.co.kr/contents/GLB/05/0506/0506030102/GLB0506030102.jsp>

⁴⁹ ETS have been trading at €18-29 a tonne in 2019 and are trading at €26-30 in July 2020

While Figure 11 presents carbon revenue as a potential source of supplementary revenue in the two scenarios with higher acquisition prices, adding carbon revenue at US\$5.3 per tonne to the US\$1 million per megawatt scenario would allow retirement of the coal-fired power assets in 8 years rather than 15. This illustrates that offsets could be a powerful tool to allow quicker retirement if a country can manage a faster transition from coal to renewables.⁵⁰ (See Appendix 4 for further discussion of carbon revenue and issues regarding offsets and Article 6 of the Paris Agreement.)

The analysis above shows that even under assumptions where coal-fired plants are operating profitably, and therefore have a value to the seller, the CRM ought to be able to acquire and use the plants' own cash flows to repay the CRM's investors within a shorter time frame than would occur in the absence of a CRM facility. It is important to note, however, that the modeling of acquisition costs, operations, cash flow, etc. is based on generalized assumptions and not specific to any particular country or power asset. There is considerable variation in the structure of electricity generation, transmission, and distribution across developing countries. Actual circumstances in any host country would dictate the method of acquisition and the acquisition prices, as operating assumptions regarding plant age, efficiency, utilization rates, fuel prices, carbon emissions, electricity pricing, etc. vary. In some countries, the CRM's cost to acquire coal-fired power assets could be less than assumed above for a number of reasons such as the electricity pricing regime or less profitable plant operations. Also, the CRM might be able to acquire assets more cheaply than modeled by using transparent methods of acquisition such as reverse auctions or by negotiating large-scale transactions of multiple plants with a single seller. There may be situations where it can acquire and retire older and less efficient plants sooner at lower costs, maximizing emission reductions and reducing pollution. In those cases, it is likely that a lower acquisition price would also come with lower cash flows or shortened revenue streams. The variety of possible scenarios calls for further research and discussion around the modeling, optimal strategy for acquisition, and the optimal period for retirement and payback based on specific national circumstances, including the capacity for transition of both the electricity generation mix and the affected communities.

Host country feasibility and transition politics

There are signs that some Asian governments with large scale current and planned coal-fired capacity are willing to consider moving away from coal and towards a more sustainable energy future. Indonesia's Energy and Mineral Resources Minister has suggested openness to replace old coal-fired power plants with renewable energy⁵¹ and several ministries are joining forces to pilot

Ember. (n.d.). *EUA price*. Retrieved July 3, 2020, from <https://ember-climate.org/carbon-price-viewer/>

⁵⁰ Forward carbon financing for projects that will produce future emission reductions is a practice in the voluntary carbon markets, but not at the scale to do all the countries envisaged here. New forward financing mechanisms may need to be established as part of this construct or perhaps could be provided by an existing global finance facility such as the Green Climate Fund. Further consideration is given below to the potential use and impact of carbon offsets under current voluntary or possible future climate regimes.

⁵¹ Asmarini, W. (January 30, 2020). "Indonesia plans to replace old coal power plants with renewable plants: minister". *Reuters*. <https://www.reuters.com/article/us-indonesia-power-coal/indonesia-plans-to-replace-old-coal-power-plants-with-renewable-plants-minister-idUSKBN1ZT17N>

carbon trading in 2020⁵². Vietnam is reported to be considering reducing the total capacity of coal-fired power plants and increasing wind and solar power plants.⁵³ These are positive signs that with appropriate assistance, developing countries could dramatically change their energy blueprints, improve health, and put the global climate math on a much better trajectory.

Export competitiveness may be another reason for countries to pursue decarbonization and establish a CRM/SETM. The European Commission has proposed a carbon border adjustment mechanism on selected sectors as part of the European Green Deal to reduce the risk of carbon leakage.⁵⁴ A carbon leakage occurs when companies transfer polluting activities to countries that are less strict about emissions. The proposed carbon border adjustment mechanism would address this risk by putting a carbon price on imports from outside the EU. As a result, countries that export to Europe may find themselves at a cost disadvantage if their energy grids are more carbon-intensive. Countries looking for favorable trading relations with Europe may find themselves in a better position by lowering carbon intensity and being in compliance with the Paris Agreements.⁵⁵

Establishing a CRM and SETM mechanism ought to increase political support for an accelerated timetable for transition. Prior owners of coal-fired assets would no longer have economic interest in the status quo. If they are incentivized to recycle the funds from the sale into renewable power, they would become advocates for change. With a 10-15-year transition period, there is adequate time for the country to build confidence in its ability to manage both cost and availability challenges of electricity generation and distribution and sign on to further reductions.⁵⁶ The transition period should provide sufficient time for the government with the help of the SETM to take necessary measures including re-training and job assistance, as well as new industry promotion in affected communities, especially those dependent on mining and refining of coal.

India's energy transition is unique in scale and complexity

The modeling and discussion thus far have focused on explaining and assessing the feasibility of a CRM/SETM concept to replace the reliance on coal-fired electricity in lower-middle and low-income countries other than India. While the CRM/SETM concept appears feasible and worthy of consideration for many countries, the size and the complexity of India's electricity ecosystem requires much deeper analysis, beyond the scope of this paper.

⁵² Oktavianti, T.K. (July 7, 2020). "Indonesia speeds up regulation on global carbon trading". *The Jakarta Post*. <https://www.thejakartapost.com/news/2020/07/07/indonesia-speeds-up-regulation-on-global-carbon-trading.html>

⁵³ The Star. (March 11, 2020). "Vietnam reduces capacity of coal power plants". <https://www.thestar.com.my/news/regional/2020/03/11/vietnam-reduces-capacity-of-coal-power-plants>

⁵⁴ European Commission. (2020). *EU Green Deal (carbon border adjustment mechanism)*. <https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12228-Carbon-Border-Adjustment-Mechanism>

⁵⁵ VOA News. (September 25, 2018). "Macron: France to reject trade deals from countries that reject Paris Climate Accord". <https://www.voanews.com/europe/macron-france-reject-trade-deals-countries-reject-paris-climate-accord>

⁵⁶ It is conceivable that within a 10-15-year period, technology may allow converting the remaining coal-fired power plants in the country to use more sustainable fuels such as green ammonia or hydrogen rather than be completely retired. See recent innovations in creating carbon-free ammonia as a fuel for transportation and power generation:

Service, R.F. (July 12, 2018). "Ammonia – a renewable fuel made from sun, air, and water – could power the globe without carbon". *Science*. <https://www.sciencemag.org/news/2018/07/ammonia-renewable-fuel-made-sun-air-and-water-could-power-globe-without-carbon>

