LOOK BEFORE YOU LEAP:

AN APPROACH FOR PHASING DOWN COAL FROM INDIA'S POWER SECTOR

Prayas (Energy Group)

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An approach for phasing down coal from India's power sector

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1. Context

India's coal and power sectors share a significantly symbiotic relationship, with over 70% of electricity generation in the country coming from coal, and over 75% of coal consumed in India being used for electricity generation. However, like countries the world over, India is in the midst of an energy transition away from coal, and hence, coal-based electricity generation – spurred by global climate concerns and sustained by favourable economic and policy levers. For instance, India is a signatory to the COP-26 declaration that calls for coal phase-down from the energy system (UNFCCC, 2021), and has also been trying to introduce emission norms for coal-based power plants to mitigate the local environmental impacts of coal use (Ministry of Environment, Forest and Climate Change, 2015; Ministry of Environment, Forest and Climate Change, 2022). India has even committed to achieve a net-zero energy system by 2070 (Press Information Bureau Delhi, 2021), which would almost surely require a total elimination of the use of coal for electricity generation by that date, if not earlier.

The shift away from coal-based generation is further facilitated by the changing economics of coal use vis-à-vis renewable electricity generation technologies such as solar and wind, which are already competitive with new coal-based capacity in generation cost terms. While such renewable alternatives come with challenges like intermittency in generation, system costs of technologies like battery electricity storage systems (BESS) have also fallen fast and are likely to continue to fall in the coming years, and this will help address the intermittency issues[1]. This shift toward renewable generation is further underscored by India's target of achieving 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030 as part of India's updated Nationally Determined Contribution (Government of India, 2022).

Given this overarching context, it is almost a given that there will be a gradual phase-down of coal-based electricity generation in India. However, the coal sector also shares complex linkages with other sectors like mining, railways, and public finance, in addition to the close relationship between the coal and power sectors discussed above. The coal sector also influences multiple aspects of development, especially in mining districts. Considering these interlinkages and the scale and scope of its socio-economic and technical impact, the phase-down of coal-based generation and decisions pertaining to it must be carefully considered and founded on robust analysis-based planning.

[1] Mature technologies such as pumped storage can also play a role in this process, subject to cost and environmental feasibility.

2. The nuances of a coal phase-down

It is important to note that coal-based generation currently accounts for an overwhelming share of the total electricity generated in the country and plays a key role in meeting the country's electricity demand. This electricity demand is likely to keep growing across Indian states, with increase in incomes, urbanisation, industrialisation, etc[2]. Thus, a coal phase-down, if not planned appropriately, could impact the country's ability to meet its rising electricity demand or could result in unproductive assets that are locked in for decades. Given the major role of coal-based generation in the electricity sector, discussions about its phase-down cannot be conducted in isolation, but should be part of planning for the future trajectory of the electricity sector itself.

Viewed from an emissions perspective, it is important to remember that it is coal-based *generation* that leads to emissions rather than coal-based *capacity*[3]. This is a crucial distinction, as in a system with increasing intermittent renewable generation, coal-based capacity could still have some role to play in balancing the grid, providing dispatchable power and addressing load requirements that renewables are unable to, given their intermittency – though such capacity may generate only occasionally, for example to address seasonal or peak demand (Tongia, 2022). Thus, the system may have a significant amount of coal capacity which does not generate—and hence emit— all the time but is still crucial to meet demand at specific times (Singh & Tongia, 2021).

Of course, one must be careful about the extent of coal-based capacity that remains or gets added to the system, because their very existence leads to 'fixed' costs even if generation from them is not high. The issue is particularly relevant for the addition of fresh coal-based capacity, as such capacity would have higher fixed costs, have a longer remaining lifetime and is likely to be used increasingly sparingly and intermittently over time. If not planned carefully, the chances of any newly added coal-based capacity becoming a stranded asset increases significantly, especially when considered along with the likely further rapid reduction in costs of alternative technologies such as BESS.

On the other hand, aggressive and early retirement of thermal power plants (TPPs) could lead to a real or perceived electricity shortage, even for a short duration. This is likely to lead to calls for new investment, most likely in established technologies such as coal for the immediate future[4],

[2] An increase of about 5% p.a. translates to generating at least 70-80 TWh or billion units more each year at the national level.

