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# Energy Security Insights

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*Editor*
Pragya Jaswal

The Energy and Resources Institute

www.teriin.org

## Rising coal use in the context of global environmental imperatives

The IEA (International Energy Agency) in its recent publication – *World Energy Outlook* – has claimed that the rise in coal consumption since 2003 has been as high as in the previous 23 years. It has attributed this phenomenon to the economic boom in China and India, and has further predicted that developing countries in Asia will account for over 85% of the growth in coal use over the next 25 years. This obviously has implications for the environment and greenhouse gas emissions. The share of developing countries in emissions is expected to rise from 39% in 2004 to over 50% in 2030, and this increase is estimated to be faster than the increase in energy demand, primarily due to more reliance on carbon-intensive fuels such as coal. These daunting statistics are often used to urge a global participatory action to mitigate climate change. However, India has dismissed calls for it to undertake formal commitments to reduce greenhouse gases on the ground that development is its first priority. Also that on a per capita basis its emissions are 23% lower than the world average and will continue to be below the world average of today, even after 25 years from now. However, it is a well-known fact, and emphasized time and again by Indian energy experts, that coal will continue to be a major fuel for the Indian economy.

The recent forecasts made by the Committee on Integrated Energy Policy reiterate this point. The Committee report cautions that India will necessarily have to find cleaner ways of not only extracting coal but also using it. In this context, the role of R&D (research and development) for establishing more resources through coal-bed methane and in situ gasification of non-mineable or deep-seated reserves is of paramount importance. Also, improving efficiency in power generation is critical, with over 75% of the coal produced being consumed by the power sector in India. This is relevant not only from an economic perspective but also from the environmental perspective. In addition to these technological imperatives for domestic coal, one seems to underplay the relevance of coal imports for the power sector, which according to some experts is likely to play a significant role in the overall energy mix of the country. A renewed emphasis on energy diplomacy with coal-rich countries is probably the new imperative for securing energy supplies for India.

This issue of the newsletter has articles addressing a range of issues related to coal from the global and the national perspective. They have highlighted the need to examine coal usage in the context of energy and environmental security, and underscored the role of efficiency improvement, R&D, infrastructural constraints, and above all to consider diversification to other sources of energy, however marginal their role would be in the overall scheme for the Indian economy.

Preety Bhandari
TERI, New Delhi

# The challenge and promise of coal for India in a climate- and energy-security-stressed world

R K Pachauri
TERI, New Delhi

In any discussion on energy security in India, the utilization of the country's coal resources would be an important element. The history of the coal industry and the manner in which dependence on coal, particularly for power generation, has grown over the years point towards a promising future, and raise concerns at the same time. Typically, concerns related to coal at the national level focus on some of the major constraints in mining and movement of coal, whereas at the international level, concerns that are frequently expressed relate to the likely increase in coal consumption in India, which would lead to an increase in GHG (greenhouse gas) emissions. The challenge for India is, therefore, quite complex when it comes to dealing with the use of coal to ensure energy security, because the country not only would have to deal with the economic, institutional, geographical, and technological constraints that characterize the coal sector in India, but would also have to ensure that the increase in carbon dioxide emissions does not reach levels that make a significant difference to the concentration of GHGs in the earth's atmosphere and thereby prejudice India's standing as a responsible country dedicated to solving the world's serious problem of climate change.

To start with, it is important to clarify that as a coal-consuming country, India still significantly lags behind countries like China and the US (Table 1).

**Table 1** Coal consumption by region, 1990–2030 (million short tonnes)

| | | Projections | | |
|---|---|---|---|---|
| Region/country | *1990* | *2010* | *2020* | *2030* |
| United States* | 904 | 1 233 | 1 390 | 1 784 |
| Russia | 447 | 263 | 330 | 382 |
| China | 1 124 | 2 535 | 3 530 | 4 645 |
| India | 256 | 583 | 775 | 887 |
| Entire world | 5 269 | 6 956 | 8 642 | 10 561 |

* Includes 50 States and the District of Columbia.
**Source** EIA (2006)

It would be seen that from the point of view of energy security and ensuring stabilization of the earth's climate, India perhaps faces a challenge lower in magnitude when compared to that of countries like the US and China, which consume not only much larger quantities of energy overall, but also a larger absolute magnitude of coal as a fuel. For instance, if growing quantities of coal have to be burned in a manner that keeps emissions of carbon dioxide at a manageable level or preferably declining over time, then it is essential for China and the US to develop and use technologies for coal that are generally low in carbon emission. These technologies would in several cases be attractive for use in India as well. Again, given the fact that both the US and China consume hydrocarbons in larger quantities than India does, the substitution of oil and gas with coal in an environmentally acceptable manner represents a much bigger task in the US and China than in India.

India faces some crucial choices in the use of coal, which would be defined by various factors such as given below.

- A relative abundance of reserves of coal
- Stagnation in the discovery of oil and gas from indigenous sources
- Growing pressure to expand supply of electricity, given the fact that almost half the population still does not use electricity at homes
- Environmental and ecological problems associated with large hydro projects, which make it difficult to expand hydro power at a major rate

The pressure for using larger quantities of coal comes mainly from the growing demand for electricity and the substantial level of unfulfilled demand that is commonplace in large parts of rural India.

The interpretation of energy security for this vast section of India's population is, therefore, not so much a question of importing large quantities of oil at reasonable prices as it is a matter of getting adequate supply of electricity to provide a set of basic energy services to homes that are very much a part of modern living, based on the expanding use of domestic appliances. In fact, the Ministry of New and Renewable Energy (earlier the Ministry of Non-conventional Energy Sources) of the Government of India has actually come up with a Village Energy Security Programme that focuses on meeting some of the demands for these domestic energy services through the provision of renewable energy technologies.

When India attained Independence in 1947, electricity supply was limited only to a few towns and cities, with a total installed capacity of about 1300 megawatts. Rural areas had hardly any access to modern fuels except kerosene. In very simple terms, the power-generating capacity at that point of time would have been adequate for lighting 100-watt bulbs in only 13 million homes, which would have represented only 20% of the country's population at that time, with of course no capacity being left for industrial or commercial applications.

Over the past six decades or so, the largely government-owned energy supply industry has attempted to supply commercial energy in the form of electricity to the entire country. At least 80% of the country should have had access to electricity by now, but actually less than 20% of the rural households consume electric power. Even where electricity is available, priority is given to applications such as irrigation pumping for agriculture. In any case, very few rural households would be able to afford investments in wiring of their homes to gain use of electricity on a regular basis. Hence, at this very basic household level, energy security cannot be achieved unless the following three conditions are fulfilled.

1 Incomes are high enough to permit investments in household-level infrastructure.
2 Adequate and reliable supply of power is available through grid or decentralized and distributed sources.
3 Fuel supplies at the front end of the energy supply cycle, which means availability of coal on a substantial scale, are available for the production of electricity.

It would be seen, therefore, that of these three conditions, supply of coal would affect only one requirement directly.

Even though several efforts are being made to discover larger quantities of hydrocarbons within the country, which would most likely be in the form of natural gas, a substantial increase in the indigenous supply of natural gas seems unlikely. While India has been attempting to get into arrangements for import of gas both by dedicated pipelines as well as in the form of liquefied natural gas, no success has been reached with any of these possibilities thus far. Consequently, the expansion of power generation will rely essentially on a major expansion of coal supply. At the same time, the domestic coal industry faces some huge challenges. Not only has there been a lack of investment in new mining capacity, but there are also growing transport bottlenecks in the movement of coal. However, a large part of India's coal reserves is located at depths that are very difficult to mine. Hence, it would make great sense if India were to develop an appropriate technology for gasification of coal underground and in situ.

Estimates from the *Integrated Energy Policy Committee Report* indicate that at the current levels of consumption, crude reserves of coal can last about 80 years. If we include inferred reserves, then our coal and lignite reserves can last over 140 years at the current rate of extraction. If domestic coal production continues to grow at 5% per year, total extracted coal reserves of all kinds would run out in 45 years. However, it is estimated that only about 48% of the potential coal-bearing area in the country has been covered so far by the regional surveys. Contrary to the popular belief that India has coal reserves that would last perhaps a couple of hundred years, it is now becoming apparent that there are serious limitation to the extent use of coal in the future. In order to ensure energy security and to conform to global expectations of lower carbon dioxide emissions, India has to take a set of measures. To start with, there is an urgent need to carry out major exploration activities in order to identify larger reserves of coal in the country. Other means by which coal resources can be stretched over a long period of usage would be through major efficiency improvements in the entire coal use and consumption cycle. In this respect, efficiency would have to be upgraded in the power sector as a whole, so that power- generation efficiency is increased, transmission and distribution losses are reduced, and end-use efficiency in electricity-using devices is also increased substantially. Thus far, very little has been done through deliberate interventions to bring about such efficiency gains.

Another area in which urgent efforts are required is the development and use of coal gasification technology. The greatest potential in this country would be realized through UCG (underground coal gasification) through which not only would a large part of inaccessible reserves be utilized, but major increases in efficiency of coal use would also become possible. Essentially, greater use of coal in the future would depend critically on a future technology vision and its realization. Current R&D (research and development) efforts appear to be totally inadequate and weak for the development of proper technologies such as coal gasification. There is a need to move away from the current framework of government-directed technology development efforts towards government funding of effective R&D institutions, universities, as well as industries working together as a consortium.

Since energy security generally centres around the question of import of hydrocarbons, if this particular issue has to be tackled, then the use of coal over hydrocarbons would have to be ensured. This means that the main hydrocarbon-using sectors will have to shift directly or indirectly towards the use of coal. In other words, the transport sector would have to move towards coal-generated electricity as a source of energy, which would happen only if major investments are made in public transport using electricity as the preferred form of traction.

That said, however, to view coal in isolation from other sources of energy would represent a limited and ineffective approach. In real terms, dealing with each end use of energy, whether based on coal or other sources, would require looking at a range of energy options and substitution possibilities by which local resources are used at an adequate level at optimal cost. Hence, while we can discuss specific actions required for creating coal-based solutions to meet India's energy security needs, such actions would necessarily have to be viewed within a much larger context involving not only other forms of energy, but also the major energy-using sectors of the economy. Energy efficiency gains across the board and the greater use of economically viable renewables, wherever possible, are essential strategies.

In conclusion, persevering with a view that coal is available in abundance in this country and can be relied on for meeting the bulk of India's energy demands could prove to be myopic and biased, and a thought largely divorced from reality.

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# Coal: the possible, the probable, the likely

Ritu Mathur and Sakshi Marwah
TERI, New Delhi

## Background

The Indian economy has evolved considerably since the advent of the liberalization process in the early 1990s. Increase in income levels and manufacturing activities and trade, and economic growth, coupled with modern and more energy-intensive lifestyles, have contributed to an increase in energy requirements over the past couple of decades. Commercial energy consumption has, in particular, increased from about 75 MTOE (million tonnes of oil equivalent) in 1981 to about 200 MTOE in 2001 (TERI various years), both as a result of the higher availability of commercial energy forms as well as increased intensity of commercial energy use.

The Indian economy's growth rate has averaged at about 7% over the past three years, while the government plans to achieve a growth rate of over 8% in the next few years (Planning Commission of India, 2005). In keeping with the country's vision of moving towards a prosperous and equitable India, the monitorable targets of the government as per the Tenth Plan are directed towards poverty reduction, providing affordable access to clean energy to all sections of society and improving the standard of living. Moreover, recognizing the fact that adequate and uninterrupted supply of electric power is instrumental in the economic development of any country, the Government of India plans to make electricity available to all by 2011/12. Given these trends and visions, it is now increasingly being recognized that rapid increase in India's energy requirements, particularly for electricity, is inevitable. Although estimates of total energy requirement and fuel mix availability vary across studies based on differences in assumptions regarding economic growth, technology diffusion, and resource availability, there is a consensus on the fact that coal would play a key role in India's energy sector at least in the next two to three decades.