Crolius, S. H. (July 18, 2019). "The evolving context of ammonia-coal co-firing". *Ammonia Energy Association*. <https://www.ammoniaenergy.org/articles/the-evolving-context-of-ammonia-coal-co-firing/>

India's current coal-fired electricity capacity (see Figure 4) is about seven times that of the next largest coal-fired power producer Indonesia. However, several unique aspects of industry structure and the government's demonstrated commitment to increase the percentage of renewable energy make coal-fired assets relatively unprofitable for large sectors of the industry. This is especially true for certain private sector owners, such that acquisition price multiples in India are lower, perhaps at half or less per megawatt, than the assumptions used in the generalized model in previous sections.⁵⁷

Our interviews indicated that about two-thirds of India's coal-fired power plants are state-owned, and one-third privately owned. The state-owned plants are typically older and benefit from fixed availability payments as described earlier. They also have access to domestic coal (domestic coal mines are typically state-owned as well), which is cheaper than imports. Privately-owned coal-fired power plants typically do not benefit from fixed availability payments, and often rely on costlier imported coal or non-subsidized domestic coal; thus, they are more likely to be dependent on maintaining high rates of utilization to be profitable. When coal-fired electricity is dispatched, power from the older state-owned plants is typically dispatched first given lower marginal cost of power to the purchaser, depressing the utilization rates of the private producers. The government also mandated that state power-distribution companies, captive power plants and other large electricity consumers purchase at least 21% of electricity from renewable sources by 2022⁵⁸. This has further depressed utilization of coal-fired plants. Overall, coal-fired power plants were only utilized 57% on average in 2019, a drop from 61% in 2018⁵⁹, and the country may see much lower utilization rates by 2022, perhaps lower than the minimum technical limit of 40% for Indian plants⁶⁰ unless operators are willing to retrofit plants to enable more flexible operations and lower utilization rates. However, cost of retrofitting may not be justified, especially for older assets. As a result, a number of privately-owned plants are not profitable.

The Government of India has grown renewable energy aggressively and plans to continue to do so. Since announcing its Paris Agreement targets in 2015, installed renewable energy capacity has grown from 14% of total capacity in March 2015⁶¹ to 36% in April 2020⁶². India's Central Electricity Authority projects that installed renewable energy capacity will grow to 63% by 2030⁶³, exceeding India's Paris Agreement target of 40% installed power capacity from non-fossil fuel sources⁶⁴. The combination of these factors means that renewable energy is sought

⁵⁷ Interviews have suggested that recent acquisition prices fall in the range of US\$0.7-0.9 million per megawatt versus US\$1.0-1.8 million per megawatt in the generalized model

⁵⁸ Government of India Ministry of New and Renewable Energy. (n.d.). *National portal for RPO*. <https://rpo.gov.in/Home/Objective>

⁵⁹ Abdi, B. (February 15, 2020). "India witnesses first drop in coal-fired power generation in 13 years". *ETEnergyWorld*. <https://energy.economicstimes.indiatimes.com/news/power/india-witnesses-first-drop-in-coal-fired-power-generation-in-13-years/74146510>

⁶⁰ Sengupta, D. (November 23, 2019). "Coal-fired plants may have to scale down utilization to 35% by 2022: KPMG". *The Economic Times*. <https://economictimes.indiatimes.com/industry/energy/power/coal-fired-plants-may-have-to-scale-down-utilisation-to-35-by-2022-kpmg/articleshow/72200926.cms?from=mdr>

⁶¹ Government of India Ministry of Power Central Electricity Authority. (March 31, 2015). All India installed capacity (in MW) of power stations. http://www.cea.nic.in/reports/monthly/installedcapacity/2015/installed_capacity-03.pdf

⁶² Government of India Ministry of Power Central Electricity Authority. (April 30, 2020). All India installed capacity (in MW) of power stations. http://www.cea.nic.in/reports/monthly/installedcapacity/2020/installed_capacity-04.pdf

⁶³ Government of India Ministry of Power Central Electricity Authority. (2019). *Draft report on Optimal generation capacity mix for 2029-2030*. Exhibit 9. http://cea.nic.in/reports/others/planning/irp/Optimal_generation_mix_report.pdf

⁶⁴ Government of India. (2015). *India's intended Nationally Determined Contribution: Working towards climate justice*. Page 29

after and relatively cost competitive. Therefore, although India generated 0.8% more electricity in FY 2019/20 than FY 2018/19, coal's share of electricity generation shrank while hydroelectricity and solar more than made up for the difference.⁶⁵

The government has demonstrated an appetite for innovation and new models to encourage the development of renewables but is also realizing limitations in its current system and technology. For example, SECI, a company of India's Ministry of New and Renewable Energy, launched a tender in February 2020 for a hybrid wind-solar-hydro-thermal generation package. Renewables must constitute at least 51% of total generation but the system must be available 80% of the time. This means renewables will be deployed most of the time, but operators can draw on coal-fired electricity to fill out the balance if required.⁶⁶

Considering the unique structural factors above, the scale and usefulness of a CRM in India needs further exploring. Some coal-fired assets may be retired due to fundamental lack of financial viability. If it were to be established, a CRM should be able to acquire and retire many assets at fraction of the costs for the models discussed in the previous section. A SETM would appear potentially very useful, however, to assist government in the upgrade and reform of the transmission and distribution system, which will be a bottleneck to achieving higher levels of renewables. The Central Electricity Authority projects 44% of generation will come from renewables by 2030/31 (see Figure 3), a level that exceeds the grid's current capability to handle. Thus, India must expand the capacity of its transmission and distribution system to accommodate higher levels of renewables and reduce transmission and distribution losses (which are estimated to be approximately 20%, more than twice the world average⁶⁷). That will depend on the capability of the state-owned distribution companies to manage the challenge.

Sources of funds — Paris and Promises; COVID-19 and COP26

In the G20 and other forums, there is a robust discussion of fostering a “green recovery” from COVID-19. With central banks creating mechanisms to provide liquidity, including the purchase of public and private debt in the hundreds of billions of dollars, financing large-scale green finance initiatives such as the CRM and the SETM are well within the reach of the global financial architecture. Large scale finance of US\$100 billion per year beginning in 2020 was already committed by developed countries at climate summits in Copenhagen (2009) and Durban (2011) and reaffirmed in the Paris Agreements of 2015. This US\$100 billion commitment could fund a large portion of CRM/SETM finance. From the perspective of the developing countries, the promised financing is essential both to enable them to meet their commitments and also a

<https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf>

⁶⁵ Worringham, C. and Buckley, T. (March 20, 2020). “IEEFA update: India's coal-fired power plant stockpiles reach record levels even as electricity demand weakens”. *Institute for Energy Economics and Financial Analysis (IEEFA)*.

