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ACCELERATING COAL PLANT RETIREMENT AT SCALE

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Abstract

Although coal plants in some countries are actively being retired ahead of their planned closure dates, there is yet to be sufficient clarity on which business model(s) might help to achieve this at scale. Policy-based and market-led closures, buyout of coal plants, auctioning them off, repurposing them, and swapping coal assets with renewables have all been tried in different parts of the world. In this paper, we first summarize these business models and reflect briefly on the insights gained from these experiences. We then focus on the core questions: How can coal retirements be scaled up? Is there a reason that one model unilaterally works better than others? Do these models need to be crafted specifically to fit the context of each country/system? Can they be combined in some shape or form to carry out retirements at scale more efficiently? We address these issues around some of the country/utility coal fleets where the World Bank team is having active dialogues under the aegis of the Accelerating Coal Transition (ACT) program. The broad conclusions that emerge from the discussion point to the need for a tailored hybrid model that best fits the policy, system, and ownership of a coal fleet.

Keywords: coal retirement, coal-fired power plants, Accelerating Coal Transition (ACT) program, energy transition mechanism, renewable energy

JEL Classification: Q40, Q41, Q42

Contents

1. INTRODUCTION

Coal-fired power plants (CFPPs or plants) across the globe—a combined 2,100 GW capacity (70% of which are located in the People's Republic of China (PRC), the US, and India)—are increasingly coming under consideration for potential early retirement. There are, however, visible impacts only in a small number of countries thus far, mostly in the UK/Europe and the US, and mostly with older plants, which account for a very small share of the current stock of CFPPs.

Low- and middle-income countries collectively host 89% of the global power capacity, a significant share of which needs to be retired or repurposed over the coming two decades. RMI (2018) and RMI (2021) have articulated the opportunities for coal retirement given that a substantial share of it is no longer competitive against cleaner forms of generation, but also highlight significant challenges around stranded asset costs. A World Bank study (2023a) estimates that US$1 trillion of capital will be at risk by 2040 associated with low- and middle-income coal generation assets. Around 69% of the global coal capacity resides in Asia, including more than 1 TW (51%) in the PRC alone and another 200+ GW (11%) in India. Although a rapid reduction in the cost of solar and wind over the past decade has rendered these technologies competitive against coal, there are several key challenges that remain to retire coal capacity at scale. Firstly, a good part of the coal fleet in the PRC and India has remained competitive (Huang et al. 2021) on the basis of short-run marginal costs. Secondly, the presence of long-term power purchase agreements (PPAs) means that even if a coal plant is not necessarily economic, it is highly likely to continue for the life of the PPA. Only one out of five developing countries in the world has a wholesale electricity market and even when there is one (e.g., in India), the liquidity of such a market is below 10%, rendering inflexible PPAs the sole choice. PPAs not only extend the life of uneconomic assets but with typical high take or pay provisions (e.g., 85% of available generation) and stringent minimum loading levels (e.g., 55% of the available capacity at any given point in time), there is often little room for renewable power. Thirdly, as many of these countries, including the PRC, India, and South Africa, extract, process, and transport coal domestically, there are a significant number of jobs tied to the upstream coal supply chain and hence a complex gamut of social issues. A "Just Transition" to address these issues, including retraining coal mining and plant workers and managing the broader impact on the local economy, will require careful planning, additional resources, and time.

Strategies and business models for early retirement of plants that are being discussed, or even in the early stages of implementation, differ enormously. Much of what has been written about them does not attempt to clarify how each may fit into the context of a specific country/system. The selection of an appropriate business model, or models, depends on various factors, including plant age, utilization, owner, the terms of any Power Purchase Agreements (PPAs), the financial health of the entity, social issues around reemployment and the broader impact on the community, and also technical issues around the impact on the power system. In prior World Bank research (Chattopadhyay et al. 2021; Srinivasan et al. 2022; World Bank 2023b), we have created a framework for this selection by creating typologies and classification of "business models" for closure, namely: policy-based closure, buyout, repurposing (of the site and equipment), and swaps/replacement with renewable energy (RE). In addition, there is also the possibility of a hybrid model that combines select elements of these four models as we discuss in more detail later. Table 1 summarizes the key attributes of the business models.

Table 1: Business Models for Accelerated Coal Transition

Business Model	Description	Examples
Policy-based	Legislates targets (GW and dates) for closure and provides financial support for plant owners and affected communities	• Reverse auction • Age, environmental, or other regulation-based
Buyout	New ownership and commitment to retire plant(s) by a certain date	• Energy Transition Mechanism • Utility buys from IPP
Repurposing	Reuse of the plant equipment and/or site for renewable energy (RE) and/or system management	• Using space on site for PV • Repurposing incumbent generators for SYNCON
Swap with RE	Building RE on other sites to replace retired coal-fired generation	• PV • Wind
Hybrid	A combination of any or all of the above	

Note: GW = gigawatt; SYNCON = synchronous condenser.

Source: World Bank.