## Growth in India's total commercial energy requirements

TERI's analysis – based on an integrated assessment of the country's energy scenario using the MARKAL model[1] – indicates that commercial energy requirements would increase by about 7.5 times from 285 MTOE in 2001 to 2123 MTOE by 2031 in a BAU (business-as-usual) scenario that reflects the most likely growth path of the Indian economy as per the current plans of the Indian government. In a low growth scenario, characterized by 6.7% GDP (gross domestic product) growth, the energy requirement is expected to increase by only 5.5 times, while a high growth scenario with 10% GDP growth is likely to result in an increase of about 11 times during the period 2001–31.

Supply side measures are aimed at reducing fossil fuel requirements. Enhancement of nuclear and renewable options can only play a minor role although efficiency improvement possibilities in conversion and end-use technology options are estimated to have a significant scope. The potential for reduction in energy requirements due to efficiency improvement is estimated to be as high as 581 MTOE by 2031 (more than two times the total commercial energy consumption in 2001), which can be effected through the deployment of energy-efficient options across the power, industry, and transport sectors.

### *Changes in India's energy mix*

Figure 1 indicates the likely energy-use pattern in the economy under a BAU scenario for 2011, 2021, and 2031. It is clear that even in the next 25 years, coal would continue to dominate the

[1] The MARKAL model is an integrated energy model. The India database has been developed by TERI. The model can be used to indicate different kinds of scenarios. The core research team of TERI, which developed this database, comprised Ms Ritu Mathur, Dr Pradeep Kumar Dadhich, Dr Atul Kumar, Ms Pooja Goel, Ms Sakshi Marwah, Ms Preety Bhandari, and Dr Leena Srivastava.

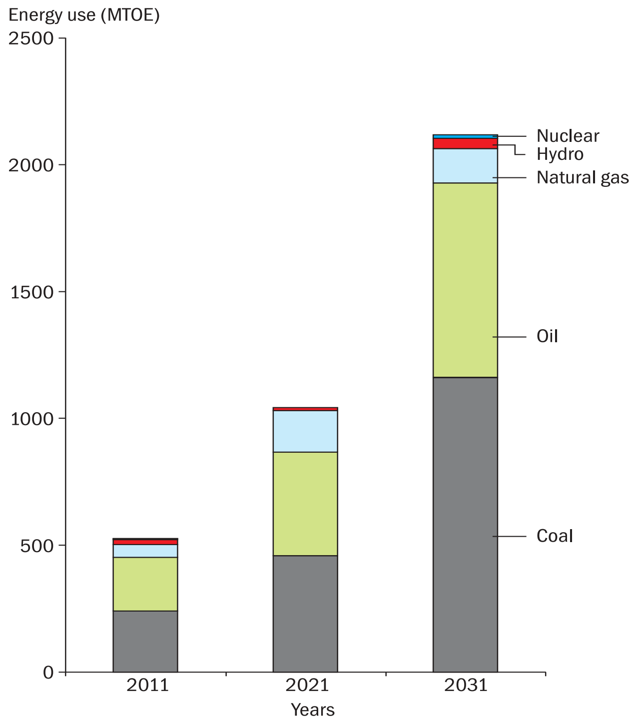


**Figure 1** Commercial energy mix by resource (business-as-usual)
**Note** The share of solar, wind, and bio-diesel is less than 1%.
**Source** TERI (2006)

energy mix followed by oil, while other sources of energy, such as natural gas, nuclear energy, hydro power, and renewables would at best be able to contribute to a small share of the total energy requirement.

The Indian government already has ambitious plans for enhancing nuclear- and renewables-based generation capacity in the country. Nuclear capacity is envisaged to increase from a mere 2.7 GW (gigawatts) in 2001/02 to 21.18 GW by 2021/22, with a further intent to increase it to about 70 GW through a three-phase programme. Moreover, there are plans to exploit the maximum potential of hydro power from a level of 25 GW in 2001/02 to 150 GW by 2031. However, given the low utilization factor of hydro power plants and the large increase in total energy requirements of the country, nuclear and renewables-based energy would play a relatively minor role even by 2031, accounting for less than 5% of the total commercial energy.

Since petroleum requirement is largely driven by growth in the transport sector, the potential for fuel switching is expected to be relatively minor in the next couple of decades (limited by the availability and penetration of bio-diesel and CNG [compressed natural gas] in the transport sector), while policy options such as enhanced rail-based movement and greater reliance on public transport might have a larger role in reducing requirements of petroleum in the future.

Although natural gas is a preferred option for power generation as well as for the fertilizer industry, both in terms of its economics and as a cleaner fuel, fuel substitution by gas is also likely to be limited on account of availability of the resource domestically and through imports. Based on the current assessment of future gas availability, it is estimated that total gas supply to the country would plateau at about 370 MSCMD (million standard cubic metres per day) by 2021 (based on the domestic availability of about 125 MSCMD and a maximum of about 245 MSCMD via imports in the form of LNG [liquefied natural gas] and through transnational pipelines).

Consequently, the country is expected to continue relying heavily on coal with its use increasing from about 150 MTOE in 2001 to 1176 MTOE by 2031, reflecting a share of 45%–55% in the total commercial energy supply during the period 2001–31.

The power sector accounts for the highest share of coal consumption, followed by the industrial sector for process heating and captive power generation. Figure 2 shows a comparison (by sector) of the likely coal consumption in a BAU scenario with that in an EFF (efficiency scenario) that includes efficiency improvement options related to energy conservation and end use. It is estimated that coal requirement in the power sector alone could be reduced significantly by 99 MTOE in 2021, and by 293 MTOE in 2031 in the EFF scenario as compared to the BAU scenario. This is on account of the shift from the sub-critical coal-based generation technology to the more efficient power generation options such as IGCC (integrated gasification combined cycle) and CCGT (combined cycle gas turbine) as well as reduction in electricity requirement by the end-use sectors.

### *Implications of a coal-dominated economy*

The current trends and plans in India's energy sector indicate that the dominance of coal is likely to continue despite the government's efforts to move towards higher levels of nuclear energy, renewables, and so on. This, however, is clearly not sustainable—be it from the viewpoint of energy security, infrastructural constraints or environmental impacts. The following sections discuss whether coal availability scenarios are practically feasible, and focus on the implications that this would have on the country if major concerted efforts are not made to deviate away from the likely energy path.

### Indigenous availability of coal

India is the third largest coal producer in the world, producing about 373 MT (million tonnes) of hard (bituminous) coal in 2004 after China (1956 MT) and the US (933 MT) (IEA 2005). However, there are mixed opinions about the estimates of extractable reserves in the future and constraints towards maximum annual production levels and consequent import requirements of coal.

Recent estimates of the Government of India state that current extractable coal reserves might last only for 45–50 years at the present level of production (Planning Commission of India 2002). The *Coal Vision 2025* document states that the production from CIL (Coal India Ltd), SCCL (Singareni Collieries Company Ltd), and CBM (coal bed methane) equivalent would be such that the country has a domestic availability of over 1000 MT in the next 25 years.

The implementation of this level of production is, however, doubtful, given the lack of availability of recoverable reserves as well as the lack of preparedness of the Indian coal industry to meet the fast expanding consumption levels. First, with the current status of coal mining technology and experience in India, it is unlikely that coal seams below 300-m depth would be exploited in the next couple of decades. Second, in a bid to quickly exploit resources, haphazard methods of mining are being resorted to, leaving behind large columns of coal that cannot be utilized later; this leads to not only large resources being rendered useless in the long run but also a large amount of extraneous material being included along with the coal mined by the opencast method. Third, the location of future proven resources at depths greater than 300 m is likely to render the coal economically unviable, given its poor quality. Consequently, it is estimated that under the BAU scenario, the maximum annual indigenous production of coal is likely to plateau at about 600 MT of coal by 2031(Chand 2005). Efforts to enhance the production without upgrading the technology would be possible only at the cost of over-

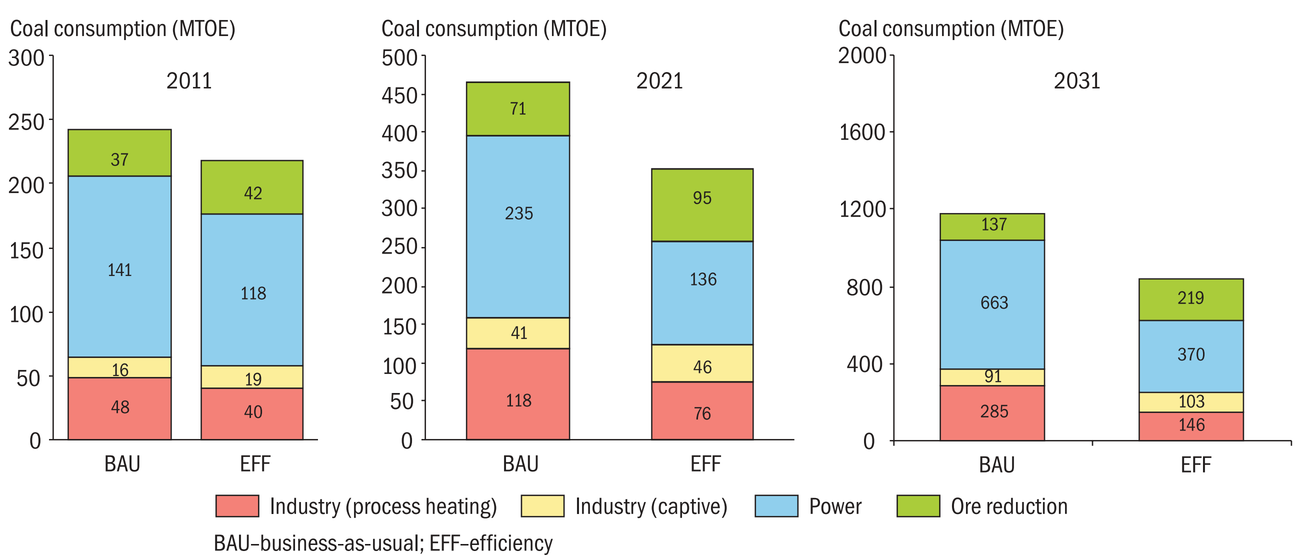


**Figure 2** Coal consumption across scenarios (by sector)
**Source** TERI (2006)

exploiting the existing mines or projects and bringing under production the virgin areas at a faster pace, implying that the reserves would be exhausted even earlier.

### Concerns of high coal import dependency

A comparison of the country's energy requirement and supply availability over the next 25 years indicates that by 2016, the domestic availability of each of the fossil fuels is expected to reach maximum limits, after which imports of each of these fuels would increase rapidly, leading to a spiralling of fuel import dependency from 27% in 2001 to 80% by 2031 under the BAU scenario. Even under a scenario of limited gas imports (255 MSCMD by 2026) on account of infrastructural and geopolitical constraints, the import dependency of gas is expected to increase from a near negligible level in 2001 to about 66% by 2021. Moreover, oil import dependency is likely to increase from 68% in 2001 to over 90% by 2031, mainly on account of the rapid growth in the industry and transport sectors—for moving both passengers and freight.

Due to the poor quality of the indigenously available coking coal, India is expected to remain dependent on imports of high-grade coking coal for iron making, such that import dependency of coking coal would range from 40% to 53% in 2011 and from 66% to 85% in 2031, under various scenarios of economic growth and technology diffusion across sectors. The import of non-coking coal is a recent phenomenon. Given that the annual domestic production of non-coking coal is expected to be restricted to about 600 MT by 2031, our analysis indicates that the import dependency for non-coking coal would increase from about 14% by 2011 to about 71% by 2031 in the BAU scenario. Even with efficiency improvement in the end-use and energy conversion technologies, the dependency is likely to remain over 50% in 2031. These levels of coal imports would lead to an enormous drain on the country's foreign exchange outflows. Even at the current price of $60 per tonne for imported coal, this translates to a monetary outflow of about Rs 4000 billion in 2031 under the BAU scenario. This may also be a rather conservative estimate, given that with coal demand expected to increase in the Asian market, prices of coal may also increase rapidly in the future, imposing an even higher pressure on the economy.