<https://ieefa.org/ieefa-update-indias-power-plant-stocks-reach-record-levels-even-as-electricity-demand-weakens/>

⁶⁶ ETEnergyWorld. (March 17, 2020). “SECI issues tender for 5,000 MW round-the-clock renewable-thermal bundled projects”. <https://energy.economictimes.indiatimes.com/news/renewable/seci-issues-tender-for-5000-mw-round-the-clock-renewable-thermal-bundled-projects/74675617>

⁶⁷ U.S. Energy Information Administration. (October 22, 2015). “India aims to reduce high electricity transmission and distribution system losses”. <https://www.eia.gov/todayinenergy/detail.php?id=23452>
Government of India Ministry of Power Central Electricity Authority. (2020). *Executive summary on power sector – March 2020*. Table 11. http://www.cea.nic.in/reports/monthly/executivesummary/2020/exe_summary-03.pdf

matter of equity as they are being asked to help solve a problem that has largely been created by the developing countries' cumulative carbon emissions since the beginning of the industrial era.⁶⁸

While it is envisaged that the MDBs would be the mobilizers and stewards of the CRM/SETM funds, they cannot be the sole source of funding. Even leaving India aside, the CRMs for the 10 lower middle- and low-income countries in Figure 10 would require US\$100 – 180 billion to purchase and retire half of the current coal-fired capacity, a huge sum relative to the total annual disbursements of the major MDBs in Asia, Europe, and Africa, which are about US\$140 billion.⁶⁹ Even though the CRMs' funding would be spread over several years, asking MDBs to redirect 10% or more of their annual disbursements towards the CRM/SETM would jeopardize other development priorities. Thus, a large part of CRM and SETM funding will need to be new finance provided by the developed countries, and it could be made available in various ways. Funding could be constructed as direct loans to or investments in the CRM by developed central governments, by national development finance institutions, and perhaps supplemented by investments from the philanthropic or impact sectors.

Other means could be explored for funding the CRM. MDBs have acted to mobilize funds for other large-scale global initiatives. One example is the Global Alliance for Vaccination and Immunization (GAVI) established in 2000. In that case, the World Bank acted as the treasurer to issue a bond backed by the pledges of governments and philanthropy.⁷⁰ As the CRM would involve considerably more funding than GAVI, it is envisaged that engagement by several MDBs would be required both in the mobilization of funds and in the stewardship of the programs in specific host countries. Funding could be via MBDs issuing a new instrument -- “Coal Replacement Bonds”. Ideally, those bonds would have a unique purpose but could be designed to be compatible with existing frameworks for Green Bonds and Climate Bonds. Unlike GAVI, the CRM will have a flow of revenue from the acquired power plants to pay back the funds it receives, so the pledges that governments make might never actually require transfer of funds. Pledges might be structured merely in the form of guarantees that would attract private capital

⁶⁸ Adow, M. (2020). “The climate debt: What the West owes the rest”. *Foreign Affairs*. Volume 99, Number 3. Pages 60-68. <https://www.foreignaffairs.com/articles/world/2020-04-13/climate-debt>

⁶⁹ Asian Development Bank. (2020). *2019 Asian Development Bank annual report*. Page 2.

<https://www.adb.org/sites/default/files/institutional-document/603881/adb-annual-report-2019.pdf>

International Bank for Reconstruction and Development. (2020). *Management discussion & analysis and condensed quarterly financial statements March 31, 2020 (unaudited)*. Page 2 Box 1.

<http://pubdocs.worldbank.org/en/269441589983117406/IBRD-Financial-Statements-March-2020.pdf>

International Development Association. (2020). *Management discussion & analysis and condensed quarterly financial statements March 31, 2020 (unaudited)*. Page 2 Box 1. <http://pubdocs.worldbank.org/en/358521590782067171/IDA-Financial-Statements-March-2020.pdf>

International Finance Corporation. (2019). *Management discussion and analysis and condensed financial statements June 30, 2019*. Page 10. https://www.ifc.org/wps/wcm/connect/ed91858c-7eac-4732-a945-5ce8870b682e/IFC+FY19+MDA+and+Financial+Statements+_FINAL.pdf?MOD=AJPERES&CVID=mNTEBV0

New Development Bank. (2020). *Annual report 2019*. Page 6. https://www.ndb.int/wp-content/uploads/2020/07/NDB_2019_ARA_1.pdf

European Investment Bank. (2020). *2019 financial report*. Page 4. https://www.eib.org/attachments/general/reports/eib_financial_report_2019_en.pdf

European Bank for Reconstruction and Development. (n.d.). *Annual review 2019*. <https://2019.ar-ebrd.com/>

African Development Bank. (2019). *Annual report 2018*. P.ii <https://www.afdb.org/en/documents/annual-report-2018>

Martina, M. (December 1, 2015). “China-backed AIIB to lend \$10-15 bln a year for first five years: president-designate”. *Reuters*. <https://www.reuters.com/article/china-aiib/update-1-china-backed-aiib-to-lend-10-15-bln-a-year-for-first-five-years-president-designate-idUSL3N13Q1T620151201>

⁷⁰ The World Bank. (July 2, 2013). “Millions of children to be protected from deadly diseases through unique global vaccine bond issuance”. <https://www.worldbank.org/en/news/press-release/2013/07/02/millions-of-children-to-be-protected-from-deadly-diseases-through-unique-global-vaccine-bond-issuance>

and the public funding would be required only if the CRM's revenue runs short. The key point is that the CRM needs public backing or funding in order to have a very low cost of funds, which is key to reducing the period that the plants are operated to pay back investors —the higher the funding cost the longer the operating period needed to repay investors.