It is worth noting that apart from these more targeted measures for coal retirement, there is the natural attrition or market-led closure of coal, most notably in the UK and parts of Europe and the US over the last two decades as a significant part of the coal fleet aged and became uncompetitive to renewables. The presence of a wholesale electricity market to weed out the expensive coal plants that were not locked into rigid long-term contracts also helped to shut them down, as did stricter regulations around air pollution (BEIS UK 2021). In fact, the market-led closure of older plants aided by environmental regulation has been the dominant driver of coal retirement thus far rather than an objective decarbonization strategy. Coal retirement in the US is also following a relatively slow process that is based primarily on commercial/market drivers due to the unprofitability of coal plants under the Clean Air Act regulations (Lessick, Targne, and O’Neil 2021). Chile also followed a similar strategy around restricting air pollution starting in 2011, and the caps on these (local) pollutants became more stringent with time. Since 2019, the process has been accelerated to mandate closure by 2040, which was further advanced to 2038 including half of the fleet to be closed by 2025 (Agora 2021).

As Srinivasan et al. (2022) and the World Bank (2023b) note, the process of shutting down coal through indirect policy measures through markets, air pollutant abatement standards, or even direct measures can be too slow for a net-zero target or anything close to it. The relevance of the four core business models stems from the need to *accelerate* the process both in terms of the time it takes to retire an individual coal plant (i.e., *early retirement*) and how many of these plants can be retired (i.e., *at scale*). Once we combine the timing and scale issues, the challenges get much steeper as it would call for retiring relatively young coal plants, finding replacement energy and secure financing for both. There are also ramifications for the applicability of specific business models. For instance, a policy-based closure by definition may target older coal plants based on age/efficiency/pollution, which may not be entirely consistent with an early-retirement strategy. Similarly, a coal repurposing model may work well with individual plants that specifically fit the context, but doing repurposing at scale may have its challenges and is largely untested. It should also be noted that these four models are not mutually exclusive by any means—e.g., a coal plant under a buyout or RE swap scheme can be repurposed. This is the motivation behind the creation of a potential fifth category of a “hybrid” business model noted in Table 1 that can combine elements from the other four models to develop a strategy that can accelerate retirement at scale.

Our subsequent works (Chattopadhyay, Handler, and Bazilian 2022; Handler and Chattopadhyay 2022) reflected on these models, including some of the important nuances around the availability of financing that may drive the choice of the model and the trade-offs involved in selecting a business model to shut down coal plants at scale. The World Bank (2023b) provides an extensive commentary on each of the business models and also a survey of the global experience with these models. In this paper, we provide further contextualization for business model—including hybrid model—selection with a particular focus on how models can help facilitate closures of multiple plants, or closure “at scale”.

2. RETIREMENT AT SCALE EFFICIENCIES

The retirement of a CFPP requires significant expenditure. This can include some or all of the following: buying out/termination payments for PPA commitments, especially for newer plants that have a long period left under a PPA; decommissioning the plant; site remediation or repurposing; potential investment in grid stability and compensation/Just Transition investment for affected employees and communities. That said, there are offsetting economic benefits, including repurposing projects that can attain a benefit-to-cost ratio of 5:1 as noted in a World Bank (2021) study.

With the closure of many plants, these costs and institutional and social issues are multiplied. For example, if the closure of multiple plants also obviates the need for major coal mines/fields, there will be costs for mine closures in addition to the CFPP site-related costs. More importantly, as significant coal plant capacity is retired, replacement with clean generation will require substantial amounts of new investment, and there will also be an associated investment in transmission and distribution to ensure secure operation of the grid. Social costs associated with retraining coal mine/plant workers and ensuring a Just Transition for the wider community and local economy can also become a more significant part of the overall costs.

To offer an illustration of this cost scaling, in the developing world, the discussion in South Africa is most advanced, commencing with the closure and repurposing of its Komati plant (1,000 MW) starting in 2023. The total project cost is estimated at more than 8 billion South African rand (approx. $490 million including $45 million towards social and community programs).[1] As the process is scaled up, however, the costs, especially the Just Transition costs, will rise sharply. The long-term cost to shut down all South African coal plants by 2050 has been estimated at $10 billion (Winning 2021).

At the same time, a program to accelerate the retirement of a large number of plants offers efficiencies (scale benefits) that do not exist with a one-off process. Most importantly, a system-wide approach allows for consideration of managing capacity by region. In other words, in grids where there is overcapacity and thus underutilized CFPPs, there is the potential for efficiencies to be realized through greater utilization of fewer plants. As several systems around the world, including parts in Europe, the PRC, and India, among others, have seen a rapid increase in RE capacity addition, the utilization of the older (and more expensive) part of the coal fleet has been dropping steadily—to 40% or less—rendering these good candidates for closure at scale.

[1] Statement made by Andre de Ruyter (CEO of ESKOM) on 22 August 2022: https://www.news24.com/fin24/economy/eskom-cput-join-forces-to-reskill-workers-as-coal-fired-komati-heads-for-reboot-20220822. As part of the social initiatives, ESKOM has signed a Memorandum of Agreement with Cape Peninsula University of Technology to start a training center to reskill Komati workers: https://www.esi-africa.com/renewable-energy/reskilling-coal-industry-workers-to-start-at-mpumalanga-training-centre/.

