KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

Coal and Renewables in India: Complementarity, Competition and Challenges

January 2017 / KS-1761-WB055A

About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology, and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

Legal Notice

Key Points

Coal and renewables are seen as the cornerstone of India's energy strategy to meet its growing electricity demand. These two energy resources are at different stages of legislative, policy, regulatory and institutional reform. KAPSARC's second workshop on this subject yielded the following insights:

- Resolving critical pricing issues related to affordability and willingness-to-pay are necessary to ensure that the evolving fuel mix provides the benefits of accessible, affordable and sustainable energy. While progress has been made in the electricity sector, the absence of a coal regulator with a requisite mandate remains a key challenge.

- International investors' appetite for Indian renewables has allowed the government to focus its public financing capacity on domestic coal infrastructure. However, the lack of reforms in the energy markets may mean that future investments in renewables could become more cumbersome and costly.

- The mechanism of "renewables bundling" — a strategy that joins comparatively more expensive solar with cheaper, already depreciated coal-based power to reduce the price of the combined bundle within the electricity supply mix — entrenches coal, not only as the main electricity resource in India, but also as the enabler in efforts to diversify the energy mix.

- To maintain grid reliability, modifications to the existing market design and practices would be necessary. Large-scale renewables integration can be enhanced by planning for flexibility, enlarging balancing areas and adopting sub-hourly markets. The option of using gas as a balancing fuel for intermittent renewables will require the development of suitable policy mechanisms to ensure the commercial viability of gas-based power generation.

- Pricing mechanisms for the promotion of renewables entail designing a feed-in-tariff that aims to maximize generation, consumer value and environmental benefits; often conflicting objectives.

Summary for Policymakers

The Indian energy sector is in the midst of a transformation. This is due to rising energy demand to fuel its expanding economy, as well as the increasing penetration of renewables amid new targets to further broaden and diversify the country's energy mix, which currently relies on coal and faces many challenges.

While reforms have progressed much faster in supporting renewables, the coal sector is still missing key reforms that are long overdue. Due to differences in the level of maturity of the reform process, both coal and renewables will probably pose different sets of challenges to a variety of stakeholders.

Pricing of coal and electricity continues to suffer distortions caused by issues such as affordability and willingness-to-pay. Despite considerable efforts to change retail electricity rates, progress is still needed for pricing reforms. An independent coal regulator with the requisite functions and authority would be able to address current inefficiencies in the system and develop a functional market-based pricing mechanism.

Sustaining the growth momentum of renewables to achieve ambitious targets is seen as the top priority for policymakers. Although competition between coal and renewables is intensifying, renewables are unlikely to pose a serious threat to coal due to India's growing economy that is characterized by huge latent demands (where customers are unable to satisfy their demand). However, this may change if energy storage becomes a viable option in the future.

Numerous growth oriented policies have been implemented, but there is still a need to develop policies that reflect the realities of the operations of federal and state level institutions. Over the past three decades, in an attempt to strengthen energy security in India, the coal sector has been the primary focus of attention and energy policy has centered heavily on the development of coal resources. In addition, meeting the growing demand for coal while addressing environmental and social issues are still the key challenges for the coal sector.

In recent years, however, due to environmental and energy security concerns, there has been a call for the diversification of fuel sources to reduce reliance on coal. This is the genesis of the coal versus renewables debate and the source of motivation for a careful analysis and review of the competition and complementarity dynamics between the two fuels.

The Indian government's decision to set a target of 175GW renewables capacity by 2022 calls for a careful analysis of the implications of achieving this target given existing constraints and potential future challenges. For example, to maintain grid reliability, modifications to the existing market design and practices would be necessary. Renewables integration can be enhanced by planning for flexibility, expanding balancing areas and aligning sub-hourly markets.

From a competitive perspective, coal as the incumbent dominant source of energy can be seen as the main obstacle to the development of renewables in India. This is so because the energy and political eco-systems in India are heavily intertwined. The grid parity price gap between coal and renewables (i.e., kWh cost of production) is shrinking, yet the pricing distortion doesn't allow for a fair comparison. Therefore, a life cycle analysis of generation costs for fossil and non-fossil fuels is needed to guide future energy policy in India. Hence, the successful integration of renewables

will require a structural shift in power from the main players in the coal industry to another group.