### Environmental aspects of a coal-dominant economy

Apart from the adverse environmental impacts associated with opencast coal mining, transportation as well as transformation of coal also pose a major threat to ecological and man-made resources as well as to human health. Problems related to ash disposal or utilization have become a major concern in terms of availability of land for disposal of ash and leaching of toxics into the soil. Given that coal is expected to play a major role in meeting India's energy needs, it is important to contain the ill effects associated with coal production and utilization whilst simultaneously identifying options for the use of coal in alternative forms such as transformation of coal to liquids, energy in the form of CBM, coal gasification, and so on. $CO_2$ (carbon dioxide) emissions likely from coal combustion are estimated to increase from about 547 MT at present to 4625 MT in 2031 under the BAU scenario (TERI 2006). Coal is expected to remain a dominant source of $CO_2$ emissions, accounting for more than 60% of the total $CO_2$ emissions.

### Infrastructural constraints

The quantum of likely coal requirement in the next couple of decades is also a cause for concern from the viewpoint of its handling and movement at the ports and through the existing rail and road transportation network. Even with the current level of coal handled at various ports (about 53 MT as in 2004/05) (IPA 2005), the port-handling capacity is over-exploited, since the capacity to handle coal is only 44 MT. As per the Tenth Plan document, coal traffic is expected to increase to about 88.3 MT by 2007. Although coal-handling capacity at ports is proposed to be enhanced to about 73.6 MT by 2007, this would still imply a capacity shortfall of 14.7 MT. Even though coal traffic constitutes only about 15%–16% of the total commodity traffic handled at various ports in the country, with coal imports estimated to increase dramatically to over 1400 MT by 2031 in the BAU scenario, it is clear that there is little possibility that additional port capacity could be developed to even meet the coal-handling requirements alone. Moreover, it is unlikely that the already stressed transportation network would be able to bear the burden of moving the imported coal to the consumers at various locations in the country. It is, therefore, extremely crucial that the country quickly finds ways to exploit coal-based energy through alternative means.

## The road ahead

There is no doubt that energy requirement and therefore, dependency levels are destined to be high, given the economic growth path that India has embarked upon. Reliance on external sources of all forms of fossil fuels cannot be wished away. However, the likely path of India's future energy use and its high dependence on coal with the current level of technology look neither justifiable nor possible, given the financial, infrastructural, and environmental implications associated with it. It is important to quickly find ways of using the indigenous coal resources as efficiently and in as clean a manner as possible.

The solution as well as challenge lie in exploiting the existing domestic coal resources in a more sustainable manner and accelerating technological progress in using some of 'today's futuristic energy resources'. Specifically with regard to the coal sector, the challenges posed as a fallback option are by no means minor. Research and development related to coal-to-liquid transformation, coal gasification, and availability of energy in the form of CBM needs to be stepped up in order to be able to sustain planned economic growth and requisite resource supplies to end-users.

Moreover, in the shorter term, it is essential that the country moves towards an integrated strategy that not only adopts an energy and technology diversification plan on the supply side, but also seeks to de-couple energy use and economic growth by targeting efficiency improvements in conversion technology as well as end-use applications.

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# Coal security issues in India

S K Chand, Anant Sudarshan, and Pragya Jaswal[1]
TERI, New Delhi

While debates and concerns on energy security issues generally tend to track global oil prices, energy security for many countries in the world is about much more than just oil security. This is particularly the case in the Indian context where 'energy security' has two interlinked but distinct aspects. The first is the need to achieve better utilization and distribution of energy among people (particularly in rural India) so that a minimal, 'lifeline' amount of commercial energy is available to everyone. The second is the need to find ways of fulfilling the growing need for energy, concomitant with at least 8% growth in GDP (gross domestic product), which is necessary to drive industrial growth and an improvement in standards of living.

To sustain 8% GDP growth till 2031, it is estimated that the country would need to increase its primary energy supply by three to four times and electricity supply by five to seven times the current consumption levels.

The latest edition of *IEPR* (*Integrated Energy Policy Report*) of the Planning Commission attempts to tackle these questions by considering a number of alternative energy-use scenarios. The first recommendation of the report states: *Coal shall remain India's primary energy source till 2031/32… current shortages are a concern.*

The *Coal Vision 2025* brought out by the Ministry of Coal, Government of India, indicates that the overall annual growth in coal demand till 2025 is expected to be 5.62% with 8% GDP growth scenario, and 5.04% with 7% GDP growth. This means that the demand for coal would increase from about 450 MT (million tonnes) in 2005/06 to 1147 MT (7% GDP growth) and 1267 MT (8% GDP growth) in 2025. The total domestic coal production, which was 407 MT in 2005/06, is projected to increase to 1086 MT in 2025, of which the opencast production will be 902 MT (83%).

Compared to the projections of *Coal Vision 2025*, the *IEPR*-projected coal requirement in the coal-dominant case scenario (which assumes maximum electricity by the most economical option, which incidentally happens to be domestic coal) is a staggering 1022 MTOE (million tonnes of oil equivalent) (about 2493 MT) in 2031/32.

TERI's own projections paint a similar picture, with a projected coal usage of 1176 MTOE (about 2868 MT) in a BAU (business as usual) scenario in the same year. Figure 1 shows TERI projections of the commercial energy fuel mix over a 30-year period, for the BAU scenario. As is evident, the share of coal remains relatively stable at a little over 50% throughout the projected period.

## Coal and energy security concerns

While it is evident that India's energy security would have to be heavily linked to coal for at least a couple of decades, serious concerns arising out of this overwhelming dependence on coal cannot be

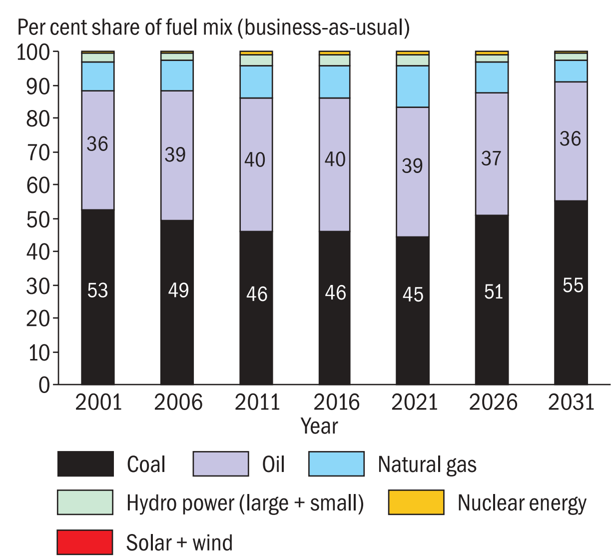


**Figure 1** India's commercial energy mix (2001–31)
**Source** TERI (2006a)

[1] We gratefully acknowledge input provided by Ms Eshita Gupta.

ignored. As will be discussed in the following sections, domestic coal supply will not be sufficient to meet the country's requirements and the magnitude of imports will increase over time. This implies that external factors such as international prices and trade trends will also affect India's coal security. Hence, it becomes important to assess internal as well as external dimensions of coal security for the country.

### *Internal dimensions of coal security*

The ability of Indian coal to meet the rising demand of its various customers at a reasonable quality and price is key to the notion of coal security. In this section, domestic coal availability is examined vis-à-vis import requirements in the long run and factors such as technology issues are being studied, which affect the availability and, therefore, the coal security of the country.

#### Resource availability and supply options

India is widely regarded both within the country and internationally as being blessed with vast quantities of coal. The 2006 *BP Statistical Review of World Energy* lists India's reserve to production ratio at 217 years, assuming that all proven reserves, as reported by India, are extractable. Unfortunately, it has become increasingly evident now that the actual extractable reserves of coal in the country are far less abundant than such statistics tend to suggest.

While the UNFC (United Nations Framework Classification) lays down a standard procedure for calculating the size of reserves and resources based on a three-dimensional system with technical feasibility, economic viability, and geological estimates, India continues to compute its coal inventory on the basis of the Indian Standard Procedure code, dating back to 1956. This is a geological classification system, under which the term 'proven reserves' refers to a particular confidence level in the presence of coal resources depending on the density of exploratory boreholes, with absolutely no reference to economic or technical feasibility of resource extraction. In addition, India's reported 'reserves' continue to be cumulative and gross, and include coal that has already been extracted and used, estimated to be about 10 BT (billion tonnes) in the past 200 years. It also includes coal that, for all practical purposes, would be inaccessible and cannot be extracted for a variety of reasons.

Pending recasting of Indian coal resources in the UNFC format for proper comprehension, the CMPDIL (Coal Mines Planning and Design Institute Ltd) has made a broad assessment of the actual extractable reserves in India. According to these estimates, the total extractable coal as on 1 January 2005 is reported to be about 52 BT (MoC 2005); this is based on a total resource of 248 BT of coal, occurring in the seams of thickness above 0.9 m and in the depth range of 0–1200 m. However, the Tenth Plan document has assumed the total extractable reserves to be 21% of the proved reserves, which is just 18 BT.

While even these reduced numbers have been debated on the grounds that they include inaccessible coal and already depleted reserves, the inescapable conclusion remains that the energy security that domestic coal apparently offers is far more tenuous than many believe.

The confusion over the amount of coal that can be extracted in the near future and the length of time our extractable reserves are expected to last is typified by the widely differing estimates that are quoted by different sources. It is also not possible to estimate with any degree of certainty the quantum of new capacities that can be built in future in the absence of the extent of available virgin property.

The *Coal Vision 2025* asserts that CIL (Coal India Ltd[2]) would be able to reach a production level of 500 MT by 20011/12 and continue to produce at the same level till 2036/37 if, in addition to its existing mines and projects, it is allowed to use the identified 289 virgin coal blocks for future projectization (meaning to bring under production). This leaves behind 136 virgin coal blocks being offered for captive mining and 74 coal blocks known as non-CIL blocks (MoC 2005), totalling to 210 blocks with only 13 BT of proved reserves and 28 BT of indicated and inferred resources. The *Coal Vision 2025* further asserts that the production from CIL alone would be able to reach 893 MT by 2025 to partially meet the total

[2] CIL is the largest public sector coal company that contributed 84% to the national coal production in 2005/06.

domestic coal demand of 1086 MT. The remaining 222 MT has to be contributed by SCCL (Singareni Collieries Company Ltd) and/or private sector, and 25 MT is expected through CBM (coal bed methane) equivalent. However, present and impending coal imports are completely ignored in the Vision document. Such a spurt in coal production of CIL can happen only if the existing mines and projects are overexploited and virgin properties are projectized at a faster rate than envisaged earlier to sustain a level of 500 MT till 2036. This would result in exhaustion of reserves at a date much earlier than 2036.

Oblivious to such long-term implications and bothered only about the widening gap between demand and supply, but taking cognizance of the fact that exploration is a time-consuming business, the MoC (Ministry of Coal) has taken two following short-term steps.

1. Approval was sought and accorded to 16 existing large opencast mines of CIL to enhance their production immediately so that 100 MT of coal could be produced quickly at a very low specific investment by avoiding the gestation period essential for a greenfield project.
2. Over 100 good coal blocks were taken out from CIL's kitty and passed on to the states/PSUs (public sector units) for quick projectization, through joint ventures with private sector, if need be.

The MoC has also asked the NCCs (national coal companies) to take up more greenfield projects at an urgent basis. These actions are a sure prescription for further reducing the extent to which domestic coal can support the demand of consuming sectors, particularly the power sector.

It is amply clear in the light of the MoC estimates that were domestic production to grow at a rate of about 5% a year, India's coal reserves would be exhausted in 30 to 40 years. TERI's analysis shows that with the short-term steps taken by the government, domestic coal production would indeed experience a sharp decline by 2020 or so.

This uncertainty with regard to domestic coal availability suggests a growing import dependency in the future. The short-term actions being taken to increase the domestic coal production will result in a lower import dependency now, but this would increase sharply by 2020 when the domestic coal production would experience a sharp decline. Projections of coal imports in the future are widely divergent. The Government of India projections suggest an import dependence of between 11% and 45% by 2030 (GoI 2006); TERI estimates (TERI 2006a) are high at 70% import dependency (about 1438 MT imports) in the same year.