Meanwhile, as Huang et al. (2021) discusses, the system-wide approach allows for consideration of which sites are best positioned for repurposing and for system RE and flexibility needs (vs. forcing each CFPP entity into replacing its capacity with RE). And scale benefits will come on the execution side for various processes: identification of coal plants; feasibility studies; decommissioning; repurposing; and social programs. A national auction may facilitate the process of identifying the candidate coal plants and set a price benchmark for these plants. Feasibility studies for all of the plants can be carried out by a central agency following a common template in part to also identify plants that are good candidates for repurposing. Decommissioning and repurposing exercises should follow for multiple plants wherever possible as there are common elements that would benefit from common tendering, including for EPC contracts and the procurement of solar PV, battery storage, and synchronous condensers (SYNCON)[2] that may be used as part of the repurposing exercise.

3. BUSINESS MODELS FOR AT-SCALE RETIREMENT

The aforementioned business models can be applied to individual plant retirement but are readily adapted to, and in some ways are better suited for, multi-plant or system-wide closure. Below, we describe and offer examples of system retirement applications to the policy-based and buyout models followed by a more detailed contextualized illustration of a hybrid model that actively uses repurposing. We do not specifically discuss the RE swapping model as it is more likely to be relatively case specific and can be accompanied by the other three models.

3.1 Policy-Based Closure

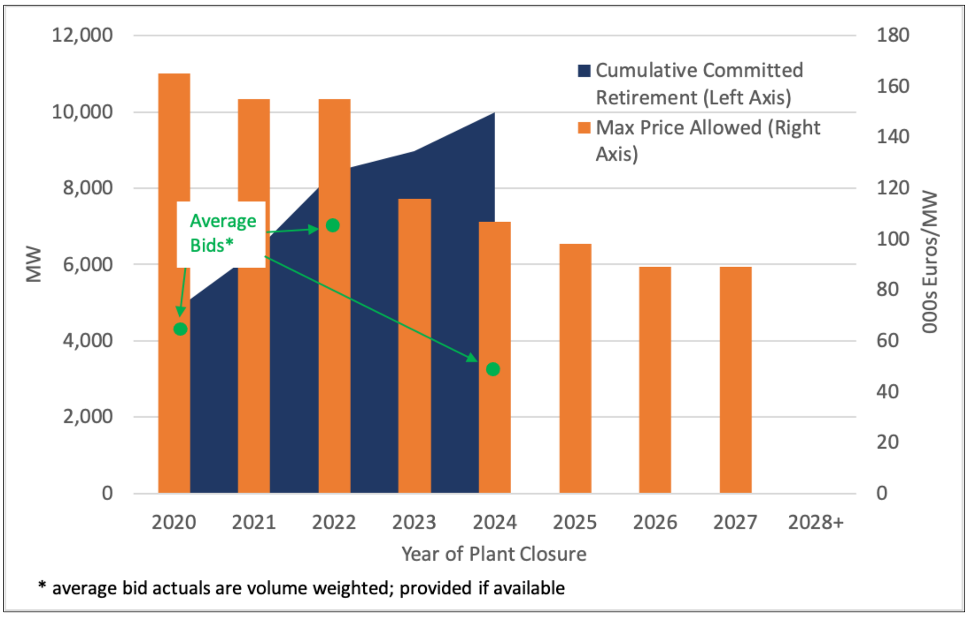
A policy-based closure approach establishes targets for system-wide CFPP closure (perhaps via decarbonization and/or air pollution targets) and a time frame. Further, it allocates funds for closure and repurposing as well as addressing social and community impacts to ensure a Just Transition. It is possible to enact a policy-based closure through the creation of a wholesale market, reforming the PPAs into a market-oriented instrument for old and expensive coal plants to retire. However, as previously noted, this has been demonstrably a slow process, lasting decades.

One tactic for engaging market forces in an accelerated form and encouraging CFPP owners to think creatively about how to manage their closures is a reverse auction. In a reverse auction, government or other sources of funds are structured to provide financial incentives to the winning bidders, i.e., CFPP owners, to support retirement and repurposing, which may include paying off remaining obligations under a PPA. As a reverse auction, the low bidder wins, so a structure must be put in place to encourage plant owners not only to bid, but to bid less than their peers. This structure has tended to include a deadline for industry-wide retirement and a defined period for the auctions. Beyond this period no more funds will be made available to support plant owners and they will simply have to proceed without financial aid. The structure has also included a declining maximum payout over time through multiple auction rounds. Thus, plant owners face a trade-off between closing their plants early and getting a higher payoff vs. delaying the closure to harvest the plant but receiving a progressively lower payoff (and eventually no payoff at all).

[2] An example of the latter is a national-level SYNCON program being discussed in India to repurpose many of the generators "at once," which is not dissimilar to past efforts directed at the rehabilitation of coal plants and the implementation of Static VAr Synchronous Compensators (SVC/STATCOMs).