An issue to be addressed in the funding strategy is foreign exchange (FX) risk. Managing FX risk is a common problem faced by all infrastructure investments when offshore financing is provided. If the funding currency is in US dollars, and all or part of the revenues are in local currency, then the CRM will be at risk of changes in exchange rates. There are several strategies that could be explored to manage or share the FX risk. CRM fund raising could be a mix of local currency and US dollars. As discussed below, if CRM/SETM reduction of emissions qualify for revenue from carbon offsets, contracts may be denominated in US dollars. Alternatively, certain investors, perhaps those from the philanthropic or impact sectors, or even the MDBs themselves, might be willing to provide a layer of capital that would take a higher level of FX risk. Another strategy would be to tap local capital markets for a portion of CRM/SETM funds. This last strategy would have the benefit of supporting the development of domestic capital markets in the host countries. Many of the lower income countries have high savings rates but underdeveloped capital markets, especially bond markets. Better mobilization of domestic savings for long term investment will help the countries finance other infrastructure needs beyond the power sector.⁷¹

While this paper has not attempted to define in detail or model the SETM, it would seem feasible to tailor its financing to the models above, but because the investments are designed to be financially variable and operating long term, private sector finance should be able to play a greater role. For example, one could envisage the introduction of “Sustainable Energy Transition Bonds” issued in US dollars or local currencies issued by the MDBs or other agencies, with or without back up from developed country pledges. Another model that could be explored would be the use of blended finance along the lines of the International Financial Corporation (IFC)'s Managed Co-Lending Portfolio Program (MCP), which has mobilized capital of public and private investors including the People's Bank of China and the Hong Kong Monetary Authority. Either the MDBs or developed countries could provide a first-loss protection to crowd in other investors.⁷² Finally, many of the initiatives in renewable energy and new energy delivery ought to be able to be funded by private sector capital as they could offer commercial returns.

Consideration of alternative ways to replace coal-fired power

This paper does not propose the CRM/SETM structure as the only or even the best alternative to replace coal-fired power in all developing countries. Other methods have been used to achieve the same ends and could be considered as alternatives or used in combination with a CRM/SETM structure.

⁷¹ Kanak, D. (November 28, 2019). “Domestic capital markets key to closing long-term investment gap”. *The Jakarta Post*. <https://www.thejakartapost.com/academia/2019/11/28/domestic-capital-markets-key-to-closing-long-term-investment-gap.html>

⁷² International Financial Corporation (IFC). (n.d.). *Managed Co-Lending Portfolio Program (MCP)*. https://www.ifc.org/wps/wcm/connect/corp_ext_content/ifc_external_corporate_site/solutions/products+and+services/syndications/mcpp

Under the current climate regime, some countries have already been able to dramatically reduce their coal-fired power. Coal-fired electricity generation in Europe and the U.S. has fallen to half the level of 2007 due to a combination of regulation and economics. In the U.S., cheap gas as an alternative fuel, energy policy promoting renewables in some regions, and effective advocacy by groups such as the Sierra Club, the National Resources Defense Council, the Nature Conservancy, with the support of Bloomberg Philanthropies and many others, not only led to the phasing out of over half the U.S.'s existing coal fired capacity⁷³, but today the U.S. has no plans for new coal-fired facilities. In some states, the prospect of using securitization or debt for equity swaps may be a mechanism to accelerate retirement of coal-fired power and new renewables.⁷⁴

In Europe, regulation including carbon charges, and energy policy supporting the growth of renewables have combined to make large proportions of coal-fired power unprofitable.⁷⁵ Reaching the state of reduced profitability has facilitated another alternative: paying existing producers to close their coal-fired plants. In Germany, the parliament adopted the coal exit law in July 2020, where the government will compensate various stakeholders with US\$45 billion to phase out coal no later than 2038. Some of the compensation will be paid to mining companies and power producers. The government has agreed with lignite plant owners to a schedule of closures, starting in late 2020 with older plants (which started operations in 1959-1976) located in economically stronger parts of Germany. Hard coal plants will go through a reverse auction process where the maximum price paid per unit of capacity decreases as the years go by -- from €165,000 per megawatt of capacity in the first auction to be held in 2020 to €49,000 per megawatt in the last auction to be held in 2023. This decreasing maximum price feature creates an incentive for current owners to sell earlier. Should the later auctions fail to yield sufficient bids, forced shutdowns may be in order.⁷⁶ This approach would be worthy of consideration in deciding the acquisition process used by CRMs.

A variation of the German approach is being used by province of Alberta, Canada, which is mandating that coal-fired power plants be closed and decommissioned early and compensating the owners for the lost value of the foregone out years.⁷⁷

Both the German and Alberta models would appear to be effective ways to retire coal in some countries but may be more easily applied to more developed country situations. In both the German and Alberta situations above, the “pay-to-close” option followed the existence of a carbon price: a carbon tax (Alberta) or tariff and cap-and-trade regime (Germany). Neither of

⁷³ Hitt, M.A. (June 7, 2019). “We’re moving beyond carbon entirely, in partnership with Bloomberg Philanthropies”. *Sierra Club*. <https://www.sierraclub.org/articles/2019/06/we-re-moving-beyond-carbon-entirely-partnership-bloomberg-philanthropies>

⁷⁴ For example, the state of Colorado securitized its coal-fired power plants to fund the transition to renewable energy. See Lehr, R. (2018). “Utility financial transition impacts: From fossil to clean.” *Energy Innovation*.

https://energyinnovation.org/wp-content/uploads/2018/12/From-Fossil-to-Clean-Brief_12.3.18.pdf and Lehr, R. and O’Boyle, M. (2018). “Steel for fuel: Opportunities for investors and customers.” *Energy Innovation*. https://energyinnovation.org/wp-content/uploads/2018/11/Steel-for-Fuel-Brief_12.3.18.pdf

⁷⁵ Gimón, E., Clack, C.T.M. and McKee, S. (2019). *The Coal Cost Crossover: Economic Viability of Existing Coal Compared to New Local Wind and Solar Resources*. Energy Innovation and Vibrant Clean Energy.

https://energyinnovation.org/wp-content/uploads/2019/03/Coal-Cost-Crossover_Energy-Innovation_VCE_FINAL.pdf

⁷⁶ Wettengel, J. (July 3, 2020). “Spelling out the coal exit – Germany’s phase-out plan”. *Clean Energy Wire*.

<https://www.cleanenergywire.org/factsheets/spelling-out-coal-phase-out-germanys-exit-law-draft>

⁷⁷ Benn, A., Bodnar, P., Mitchell, J. and Waller, J. (2018). *Managing the coal capital transition: Collaborative opportunities for asset owners, policymakers, and environmental advocates*. In Guevara-Stone, L. (Ed.) Rocky Mountain Institute. Pages 56-59. <https://rmi.org/insight/managing-coal-capital-transition/>

those regimes exist in most low-income developing countries. Developing countries may not have adequate public fiscal resources to transfer large sums to owners of coal-fired power plants. Fiscal challenges have increased further due to COVID-19. It would be politically difficult in many low-income countries to explain the diversion of public funds from health or other social programs, introduce ratepayer surcharges, or raise direct taxes in order pay money to power plant owners. A possible reason the compensation was politically feasible in Alberta was that the government had supplementary revenue from a provincial carbon tax from which to make the payments.⁷⁸ Also, as noted above, many developing countries are still very dependent on coal-fired power for meeting current needs, and not yet confident that they can meet rising needs for electricity with renewables. In the case of Germany and Alberta, the “pay to close” approach is being employed after coal-fired power is no longer a critical part of the energy mix and feasible alternatives have been demonstrated.