At these levels of coal imports, it is unclear what the combined effects of greatly increased coal demand from China and India would do to global coal prices in the future. Increased competition amongst buyers of coal in the region could result in a seller market pushing coal prices higher.

### Technology issues

Following complete nationalization in 1973, indigenous production of coal has increased substantially in order to meet the growing needs of the power and industrial sectors. This increase has been driven mostly by large-scale opencast mining and to some extent by labour-intensive manual underground mining. As a result, while there has been an exponential increase in coal production by exploitation of shallow deposits through opencast mines, coal production from underground mines has largely stagnated at about 50 MT (Figure 2). Underground mining still remains primarily manual, and more efficient long-wall mining has not adapted successfully to Indian conditions.

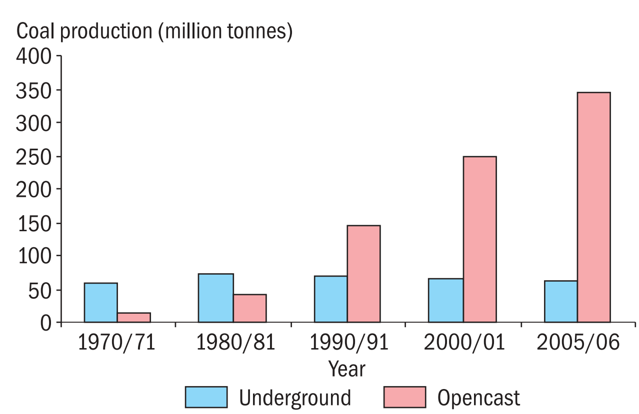


**Figure 2** India's coal production from underground and opencast mining (1970/71–2005/06)
**Source** CCO (various years)

With large-scale opencast mining, shallow deposits are getting exploited at a much faster rate, and this would need deeper seams to be exploited by underground mining. However, this may not happen because of the meagre resources discovered beyond 300 m depths. New explorations would require time and money.

In addition, the efficiency of Indian mines remains extremely low with an average productivity of 7.84 tonnes per man shift in opencast mines and only 0.74 tonne per man shift in underground mines in 2005/06. In comparison, the average productivity per man shift in opencast mines in the US was 54.8 tonnes in 2001 (IEA 2002). These figures reflect grossly inefficient use of labour and technology, and raise serious questions on the ability of national coal mining companies to meet plan targets in the future at a reasonable cost.

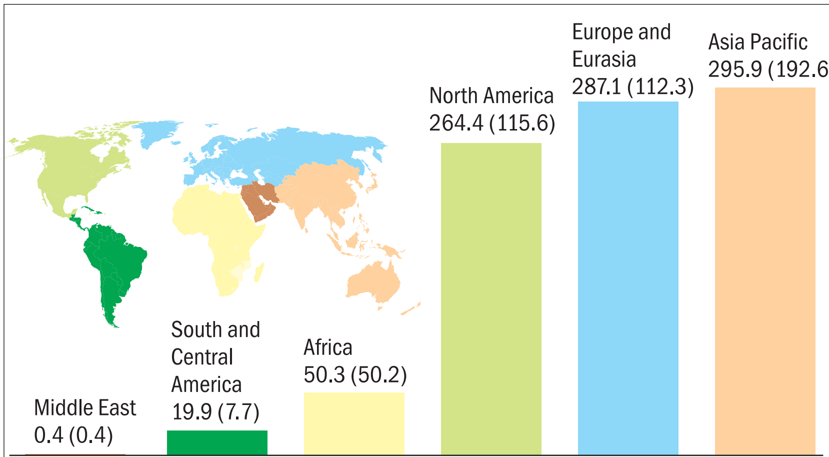


**Figure 3** World coal proved reserves at the end of 2005
**Note** Thousand million tonnes (share of anthracite and bitumenous coal is shown in brackets)
**Source** BP (2006)

### *External dimensions of coal security*

Given the important role that coal has played, and will continue to play, in the country's energy security and the increasing import dependence that has been projected, it becomes important to look at how coal is being traded globally and consider the concerns for India's coal security. This is particularly important because the world energy market has changed drastically in the past few years.

Coal has the advantage of being much more evenly and widely dispersed than oil and gas, with the major coal-producing countries being situated in four continents of the world.[3] It is also globally the most abundant fossil fuel: the total global proven coal reserves at the end of 2005 were 909 000 MT, with the Asia-Pacific region being the richest coal region (Figure 3) (BP 2006). While a large amount of coal is traded internationally, with the total international trade in 2005 standing at 775 MT, it still constitutes only 16% of the total world coal consumption (WCI 2006). This is because a majority of the global coal produced is used for domestic consumption by countries. One of the important characteristics of the coal industry is that imports for coal are driven not just by domestic resource availability in general, but also by logistical ease and the need to obtain certain types of coal by the coal-consuming countries.

World demand for coal is projected to double from 5.4 billion short tonnes[4] (4.9 BT) in 2003 to 10.6 billion short tonnes (9.6 BT) in 2030, at an average annual rate of 2.5% per annum (EIA 2006). Almost 70% of this projected increase in demand is expected to come from China and India. China, with its rapid economic development and growing electricity and steel requirements, is driving the coal demand to a large extent. Demand is also growing in other countries like India, Indonesia, South Africa, and the US. The biggest market for coal is Asia, which at present accounts for 54% of the global coal consumption. Australia is the largest coal-exporting country, followed by Indonesia and China (Figure 4).

While coal is considered to play an important role in energy security, given its advantages in terms of geopolitics, safety, economics, and the existence of a well-developed market, price volatility since 2003 and tight international and

[3] The largest coal producing countries are China, the US, India, Australia, and South Africa.

[4] 1 metric tonne = 1.1023 short tonnes (BP 2006).

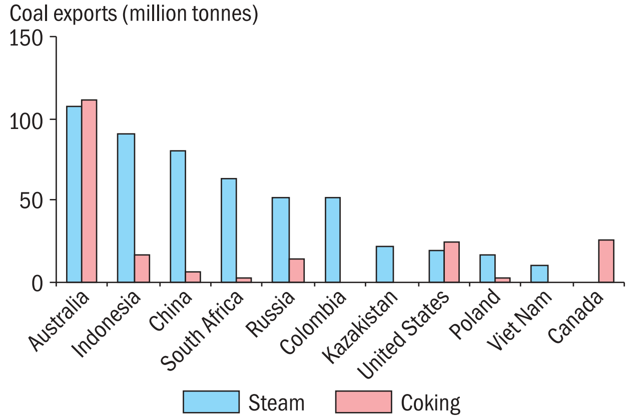


**Figure 4** Major coal (steam and coking coal) exporters in 2004
**Source** IEA (2005)

domestic coal markets with rising global demand pose concerns for coal security in coal-consuming countries.

### International coal prices

The international coal industry has witnessed substantial price surges and volatility in the past three years. While more competitive than oil and gas, which experienced phenomenal price increases, coal prices more than doubled from $30/MT (spot price of thermal coal delivered to Europe and Japan) in May 2003 to above $70/MT for most of 2004 (Figure 5). Coking coal prices also crossed $100/MT mark, which was driven by a surge in steel demand (Platts 2005).

The price rise of 2003 and 2004 was attributable to an upscale in demand – particularly

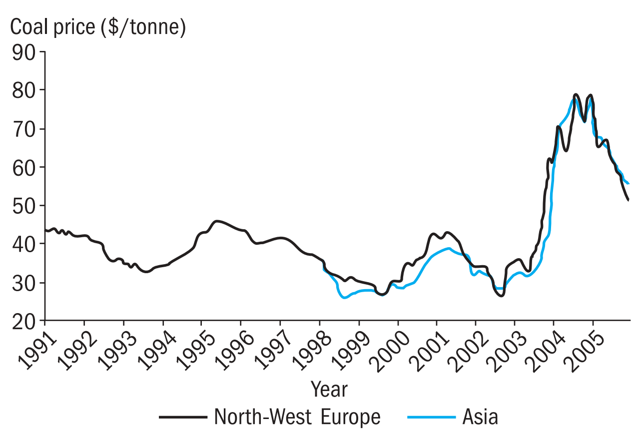


**Figure 5** Steam (thermal) coal marker prices (1991–2005)
**Source** IEA (2006)

in the Asian region – and a tight supply situation. During these two years, China's energy demand, driven by its rapid economic growth, grew at such a rate that it had to reduce its thermal coal exports. The country also became a net coking coal importer from an aggressive exporter in 2000. In addition, the high overall economic demand also led to a squeeze in the shipping industry with shortage of ocean-going bulk carriers driving up freight rates and consequently increasing coal prices further. At the same time, various weather-related disasters and mine problems in Indonesia and Australia, together with port congestion, adversely affected coal supply.

As per the long-term coal price predictions, however, coal prices are expected to remain moderate despite the rapid price rise in the past couple of years (IEA 2004). In 2005, prices slowly started declining. Similarly, freight rates, which increased by a factor of five in late 2003, also started to come down slowly through 2005, with improvement in bulk freight availability. On the supply side, the tight supply situation has eased to some extent; mines in South Africa, Australia, and Indonesia have ramped up production (Ryan 2005). On the demand side, growth remains high, essentially in Asia (particularly China and India) and also in the US. The three largest producers and consumers of coal (the US, China, and India) are struggling to balance their domestic demand and supply situation. In addition to growth in Chinese demand, the US has also withdrawn from the export market with increase in domestic demand and coal prices. Earlier, the US was able to act as a price stabilizing swing producer by utilizing its marginal steam coal production and port capacity (IEA 2006). These factors continue to put an upward pressure on coal prices. In addition, mining costs have been increasing on account of rise in the cost of the energy industry (both for fuels and energy service). Whether the prices will decline further will also depend on whether suppliers, who opened new mines or expanded capacity when the price was high, will maintain or raise their supply.

One of the consequences of the uncertainty in energy markets and the price fluctuations, together with the deregulation of electricity markets, has been an increased commoditization of coal as well as interest in hedging and better management of risks with more long-term contracts. New players, like investment banks and hedge funds, who earlier paid little attention to coal, are now entering the coal markets.

### Imports and changing trade pattern

Energy security concerns have prompted buyers to move away from their traditional markets and look for non-traditional markets to satisfy their needs. This has led to some shift in trade. Asia, particularly India (Figure 6), which typically imported from Australia, China, and Indonesia, has started exploring other markets like South Africa, while European buyers are looking at Australian and Indonesian markets to fulfil their import needs. The US, which till recently managed with its domestic reserves, is now using Latin American supplies to meet shortfalls in its domestic thermal coal supplies (Clark 2005).

In order to deal with impending large coal imports, especially of coking coal, India is looking to acquire equity in coal mines abroad. CIL has created an overseas wing to scout in countries, such as Australia, Indonesia, Mozambique, and South Africa. Overseas acquisitions began in late 2004, when India's largest independent metallurgical coke producer, Gujarat NRE Coke Ltd, acquired coking coal mines in Australia (TERI 2006b). The Indian government is also exploring collaboration possibilities with advanced coal-producing countries, such as France, the US, Russia, Germany, UK, Australia, and Canada, to bring in new technologies, develop skills, and provide training and financial assistance to meet investment requirements. In addition, a new approach adopted by companies such as CIL is technology upgrading through global tenders (MoC 2006).

## Conclusions

The method of reporting gross cumulative coal resources adopted almost 50 years ago and a delay in reforming and adopting the UNFC method have resulted in creating a mindset amongst decision-makers that India is 'coal secure'. It is precisely due to this misplaced confidence in domestic coal reserves that other options were not pursued early as vigorously as would otherwise have been the case.

While the reforms in the coal sector started in the early 1990s, more than a decade later, the sector remains as closed as ever. Even after realizing the finiteness of resources, the extra push needed for enhanced exploration is not seen, and short-term measures are being put in place to tide over the immediate shortages. Over the past 30 years, the total apathy towards R&D (research and development) to find solutions to recover the coal locked in pillars of numerous partially developed mines has reduced the available extractable coal to a great extent.