Germany provides an illustration (Agora 2019, 2021; Scott et al. 2022; Aurora Energiewende 2022). The country has now held five out of a scheduled seven bid rounds that provide a financial incentive for hard coal CFPP closure by a prescribed year (with the last round involving a commitment to decommission by 2026). Plant closure after 2027, while still mandated, will receive no financial support from the government. The maximum bid allowed declines in each round, to €89,000 per MW in the seventh round from €165,000 per MW in the first, to encourage earlier participation. In the five completed auction rounds, 34 plants comprising 10,000 MW have committed to closing. Although the average payout per MW was not reported for every round to protect privacy, bids have averaged below the maximum allowed in all five rounds, illustrating the savings as the utilities/plants sought to ensure receipt of at least some compensation (see Figure 1).

Figure 1: German Hard Coal Auction: Retirement Commitments and Winning Bids



Source: Bundesnetzagentur.

The applicability of a reverse auction as an integral part of a policy-based closure will, however, need to be assessed carefully in the context of each country. Factors in this context may include the policy and political buy-in for coal transition; the ownership structure, which may determine the level of participation; the presence of other enabling factors, including a wholesale market; the associated reform of PPAs; system security concerns; and the ease of entry of renewable and other cleaner forms of generation (Chee and Kansal 2022).

In the absence of a market-led policy-based closure, age/efficiency/environmental regulation-based criteria may remain the norm in many countries, especially in the developing world. The process may be slower, as demonstrated by the experience of India, which has earmarked only 4.6 GW of plants that are on average more than 40 years old (although the stated criterion is 25 years) and another 2.8 GW due to environmental norms (CEA 2022). The success of a policy-based closure in predominantly regulated markets will depend on the efficacy of the implementation of standards that may include, inter alia, reneging the incumbent PPAs as well as prevailing demand-supply conditions, and supporting environmental policies and efforts through multilateral development banks to provide concessional financing and successfully address the social issues. More generally, it is fair to say that the success of any of the business models would need to be crafted to each country's situation to fit the context around the state of regulation, ownership, grid security, and social issues.

3.2 Buyout

While reverse auctions provide cash to current CFPP owners to help fund plant retirements, buyouts involve a change in ownership. That said, because intimate knowledge of the plant can be very useful, and because the current owner may have an interest in maintaining its earnings base, it is logical that the buyout consortium includes the current owner. The advantage for the existing owner is an injection of cash from the CFPP buyouts and the release of the obligation of the associated financial burden of retirement.

Investors in a buyout model seek to earn a financial return through some or all of the following:

(1) Ongoing operations. The CFPP is to be run for an agreed upon period of time, still earning revenues from ratepayers;

(2) Capital structure. Equity is to comprise a smaller portion of the funding sources (in comparison to "normal" owner balance sheets) and debt is subsidized through concessional financing;

(3) The sale of carbon offset credits tied to the earlier-than-business-as-usual retirement of the CFPP; and

(4) The sale of RE-generated power via ownership in replacement power.

Although the buyout model can make sense at an individual plant level, its rationale is significantly stronger for a portfolio of retirements. For starters, since much larger sums are involved, retiring multiple plants is more likely to stress the financial resources of utilities too much. It simply becomes more likely that additional, nonconcessional funds must be included as the sums grow, including risk capital (i.e., third-party equity).

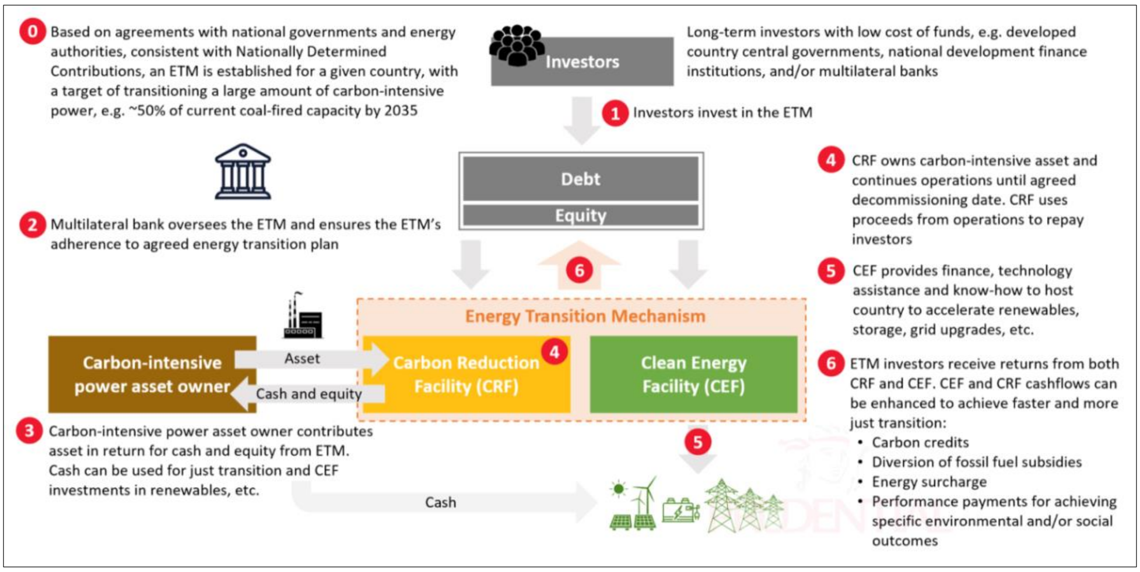
Meanwhile, the investment case for buyout *improves* when considering a portfolio vs. for an individual plant. Since the objectives for outside capital include *risk-weighted* returns, investing in a system-wide program offers a chance to enhance returns by lowering risk through diversification in addition to the system-wide savings that can be realized as discussed above. For example, exposure to multiple decommissioning projects can lower the risk of cost overruns from one project. Similarly, exposure to ongoing revenues from multiple plants can lessen the risk that utilization from a single plant falls below expectations. And administratively, there should be efficiencies for a portfolio of plants, e.g., in terms of resources required for disclosures/communication with constituencies (host governments, concessional financing sources, and investors).