If, as mentioned above, a new global climate regime results in large-scale markets for carbon offsets at relatively high prices, then the “pay to close” approaches in Germany and Alberta discussed above would be worthy of consideration in lieu of or as a supplement to CRM/SETM. Our model suggests that if there were a large enough market for carbon priced US\$18-34 per tonne then it would be feasible to offer current owners of profitable coal-fired assets an immediate opportunity to close (and forego all future profits)⁷⁹. But the feasibility of that option depends on the existence of large-scale buyers or financiers who are willing and able to outlay billions of dollars for future carbon emission reductions at relatively high prices.

One other caveat for accelerated “pay-to-close” as an option: speeding up transition is not just a climate or financial consideration. It must be done according to the host country’s ability to increase renewables in its energy system while still delivering affordable and secure power, and also its management of social and economic impacts to communities. Therefore, as of writing and working within the “Paris Agreement” regime, the carbon markets are seen as potential “boosters” or accelerators to a CRM/SETM framework if they materialize but not as reasons to delay consideration of CRM/SETM.

One possible argument against the CRM/SETM is that it might not maximize the funds invested in accelerating energy transition, especially if a large portion of funds used to acquire the existing coal-fired assets are not recycled into new renewables. Current coal-fired power plant owners and operators may not be in the best position to invest in clean energy technologies, such that allowing them to develop renewables would not be the most efficient use of funds. While some current owners have experience in developing and operating renewables, in many cases the existing power plant owners and operators lack experience operating a diversified portfolio including renewables. It will be necessary to can supplement their knowledge and capacity, assisted by the SETM and outside experts. In many countries, state-owned companies play a large role in power generation, transmission and/or distribution and so the buildup of technical and financial capacity to manage the electrical ecosystem with high percentages of renewables is critical. This will be one of the basic missions of the SETM. Together with the host country, the

⁷⁸ Ibid

⁷⁹ Calculation assumes acquiring a 10-year-old plant with acquisition cost of US\$1.0 – 1.8 million per megawatt of capacity, 6.5 million tonnes of carbon emissions per gigawatt of capacity per year, 15 years of carbon revenue, and 25% tax rate on carbon revenue.

SETM would also need to create transparent policies and incentives for local and international companies to participate in the new energy projects to “crowd in” both new sources of financing and know-how.

The key role of China

The concept of the CRM and SETM is designed to foster faster energy transition in the lower middle- and low-income countries. This presumes, perhaps with a degree of optimism, that high income countries and upper middle-income countries will exert more determined efforts to phase out their coal-fired power. Within that group, China stands out as the largest user of coal-fired power⁸⁰ and the largest source of public financial support for new coal-fired power overseas⁸¹. At the same time, on a positive note, China is also the largest user of renewables⁸² and is the world’s largest producer, exporter and installer of solar panels, wind turbines, batteries, and electric vehicles⁸³. Thus, China’s role in both its own transition and in assisting other countries will be pivotal.

China has reduced coal’s percentage of domestic electrical generation from 74% to 64% over the past 5 years⁸⁴ and plans to further reduce it to 44% by 2035⁸⁵. That continuing level of coal-fired generation will still, however, likely be greater than the IPCC’s global target for coal-fired electricity emissions for all countries.⁸⁶ Upon seeing serious commitment to retire coal among other G20 economies, if China can further accelerate its own transition away from coal, it could contribute greatly to achieving 2030 and 2050 targets. Already, China has announced it will exclude clean coal projects from the list eligible for green bonds⁸⁷ and will continue to “100% fulfill” its Nationally Determined Contributions on climate change under the Paris Agreements⁸⁸.

⁸⁰ Globally, in 2018, 47% of coal-fired electricity generated is by China

BP. (2019). *Statistical Review of World Energy 2019 (68th edition)*. <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf>

⁸¹ China plans to finance 39 GW of coal-fired electricity overseas, which is 69% of total foreign public financial support for coal-fired power. Global Energy Monitor. (n.d.). *Global coal finance tracker (February 2020 version)*. Retrieved May 8, 2020, from <https://endcoal.org/global-coal-finance-tracker/>

⁸² Globally, in 2018, 26% of renewable energy and 29% of hydroelectricity is generated by China.

BP. (2019). *Statistical Review of World Energy 2019 (68th edition)*. <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf>

⁸³ Global Commission on the Geopolitics of Energy Transformation. (2019). *A new world: The geopolitics of the energy transition*. Page 40. <http://geopoliticsofrenewables.org/assets/geopolitics/Reports/wp-content/uploads/2019/01/Global-commission-renewable-energy-2019.pdf>

⁸⁴ Changes from 2013 to 2018.

See China Electricity Council. (2019). *中国电力行业年度发展报告 2019*. <http://www.cec.org.cn/yaowenkuaidi/2019-06-14/191782.html>

Also, China Electricity Council. (2014). *2013 年电力统计基本数据一览表*.

<http://www.cec.org.cn/guihuayutongji/tongjixinxi/niandushuju/2015-03-06/134849.html>

⁸⁵ China Electric Power Planning & Engineering Institute. (2019). *China Power System Transformation*. Page 99 Figure 18. <http://www.efchina.org/Reports-en/report-20191217-en>

⁸⁶ 44% of electricity generation by coal in China by 2035 is equivalent to 4,328 TWh, which exceeds IPCC’s target of 10.41 EJ (2,892 TWh) from coal-fired electricity by 2030. IPCC targets from *Special report on global warming of 1.5°C*. Table 2.7 scenario 1.5°C high overshoot: <https://www.ipcc.ch/sr15/>

⁸⁷ Stanway, D. Xu, M. and Galbraith, A. (May 29, 2020). “China excludes clean coal projects from list eligible for green bonds”. *Reuters*. <https://www.reuters.com/article/us-china-environment-finance-idUSKBN2350FW>

⁸⁸ Reuters. (June 2, 2020). “China says sticking to climate pledges despite coronavirus outbreak”. <https://www.reuters.com/article/china-environment-climate/update-1-china-says-sticking-to-climate-pledges-despite-coronavirus-outbreak-idUSL4N2DF108>

Hopefully, with large-scale multinational support for more rapid energy transition in lower income developing countries, China, Japan, and other countries that are exporting the construction and financing of new coal-fired power will see much greater opportunities for their citizens and corporations in exporting renewable energy solutions. President Xi Jinping's keynote speech at the second Belt and Road Forum for International Cooperation⁸⁹ announced China will "pursue open, green and clean cooperation", mentioning the four greens – "green development", "green infrastructure", "green investment" and "green financing". Various commentaries and working groups in China and between China and other countries⁹⁰ are now focusing on greening the Belt and Road Initiative. These efforts could have enormous synergies with the establishment of CRMs and SETMs in lower income developing countries. Institutions such as the Asia Infrastructure Investment Bank and the New Development Bank, if they embrace the objectives of the CRM and SETM, could be among the multilateral institutions serving as shareholders and operators of the CRMs in host countries individually or alongside the longer established development banks.