In terms of complementarity, there is certainly less of a debate about the ability of coal and renewables to coexist and be utilized in an efficient manner. Since coal is inherently cheap, it is seen as an enabler to diversify the energy mix using "renewables bundling", which dilutes the relatively higher price of renewables in the combined bundle. The question for India is how would it create or modify market structures to achieve the desired fuel mix targets and ensure their sustainability on a commercial level?

While there is competition and complementarity between coal and renewables, there continues to be sector specific challenges along with issues arising from the political economy of energy in India. It is therefore important to separate the issues affecting the energy sector as a whole from issues affecting only coal and renewables.

Background to the Workshop

KAPSARC's Energy Workshop Series on India's Energy Policies aims to create a collaborative space for the discussion of some of the most pressing issues facing the country's economic development and energy economy. The workshop hosted in New Delhi in November 2016 was the second in this series. The previous workshop held in Jaipur, Rajasthan, in March 2016 had focused on the design, implementation and efficacy of policy reforms introduced in India's renewable energy sector.

The importance of reforming the coal sector and its policies overshadow current developments in the renewables sector. As such, we held the two-day workshop to focus on coal and renewables; discussions were held to develop a better understanding of the challenges facing the coal sector and the complementarity that it provides for the uptake of renewables that is envisaged by Indian policymakers. Discussions also included the development of market mechanisms and associated policy for renewables. The workshop, attended by more than 35 people, initiated dialogue among key stakeholders including policymakers, academics and industry executives.

Strengthening the Coal Sector

India's reliance on coal as its main source to fuel its energy growth will probably continue, at least up to 2050. With over 75 percent of the country's electricity generation and almost half of the primary energy sector, coal dominates the discussion when we talk about energy security, reliability or even introducing renewables. It has defined energy security and reliability for decades in India because of its inherent advantage as a cheap, abundant and accessible source. It is also now utilized as a tool to speed up the penetration of renewables via the "renewables bundling" mechanism.

However, coal hasn't been able to meet latent demand due to challenges within India's energy sector such as production bottlenecks, pricing issues, rising imports, lack of investments and a weak infrastructure. The coal sector represented by coal and utility companies, both state and privately-owned, operates under pricing mechanisms that are defined by the government. Even though there has been much effort over the last couple of decades to move toward a more liberalized market, sustained reform efforts are still needed for effective market pricing. Strengthening the coal sector is necessary in order to achieve renewable energy targets. Therefore, tackling the challenges faced by the coal sector is important in order to realize its full potential and ensure that renewables are able to integrate further into the energy mix.

Moreover, the mechanism of renewables bundling proposes to make solar affordable by cross subsidizing it with low cost, depreciated coal assets to provide a cheaper proposition to State Distribution Companies than solar alone. This positions coal as not only the main electricity resource but also the enabler to move toward other resources for the expansion and diversification of the energy mix.

Resolving Pricing Issues

Inefficiencies and lack of investments in the energy infrastructure as a result of financial bankruptcies in the distribution sector mean that electricity supply to large parts of the country suffer from quality and reliability issues. This affects the willingness of consumers to pay for such supply and as a result the electricity sector is caught in a vicious cycle of low revenues and inadequate investments.

The establishment of a functional, market-based pricing mechanism for coal and electricity coupled with strong regulatory oversight can help resolve these inefficiencies.

The price of coal is directly related to the cost of power generation for producers and price of electricity for consumers. It is therefore necessary to validate existing assumptions and evidence of the consumers' true willingness to pay and the financial requirements for producers to remain in business. In addition, there are also issues related to the pricing of renewable-based power as renewables are gradually integrated into the energy mix.

In general, power purchase costs account for approximately 70-80 percent of the total annual revenue requirements of the electricity distribution company where the supply mix is largely dominated by relatively cheaper coal-based electricity production. The existence of low-cost coal based generation capacity allows the government to leverage it and absorb relatively more expensive renewable energy capacity. Yet, large scale integration of renewables in the future may increase the costs burden (or government subsidies) of the already stressed distribution companies.

Therefore, renewable purchase obligations have been implemented to ensure their successful integration into the energy mix. The high level of capital expenditure required for renewable-based power generation implies an overall increase in the price of power and the issue of consumer affordability arises. Once the existing integration capacity of coal-fired generation is used up, future integration of renewables would require a review of coal capacity and the role that it can play to ensure a stable grid and smoother integration.