The portfolio diversification can also help to attract investors as it simplifies the task of outside investors having to build their own portfolio—i.e., it makes it easier to invest larger sums in a portfolio of closure projects.

One example of a model of this type currently under consideration is known as the Energy Transition Mechanism (ETM) developed by the Asian Development Bank (ADB).[3] As part of the original ETM (Kanak 2021) "Acquisition Model," two holding companies are created. In the first, known as a Carbon Reduction Facility, a third party (or consortium) buys the plants. The buyer(s) commits to retiring or decommissioning the plants within specified time frames. In the second company, known as a Clean Energy Facility, replacement RE is built (see Figure 2).

ETM proposals are currently under various stages of consideration in East and South Asia, including as part of the Climate Investment Fund's Accelerating Coal Transition (ACT) program.[4] One of the attractions of the ETM is indeed its potential to truly accelerate the coal transition. As ADB has noted: "*Once it is scaled up, ETM has the potential to be the largest carbon reduction model in the world. For example, retiring 50% of coal power plants over the next 10–15 years in Indonesia, the Philippines, and Viet Nam could cut 200 million tons of CO2 emissions per year—the equivalent of taking 61 million cars off the road*" (ADB 2021).

Figure 2: Schematic of the Energy Transition Mechanism



Source: Kanak's (2021) article on the World Economic Forum. https://www.weforum.org/agenda/2021/01/how-to-accelerate-the-energy-transition-in-developing-economies/.

There are, however, significant issues that need to be addressed around the buyout/acquisition model, not least of which is the availability of capital to buy plants out at scale. A country like India with its 200+ GW coal fleet would eventually need at least $100 billion to cover coal plant-related compensation, and Just Transition and decommissioning costs (and still more for repurposing and RE investments). The available concessional financing avenues like ACT and the Powering Past Coal Alliance (PPCA) represent less than 5% of the investments needed for India alone. The available concessional funds also account for only 10% of the $5 billion needed to shut

[3] Refer to ADB's Energy Transition Mechanism site for further details: https://www.adb.org/what-we-do/energy-transition-mechanism-etm. ADB is joining the governments of the Philippines, Indonesia, and Viet Nam to pilot the ETM in Southeast Asia.

[4] Refer to the Climate Investment Fund's (CIF) ACT information page for further details: https://www.climateinvestmentfunds.org/topics/accelerating-coal-transition.

down the initial ~5 GW of coal capacity identified by PLN, the Indonesian utility. Heijmans and Murtaugh (2022) cited a government study that noted that the nation will need a $150–$200 billion investment in low-carbon programs annually until 2030, or roughly 3.5% of projected GDP, to meet its net-zero targets.

There are also important nuances if the ETM is to be deployed. For example, if the ETM entity needs to operate the coal plants after acquiring them, the usage of concessional funds like ACT may be restricted. There will also be institutional, regulatory, technical, and logistical challenges associated with reduced operation of plants, resource adequacy, system operation and security, and monitoring net CO_2 reduction resulting from the ETM scheme. There has been little clarity on all of these issues and the ETM model has evolved since its early days to adopt a more flexible structure. As Figure 3 shows, the ETM facility includes additional possibilities like an SPV model wherein the ETM invests in a coal plant rather than owning it, or provides finance to a corporate body to finance a clean energy project. The original Acquisition Model has in fact now been relegated to being used only in an exceptional scenario. The ETM also makes provision for repurposing a coal plant, thereby marking what may be deemed as a “hybrid model” combining facets of different business models. Nevertheless, this process of evolution is likely to continue, and a proper resolution or reform of commercial contracts, availability of, and access to, capital, and power system issues holds the key to success.

Figure 3: Updated ADB Energy Transition Mechanism Model

01 Acquisition Model (SPV Level)	02 Synthetic Model (SPV Level)	03 Portfolio Model (Corporate Level)
ETM acquires share capital in CFPP	ETM invests senior/junior debt and/or other mezzanine capital to the CFPP	ETM provides funding to the corporate sponsor with CFPPs and greenfield clean energy projects
ETM to take role as owner and operator of the coal plant	Equity ownership and operational responsibility kept with the current asset owner	Sponsor guarantees greenfield clean energy projects will be built and coal plants retired ahead of schedule
ETM agrees an early termination date with the utility and operates the plant until that date and then closes it or repurposes	Investment conditional on early termination being contractually agreed with owner and utility and appropriate security being provided	Incentives (such as penalty interest) can be used to ensure that the transition occurs
Most suitable for **IPP plants with international bankable PPA**	Most suitable for **IPP plants with international bankable PPA**	Most suitable for **Utilities with a portfolio of plants**

Note: Acquisition Model to be utilized only in exceptional scenarios.