The changing world energy market makes it even more important for policy-makers to address concerns relating to the coal industry. In today's world, given the importance of energy security in economic and national security, countries are aggressively looking to secure energy resources—not just oil and gas, but coal as well. India, therefore, needs to recognize the magnitude of impending coal imports and further strengthen measures such as import diversification and risk management in its coal import policy.

India now has no other alternative but to use both domestic and imported coal to meet the increasing requirement of energy for at least the next two decades, but it would be wise to utilize this small window of opportunity to focus on R&D efforts not only to develop technologies for enhanced recovery of coal reserves, but also to develop alternative indigenous sources of energy for long-term energy security.

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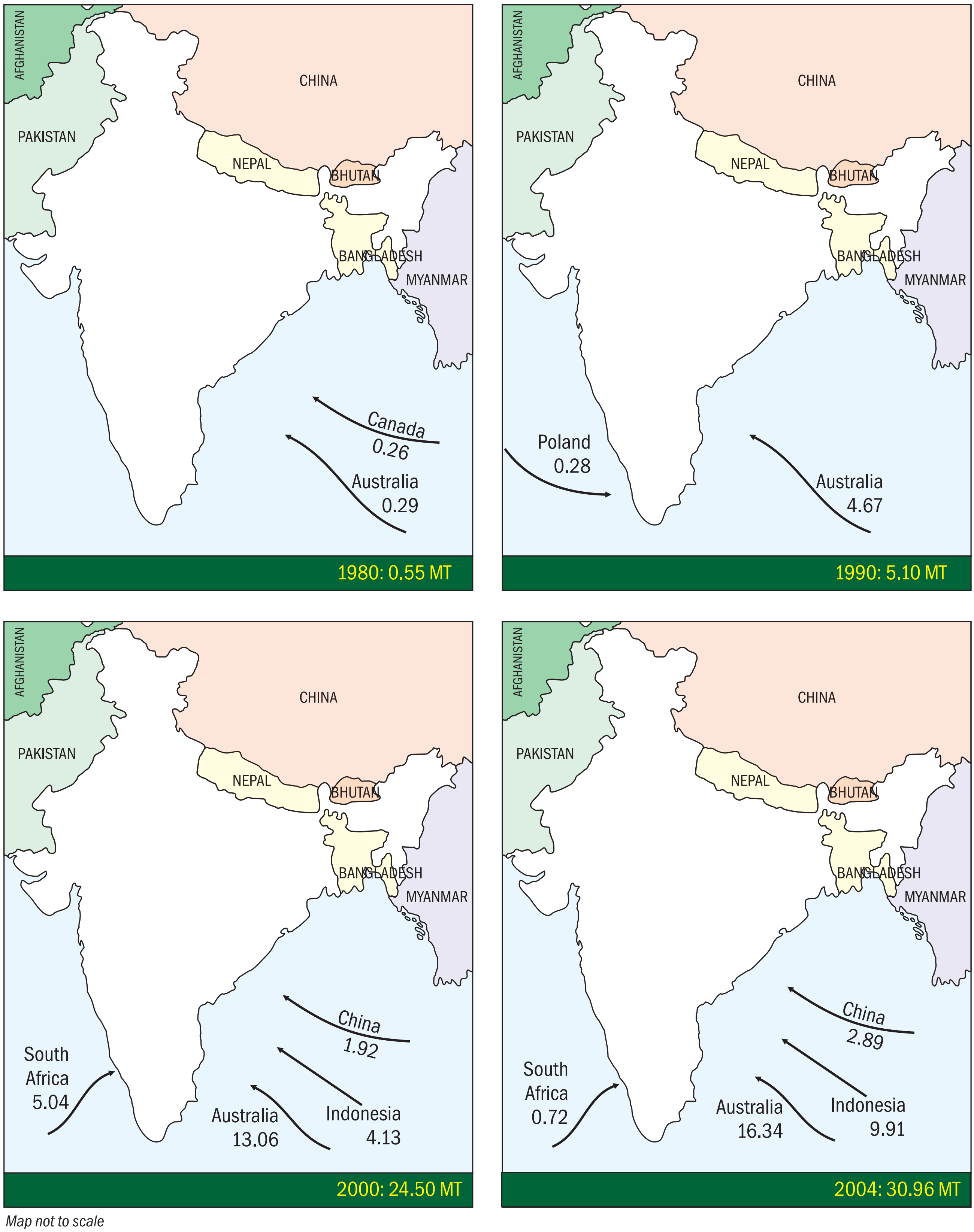


**Figure 6** Coal import flows for India
**Note** Figure in the bands give total imports for the particular year.
**Source** Adapted from IEA (2002, 2005)

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# Indian coal: pricing and institutional issues

P C Parakh
Former Secretary, Ministry of Coal, Government of India

Coal is considered to be the most important source of primary energy in India in the foreseeable future. At present, it is the dominant source of commercial energy, accounting for over 50% of the energy requirement in the country. Despite great emphasis being laid on developing and promoting non-conventional energy resources, it is unlikely that the share of coal will come down in next two to three decades. However, despite holding a relatively large resource base as compared to other energy forms, India has been facing shortages of coal from time to time. Also, our reserves are overstated as the reserve assessment process does not take into account the quality, feasibility, and economic viability of coal mining or extraction. We, therefore, need to reorient our policies in order to optimize coal production and consumption.

In this paper, various concerns facing the Indian coal industry – particularly at the policy, institutional, and pricing levels – have been highlighted, and possible options to deal with them have been suggested.

## Coal pricing

Ever since World War II, coal prices in India have been controlled by the government, first under the Defence of India Rules and then under Essential Commodities Act. Coal prices were partially deregulated in 1997 (grades A to D) and completely deregulated in January 2000 (grades E to G). This conferred the right to fix the price of coal on two public sector companies, CIL (Coal India Ltd) and SCCL (Singareni Collieries Company Ltd).

However, prices fixed by these companies are actually guided by the Ministry of Coal, Government of India. Though the principles of fixing price are not set out explicitly, prices are essentially fixed on the basis of costs incurred in the production of coal from different mines by a company, with an added reasonable profit margin. However, this has proved to be unsatisfactory as the demand for coal from non-power users at the fixed price is far in excess of the available supply at this price.

There is a wide variation in the cost of extraction and quality of Indian coal. Cost of extraction varies from Rs 7000 per tonne in some underground mines of North Eastern Coalfields Ltd to as low as less than Rs 200 per tonne in some mines of Mahanadi Coalfields. Similarly, quality of coal varies from 6200 kilocalories/kg in some seams of North Eastern Coalfields Ltd to as low as 1300 kilocalories/kg in many coalfields. However, the linkage between the coal price and the actual calorific value of coal is very tenuous, with coal being graded in terms of 'useful heat value' bands instead of GCV (gross calorific value), a more scientific grading method followed internationally.

In order to ensure that the coal industry is able to meet the growing energy requirements of the country, a fair pricing model for coal, taking into account the industry's special characteristics, needs to be developed urgently. But establishing a market mechanism for pricing of coal is not very easy owing to multiple producers and consumers within the industry. Also, the price determining the demand and supply balance for coal is intricately tied up with transport costs and availability of rail and port infrastructure.

Due to the poor quality and skewed availability of coal in the eastern India, and the fact that consumers are scattered all over India, we seriously need to consider the use of imported coal as a viable long-term option, especially for major power plants located in the southern and western parts of the country. This will reduce pressure on Indian Railways, reduce wasteful use of energy in hauling high-ash coal to long distances, bring efficiency to the Indian coal mining industry by subjecting it to competition from imported coal, and enable the development of a healthy coal market.

In its efforts to move in the direction of creating a coal market, CIL introduced e-marketing of coal at the end of 2004. There was a stiff resistance to this move from within CIL, as well as from politicians of all hues and the powerful coal mafia, all of whom were the beneficiaries of an arbitrary and opaque marketing and pricing policy, which promoted rent-seeking and black marketeering. E-marketing made it possible for coal consumers to meet their requirements through legal channels instead of depending on the coal mafias. The premium, which was being cornered by corrupt officials and criminal mafia, would now accrue to the coal companies improving their profitability and viability. The average e-auction price of coal sold through e-marketing by CIL during 2006/07 (up to July 2006) has shown a declining trend.[1] The reasons for the decline could be attributed to factors like gradual maturity of the market, stabilization of prices due to removal of fear of scarcity of coal, and substantial increase in supply of coal through e-marketing. From an average of 46% above notified price and 23% above floor price in 2005/06, the prices dropped to 26% above notified price and only 5% above the floor price by June 2006, making coal easily available to all consumers at a reasonable price.

In the light of the highly successful operation of the e-marketing experiment, the following model is suggested for creating a coal market in India, pending a total opening up of the coal sector to private investment.

CIL and SCCL should enter into long-term FSAs (fuel supply agreements) to the extent of about 75%–80% of the consumer's coal requirements and retain 20%–25% of their production for sale in spot/future market through e-marketing. All major consumers should buy 20%–25% of their requirement from the spot market. This will put about 100 MT (million tonnes) of coal into the spot market. This large quantity of coal competing with imported coal will give correct price signals to both consumers and coal companies. Price trends in the spot market would provide benchmarks for the annual price negotiation for coal to be delivered through long-term FSAs. Despite some rigidity inherent in coal marketing, inter- company and area competition within various subsidiaries of CIL, as well as competition from imported coal, should bring about greater efficiency in coal mining and consumption. A market-determined price that takes into account coal quality would also create adequate incentives for coal washing in the country.

## Institutional issues

The nationalization of the Indian coal industry took place in the early 1970s with the intent of

[1] Press Information Bureau release available at <http://pib.nic.in/release/release.asp?relid=20206>, last accessed on 15 September 2006.

speeding up the development of the sector so as to ensure adequate coal supply. Although CIL and SCCL – two public sector companies with a virtual monopoly of coal mining since nationalization – have made significant strides in increasing coal production, coal availability in India has never been adequate and it has always remained a sellers' market with all the concomitant ills that shortages bring. A direct result of the public sector monopoly and recurrent shortage in availability of coal is the existence of flourishing and powerful coal mafias.

### *Participation in the coal industry*

Continuing with a public sector monopoly in coal mining now has lost its justification. Recognizing the importance of private investment in coal mining, captive mining for power and steel industry was permitted under the Coal Mines (Nationalization) Act and subsequently extended to cement industry as well. Also, with a view to help some of the companies that were allotted captive coal mines but had no experience of mining, the government had made some allowances. For instance, a company can mine coal from a captive block through a JV (joint venture) coal company, provided both the end-user and the associated coal companies are formed and registered under Section 3 of the Companies Act, 1956, and the JV is formed with the sole objective of mining coal and supplying it from the captive coal block to the end-user company.

However, even these efforts have not left a significant impact and the coal production by captive miners (including TISCO mines, which were not nationalized) remains at merely 27 MT against a total production of 407 MT during 2005/06, 13 years after captive mining was permitted. Captive mining suffers from a number of drawbacks, although some of the problems have been addressed by policy changes brought about in the past two or three years. However, in order to promote an efficient coal mining industry and develop a healthy coal market, it is necessary to open up coal mining to the private sector including foreign direct investment without restriction of captive use.

### *Coal exploration*

There is also a need to open up coal exploration for the private sector. At present, exploration for coal in India is carried out by the GSI (Geological Survey of India), MECL (Mineral Exploration Corporation Ltd), CMPDIL (Coal Mines Planning and Design Institute Ltd), SCCL, and Directorates of Mines and Geology of some states. Out of 22 400 $km^2$ (square kilometres) of coal-bearing sedimentary formations identified by the GSI, only about 10 200 $km^2$, or 45% of the total area, has been systematically explored through regional and promotional drilling. In order to increase the resource base and improve the quality of inventory, it is necessary that private sector investment be promoted in coal exploration.