Conclusion, next steps, and need for further research and discussion

Left unaddressed, coal-fired electricity alone will overwhelm IPCC's 2030 and 2050 targets for emissions reductions.

This paper has presented arguments for the urgent need and the potential feasibility of for a large-scale financial mechanism to assist developing countries to replace half of their coal-fired electrical capacity and transition, over an agreed timeframe, to an energy mix driven by renewables.

In the leadup to COP26, leaders of developed countries and the MDBs have a golden opportunity to support a "green recovery" from COVID-19 and tackle climate change by accelerating the shift to renewable energy in their own countries and supporting the creation of CRMs in developing countries. There are a range of topics regarding structure, governance, operational, and funding details that must be weighed and resolved and considered in the context of specific countries. Hopefully, the analysis presented will provide the basis for further research and discussion from various perspectives and among multiple stakeholders to develop a workable model that can be piloted in specific countries. Though the focus of this paper has been replacing coal-fired power, the concept could also be applied in countries where electrical generation is highly dependent on oil, diesel, or other fossil fuels.

The paper makes a case for not attempting to create a new global or supra-national bureaucracy to administer either the CRM or SETM but rather to look to the existing MDBs to take the lead role in establishing and overseeing the structures in specific countries. This is to avoid adding to the

⁸⁹ Xi, J. (2019). *Working together to deliver a brighter future for Belt and Road cooperation. Keynote speech by H.E. Xi Jinping President of the People's Republic of China at the opening ceremony of the Second Belt and Road Forum for International Cooperation.* https://www.fmprc.gov.cn/mfa_eng/zxxx_662805/t1658424.shtml

⁹⁰ For example, the UK and China are working on green Belt and Road investments together through the UK-China Economic and Financial Dialogue. See Government of United Kingdom HM Treasury. (2019). *Policy outcomes of the 10th UK-China Economic and Financial Dialogue.* Paragraphs 44 to 46. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/809569/190617_FINAL_P OP_v2_002_.pdf

multiple views that host country governments already receive from various DFIs and eliminate the significant amount of time that would inevitably be taken up by financial diplomacy to agree the shareholding, governance, and leadership of a new multilateral institution. It would also help to ensure that the operating structure of the CRM and SETM remains lean, transparent, and capable of acting within the short time available to change the trajectory of emissions and provide a just transition to a more sustainable energy future. The old saying is that “time is the enemy” has never been more relevant.

Appendix

Appendix 1: Examples of organizations and initiatives encouraging sustainable investment portfolios and business practices

UN-backed Principles for Responsible Investment (UNPRI)

The UNPRI are a voluntary and aspirational set of investment principles that offer a menu of possible actions for incorporating ESG issues into investment practice. There are over 3,000 signatories representing US\$103 trillion assets under management as of March 2020.

The FSB Task Force on Climate-related Financial Disclosures (TCFD)

In April 2015, the G20 asked the Financial Stability Board (FSB) to consider climate risk. In December 2015 the FSB launched the industry-led Task Force on Climate-related Financial Disclosures (TCFD) to develop recommendations on climate-related financial disclosures. As of February 2020, support for the TCFD has grown to over 1,000 organizations, representing a market capitalization of over US\$12 trillion.

The Network of Central Banks and Supervisors for Greening the Financial System (NGFS)

The NGFS is a group of central banks and supervisors sharing best practices, contributing to the development of environment and climate risk management in the financial sector and mobilizing mainstream finance to support the transition toward a sustainable economy. As of June 2020, the NGFS has 66 members and 13 observers.

Appendix 2: Major multilateral institutions' initiatives to invest in renewable energy and divest from coal-related investments

World Bank and IFC

World Bank announced in 2013 that it “will provide financial support for greenfield coal power generation projects only in rare circumstances”.⁹¹ The IFC announced the “Green Equity Strategy”⁹² in 2018 where in exchange for equity investment, financial intermediaries have to formally commit to decarbonize their lending books and shift capital towards green energy with an ultimate goal of zero coal exposure by 2030.⁹³

Asian Development Bank (ADB)

ADB's energy policy was written in 2009 and has not been updated since. The policy states that ADB “will not finance coal mine development except for captive use by thermal power plants” and “will selectively support coal-based power projects if cleaner technologies are adopted and adequate mitigation equipment and measures are incorporated into the project design”. ADB will

⁹¹ World Bank. (2013). *Toward a sustainable energy future for all: directions for the World Bank Group's energy sector (English)*, Washington DC. <http://documents.worldbank.org/curated/en/745601468160524040/Toward-a-sustainable-energy-future-for-all-directions-for-the-World-Bank-Group-8217-s-energy-sector>

⁹² Le Houérou, P. (October 8, 2018). “Opinion: A new IFC vision for greening banks in emerging markets”. *Devex*. <https://www.devex.com/news/opinion-a-new-ifc-vision-for-greening-banks-in-emerging-markets-93599>

⁹³ Roasa, D. (2019). *Digging deeper: Can the IFC's green equity strategy help end Indonesia's dirty coal mines?* In Pred, D. and Bugalski, N. (Ed.). *Inclusive Development International, Bank Information Center Europe, and Jaringan Advokasi Tambang (JATAM)*. Page 12. <https://www.re-course.org/wp-content/uploads/2019/04/Digging-Deeper.pdf>

support less efficient coal-fired power plants in developing member countries with smaller grids if these plants enable system reliability and energy security and are the least-cost option.⁹⁴

Asian Infrastructure Investment Bank (AIIB)

AIIB Energy Sector Strategy states that it “will support clients to reduce the carbon intensity of energy to help them achieve their long-term climate goals provided in the Paris Agreement”. It also states that “carbon efficient oil and coal-fired power plants would be considered if they replace existing less efficient capacity or are essential to the reliability and integrity of the system, or if no viable or affordable alternative exists in specific cases, particularly in low income countries.”⁹⁵ AIIB President Jin Liqun said at an interview in November 2019 that AIIB “[does not] finance coal power plants and there are no projects in [their] pipeline”.⁹⁶

European Bank for Reconstruction and Development (EBRD)

In December 2018, the EBRD announced that it will not finance thermal coal mining or coal-fired electricity generation capacity, including upgrades to existing plants or the construction of new capacity. The Bank will also engage with countries of operations with significant coal dependence to develop strategies to support a transition away from coal that addresses issues of air quality, retrenchment, and energy security.⁹⁷

European Investment Bank (EIB)

In November 2019, EIB announced that it will no longer consider new financing for unabated, fossil fuel energy projects, including gas, from the end of 2021 onwards. The new policy replaced the 2013 standard that ended financing for coal and lignite power generation.⁹⁸ The EIB Group will aim to support €1 trillion of investments in climate action and environmental sustainability from 2021 to 2030.