Source: Manisha Pradhananga, Comments by Discussant, ADBI Workshop, February 2023.

3.3 Hybrid Model

As the preceding discussion alludes to, the two most prominent business models, namely policy-based closure and buyout, both have promise but also face significant challenges in accelerating the coal retirement process. This naturally leads to the question of whether countries should consider mixing and matching these and other strategies to accelerate the pace of coal retirement, taking into consideration, inter alia, financing and social issues, and system requirements. The advantages of working with plant systems, along with the frequent RE replacement considerations, suggest that a combination of business models, i.e., a hybrid model, tailored for each system, may generally be optimal, as opposed to relying on a single model, when considering at-scale retirement. This may include opportunistically taking advantage of policies in place, including RE targets, the presence of a market, the need for storage and ancillary services in the system as coal plants retire, innovating around the replacement of coal PPAs, swapping them with RE counterparts, etc.

To illustrate this point, NTPC, the single largest owner of coal in India with a 48 GW CFPP portfolio, is also investing heavily to develop 60 GW of RE by 2032.[5] One of its challenges is to swap part of its contractually provisioned supply from coal to RE with state customers in India that aspire to go green. NTPC's coal fleet is also slated to be the first one to join the new Market Based Economic Dispatch (MBED) model that introduces its coal generation to the wholesale market (CERC 2018).[6] Finally, a reasonable proportion of NTPC's coal fleet dates back to the 1980s and is highly inefficient, i.e., it produces expensive electricity. It is conceivable that some of these older units will be shut down, as per the Central Electricity Authority (CEA) norm, and repurposed to provide storage and ancillary services.

A plausible strategy may therefore combine all of the following:

1. Retire the older coal fleet that meets the age and efficiency criteria stipulated by the CEA. This may potentially also be achieved through an auction mechanism on a broader (e.g., national or even regional/multinational) scale;
2. Repurpose some of these units wherever there is a technical and economic case for it. These initiatives are eligible for concessional climate financing under the Accelerating Coal Transition (ACT) program sponsored by the Climate Investment Funds or other programs;
3. Build RE in part to replenish the generation, including possibly a small part of it on repurposed coal sites. RE initiatives are also eligible for concessional financing;
4. Swap incumbent coal contracts with RE for states that are interested in such deals through a transparent and competitive approach;
5. Rebalance coal generation across the remainder of the coal fleet to use the more efficient and cheaper plants more effectively; and
6. Offer both coal and RE on the wholesale market to ensure uncontracted part of the generation is cleared through the market.

As the NTPC example highlights, the optimal closure solution is likely to be not only a hybrid model but also bespoke for each entity depending on its business goals, policies in place, funding (including concessional financing) availability, and market-based mechanisms. NTPC's solution may or may not suit other players in India, whether they are state-owned coal fleets or independent power producers, depending on their aspirations to invest in RE, the age and competitiveness of the coal fleet, the nature of contracts with buyers, and access to, or interest in, participating in a wholesale market.

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[5] Refer to: https://www.ntpc.co.in/en/power-generation/renewable-energy#:~:text=NTPC%20is%20taking%20various%20steps,its%20overall%20power%20generation%20capacity (accessed 2 August 2022).

[6] Also, refer to the Ministry of Power paper on Implementation of MBED, June 2021, which discusses Phase 1 of MBED to include NTPC plants, albeit the planned start date of Phase 1 in April 2022 has been delayed: https://powermin.gov.in/sites/default/files/Seeking_comments_on_Discussion_Paper_on_Market_Based_Economic_Dispatch_MBED.pdf.

4. OTHER CONSIDERATIONS

4.1 Leveraging Existing Policies

For an individual jurisdiction, there may be existing policy in place with respect to CFPP or system management that can serve as a “launching point” for coal retirement business model development. One clear example is in countries that have an age/efficiency-based policy for closure. In other words, their host countries have laws mandating that coal plants should be marked for closure once they reach a certain age. This policy is generally set while recognizing the energy/operating inefficiencies and higher pollution from older plants (see, for instance, discussions on Germany, Chile, the UK, and the US: Agora 2019, 2021; BEIS UK 2021; Lessick 2021; World Bank 2023a). This set of CFPPs presumably has a lower cost of buyout as asset owners must incorporate the finite operating period and decommissioning costs into their return expectations. Further, their closure yields avoided expenditure on life extensions and pollution abatement equipment.

4.2 Supranational Portfolios

It may be attractive from an investor perspective to consider a portfolio of plant retirements across multiple countries—an extension of the buyout model. In this case, there can still be portfolios of plant retirements within each country, but outside investors will be buying out a set of CFPPs in all of the countries represented. It must be acknowledged that these logistical challenges multiply with more systems/countries, raising the demands on the management of the buyout organization. However, if such an additional burden can be managed, the appeal for investors can lie in additional diversification—providing a hedge to a country, which may be the off-taker or the guarantor of the off-taker, and currency risks.