With respect to greenfield areas, which have not been explored by any government agency, RP (reconnaissance permission) should be given to private investors on a non-exclusive basis as suggested by Hoda Committee on mineral policy. RP holders can be given prospecting licenses and mining leases on a first come first serve basis after they submit detailed information about the exploration work done by them. In respect of areas where availability of coal has already been established by any of the government agencies, drilling activity should be outsourced to the private sector under the supervision and guidance of CMPDIL.

### *Allocation of blocks*

The present system of allocation of coal blocks is entirely arbitrary and subjective, and leads to unhealthy pressures and large-scale corruption. Coal blocks have also been created artificially without giving any regard to sound principles of mineral conservation. Given that coal quality and cost of mining vary by a ratio of 1:10 in different mining areas, the profitability of coal mining will vary substantially according to the cost and quality of coal.[2] It is, therefore, necessary to bring about transparency and a level playing field in allocation of coal blocks.

Once detailed exploration data is available, CMPDIL should form coal blocks of optimal size

[2] Someone who gets an open castmine with a low overburden to coal ratio would make substantial profits from the coal mining business, whereas those who get blocks of poor quality amenable only to underground mining would be seriously disadvantaged.

with reference to geological and geographic features, with due regard to coal conservation. These scientifically formed blocks should be offered for mining through open and transparent bidding after making detailed exploration data available to the prospective bidders. All coal blocks earmarked for CIL, which are not in its production plan up to the Eleventh Five Year Plan, should be de-reserved and made available for open bidding. CIL subsidiaries should also participate in open bidding for their future requirements.

### *Opening the sector to private participation*

To remove the restriction of captive use and to open up the coal sector to private entrepreneurs, Coal Mines Nationalization (Amendment) Bill was introduced in the Parliament as long back as April 2000. The bill was referred to the Parliamentary Standing Committee on Energy, which – after wide-ranging consultations with various stakeholders including representatives of the concerned ministries of the Government of India, state governments, industry associations, and trade unions, which lasted for about nine months – recommended adoption of the bill with a majority of 16 to 5. All parties except the Left parties supported the bill. During hearings of the Committee, all ministries of the central government, all state governments except the Government of West Bengal, and representatives of trade unions supported the bill.

In their note of dissent, members of the Left parties cited arguments for opposing the opening up of coal mining to the private sector, which were based on an outdated economic and political philosophy and lacked any understanding of the changes that have taken place in Indian and world economies in the past two decades. For instance, there have been arguments like prior to 1970, private sector coal mining companies were indulging in slaughter mining, neglecting conservation, safety, and environmental aspects or that, given the necessary budgetary support, CIL is capable of meeting the demand for coal in the country, and so on. None of the arguments have any merit. If the private sector can operate the largest oil refinery, large telecom networks, and air travel networks and bring significant reduction in the cost of these services without any negative fallback, there is no reason that the same will not happen in coal sector. It is unfortunate that a small minority consisting of Left parties and trade unions has effectively stalled reform in a major sector of the economy to the detriment of the average Indian citizen, who has to pay a high price for energy because of inefficiencies inherent in a state monopoly. Opening coal mining to the private sector without restriction of captive use will bring efficiency by exposing CIL to competition, improving the availability of coal to consumers at lower prices, enabling the development of a robust coal market in the country, and eliminating the existence of coal mafias.

## Some concluding thoughts

With increasing participation of the private sector, it will be necessary to bring about compliance with conservation and environmental laws as well as assess the need for a regulator.

### *Conservation of coal*

In order to prevent slaughter mining and ensure that all economically mineable coal is extracted, it is necessary to create an institutional arrangement for mine plan approvals and their enforcement. The present system of mine plan approvals through a committee chaired by the Secretary, Ministry of Coal, with no mechanism for monitoring and enforcing mining as per the mine plan, is extremely unsatisfactory and can in the long term lead to slaughter mining.

### *Environmental issues and closure*

While great emphasis is laid in India on the preparation of EIA (environment impact assessment) reports and their approval through several layers of government, delaying approval and implementation of projects by several years, there is very little effort towards stopping environmental degradation. While in most developed countries, coal mining areas are restored and made useful to society after exhaustion of reserves, in India, large tracts of land have been left unused after mining. This is because as mining activity reaches its terminal years, the profitability of mining operations falls substantially, reducing the generation of surplus funds. Therefore, despite various provisions made in the approved mining plan for mine closure, the mining company may not be able to implement the mine closure plan and may simply abandon the mine.

It is, therefore, necessary to create a fund to which mining companies should make an annual contribution (by way of tax). If the company faithfully implements a mine closure plan, its contribution along with any income generated out of the fund can be refunded. However, if a company fails to implement the mining plan, the fund should be used for mine closure.

### *Need for a regulator*

While there has been a demand to establish a coal regulator for enforcing the price of coal, it will be a retrograde step to have a controller to artificially fix the price of coal. On the other hand, it will be more appropriate to create a post of coal controller for the allocation of coal blocks in a fair and transparent manner, approve and monitor the implementation of mining plans, and ensure that mining is undertaken as per the approved mining plan, and that commitment towards environmental management and mine closure is honoured by the mining companies.

# Critical connections: Indian Railways and coal

Shri Prakash
Ministry of Railways, Government of India

The high growth path of the Indian economy can be sustained only with efficient and reliable energy availability. Unfortunately, energy source options for the country are limited. Conventional non-renewable sources will continue to dominate in meeting energy requirements. While efforts are being made to shift towards renewable resources, India's commercial energy needs are addressed primarily by coal. Coal has the largest share in India's energy production and consumption. About 55% of the commercial energy consumption is accounted for by coal. Similarly, about 70% of the domestic coal produced is consumed for power generation.

India's total coal reserve stands at 253 BT (billion tonnes), with a steadily rising coal production that reached 383 MT (million tonnes) in 2004/05. The current growth of coal production is propelled by the power sector, the primary consumer of non-coking coal. India's coal-based thermal power generation capacity is about 55% of the installed power generation capacity of about 127 000 MW (megawatts). The demand of the metallurgical sector is met increasingly through imports of high-grade coking coal. It is a matter of concern that the annual per capita electricity consumption of India, at about 606 kWh (kilowatt-hour), is among the lowest in the world. To provide availability of over 1000 units of per capita electricity by 2012, it is estimated that need-based capacity addition of more than 100 000 MW would be required during the period 2002–12. Apart from the energy sector, a significant part of coal is consumed by steel, cement, and other industries such as brick-making.

Coal transportation, globally, is heavily dependent on railways that is one of the dominant freight transportation modes in India, China, and the US, three of the world's major producers and consumers of coal. About 66% of India's and 70% of China's coal is moved by rail. The share of coal in total freight transportation by rail is about 45% for India (MoR 2006) and 40% for China.[1] In the US, too, coal has emerged as the most important commodity carried by rail. In 2003, rail-delivered coal accounted for about two-thirds (65%) of the total US coal (Hamberger 2005).

In India, the various modes adopted for movement and dispatch of coal are rail and MGR[2] (merry-go-round) system, road, belt, and ropeway.

[1] **Freight transport in China**, available at <http://www.converger.com/china/ChinaTransportBriefing.htm>, last accessed on 23 November 2006.

[2] A closed-loop captive rail system between a pithead power plant and the mine. MGR systems deliver wagons with coal to the power plant, return to the mine to be refilled, and return to the plant in a continuous process.

The modal share is 51% by rail, 24% by MGR, 21.5% by road, 2% by belt, and 1.5% by ropeway. Despite the fact that the transmission cost of electricity as compared to the transportation cost of coal is cheaper, the state utilities prefer to add to their installed capacity within their own geographical boundaries in order to have energy security. This, of course, creates the need to transport fuel across the country to dispersed power plants. The railways also transport a significant percentage of petroleum products within the country. The vast expanse of the country, availability of resources in various confined pockets and production centres, and widely separated consumption centres have meant that the railways, as a bulk carrier, have been acting as a significant facilitator of various activities of the economy. This key role of the railways in the transportation of coal in India poses a number of challenges, which are discussed in this paper.

## Railways in coal transport

Coal freight made up 46% of the total freight revenue earned by the railways in 2004/05 (Figure 1) and the component of coal in freight has increased over time. Currently, coal comprises 45% of the total originating freight traffic carried by Indian Railways. This is up from 33% in 1977/78, and 39% in 1985/86. Coal traffic has grown 14.5 times in terms of loading freight and 15 times in terms of NTKM (net tonne kilometres), since 1950/51. This has happened even though route kilometres have increased by only 1.2 times for the same time period.

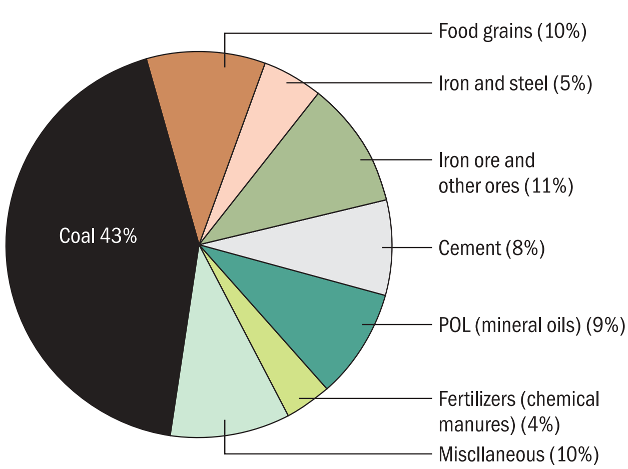


**Figure 1** Freight earnings for the Indian Railways in 2004/05
**Source** MoR (2006)

Of the total coal carried for various sectors, the coal carried for thermal power plants has grown from 52% in 1985/86 to about 75% in the current year. In the years to come, transport requirements are expected to increase, especially between ports and power and steel plants and other industries. This is a consequence of the projected rise in coal imports. During 2006/07, the gap in demand and domestic coal production has risen to a level of 20 MT, which is being planned to be bridged by importing coal. *The Integrated Energy Policy* estimates that coal imports could go up to 462 MTOE (million tonnes of oil equivalent) (1127 MT) in a high-growth, coal-dominant scenario by 2031/32.

Transportation of coal to various end-users forms a significant back end in the entire supply chain. The projection of demand made in *Vision Coal 2025* for the various utilities at a uniform growth of GDP (gross domestic product) at 7% and 8%, brings out the total requirement of coal in 2024/25 as 1147 MT and 1201 MT, respectively. The *Approach Paper for the Eleventh Five-year Plan* aims at a highly ambitious growth of 10% of GDP. This implies a much higher growth of production and transportation of coal than the requirements mentioned in *Vision Coal 2025.* The ultra mega thermal power plants being planned at coastal locations would minimize the landed cost of both imported coal as well as the indigenous coal transported via rail-cum-sea mode. The additional movement of coal on this account from the existing coalfields in the country will depend on the strengthening of the existing connectivity between such coalfields and the linked ports. While the greatly increased reliance on coal might be accompanied by an increased share of MGR systems as well, in absolute terms, the railways sector can still expect a huge increase in its responsibilities as a major freight carrier.

### *Challenges before the Indian Railways*

Over the years, the share of railways in coal transport has slipped from over 70% in 1983/84 to just about 51% today. In the short run, the *Approach Paper for the Eleventh Five-year Plan* anticipates a slight rise in the share of coal transported by rail. Over a longer period, however, *Coal Vision 2025* projects the share of the railways as going down from current 51.4% to 47.33%. A significant growth has been projected in the share of MGR from its present level of 23.2% to 41.34%. Pipelines at 2.30% are expected to play only a minor part. The following are the five major factors that could affect the competitiveness of the railways.

1 **Project location** Many projects are being planned near pitheads (Figure 2), so MGRs have a larger role to play. With MGRs showing the possibility of being extended up to even 100–200 km, their share is only likely to rise. Of late, the railways have been keen to begin setting up MGRs as well. Although initially, railways did not consider the setting up of MGRs profitable, they are now interested in operating them, probably because of increased volumes of freight. A study conducted by the Ministry of Railways to assess the cost incurred on operation and maintenance of the MGR system, presently owned by NTPC (National Thermal Power Corporation), as compared to that of the operation by the railways, concluded that there would be substantial savings if the railways managed the operation and maintenance of all these MGRs. This would help in bringing down the overall cost of production of electricity. With a substantial increase in the addition of power generation capacity at pithead, this would translate into substantial savings, a part of which may also be transferred to consumers. Should this be implemented, technical expertise within the railways could then be used more fully.