On the producer side, there is a need to take into account the affordability for producers in addition to consumers during policy analysis. There is a risk of triggering a ''utility death spiral'' that arises due to existing cross-subsidization, which sees utilities relying on differential and higher tariffs to industrial consumers compared to residential users in order to maintain operations.

Technological improvement is another component that is required on demand and supply. This could include, on the demand side, monitoring usage and improving consumers' ability to track their usage and expenses and, on the supply side, increasing production and delivery efficiency. Technology can also help to minimize system leakages caused by transmission and distribution losses.

If costs continue to fall, the adoption of solar energy may allow Indian policymakers to diversify the energy mix, and facilitate the penetration of technological innovations simultaneously, which will help resolve pricing issues.

Managing the Pursuit of Sustainability

Meeting the growing demand for coal while addressing the environmental and social issues are key challenges in the coal sector. Balancing the objectives of achieving energy security from coal on one hand and ensuring environmental sustainability by reducing carbon emissions is at the heart of India's energy mix challenge. Implementation of renewables plays an important role in addressing environmental sustainability. Reforms in the coal sector, which include pricing of coal, greater participation of private investors and merchant miners, and strong regulatory oversight will help to bring greater affordability and energy security.

To meet the growing needs of the expanding economy, the energy sector is in need of investments. More specifically, the coal sector requires investment in infrastructure for more efficient production of coal, cleaner power generation and efficient distribution of electricity.

There is a need to balance energy security and environmental sustainability simultaneously so as to ensure that the increase in renewables capacity is commensurate with developments in clean coal capacities. Therefore, investments in the coal industry must be sustained to solve challenges that keep the sector from working at its full potential.

Reforming the Market Design for Renewables Integration

India's power system is facing the challenge of integrating an ambitious plan for renewables into an existing fossil-fuel dominated power sector. The electricity grid is designed and built to handle a relatively small number of large capacity power plants, which mainly run on fossil fuels. The deployment of renewables is gaining traction due to many reasons, ranging from energy security to environmental considerations as well as policy push and declining costs.

However, unlike conventional power plants, renewable energy sources are characterized by their intermittent nature of supply and wide distribution, i.e., a large number of small capacity installations that feed into the grid from multiple locations, dispersed over a large geographical area. Therefore, increasing the share of intermittent renewables into the supply mix is likely to pose challenges in maintaining the stability and reliability of the electricity transmission system. As India is running one of the largest renewables capacity expansion plans in the world, the growing fleet of intermittent renewables would require larger balancing capacity in the system for effective use of the resource.

Currently, existing electricity generation capacity is not flexible in terms of being able to ramp up and down in line with load demand. Some states such as Gujarat and Rajasthan have more flexibility than others (including, for example, Telangana). With the integration of renewables in states such as Punjab, minimizing the costs of integration is a crucial issue.

Renewables cannot operate on an opportunistic basis, they require credible free markets and robust forecasting, which is critical to ensure an effective market that is able to manage renewables from a centralized and de-centralized approach. Market regulations need to progressively be upgraded to reflect the new learnings from renewables integration and technological developments. Appropriate risk allocation is also necessary and renewables curtailment must be avoided or else paid for.

To maintain grid reliability, modifications in the existing market design and practices would be necessary if India is to fulfil its vision of having at least 40 percent share of renewables in its overall electricity mix by 2030. Some of the market design options that can help ease the integration of renewables in India are:

> *Planning for flexibility* will become a requirement as renewables increase variability and uncertainty in the grid due to its intermittent nature; cycling (fast ramping up or down) of conventional plants is one of the important sources of bringing in reserves that are available in the system. However, frequent and fast changes to power output may result in higher cost of operation. Existing conventional stations should be encouraged to undertake retrofitting to improve technical flexibility by offering appropriate incentives. This would require having in place a market mechanism that will not only encourage conventional generators to offer flexibility but also make it accessible to market participants at appropriate prices. New conventional power plants will need to be developed with higher flexibility features. Increasing gas allocation to renewables rich states for operating gas-based power plants will also help meet the balancing requirements. Energy storage is another option that can be used for effective utilization of variable renewable energy. However, the cost of battery storage is still prohibitively high for utility-scale battery storage to become a viable option for providing flexibility in the grid.