[3] To be sure, how the capacity is used also affects emissions. Part-load operations and frequent ramping up and down of coal-based generation units reduces their efficiency and hence increases their emissions a little. But the effect of this is very small compared to the overall emissions from the power sector.

[4] In the near to medium term, coal is likely to be the preferred alternative in such situations either because it would be impractical to build renewables any faster or because renewables cannot effectively meet the unmet demand due to its intermittency.

which in turn may lead to stranded assets. This is especially true at the state level – given state energy politics and incentives (Chirayil & Sreenivas, 2021).

A good illustration of the tendency to bring in additional capacity in response to a perceived crisis is the response to the 'heat-wave induced power and coal shortage' in April 2022. A combination of factors such as an unexpected increase in demand due to high temperatures, unavailability of alternatives, relative shortfall in coal production, bottlenecks in coal evacuation, and the inability of some generators to pay coal companies, is reported to have led to the shortage (Kala, 2022). In particular, generation capacity shortage was not one of the factors responsible for the shortage. Still, reports suggest that some states started up old and unused coal plants and NTPC has even announced the construction of a new 1.32 GW coal-based plant in Odisha in addition to accelerating plans to expand coal-based capacity at two other locations (Bloomberg, 2022).

There are also international examples of going back on decisions to aggressively retire capacity. Germany had planned to phase out its nuclear plants before the end of their useful life following the Fukushima disaster, and idled a significant portion of its coal capacity as part of its coal phase-down plans. In the process, it had increased its dependence on imported gas-based generation. However, with the recent international turmoil leading to a spike in gas prices, the country has now decided to reopen 8.5-10 GW of idling coal capacity and postponed the phasing out of nuclear capacity (Eddy, 2022; Conolly, 2022).

Such likely unintended consequences of well-meaning but 'hasty' decision making strengthen the importance of careful planning with regard to coal phase-down from the electricity sector in India. Phasing down coal-based capacity without a comprehensive consideration of the electricity sector, could prove ineffectual and may lead to unmet demand, resource lock-ins, adverse economic impacts, and other unplanned repercussions.

Over the last few years, coal phase-down has drawn significant attention, especially in policy and research circles. Much of this discourse (Fernandes & Sharma, 2020; Shrimali, 2020; Bodnar, et al., 2020; Maamoun, et al., 2022; Srikanth & Krishnan, 2020; World Bank, 2021) is focused on early retirement of thermal capacity based on different criteria such as age, cost and emissions. They typically do not provide a 'plan' for such capacity retirement but just indicate that they should be retired. Often, the capacity suggested for retirement is significant – ranging from 30 GW to 50 GW[5]. In most cases[6], it is implicitly assumed that renewables would plug the gap – meaning about

[5] A study, (Bodnar, et al., 2020) which recommends replacing non-competitive coal with RE suggests that up to 240 GW (85% of the country's coal fleet) could be retired by 2025.
[6] One study (Srikanth & Krishnan, 2020) recommends replacing older, inefficient coal capacity with newer high-efficiency, low emissions coal capacity. We are sceptical of a general use of this approach too, due to

75 GW to 125 GW of additional renewables capacity would need to be commissioned just to make up for the retiring coal capacity (even ignoring issues of intermittency)[7] – over and above what is required to meet India's growing energy demand. Even assuming replacement over a five-year period, this implies adding 15-25 GW of renewables each year just to replace the retired coal capacity. In addition, given India's low per-capita electricity consumption, its electricity demand will increase by at least 70-80 TWh each year for the foreseeable future. Even if one were to ignore issues with variability and intermittency of renewables, just meeting all of this incremental demand with renewables would require an additional 32-37 GW[8] of fresh renewable capacity each year. This, along with the 15-25 GW of renewable capacity to replace retired coal capacity, effectively requires an annual renewable capacity addition of around 47-62 GW, which is about 3 times the rate at which India has ever added renewables in the past, and is highly unrealistic.