   In case of projects located in coastal areas (as many of the ultra mega power projects are planned on the similar line), it might be cheaper to use either imported coal or transportation via coastal shipping.

2 **Costs** The delivered cost of coal for rail-fed thermal power stations in this country is higher due to high transportation cost, though the

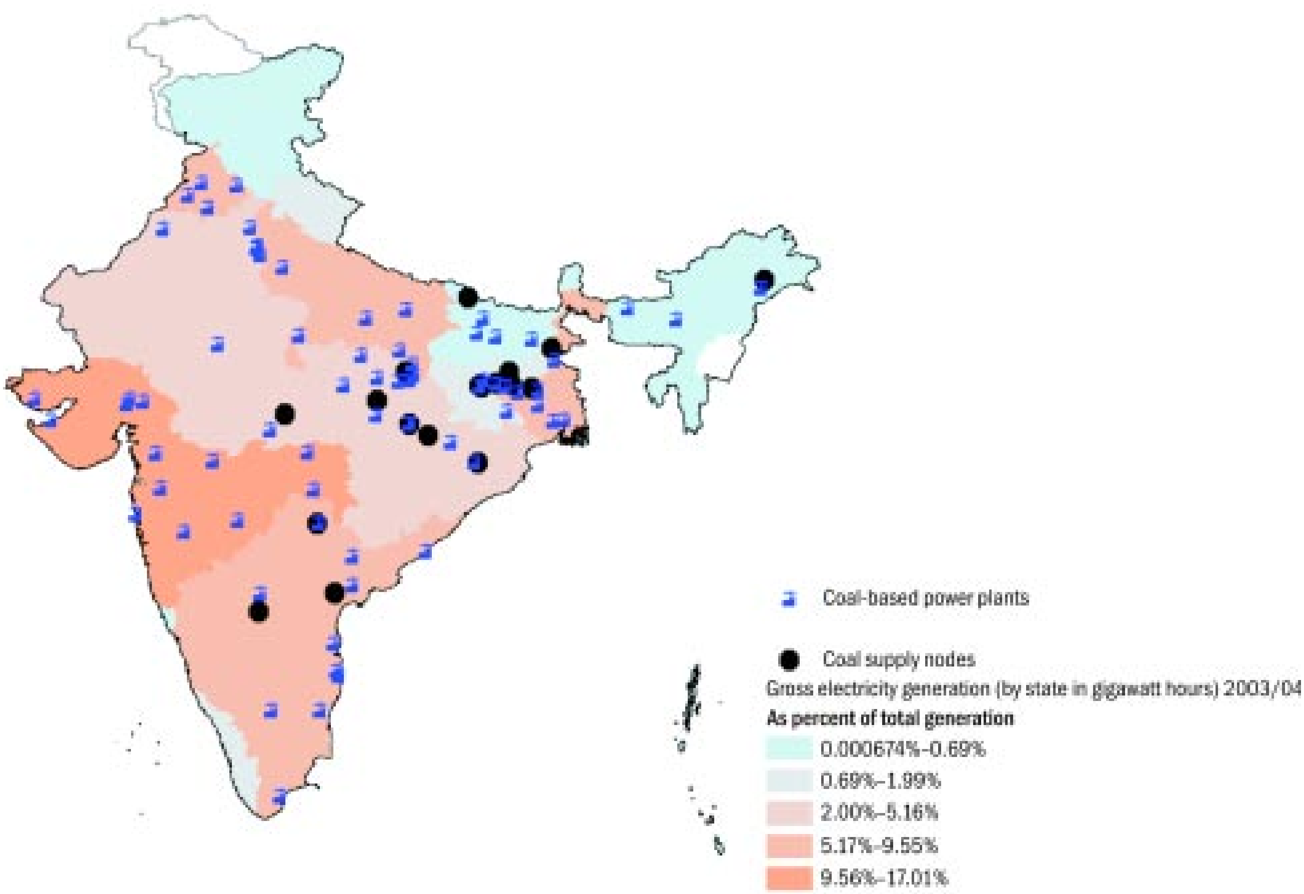


**Figure 2** Thermal power stations in India as on March 2005
**Source** Data from CEA (2005)

inherent strengths of railway transportation in carrying bulk traffic helps in bringing down the unit cost of operation. The composite input cost of the railways between 1993/94 and 2004/05 has increased by 2.9 times, which includes an increase in the cost of diesel by 3.6 times and that of electricity by 2.4 times. Indian Railways, which is one of the largest consumers of electricity, has been placed in one of the highest brackets for the payment of electricity charges. The advantage of bulk movement of commodities, such as coal, therefore, does not get transferred to the end-user, and ends up in increasing the landed cost of coal in the thermal power houses.

3 **Competition from road transport** As India is improving its road infrastructure, road transport is growing faster, with increased coverage. This poses some threat to the railways that operate over short distances. Previous barriers to the road transport, such as state taxes, are also being tackled. Additionally, substantial rail freight is lost to heavily loaded (8 tonnes and 10 tonnes) trucks. With high-capacity trucks entering the Indian market, made possible by good roads, these losses will only increase.

4 **Service issues** Given the importance of freight transport, especially coal transport, in the nation's economy and because of increased competition, there is a need to make the railways more consumer friendly. One way of making the process of coal transportation more consumer friendly is by introducing proper, tripartite legal agreements among the producers, transporters, and consumers of coal. This will enable better planning for the consumers as well as the railways, and also help in reducing inventory costs.

5 **Cross-subsidization** Cross-subsidization both within the freight structure (freight rates of iron ore, petroleum and petroleum products, and coal are the highest) and across the freight and passenger tariffs has skewed coal transport costs. However, over the years, some rationalization of freight rates has taken place; in fact, rates have not increased in the past two years.

The railways have made a number of efforts to improve the efficiency and prospects of coal transportation. These include providing longer and heavier trains, cutting down the terminal detentions of wagons, and introducing higher capacity locomotives. While the average cost per unit of traction energy increased by 3.2 times between 1993/94 and 2004/05, the railways' freight per tonne of coal for an average load of 600 km increased only by 2.5 times during this time. The report of the Expert Group on Indian Railways headed by Dr Rakesh Mohan had also recommended a reduction in cross-subsidies, and a rebalancing and rationalization of fares. While some of the changes might have enhanced the financial strength of the railways, some of the recommendations have proved politically difficult to implement.

With gradual increase in the movement of washed coal, the gap between the transportation cost of coal and transmission cost of electricity will come down further. Presently, the installed washing capacity for both coking and non-coking coal is 70.35 MT. With gradual depletion in the qualities of both coking and non coking coal, quality can be maintained only by increasing washing capacity, which will, to a great extent, help in addressing the problems of fly ash, apart from bringing down the overall requirement of transportation. The *Coal Vision 2025* report envisages a minimum additional requirement of washing capacity of about 305 MT per year by 2025. This figure excludes coal linked directly with pithead power stations.

## The way ahead

The railways have been consistently making efforts in bringing down the unit cost of operation, a component of which can also be passed on to its users. In the past two years, Indian Railways have gradually introduced heavier trains by increasing the axle load from 20.5 tonnes to 22.4 tonnes for coal traffic on all routes. Railways have also planned an increase in the axle load to 25 tonnes on certain identified corridors.

Dedicated freight corridors along the high-density network will help the railways in generating additional capacity in these sectors. A new company DFCCIL (Dedicated Freight Corridor Corporation of India Ltd) has been set up to implement dedicated freight corridor project. The eastern corridor will primarily carry coal to the northern part of the country. The western corridor will also help in movement of imported coal to the thermal power stations and other utilities like cement, and fertilizer plants in northern India. In addition, four other dedicated freight corridors with high-density network have been planned to generate adequate capacity to carry coal and other mineral traffic. The total length of the dedicated freight corridors will be about 11 000 km, and cost of construction has been estimated at Rs 1000 billion. In addition, feeder routes on the existing networks will be developed to carry heavier and longer trains.

The dedicated freight corridors are being planned with 25-tonne axle load and long haul freight trains. The longer and heavier trains with improved maintenance and operating methods will cut down the cost of transportation substantially. This will also bring down the transit time, which will help users in maintaining low inventory, thereby helping them to bring down the cost further.

The capacity on rail routes connecting ports with hinterland is also being augmented in a time-bound manner to carry imported coal to steel plants and thermal power stations.

Apart from physical capacity additions, it is also necessary to reduce the cost by facilitating commercial transactions. Introduction of an electronic payment system, which facilitates immediate payment through banks electronically, tracking of coal trains online through countrywide FOIS (freight operation information system), and introducing guaranteed transit and delivery systems will definitely help in cutting down the logistics cost of coal transportation. In the first phase of FOIS implementation, the Rake Management System has been implemented at major locations. Terminal Management System which has been implemented at most of the locations in the country will help to cut down the delays in commercial transactions at coal loading and unloading terminals. Electronic Payment System that helps instant payment facilities through the banks is gradually being extended to thermal power stations. All these measures would ensure cutting down the transaction costs drastically. Other measures include implementation of control charting, crew management, and a Coaching Operations Information System.

Railways have till now provided a critical link in the coal supply chain for the power, steel, cement, and other industries, and will continue to be an integral part of the coal industry. These improvements in efficiency and capacity of the Indian Railways and reduction in cost of coal delivery system will help in improving the performance of the railways in coal transportation. The Indian Railways could possibly give more emphasis on issues such long-term contracts for guaranteed delivery, reduction of cost of transportation, and increased availability and reliability.

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# Environmental challenges of coal production and use in India

P V Sridharan
T E R I, New Delhi

Coal has been and will remain one of society's most secure forms of energy and will continue to play a significant role in meeting energy demand worldwide. Addressing environmental and social concerns, however, will be the key to the coal industry's future. Compared to other fossil fuels, coal is less efficient and more polluting. The key environmental challenges facing the coal industry are related to both coal mining—particle emissions, disturbance of land, flora, fauna, and the hydrological regime (depletion of aquifers and groundwater); and the use of coal—emissions, GHGs (greenhouse gases), acid rain, ground-level ozone, and waste disposal. Large-scale coal mining, especially surface mining, disturbs large tracts of land. The disturbances include removing vegetation, moving overburden (waste rock and soil), removal of coal, and relocating overburden to backfill. The main environmental problems associated with land disturbance include soil erosion, loss of top soil, dust pollution, losses to natural vegetation and biodiversity, and pollution of water bodies/rivers. Underground mining may also lead to subsidence of surface land and mine fires.

The coal industry is concerned about all these impacts. However, the severity of the impact from coal varies across regions, and this is largely because of the differences in mining practices and combustion technologies that reflect various levels of development. In most countries, including developing countries, minimizing the impacts of land degradation and rehabilitating land conditions to those existed before mining began are legal requirements. However, the degree of compliance with national legislation varies across countries. In developed countries, the compliance levels are of a much higher order, especially with large-scale mining operations. These trans-national mining companies generally apply advanced reclamation techniques to meet strict regulations in the developed countries. Good environmental performance among these companies is essential to maintain the economic viability of their mining operations.

### Environmental and social issues in the Indian context

The environmental and social issues in the Indian context are of special concern as coal reserves are located in river basins that are rich in forest cover and serve as habitats for tribal people. Due to the high density of population in some areas (covering both existing and potential coalfields), acquiring large tracts of land required, specially for opencast mines, becomes difficult, and the issue of displacement and resettlement of people gains immense significance. With the envisaged increase in coal production from opencast mines of CIL (Coal India Ltd) alone, from 346 MT (million tonnes) in 2005/06 to over 800 MT in 2025, the need for land acquisition and the resultant displacement of people would also increase manifold. *Coal Vision 2025* has estimated that 170 000 families – or 850 000 displaced persons – would have to be rehabilitated by 2025 when the requirement for land would double from current 147 000 ha (hectares) to 292 500 ha. The requirement of forest land for mining would also increase more than three-fold from the current 22 000 ha (15% of the current total land requirement) to 73 000 ha (25% of the projected total land requirement) since much of the coal resources to be exploited in future are located in forests.