Green Climate Fund (GCF)

The GCF was set up by the United Nations Framework Convention on Climate Change in 2010. It aims to use public investment to catalyze and stimulate private investment into low-emission and climate-resilient development. However, the GCF refused an explicit ban on fossil fuel projects at its board meeting on March 2015, therefore effectively allowing for the funding of coal-fired power plants.⁹⁹ This official position has not changed since. It raised US\$8.2 billion in 2014 and donors pledged another US\$9.8 billion in 2019 for 2020-2023.¹⁰⁰ As of May 2020, the

⁹⁴ Asian Development Bank. (2009). “Energy Policy”, ADB Policy Paper, Paragraphs 15 and 33.

<https://www.adb.org/sites/default/files/institutional-document/32032/energy-policy-2009.pdf>

⁹⁵ Asian Infrastructure Investment Bank. (2018). *Energy sector strategy: Sustainable energy for Asia*. Paragraphs 22 and 37.

<https://www.aiib.org/en/policies-strategies/strategies/sustainable-energy-asia/.content/index/download/energy-sector-strategy.pdf>

⁹⁶ Suroyo, G. and Davies, E. (November 26, 2019). “China-backed AIIB offers to help fund Indonesia’s capital relocation”. *Reuters*. <https://www.reuters.com/article/indonesia-aiib/china-backed-aiib-offers-to-help-fund-indonesias-capital-relocation-idUSL4N2861YT>

⁹⁷ European Bank for Reconstruction and Development. (2018). *Energy sector strategy 2019-2023*. Page 21.

<https://www.ebrd.com/power-and-energy/ebrd-energy-sector-strategy.pdf>

⁹⁸ European Investment Bank. (November 14, 2019). “EU bank launches ambitious new climate strategy and Energy Lending Policy”. <https://www.eib.org/en/press/all/2019-313-eu-bank-launches-ambitious-new-climate-strategy-and-energy-lending-policy>

⁹⁹ Upadhyay, A. (April 7, 2015). “Green Climate Fund can be spent to subsidize dirty coal”. *CleanTechnica*.

<https://cleantechnica.com/2015/04/07/green-climate-fund-can-spent-subsidise-dirty-coal/>

¹⁰⁰ Donors pledged US\$10.3 billion in the initial round but only US\$8.2 billion was confirmed

Green Climate Fund. (n.d.). “Resource mobilization”. <https://www.greenclimate.fund/about/resource-mobilisation/irm>

GCF has approved US\$5.6 billion for 129 projects. These projects are worth US\$19.7 billion co-financing is included.¹⁰¹

Appendix 3: Examples of public-private initiatives for mobilizing policy and finance for sustainable infrastructure

The World Business Council for Sustainable Development

The World Business Council for Sustainable Development (WBCSD) is a global, CEO-led organization of over 200 leading businesses working together to accelerate the transition to a sustainable world. The Council also works with partners in the civil society, academia, governments, and philanthropy.

Ceres

Ceres was founded by investors and environmentalists in response to the 1989 Exxon Valdez oil spill. It is a sustainability nonprofit organization working with investors and companies to transform the economy and build a sustainable future for people and the planet. Their network includes investors from both the public and private spheres, companies, and non-profits.

Sustainable Development Investment Partnership (SDIP)

The SDIP is a joint initiative of the World Economic Forum and the OECD. It is a global platform of 42 public, private, and philanthropic institutions with the shared ambition to scale finance for the UN Sustainable Development Goals and overcome the barriers hindering private investments in emerging and developing countries.

The Blended Finance Taskforce

The Blended Finance Taskforce was established to help mobilize largescale capital for the UN SDGs. The Taskforce has an Action Plan with 8 core workstreams to increase mainstream private investment for the UN SDGs. The Taskforce consists of a group of around 50 experienced practitioners and experts, from across the finance, business, development, and policy community.

Appendix 4: A greater role for carbon offsets?

In the analysis above, although revenues from the acquired power plants are the primary sources of cash to pay back the CRM's investors, it was mentioned that revenue from carbon finance might be a source of supplementary revenue in certain scenarios. Discussions with several participants in the voluntary carbon market suggested considerable support for the potential for CRM/SETM offsets to qualify (be certified) under VCS or other voluntary regimes, or as acceptable offsets for certain compliance markets, assuming that the appropriate methodologies for certification and verification were developed. The discussions were not conclusive, however, on what the demand or pricing would be for CRM/SETM offsets. Part of the reason for uncertainty is that some observers see the emission reductions from a CRM/SETM scheme as "high quality" in that they would be "verifiable, additional and permanent" (assuming they were tied to national emission targets and that relevant certification bodies can establish methodologies

¹⁰¹ Green Climate Fund. (n.d.). "Project portfolio". Retrieved June 9, 2020, from <https://www.greenclimate.fund/projects/dashboard>

for measurement and verification). On the other hand, there was the view that some offset buyers would not see them as “high quality” because they are associated with coal — even though the association is for the purpose of retiring coal and converting to renewables. Beyond any issues of perception of the CRM itself, there are more fundamental reasons that the future pricing and demand for offsets remains hard to predict.