Results from simulating such early retirements using the PIER model broadly confirm the above concerns (Prayas (Energy Group), 2022). When coal plants older than 30 years of age and with variable cost greater than Rs. 3/kWh are retired[9] and no new coal-based capacity beyond the extant pipeline is allowed to be added ("early retirement" scenario), it results in about 41 GW lower coal capacity in FY31 compared to the "reference" scenario. In the reference scenario, coal-based plants are retired as they reach end of useful life (40 years), and coal-based capacity beyond the pipeline is also allowed to be brought online, if required. Since this is not allowed in the early retirement scenario, it sees the addition of about 8 GW of gas-based capacity and 3GW of large hydro capacity in excess of that seen in the reference scenario, in addition to 19 GW more of solar capacity and 2.6 GW more of small hydro capacity. The model also finds that it needs to add about 46 GWh of additional storage – mostly BESS – capacity compared to the reference scenario. Interestingly, despite the seemingly large reduction in coal *capacity* in FY31, the share of coal-based *generation* in FY31 only falls by 2 percentage points – from 54% in the reference scenario to 52% in this scenario[10]. This highlights the difference between capacity and generation, and that retiring capacity alone may not result in greatly reduced generation or

its risks of long-term lock-in of investments and capacity, and suggest that it be taken up based on rigorous case-by-case analysis.

[7] Assuming coal PLFs being about 2.5 times of renewables (say, 62.5% and25%)

[8] Assuming a weighted average CUF of 25% for renewables - compared to actual CUF of 18% in FY22. Lower CUFs would require even higher RE capacity addition.

[9] This criterion roughly represents the criterion used for early retirement in the literature mentioned in the previous paragraph.

[10] The coal fleet in the reference scenario operated at an average plant load factor of 53% and the same in the early retirement scenario was higher, at 58%

emissions. In addition, the total electricity cost of this scenario is similar to the reference scenario indicating the lack of an economic benefit of such early retirement.

Moreover, despite adding more capacity of other types, this scenario is unable to fully make up for the loss of coal capacity in the reference scenario, as it results in much greater unmet electricity demand. For example, even after considering a very high value of unmet demand (Rs. 100/kWh) for both scenarios, the unmet demand for the year FY30 in the early retirement scenario is around 28 times that in the reference scenario. Also, the reference scenario has unmet demand only in FY30, while this scenario has some unmet demand in FY27 and FY29 as well.

The early retirement scenario itself results in aggressive addition of new renewables capacity, to the tune of 40 GW per year on average between FY24 and FY31 – which is more than twice the maximum annual renewables capacity addition in the past. The unmet demand issue does get addressed if the model is allowed to add even higher amounts of renewable capacity. In such a scenario, demand could be met as effectively as the reference scenario. But this required an addition of over 51 GW of renewables on average each year between FY24 and FY31, which is highly unrealistic.

This highlights the likely impact of looking at retirements in a simplistic manner, and illustrates the scale of the challenge when planning the phase-down of coal from India's electricity sector.

Given this complex challenge, in this paper, we present an approach for thinking about how coal can be phased down from the electricity sector in India using a comprehensive approach, while ensuring that the country's electricity demand is met at reasonable cost, emissions from electricity generation are minimised, and locked in or stranded resources are reduced. In addition to effective planning for the electricity sector, such a framework will also help in planning for the coal sector regarding decisions such as which mines to continue operating and which new mines to open, and for planning associated infrastructure such as coal evacuation, washeries, coal handling systems, ports, etc. A nuanced and detailed understanding of this nature can also be very useful to plan for a systematic and just transition away from coal and coal-based generation for communities dependent on coal. Thus, such a comprehensive, realistic plan for phasing down coal-based generation is an important public policy issue for the country.

3. Proposed approach

Electricity supply in the country happens through multiple avenues, such as distribution utilities, markets, bilateral contracts, and captive generators. The distribution utilities account for a bulk of the total electricity supply and have contracted most of the existing coal-based capacity. Given this, we focus on an approach to phasing down coal-based generation from electricity supplied by distribution utilities in this paper. While other (captive and merchant) coal-based capacity also would get phased down, the issues governing them are different and perhaps less relevant from a public policy perspective, and are thus beyond the scope of this paper.