Valuing flexibility and quantifying the costs associated with integration (system externalities) will be important to provide the necessary flexibility in the grid. This will help in designing appropriate incentives that would not only encourage investments in building the required flexibility into the system but at the same time decrease the risk of any significant curtailment of renewables and the possibility of negative pricing. Existing market design and rules in India don't include the value of flexibility. Moreover, the performance metrics are not mature enough to estimate such value contribution offered by flexible generators or any other potential sources at the user-end. It is desirable to develop an acceptable methodology that incorporates the data needs, role of grid operator and system planner.

Planning for a transmission system that avoids restricting renewable energy flows (curtailment) due to bottlenecks in distribution. The presence of a strong grid infrastructure at the intra-state, inter-state and inter-regional (across power systems) levels will not only facilitate better integration of renewables with the grid but also lower the off-take risks of renewable energy generators. It is also desirable to change the transmission planning criteria from long-term Power Purchase Agreements (PPAs) to markets that clear on the basis of demand and supply. Further, more innovations in transmission pricing frameworks would be required to encourage efficient use and investments.

Enlarging balancing areas can help reduce the overall balancing requirements due to the intermittency of renewables. Scheduling, dispatch and accounting of electricity transmitted through the state grid is carried out at the state level and handled by the respective State Load Dispatch Centre. Due to smaller control areas, balancing requirements within a state for accommodating renewable energy may be higher, which could result in bigger balancing costs. On the contrary, a larger control area can capitalize on geographic diversity in terms of both demand and supply, including renewables, and help smooth the variability of renewables and reduce the overall balancing requirements. Suitable regulatory frameworks needs to be developed for promoting regional balancing between the individual control regions.

Sub-hourly markets must be adopted for a better forecast of renewables. Hourly dispatch market locks in the merit-order-dispatch for a period of one hour, which may not be a cost optimal solution. In contrast, a sub-hourly market provides better economic signals to generators to respond to the variations in demand and variable renewable energy production, thereby utilizing the flexibility of the entire conventional capacity. Grid operators in India have already moved to sub-hourly 15-minute dispatches. However, adoption of sub-hourly market with higher penetration of renewables will require high quality forecast for renewable energy generation in order to improve schedule and dispatch correlation.

Pricing Mechanisms for the Promotion of Renewables

Currently, renewable energy producers in India are compensated via two regimes: administratively determined feed-in-tariff (FiT) and/or competitively determined prices. Although costs of solar energy technologies have dropped significantly over the past 3-4 years, it is still not competitive enough in a number of countries, especially when compared to fossil fuels.

In India, the procurement of solar and wind power through competitive bidding is becoming increasingly popular, however, several states still prefer to attract investments in renewables through FiT. In such cases, rates are determined by the state electricity regulators, with a control period of two years (but not always) and is applicable for the useful life of the renewable energy.

Therefore, how to incentivize renewables to be competitive, economically viable and more sustainable becomes a key challenge for regulators as they design FiTs that will attract investments and meet policy objectives.

The four potential objectives that are pursued through FiT design are: optimize benefits, maximize generation, consumer value and environmental gains. However, these objectives are often opposed to each other.

In addition, managing intermittency is a critical issue that needs to be appropriately factored into pricing. Capacity value of intermittent energy is also questionable. Despite this, the single part tariff offered as FiT for various renewable energy technologies in India is based on capacity value. On and off-grid renewables also offer different sets of issues in terms of pricing. Large, utility-scale renewables are more efficient compared with small-scale distributed generation. Whereas off-grid renewables may offer greater benefits than grid-connected renewables, such as micro grid and independent generation. Such considerations if included in determining the level of subsidies may change policy preferences. Therefore, while deciding subsidies, picking winners and losers becomes crucial.

Designing FiT is a complex issue but we should take note of conflicting policy objectives. Understanding the system benefits and costs of renewables integration as well as the different off-grid and on-grid dynamics is crucial for effective FiT designing.

About the Workshop

KAPSARC convened the two-day workshop on Nov. 15-16, 2016, with a combined attendance of more than 35 experts in areas including coal, electricity, renewable energy, international relations and governance to facilitate a discussion on India's coal and renewables policies. The workshop was held under a modified version of the Chatham House rules under which participants consented to be listed below. However, none of the content in this briefing can be attributed to any individual attendee.