5. CONCLUSION AND POLICY RECOMMENDATIONS

5.1 How Can Coal Retirements Be Scaled Up?

Planning for closure of coal plants at scale is necessary to contribute more substantially to reaching global decarbonization goals, offers scale efficiencies, and is a more efficient and attractive means of securing private investment. The efforts to date have largely relied on ad hoc policy-based closures, in some cases aided by market-based instruments, or, at a concept stage, by buyout of a large segment of the coal fleet in some countries. The former has generally proven to be either slow or to rely on prerequisites (for market/auction-based instruments) that may, or may not, be universally applicable—especially in developing countries that account for the most substantial part of the existing stock of coal plants. Governments and multilateral institutions must broaden their own appraisal capabilities and ambition to include these system-wide approaches to closure, repurposing, and constituency support. Accelerating coal retirement at scale will require a holistic strategy tailored for each country, taking into account the massive financing needs not only to retire (and in some cases repurpose) coal plants but also replenish the need for energy and meet a growing need for ancillary services and storage. A holistic consideration of all facets of retirement would most likely require multiple elements from different business models. Such a strategy should give due regard to the long-term impact of coal retirement to avoid being too aggressive in shutting down coal plants to a point that it sparks a financial collapse of the sector and/or load shedding as the system cannot sufficiently replenish lost capacity, energy, and ancillary services.

5.2 Is There a Reason Why One Model Unilaterally Works Better than Others?

It is still early days for coal retirement in general and accelerated coal retirement is in a nascent state. As the preceding discussions suggest, there is no reason to believe that one model has performed or can perform unilaterally better than others. If net zero or anything close to it needs to be achieved over the next two decades or an even longer time frame, the pace for coal retirement in this decade needs to pick up substantially over what transpired over the last two. The age/efficiency/environmental regulation-centric criteria still being followed in most countries are unlikely to achieve this end. The buyout model has great potential but is largely untested and faces serious challenges on the financing front. Repurposing of coal plants has seen some success, but it requires a solution to be crafted for each plant and in itself may not form a consolidated strategy.

5.3 Do these Models Need to Be Crafted Specifically to Fit Each Country/System Context? Can They Be Combined in Some Shape or Form to Carry Out Retirements at Scale More Efficiently?

The current reality is that there have been many more discussions on accelerating coal transition but with only scattered efforts or without any action in most cases. It is therefore imperative that countries/states/utilities develop a tailored model that best fits the prevailing policy settings, financing capability, system requirements, and social obligations. As we presented in the example of NTPC India, it may be a case of crafting a solution that brings together a coal retirement strategy that reflects the idiosyncratic conditions unique to each country/state/business entity.

With that said, there is often consistency regarding what goals are being sought. These include alignment with RE target as well as age/efficiency-based coal retirement policy; market orientation of dispatch to encourage RE and discourage use of the inefficient and expensive part of the coal fleet; replacement of the coal PPAs with RE; repurposing of some of the coal sites judiciously to address system security; and the addressing of social needs. This commonality of goals suggests that it is helpful to develop a general framework that is sufficiently flexible to accommodate different needs across countries and systems. More often than not, there will be options to eliminate the uneconomic part of the coal fleet in any system to initiate the process. Even if there is no formal wholesale spot market in countries like Indonesia, the dispatch mechanism and the PPAs with independent power producers can be enhanced to achieve an outcome that lowers system costs as well as carbon emissions. Such a process can then pave the way for a wholesale market, lower the need for compensation, and reduce financing needs.

Further, it is pragmatic to start the retirement process with those plants where the cost and emissions reductions coincide. In most coal-dominated systems, including the coal fleet in South East Asia that is relatively young, there is still a reasonable share of such plants to provide sufficient scale. If reducing the coal capacity is realistic and compliant with the policy directives in place, the political buy-in is more likely to be achieved and the financing needs can also be met more easily, including concessional financing to complement the process in critical areas.

REFERENCES

Agora. 2019. The German Coal Commission. https://www.agora-energiewende.de/fileadmin/Projekte/2019/Kohlekommission_Ergebnisse/168_Kohlekommission_EN.pdf.

———. 2021. Phasing out Coal in Chile and Germany: A Comparative Analysis. https://static.agoraenergiewende.de/fileadmin/Partnerpublikationen/2021/Energy_Partnership_Chile-Alemania_Phase-Out-Coal-Chile-Germany/20210614_CHL_ Comparative_Study_Coal_Exit_CHL_GER_web.pdf.

Asian Development Bank. 2021. *What is Energy Transition Mechanism*. https://www.adb.org/what-we-do/energy-transition-mechanism-etm.

Aurora Energiewende. 2022. *The Role of Coal Exit Auctions.* https://static.agora-energiewende.de/fileadmin/Projekte/2021/2021_12_INT_Hard_Coal_Auction/A-EW_261_Hard-Coal-Auction_WEB.pdf.