3.1. Parameters to be considered

As mentioned above, planning to phase down coal from the electricity sector, when it contributes more than 70% of electricity generation, is effectively planning for the future of the electricity supply sector itself. To that extent, it necessarily must consider all the complexities and inter-connections of the electricity sector. The important parameters that need consideration are listed below.

- *Planning and optimisation at the state level:* Electricity distribution is a state subject and consequently, planning for electricity procurement is done at the state or distribution utility level. Such procurement plans are approved by State Electricity Regulatory Commissions (SERCs). Hence, states are the right unit at which utility-level planning for the electricity sector, and coal phase-down, should be carried out. To be sure, there are some benefits to planning over larger geographic areas such as easier integration of renewables over a larger balancing area, and efficient discovery of prices in a national level exchange. However, given the sector's organization in India, there are limits to which 'national level optimisation' might be possible, since each state would have different considerations, priorities and pressures[11]. Thus, planning should be carried out at the state level, but should include the benefits of considering larger balancing areas, in due course.
- *Accounting for growing future demand:* Electricity demand is going to increase in all Indian states for the foreseeable future. Meeting such demand 24x7 should be one of the objectives of planning for the sector's future. Given that India's per-capita energy demand is much lower than global standards (IEA, 2021), there may even be a case to be made for trying to increase demand even faster among those who consume less and meet such demand. Such demand forecasting exercises should also factor in the impact of appropriate energy efficiency measures.
- *Addressing demand variations across time and seasons:* Electricity demand changes over the day and across seasons and the available capacity should be able to meet this varying demand. The demand shape also changes over the years. For example, increased solarisation of agriculture due to schemes such as PM-KUSUM and similar state level schemes would tend to shift demand towards day time (Gambhir & Dixit, 2019). Schemes

[11] For example, imposing a national level efficiency-based merit order, is likely to be politically difficult. Instead, approaches such as more stringent monitoring and implementation of SHR norms, or imposing financial disincentives for high SHRs may work better to promote improvements in efficiency. However, electricity markets are national and states do participate in such markets to a limited extent – such elements need to be factored in even for a state-level exercise.

based on demand response, digitalisation, and time of day tariffs are being introduced at various states in an attempt to shift load from periods of high marginal costs to those with low marginal cost (PwC India Private Limited, 2010). On the other hand, greater penetration of electric vehicles, backed by various national and state level policies, encouragement of induction-based cooking and behind-the-meter rooftop generation may affect utility load shapes differently, and perhaps increase evening and night demand. Planning needs to account for such factors.

- *Considering existing legal and contractual obligations:* Existing generation capacity would typically have some contractual and financial obligations. These could include aspects such as power purchase contracts (under which power procurers are obliged to purchase a certain amount of power for a fixed number of years), fuel supply agreements with coal or gas suppliers (which could have obligations to offtake a minimum amount of fuel each year), outstanding debts and other liabilities, and undepreciated capital assets. The costs and benefits of a planned future trajectory must include these aspects.
- *Factoring in economic and technical considerations and adhering to statutory norms:* Phasing in any new capacity and operating existing capacity optimally must consider the changing economics of various alternative technologies, along with their technical limitations. This needs to be supplemented with considerations of operational constraints, such as transmission bottlenecks, and limits on how fast some generators can be ramped up or down and turned on and off[12]. In addition, the need for adherence to statutory norms such as the grid code and coal plant emission norms must also be factored in.
- *Considering financial and capital requirements:* Phasing down coal, and phasing in new technology is likely to need significant capital investment. This is especially the case when considering wind, solar, and storage capacity, which are all capital expenditure heavy technologies. There are also other system and sector costs, including costs to enable a just transition, that are likely to be significant given the scale of the phase down, making the availability of and planning for capital a crucial parameter to consider.

Electricity planning, including planning for phasing down coal, requires consideration of the gamut of parameters mentioned above, and should aim to minimise overall system cost and improve overall system efficiency and operation.

It should be emphasised that, given the kind of unknowns and variables that have to be considered as part of the planning process, and given the dynamic nature of the electricity sector, no single 'blueprint' framework will work for the long term. The plan should be revisited and

[12] Unfortunately, much of this essential information is not shared transparently, and there is ambiguity on the actual technical capabilities of generating units as compared to CEA regulations.

refined regularly to reflect changing realities – say every three to five years, which may lead to suitable revisions, including what capacity to consider for retirement or addition, and when.