List of Participants:

Carlos Fernandez Alvarez – Senior Coal Analyst, International Energy Agency

Pankaj Batra – Chief Engineer, Central Electricity Authority

Amit Bhandari – Fellow, Gateway House: Indian Council on Global Relations

Vineet Bhatia – Manager, Energy & Utilities, PricewaterhouseCoopers Private Limited

Yagyawalk Bhatt – Himalayan Environment Studies and Conservation Organization

Sumantra Bhattacharya – Professor, Indian School of Mines

Partha Sarathi Bhattacharyya – Former Chairman, Coal India Limited

Ashley Brown – Executive Director, Harvard Electricity Policy Group

Puneet Chitkara – Technical Director, KPMG

Dipesh Dipu – Partner, Jenissi Management Consultants

Ashwin Gambhir – Senior Research Associate, Prayas Energy Group

Probal Ghosh – Head Modelling Group, Integrated Research and Action for Development

Shahid Hasan – Research Fellow, KAPSARC

David Hobbs – Head of Research, KAPSARC

Abhinav Jain – Research Associate, The Energy and Resources Institute

Anil Kumar Jain – Advisor (Energy), NITI Aayog

Balawant Joshi – Managing Director, Idam Infrastructure Advisory Private Limited

Amit Kumar – Partner, PricewaterhouseCoopers Private Limited

Aruna Kumarankandath – Programme Manager, Center for Science and Environment

Noura Mansouri – Senior Research Associate, KAPSARC

Rajesh Mediratta – Director, Indian Energy Exchange Limited

Sruthi Nair – Research Associate, The Energy and Resources Institute

Jane Nakano – Senior Fellow, Center for Strategic and International Studies

Kate Penney – Manager, Department of Industry, Innovation and Science, Australia

Lydia Powell – Head, Centre for Resources Management, Observer Research Foundation

K Ramanathan – Distinguished Fellow, The Energy and Resources Institute

Soundaram Ramanathan – Programme Officer, Centre for Science and Environment

Jitendra Roychoudhury – Research Fellow, KAPSARC

Vinay Rustagi – Managing Director, Bridge to India Energy Private Limited

About the Workshop

Raj Kumar Sachdev – President, Coal Preparation Society of India

Aarsi Sagar – Consultant, Indian Council for Research on International Economic Relations

Anurag Sehgal – Research Associate, The Brookings Institution

Sarang Shidore – Visiting Scholar, University of Texas at Austin

Anoop Singh – Associate Professor, Indian Institute of Technology

S K Soonee – Chief Executive Officer, Power System Operation Corporation Limited

Ashok Sreenivas – Senior Research Fellow, Prayas Energy Group

Rahul Tongia – Fellow, The Brookings Institution

Masakazu Toyoda – Chairman and CEO, Institute of Energy Economics, Japan

Ben Wise – Visiting Fellow, KAPSARC

About the Team

Brian Efird

Brian is a senior research fellow and Human Geography of Energy program director at KAPSARC, leading teams on China, India, local content, policy and bargaining models.

Shahid Hasan

Shahid is a research fellow at KAPSARC working on renewable energy in India and other countries. He is an energy specialist who has worked in energy policy, regulation, market design and energy infrastructure, particularly in the electricity industry.

Noura Mansouri

Noura is a senior research associate at KAPSARC working on energy modelling and policy analysis. Her previous experiences include researching and publishing as well as working in the clean energy domain.

Waheed Olagunju

Waheed is a research associate at KAPSARC working on energy modelling and policy analysis for India. He previously worked as an economist and financial analyst.

Jitendra Roychoudhury

Jitendra is a research fellow at KAPSARC working on the India energy research project. He previously worked in consulting, advising organizations on commodity flows and markets.

About the Project

KAPSARC is engaged in analyzing the dynamics of India's energy economy and decision-making process. This will help provide deeper and more comprehensive understanding of the domestic Indian energy challenges and policies designed to address these challenges. The research project aims to investigate the global consequences of changes to energy markets within India, thus allowing assessment and analysis to obtain policy relevant insights.

In line with KAPSARC's overall objectives, the aim is to assist stakeholders outside India to understand the consequences of decisions taken by Indian policymakers.

مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

www.kapsarc.org