BEIS UK. 2021. Consultation on the Early Phase Out of Unabated Coal Generation in Great Britain. Department for Business, Energy and Industrial Strategy, Government of the United Kingdom. https://assets.publishing.service.gov.uk/government/ uploads/system/uploads/attachment_data/file/943817/consultation-coal-renewable.pdf.

Central Electricity Authority. *Draft National Electricity Plan: Generation.* Volume 1. September 2022. Ministry of Power, New Delhi. https://cea.nic.in/wp-content/uploads/irp/2022/09/DRAFT_NATIONAL_ELECTRICITY_PLAN_9_SEP_2022_2-1.pdf.

Central Electricity Regulatory Commission. 2018. Market-based Economic Dispatch of Electricity: Re-designing of Day-ahead Market (DAM) in India, Staff Discussion Paper. https://www.eqmagpro.com/wp-content/uploads/2019/01/DP31-min-compressed-1-37.pdf.

Chattopadhyay, D., M. Bazilian, B. Handler, and C. Govindarajalu. 2021. Accelerating the Coal Transition. *The Electricity Journal.* 34(2). March 2021. https://www.sciencedirect.com/science/article/pii/S1040619020301986.

Chattopadhyay, D. B. Handler, and M. Bazilian. 2022. The Case for Closing Coal Plants at Scale. *World Economic Forum Blog.* 23 August 2022. https://www.weforum.org/agenda/2022/08/why-we-need-to-start-closing-coal-plants-at-scale/.

Chee, B., and R. Kansal. 2022. *The Role of Auctions to Accelerate Coal Transition*. NERA Economic Consulting and Rocky Mountain Institute presented at the Innovate4Climate Workshop. May 2022. https://www.nera.com/news-events/events/2022/the-potential-for-auctions-for-decommissioning-coal-power-genera.html.

Handler, B., and D. Chattopadhyay. 2022. Scrap, Sell, Auction or Repurpose? What's the Best Business Model for Coal Plant Closure? *World Economic Forum Blog.* 29 July 2022. https://www.weforum.org/agenda/2022/07/scrap-sell-auction-or-repurpose-whats-the-best-business-model-for-coal-plant-closure/.

Heijmans, P., and D. Murtagh. *Rich Nations May Fork Out Billions to Wean Indonesia Off Coal*. Bloomberg. 7 June 2022. https://www.bloomberg.com/news/features/2022-06-07/breaking-indonesia-s-coal-habit-may-cost-rich-nations-billions?leadSource=uverify%20wall.

Huang, Z. et al. 2021. ACT on RE+FLEX: Accelerating Coal Transition Through Repurposing Coal Plants into Renewable and Flexibility Centers. *IEEE Access.* 9: 84811–84127.

Kanak, D. M. 2021. How to Accelerate the Energy Transition in Developing Economies. *The Davos Agenda 2021. World Economic Forum*. January 2021. https://www.weforum.org/agenda/2021/01/how-to-accelerate-the-energy-transition-in-developing-economies.

Lessick, J. D., B. W. Tarekegne, and R. S. O'Neil. August 2021. *Business Models for Coal Plant Decommissioning*. Report # PNL-31348, Pacific Northwest National Laboratory, RMI. 2021. How to Retire Early. https://rmi.org/wpcontent/uploads/2021/03/rmi_how_to_retire_early.pdf.

RMI. 2018. Managing the Coal Capital Transition. https://rmi.org/wp-content/uploads/2018/09/RMI_Managing_the_Coal_Capital_Transition_2018.pdf.

Scott, J., N. N. Thuy, P. Litz, H. Koenig, and S. Rinasky. 2022. *Coal Phase-Out in Germany: The Role of Coal Exit Auctions*. Aurora Research. June 2022. https://static.agora-energiewende.de/fileadmin/Projekte/2021/2021_12_INT_Hard_Coal_Auction/A-EW_261_Hard-Coal-Auction_WEB.pdf.

Srinivasan, S., D. Chattopadhyay, C. Govindarajalu, and I. Zabidin. 2022. Business Models for Accelerating Phase-out of Coal Based Generation: Developing Typologies and a Discussion of the Relative Merits of Alternative Models. Forthcoming in *The Electricity Journal.* October 2022.

Winning, A. 2021. Africa's Top Emitter Seeks $10 bln for Shift from coal. *Reuters*. 1 July 2021: Coal. https://www.reuters.com/business/environment/africas-top-emitter-seeks-10-bln-shift-coal-2021-06-30/.

World Bank. 2021. Coal Plant Repurposing for Ageing Coal Fleets in Developing Countries, 25 August 2021. https://esmap.org/esmap_coal_plant_repurposing_ageing_coal_fleets_in_developi. Some of these findings were also reported in a subsequent publication that was based on the World Bank report: https://ieefa.org/resources/ieefa-repurposing-coal-plants-solar-and-battery-can-pay-5-times-more-decommissioning.

———. 2023a. *Scaling Up to Phase Down: Financing Energy Transition in the Power Sector*, White Paper. February 2023.

———. 2023b. *Business Models for Transition of Coal Generating Capacity*. ESMAP. May 2023.