3.2. Overview of the approach

For completeness, we briefly describe how such sector planning should ideally be undertaken, accounting for the parameters discussed above. The approach is also illustrated in Figure 1 and is broadly similar to approaches such as Integrated Resource Planning (Central Electricity Authority, 2022).

Planning for the electricity sector is crucial and will remain essential toward ensuring the health of the sector as it is poised for fundamental change (Nhalur, Chitnis, Vaishnava, & Gambhir, 2019; Prayas (Energy Group), 2018). It is best done at the state level given the structure of the sector in India, and because that would allow for the incorporation of state-specific factors, such as state level policies, resource endowments, consumer mix, and agroclimatic and economic considerations[13].

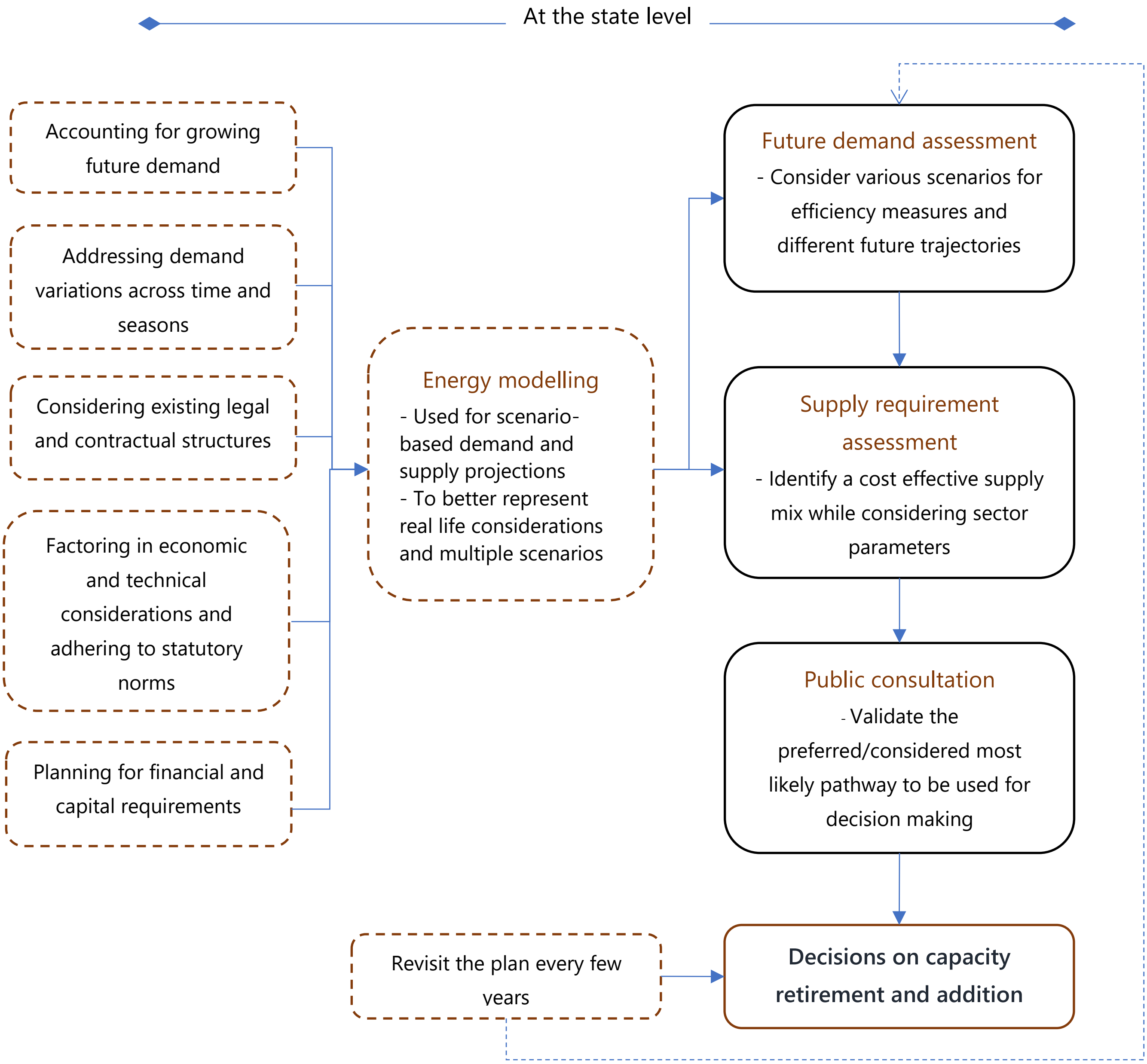
A critical ingredient of such planning is estimating likely future demand, including the shape of the demand over the year and likely new kinds of demand such as electric vehicles, and green hydrogen production. Using demand estimates that are overly optimistic, as had been the case in the past, is likely to result in increased costs and potentially stranded assets in the form of 'excessive capacity' (Prayas (Energy Group), 2017), while estimates that are overly pessimistic could result in shortages. Demand estimations should preferably be undertaken for each consumer category, and not only factor in state level realities but also aspects such as consumer migration, out of state power purchases, changes in load shape, and self or behind-the-meter generation. Such an exercise should also consider appropriate energy efficiency measures to ensure that energy services are provided with minimal energy footprint. This should ideally be done for a few different scenarios to understand the range of possible demands under different future trajectories. Currently, this is not the case and many states and distribution utilities typically proceed with a single load forecast based on their own analysis and/or using the CEA's Electric Power Survey, which may or may not take these factors into account.