Article 6 of the Paris Agreement provides three methods for international finance of carbon emission reductions in developing countries, but the rules are yet to be finalized and there remain many points of contention.¹⁰² Figure 11 above presented the example of retiring half of the coal-fired capacity of an “average” country in Figure 10, producing 25 million tonnes emissions reduction per year on average, and assumed carbon priced at US\$5 - 9 per tonne. Finding demand in the voluntary carbon markets at those prices is conceivable, and in some existing compliance markets such as South Korea, higher pricing for offsets could be available. If, however, one were to aggregate across all ten of the countries in Figure 10, retiring half of the existing coal-fired capacity would approximately 250 million tonnes of emission reductions per year. India itself might be twice this size in total emission reductions. 250 – 750 million tonnes of offsets would be very significant additions to supply for either current compliance markets that accept foreign offsets¹⁰³ or voluntary carbon markets, especially for VCS and Gold Standard offsets, which can price in the assumed range.¹⁰⁴ In 2019, VCS and Gold Standard issued 120 million tonnes of offsets.¹⁰⁵

While current demand for high quality offsets falls short of the amount required for full scale use of the CRM/SETM, some market participants expect a large potential demand increase over the next 10-15 years. The potential for carbon revenue would be more dramatic were there to be a breakthrough at COP26, creating a new architecture for carbon finance. Hundreds of companies globally are signing on to “Race to Zero”¹⁰⁶ and other pledges to offset all or a portion of their carbon footprints. Large-scale demand created by airlines¹⁰⁷, the shipping industry, and large oil

¹⁰² A discussion of the issues and possible outcomes is far beyond the scope of this paper. See Evans, S. and Gabbatiss, J. (November 29, 2019). “In depth Q&A: How ‘Article 6’ carbon markets could ‘make or break’ the Paris Agreement”. *CarbonBrief*. <https://www.carbonbrief.org/in-depth-q-and-a-how-article-6-carbon-markets-could-make-or-break-the-paris-agreement>

Great uncertainty remains both on the supply and demand for offsets and their pricing. As previous attempts to reach agreements have failed, there is no certainty that there will be resolution at COP26 in 2021 in Glasgow. Thus, the discussion in this paper has attempted to regard carbon offset revenue as a potential supplement to the CRM and to use conservative prices for carbon that are generally lower than those projected as needed by the IPCC or other experts.

¹⁰³ For example, South Korea’s emissions trading system covers approximately 500 million tonnes of carbon, where 5% in offsets can be purchased from the international market.

International Carbon Action Partnership. (2020). *Korea Emissions Trading Scheme*.

https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=47

¹⁰⁴ Gold Standard and Verra’s VCS are regarded by many as high quality carbon credits. As of July 3, 2020, a Gold Standard carbon credit can be purchased for US\$10-28 / tonne.

Gold Standard. (n.d.) *Offset your emissions*. Retrieved July 3, 2020, from <https://www.goldstandard.org/take-action/offset-your-emissions>

¹⁰⁵ In 2019, Gold Standard and VCS issued 18 million and 99 million tonnes of carbon credits respectively. See: Gold Standard. (2020). *Market report 2019*. https://www.goldstandard.org/sites/default/files/market_report_2019_hd.pdf
Verra. (2020). *Data and insights – VCS quarterly update issue #2 – Q1/2020*. <https://verra.org/datainsights/april-2020/>

¹⁰⁶ Participants in the “Race To Zero” campaign pledge to reach net zero emissions by 2050 and submit net-zero roadmaps ahead of COP26. Almost 1,000 businesses have backed the campaign.

United Nations Climate Change. (June 5, 2020). “Cities, regions and businesses race to zero emissions”.

<https://unfccc.int/news/cities-regions-and-businesses-race-to-zero-emissions>

¹⁰⁷ The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) addresses the increase in total CO₂ emissions from international aviation above 2020 levels. It is estimated that CORSIA will address around 2,500 million tonnes of carbon credits between 2021 and 2035.

companies has the potential to expand demand for offsets into the several billions of tonnes per year. This could result in a larger global compliance carbon market, which would presumably in the future create higher prices.¹⁰⁸ Under such a regime, the CRM/SETM could take another form or rely more on carbon revenue, and thus make it financially possible to accelerate the plants' retirement. For example, modeling suggests that a carbon price of about US\$17 per tonne would shorten the required years of CRM operation from 15 to 8 years under the higher price acquisition scenario (see Figure 12). *(While the creation of a large-scale carbon trading regime based on binding commitments is an imaginable outcome of COP26, as the pathway for international offsets remain uncertain, Figure 12 is presented as purely as illustrative at this time.)*

Figure 12: Sensitivity of CRM payback period and plant retirement to carbon revenue from 5 GW coal-fired power (base case is presented in Figure 11)

Acquisition price	US\$1 million / megawatt		US\$1.8 million / megawatt	
Scenario	Base case (see Figure 11)	Alternative assuming more carbon revenue	Base case	Alternative assuming more carbon revenue
Years of operations	15	8	15	8
Total acquisition price (US\$ M)	5,000		9,000	
Annual plant revenue (US\$ M)	1,883	1,876	1,883	1,876
Annual carbon revenue (US\$ M)	-	152	224	484
Carbon price in nominal terms (US\$ / tonne)	-	5.3	8.9	16.9
Total carbon purchased (M tonnes)	-	430	379	430

Source: Internal model based on published data, consultations, and analysis

Note: 5% returns presented here assume zero leverage. Assumes supplementary carbon revenue of 15 years, tax rate of 25% on plant profits and carbon revenues.

Note: The power plant was modeled assuming a decreasing capacity factor (i.e. lower utilization) and degrading heat rate (i.e. lower efficiency), the net effect of which is that earlier retirements result in more carbon avoided annually. In this example, closing the plant 8 years after acquisition results in avoiding 29 million tonnes of carbon emissions per year on average (vs. 25 million tonnes per year on average if the plant is closed after 15 years after acquisition).

Note: Carbon prices expressed in nominal terms over plant operating period. Assumes forward carbon pricing for Years 9 to 24 of 29 million tonnes of emissions reduction per year, discounted at 5% per annum. This would imply carbon prices of

IATA. (n.d.). Carbon Offsetting Scheme for International Aviation (CORSA).
<https://www.iata.org/en/programs/environment/corsia/>

¹⁰⁸ Various sources suggest that carbon prices will rise over time. For example, IPCC estimates carbon needs to rise from US\$135–6,050/tCO₂e in 2030 to US\$690–30,100/tCO₂e in 2100 (undiscounted values) to keep warming below 1.5°C. CDP found that “50% of the power sector panel identified US\$24-35/tonnes as the needed range of carbon price signals in the short-term (2020) to drive fuel switching and renewables deployment, rising to US\$38-100/tonne by 2035”. However, there was “lack of confidence that this is likely to be achieved via explicit carbon pricing policies in the short-term”, but the majority thought it was likely that the prices will materialize after 2025.

IPCC. (2018). *Special report on global warming of 1.5°C*. Section 2.5.2.1. <https://www.ipcc.ch/sr15/>
 CDP. (2018). *Carbon pricing corridors: The market view 2018*. Executive summary and Figure 12.
<https://www.cdp.net/en/reports/downloads/3326>

US\$7.8 and 11.0 per tonne in Years 9 to 24 in the US\$1.0 million per megawatt scenario, or US\$25.0 - 35.1 per tonne in Years 9 to 24 in the US\$1.8 million per megawatt scenario.

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