

# **Cleaner Power in India: Towards a Clean-Coal-Technology Roadmap**

## ***EXECUTIVE SUMMARY***

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Availability of, and access to, electricity is a crucial element of modern economies and it helps pave the way for human development. Accordingly, the power sector has been given a high priority in the national planning processes in India and a concerted focus on enhancing this sector has resulted in significant gains in generation and availability of electricity in the years since independence.

Coal-based power has driven much of the growth in India's power sector over the past three decades. By 2004-05, coal and lignite accounted for about 57% of installed capacity (68 GW out of 118 GW) and 71% of generated electricity (424 TWh out of 594 TWh) in the country; currently, the power sector consumes about 80% of the coal produced in the country. As the demand for electricity is expected to rise dramatically over the next decade, coal will continue to be the dominant energy source. The Central Electricity Authority (CEA) has estimated that meeting electricity demand over the next ten years will require more than doubling the existing capacity, from about 132 GW in 2007 to about 280 GW by 2017, of which at least 80 GW of new capacity is expected to be based on coal.

Sub-critical pulverized coal (PC) combustion power plants manufactured by Bharat Heavy Electricals Limited (BHEL) – based on technologies licensed from various international manufacturers – have been the backbone of India's coal-power sector. Although the unit size and efficiency of these BHEL-manufactured power plants have steadily increased, the basic technology has not changed much. Internationally, however, there is now a range of advanced, more efficient, and cleaner technologies for producing electricity using coal. Combustion based on supercritical steam, offering higher efficiencies than sub-critical PC, is a commercial technology. Ultra-supercritical PC, which offers even higher efficiency, is also being deployed, while oxy-fuel combustion for facilitating capture of carbon-dioxide (CO<sub>2</sub>) is under development. Integrated gasification with combined-cycle operation (IGCC), with significant potential for high efficiency and for cost-effective reduction of CO<sub>2</sub> and other emissions, is likely to be commercially available in the near future.

Therefore, even as India stands poised on the edge of significant growth in coal power, it is critical to promote technology trajectories that not only meet the near-term needs of the country but also set the coal-based power sector on a path that would allow it to better respond to future challenges. Current policies in the power sector are primarily driven by the need to increase generating capacity, which has had the result of deploying the least risky and cheapest technology (subcritical PC). On the other hand, growing international and domestic concern about limiting carbon emissions from the power sector has implicitly pushed the debate on technologies towards deployment of IGCC in India. However, such technology choices cannot be made blithely; today's decisions about power plant technologies will have consequences over the plant's entire lifetime – a period of about 40-60 years. Therefore, an explicit focus on technology policy in the coal power sector is imperative in order to ensure that any technology decisions are made with deliberate care.

In an evolving technology landscape, it would be risky to pick technology winners *a priori*, and hence, a systematic and objective analysis of emerging technologies is required, keeping in mind India's historical trajectory and its current and future needs, challenges and constraints. Such an analysis can be a foundation for developing consensus on an appropriate technology roadmap for the country, as well as on an innovation strategy to help implement such a roadmap. This paper aims to contribute to such a planning process by assessing technology options in the Indian context, and offers suggestions towards developing a coal-power technology roadmap for India.

The key challenges facing India's power sector include: an urgent need to increase energy and electricity availability for human and infrastructure development; increasing energy security; local environment protection and pollution control; and control of greenhouse gas emissions (particularly carbon dioxide). The task of meeting these broad challenges is further complicated by several constraints: availability and quality of domestic coal; limited financial resources; inadequate technical capacity for R&D, manufacturing, and O&M; and the institutional characteristics of the Indian power sector. Based on a broad vision of 'expanding power generation at low cost while enhancing India's energy security and protecting the local and global environment' we assess, using a ranking scheme, various coal combustion and gasification technologies on a number of key dimensions for the present and for the short-to-medium-term future (~10 years).