Detailed demand projections can then be used to estimate the supply requirements, including the requisite generation capacity from different sources, to identify a feasible cost-effective (ideally cost-optimal) supply mix. This exercise should factor in the various parameters discussed

[13] Having said that, state level plans should be consistent with any national level policies or targets such as renewable purchase obligations, international commitments on the share of non-fossil or renewable capacity and generation, and adherence to statutory emission and environmental standards. Of course, ideally, such targets or commitments should be determined based on bottom-up state-level consultations in the first place. It should also be noted that states have generally not been very effective with their planning historically.

above such as existing capacity and contractual obligations, likely future costs of different future technologies and fuels, technical and operating constraints of different technologies and any state or national level mandates. Ideally, this exercise should also be undertaken for a few different scenarios with varying assumptions of future costs and technology trends, since they too are uncertain.

Figure 1. Flowchart of proposed approach



Source: Prayas (Energy Group)

Typically, energy models are good tools to use for such scenario-based demand and supply projections, with increasingly sophisticated models that are better able to represent real-life scenarios becoming available (Prayas (Energy Group), 2022; Prayas (Energy Group), 2021;

Spencer, Rodrigues, Pachouri, & Thakre, 2021; NREL, LBNL, POSOCO, USAID, 2017; Central Electricity Authority, 2020; Central Electricity Authority, 2022). Currently, the use of such models is not very prevalent for electricity sector planning, owing to various challenges such as pre-existing practises, inadequate institutional capacity, and lack of sufficient reliable data. But we believe that with the growing complexities of the sector, it is progressively becoming necessary to include the use of such models in planning. However, it should be remembered that models only provide estimates or projections of the future based on the inputs given to them. This highlights the critical importance of developing transparent models with various scenarios to illustrate different possible future trajectories. These scenarios can then form the basis for broader public consultations and dialogue, to identify the basis for future planning for the sector.

This exercise would indicate how much generation is likely to come from which technologies, and also naturally result in a coal phase-down plan. It would not only indicate what new capacity (of different technologies) should be added, but also which capacity of which technologies should be retired. The coal phase-down plan that emerges from such a planning exercise can also inform other policy and investment decisions regarding coal production and enabling a just transition.

As discussed above, such plans need to be revisited and refined on a regular basis, given the fast-changing nature of the sector. It is usually easy to update an already set-up model with revised assumptions and inputs to obtain new results, unless there have been some very fundamental changes in the sector. Therefore, such refinements should typically be relatively inexpensive and straightforward once the base model is set-up. This will help adapt the plan – including the phase-down plan – accordingly.

For example, if the price and availability of storage technologies improves faster than expected, it may be possible to become more aggressive on phasing out coal capacity. On the other hand, if either it is not cost effective or practical to add renewables or storage at the scale required, or if demand grows faster than anticipated, then one may have to resort to alternatives such as demand management, not retiring coal capacity as envisaged, or perhaps even adding some new ultra-efficient coal capacity.

Similarly, the availability of international climate finance that enables accelerated phase-down of coal-based generation could change the economics sufficiently to enable a more aggressive approach to retirement, subject to feasibility of addition of other capacity to meet demand. The imposition of national or cross-border carbon taxes, or the increasing difficulty of obtaining finance for coal-based generation, could make it prohibitively expensive to run some coal plants or install new coal capacity. Whatever be the case, using a comprehensive, analytically derived approach that is also subject to public scrutiny would provide much greater confidence that the adopted plan has tried to factor in the various considerations as well as possible.

SERCs could oversee and ensure that such an approach, along with periodic refinements, is followed. They are the institutions responsible for ensuring that distribution utilities incur only prudent costs for supplying electricity, and the cost of power procurement forms about 70% of the cost of supplying electricity. Hence, it is well within their mandate to insist on such an approach given the dynamic nature of the sector and increasing constraints due to climate change. SERCs overseeing this process would also ensure that there is greater public scrutiny of the whole planning process. Until now, SERCs often did not adopt such an approach largely due to limitations of institutional capacity and the lack of a pressing mandate to do so. However, as discussed above, with the rapid changes in the sector and with the availability of more sophisticated tools, such a planning approach has become both more necessary and feasible.

4. Conclusions

Changing economics of the electricity sector and India's ambitious goals for renewable capacity expansion mean that the role of coal in India's electricity sector will gradually reduce over time. However, the predominant role that coal plays in the electricity sector today means that any plans for phasing down coal needs to be carefully thought through, to ensure an orderly transition that does not result in energy shortage or undesirable lock-ins or high cost of energy, while minimising emissions.

For this reason, we believe that while it is essential to plan for a phase-down of coal, it must be done as part of the overall planning of the electricity supply sector. Retiring coal-based capacity aggressively – particularly before important alternative technologies such as storage become economical and deployable at scale– is likely to prove counter-productive, given the growing demand for electricity and prevailing political economy around perceived or real electricity shortages.

As alternatives become cheaper and available at scale, more aggressive coal plant retirement can be considered, as long as sufficient alternative capacity becomes available to meet rising demand. The same is true if international climate finance and supply chains for cleaner alternatives become available at scale in order to accelerate a shift away from coal.

The proposed approach allows for both the above kind of decision making while also being responsive to changing circumstances. Such a considered and deliberate approach for phasing down coal would be appropriate for a country like India as it strives to meet its development obligations while addressing the climate change problem, rather than acting in haste and repenting at leisure.

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In light of several global and domestic levers, such as the ongoing energy transition, changing sector economics and policies, and climate change concerns, a phasedown of coal from the power sector is almost inevitable. However, the coal sector not only supplies over 70% of electricity currently, but also shares complex interlinkages with several other sectors and influences aspects of development in coal bearing regions. Therefore, the phasedown of coal needs to be carefully planned to ensure that growing electricity demand is met at least cost while minimising emissions and avoiding long-term undesirable lock-ins.

An effective approach toward the coal phasedown must:

- Include planning and optimisation at the state level
- Account for growing future demand
- Address demand variations across time and seasons
- Consider existing legal and contractual obligations
- Factor in economic and technical considerations and adherence to statutory norms
- Consider financial and capital requirements

These considerations are best accounted for by using sophisticated modelling tools that can support development of multiple scenarios so as to better reflect different possible futures. This can inform future demand and supply assessments, which would then lead to robust decision making in matters of capacity, subject to public consultations and regular reviews.

Such an analysis-based approach to phasing down coal will not only aid in circumventing challenges such as power shortage, high cost of power and resource lock-ins, but also help in planning for other aspects such as a just transition, and opening and closing of coal mines, making it key for navigating a transition away from coal in a developing country like India.

Prayas (Energy Group)