Our analysis suggests that commercial supercritical combustion technology is the best option for India in the short-to-medium term. While gasification and advanced combustion technologies will be potentially important options for the longer-term future, there are significant issues surrounding the current relevance of these emerging technologies for India, including uncertainties in technical and cost trajectory, suitability for Indian conditions, and timing of India's greenhouse-gas mitigation commitments. Given the still evolving (technical and deployment) nature of many of the key technologies, our analysis suggests that India should not make rigid technology choices for the long term, but rather keep its options open. We have also developed an illustrative technology roadmap for the India's coal-power sector, along with key policies to help implement the roadmap:

- (a) improve the efficiency of the power system (generating stock, T&D network, and end-use sectors) to reduce the need for addition in generation capacity and therefore buy time for making appropriate technology decisions;
- (b) implement supercritical-combustion-based generation plants to meet capacity addition needs in the short-to-medium term;
- (c) evaluate on an ongoing basis the appropriateness of emerging technologies for India through a monitoring and feasibility assessment program, and by advancing specific elements of these technologies and ensure that they can be deployed as and when needed through a strategic research, development, and demonstration program, in partnership with key actors from the coal and hydrocarbon mining, and the petrochemical industry;
- (d) enforce and tighten local environmental pollution controls through better pollution control technologies and greater and meaningful public participation; and
- (e) invest in a focused plan to examine geological carbon storage options, with detailed assessment of CO<sub>2</sub> storage locations, capacity and storage mechanisms in order to collect

valuable information for India's carbon mitigation options and inform future technology selection as well as siting decisions for coal-power plants.

We believe that a 'no-regrets' approach of this kind will keep appropriate options open and help make better technology choices as more information becomes available in the future. Furthermore, implementation of a technology roadmap and the 'no-regret' policies discussed above will be facilitated by several broader activities and programs. Some of the key activities include better understanding and use of coal resources and improving coal sector institutions, improving the institutional and financial health of the power sector, better inter-ministerial and regulatory coordination, improving systems of technology and policy innovation, systematic and coherent domestic energy policy analysis, and international action and cooperation on climate change mitigation.

Although the roadmap and the implementation program presented in this paper are meant to be illustrative (rather than definitive), many aspects of the policy elements and facilitating conditions will hold regardless of the specifics of the final roadmap. Our roadmap and the policy suggestions are intended to catalyze discussions on the technology path forward for the coal-power sector. We also hope that it will serve as a foundation for a formal roadmapping process which brings together appropriate stakeholders (including government planners, key ministries, private and public sector utilities and manufacturers, financial institutions, employee unions, academia, and NGOs) and engage them in productive discussions aimed at developing a consensus roadmap that serves the country's needs. In fact, it must be emphasized here that a successful outcome of a roadmapping exercise and its implementation are very much dependent on the underlying process. Generating utility-scale electricity from coal requires a range of tradeoffs – financial, natural resource, environmental, and social – and there is a diverse set of stakeholders who have strong concerns about decisions made in this sector. Our belief is that the Planning Commission of India may be the best body to facilitate these discussions, given its relative 'neutrality' and its existing broad analytical base on power sector issues.

While it is important for the government to lead such a roadmapping exercise, a transparent and inclusive process must aim to build consensus among stakeholders on a range of key issues. Hence, the roadmapping process must ensure outcomes that are consistent with the country's agreed-upon developmental priorities, and also acceptable to the local populace whose lives will be directly affected by building large coal power plants. This will go a long way in advancing the long-term strategic technology policies and planning in the sector and assist the decision-making process for developing and deploying advanced coal-power technologies. Finally, the roadmapping process will also help consolidate the existing coal-based R&D programs in industry, research institutes, and academia under a common vision with specific objectives and plans for the future, and help make appropriate international linkages.

*You may download the full paper, "Cleaner Power in India: Towards a Clean-Coal-Technology Roadmap" by Ananth Chikkatur and Ambuj Sagar from the Belfer Center website. Visit <http://belfercenter.ksg.harvard.edu/publication/18186/> for a link to the paper.*