Apart from the issue of R&R (resettlement and rehabilitation), the coal industry is also faced with pollution of land, air, water, noise, and adverse impacts on flora and fauna. Further, future resources are concentrated in a few coalfields and would pose danger of contamination of underground and surface water if adequate precautions are not taken. The pollution of air is also likely to be more concentrated.

### *Social impact assessment*

SIA (social impact assessment), according to international guidelines, is defined as 'the process of assessing or estimating in advance the social consequences likely to follow from specific policy actions or project developments'. SIA's input would be essential and useful in the preparation of R&R plans and other community development schemes including capacity building of the affected population. Environmental assessments and SIAs were introduced in the 1970s in some developed countries in recognition of the critical importance of stakeholder engagement. In India, EIA (environmental impact assessment) is mandatory for many types of projects but SIA is not mandatory. EIA reports typically include a section/chapter on social aspects but this is limited to providing demographic information in and around the project area.

The contribution of coal to social development has two dimensions—one associated with coal mining and the other with coal use. Coal mining is both land and labour intensive and hence there are a number of issues that affect the welfare of the communities. These include employment, conflicting land uses, health and safety, and involuntary displacement of population. The positive impacts are employment opportunities, income generation for local communities, and community development. The most common negative impacts are change in land use, especially change from traditional uses (typically agriculture), and cultural disturbance. Relocating people from their traditional land into alternative communities often causes conflict. Also, cultural conflicts are caused when people from other areas move into the local community to work or seek work. The companies involved in large-scale coal mine operations are sensitive to these potentially negative impacts of mining and seek to minimize these impacts through various initiatives. One such initiative in India is R&R of project-displaced/affected persons under which the government is also making efforts to minimize the burden through liberal packages and legislative actions.

### *Stakeholder engagement and R&R*

Stakeholders are groups and individuals who affect or are affected by the activities of mining companies. Depending on the scale and significance of a mining project, the stakeholders include the following.

- Local communities
- A range of government departments/institutions with an interest or responsibility for the management or protection of natural resources.
- Employees
- Investors
- NGOs (non-governmental organization), and academic and research institutions

Stakeholder engagements in the coal sector in India have been continuing for many years (especially since the nationalization of coal mines) in a variety of ways, and important lessons have been learnt over a period of time.

The delay in implementation of many coal projects in the past has been mainly due to the opposition of the community centred on the issues of land, livelihood deprivation, and fair compensation. There is a strong perception among the affected communities and NGOs operating in these areas that the project-affected people would end up worse off than before instead of benefiting from the project.

The country did not have a national policy on R&R until 2003 when the NPRR (National Policy on Resettlement and Rehabilitation) was enunciated. In the 1970s and 1980s, the coal industry had an ad hoc policy of providing employment to one member of an affected family. In the 1990s, CIL came out with a comprehensive R&R policy but this policy has not been fully accepted by the affected population. NTPC (National Thermal Power Corporation), the leading power-generating company, has also substantially revised its R&R policy based on its experience.

The gap between expectation and delivery continues to exist. Many of the mineral-rich states still do not have an R&R policy. Orissa has come out with a comprehensive policy in 2006—the Orissa Resettlement and Rehabilitation Policy. Other states have issued government orders or resolutions on R&R either by sector or, more often, for specific projects. The national policy is more in the nature of broad guidelines and grants individual states with the provision to devise their own packages, provided they are better and more inclusive than the NPRR.

The following strategic approaches for effective stakeholder engagement are suggested.

- Go beyond compliance to build relationships
- Build long-term, continuing, and sustainable relationships with communities
- Consider the involvement of a neutral third party to help overcome perceived asymmetries in terms of power, resources, and so on, and develop trust

### *Industry responses to environmental impacts*

Table 1 shows the technological responses of the coal and power sectors to environmental challenges, and their status in developed and developing countries.

### *Clean coal technologies in the power sector*

Future technology trends are being driven by two criteria, namely efficiency improvement and environmental considerations. These two main drivers are inter-related in that any improvement in efficiency would result in less fuel being burnt, thus resulting in corresponding environmental benefits. The first thrust area has to be on coal quality improvements at the pithead through more efficient methods of quality control in mining and coal preparation/washing. The second is adoption of CCTs (clean coal technologies) in a phased manner for achieving higher efficiencies with resultant environmental benefits. The technologies developed and commercially available are super critical PF (pulverized fuel) cycle, and CFBC (circulating fluidized bed combustion) system. PFBC (pressurized fluidized bed combustion) system, IGCC (integrated gasification combined cycle), and ultra super-critical PF cycle are becoming commercially practical.

### *Barriers to adoption of clean coal technologies in India*

Clean technologies, as distinct from 'end-of-pipe' abatement technologies, minimize the generation of waste streams in the production processes themselves, rather than treating the waste after generation. In general, clean technologies are less intensive in the use of raw materials and energy, than conventional technologies. For this reason, they may also offer significant cost advantages to the producer. In spite of these benefits, the power sector in India has not made any progress in the adoption of CCT in its future plans. The barriers to the adoption of clean technologies are stated below.

- Many CCTs are proprietary, and protected by strong patent regimes held abroad. The vendors, accordingly, would be able to extract large premiums in the absence of competitive substitutes.
- Financial institutions lack the capacity to appraise proposals for switching existing production facilities to clean technologies.
- R&D efforts in India lack coordination in developing a shelf of commercially viable clean technologies.
- The sector faces tough competition from natural gas.
- Utilities are conservative.
- New technologies are not proven and involve higher capital costs.

Developing countries like India may choose the cheapest and the simplest option, which is the sub-critical PF cycle. In an evaluation of expected technologies for thermal power generation in India, it is estimated that in the period 2002–07, all capacity additions will be on base technology (sub-critical steam cycle). During the period 2007–12, 1980 MW of super-critical PF cycle units may be installed and an IGCC demonstration project (500 MW) may materialize. Based on the experience gained from the introduction of these new technologies, further plants will come up in the subsequent plan period of 2012–17. During this period, the first commercial plant on IGCC technology (coal-based) will come up. During 2017–22, the first coal-fired plant with ultra super-critical steam parameters is likely to come up. This will be followed by the full-scale adoption of these technologies in subsequent years.

## Global responses to environmental and social challenges

### *World Coal Institute initiative*

In the long term, the greatest challenge facing the future of global coal industry is to reduce the emission of GHGs. The coal industry recognizes that GHG emissions can be reduced significantly through development and deployment of CCTs. In this context, WCI (World Coal Institute) has

**Table 1** Status of technological responses to environmental challenges in developed and developing countries

| Environmental challenges | *Technological response* | *Status* |
|---|---|---|
| **Coal mining** | | |
| Land: Disturbance of land, forests, and biodiversity | Land reclamation techniques are well developed and practised in many countries. | Legal requirements on land reclamation are in place in many countries. Generally, compliance levels are of a much higher order in developed countries. In India, degraded mined land including waste dumps are 'greened' without any effort to bring the degraded land up to its optimum economic value. |
| Water: Depletion of aquifers and changes in drainage pattern. Deterioration in quality of water in receiving water bodies due to mine/washery discharge water | Technologies and systems for water quality improvement are available and practised. | Legal requirements are in place in many countries on water quality. Recycling treated water and zero discharge from washeries and power plants are practised in many countries. Groundwater depletion is a problem and needs attention. In India, the standards for mine effluent discharge into sewer/stream/land are well laid down. |
| Air: Fugitive dust emissions, noise, and ground-level vibrations | Technology to control dust at various sources is available and adopted. Surface miners are available for selective mining to improve coal and environmental quality (eliminates multi-operations of drilling, blasting, and so on). | Technology is developed and widely accepted to control blasting operations and reduce ground-level vibrations. In India, 30 surface miners are presently working in coal mines and have proved to be very successful. |
| **Coal-based power generation** | | |
| Particulate emissions | ESP and fabric filters control particulate emissions with removal efficiency of over 99.5%. | Technology has been developed and is widely accepted both in developed and developing countries. |
| $NO_x$ emissions | Low $NO_x$ burners. Advanced combustion technologies can reduce emissions by 90%. | Technologies have been developed and are widely applied in developed countries. In India, low $NO_x$ burners are widely accepted. |
| $SO_2$ emissions | FGD and advanced combustion technologies can reduce emissions by 90% to 95%. | Technologies have been developed and are widely applied in developed countries. FGDs are less prevalent in developing countries. In India, there are no stack emission standards for $NO_x$ and $SO_2$. $SO_2$ emission dispersal is controlled through stack heights. |
| Waste from coal combustion (ash) | Waste can be minimized both prior to and during coal combustion. Coal washing is a very cost-effective method of providing high-quality coal; it reduces waste generation and emissions of $SO_2$ and also increases thermal efficiency. Adoption of CCT also reduces waste. | Technologies have been developed and are continually improving. Awareness of opportunities for the use of fly ash is steadily increasing. Coal washing, especially in India and China, is steadily increasing. |
| $CO_2$ reduction | Various CCTs are available and can be adopted to improve efficiency of combustion, thereby reducing $CO_2$ emission per unit of electricity produced. In addition, other gaseous pollutants can also be substantially reduced. | Many CCTs have been developed and commercialized. More than 240 high-efficiency super-critical units are in operation worldwide. China has 22 super-critical units in operation. In addition, there are ultra super-critical units in operation in developed countries. Another major technology, IGCC, is becoming commercially practical. Indian power sector is lagging far behind in the adoption of CCTs. |

$NO_x$ – oxides of nitrogen; $SO_2$ – sulphur dioxide; $CO_2$ – carbon dioxide; FGD – flue gas desulphurization; CCT – clean coal technology; IGCC – integrated gasification combined cycle; ESP – electrostatic precipitator brought out a number of reports on sustainable development issues facing the industry. The WCI is a non-profit, non-governmental association of coal producers and consumers, and is the only international body that represents the coal industry worldwide. The institute has listed 10 key principles and objectives of member companies in addressing sustainable development issues. In addressing these issues and to give practical effect to sustainable development, the coal industry has identified five key action areas as outlined below.

1 Minimize coal production impacts on the biosphere (land, water) and on local communities.
2 Improve the technical and economic efficiency of energy conversion, thereby minimizing resource use.
3 Significantly reduce 'per unit' emissions from the production and use of coal.
4 Contribute to the efficient and beneficial transfer of new and advanced cleaner coal technologies to enhance their global uptake and to assist in meeting the needs of developing countries (recognizing their legitimate development aspirations and the low energy efficiency of existing thermal plant).
5 Increase support by individual coal companies for community development initiatives to address local sustainability issues, providing enhanced economic and social opportunities relevant to the location and scale of their operations.

### *Asia-Pacific Partnership on Clean Development and Climate Initiative*

Another initiative in 2006 has been the formation of the Asia-Pacific Partnership on Clean Development and Climate, which is an innovative new effort to accelerate the development and deployment of clean energy technologies. Founding partners Australia, China, India, Japan, Republic of Korea, and the US, which together account for 65% of the world coal production, have agreed to work together with private sector partners to address issues of energy security, national air pollution reduction, and climate change in ways that promote sustainable economic growth and poverty reduction. The partnership will focus on expanding investment and trade in cleaner energy technologies, and goods and services in key market sectors. The partners have approved eight public–private sector task forces covering the following.

1 Cleaner use of fossil energy
2 Renewable energy and distributed generation
3 Power generation and transmission
4 Steel
5 Aluminium
6 Cement
7 Coal mining
8 Buildings and appliances

The task force on coal mining will address the reclamation and rehabilitation of mined lands, run-off, abandoned mines, and best safety practices. This task force will work in collaboration with the Cleaner Fossil Energy Task Force to ensure that synergies are captured in improving coal processing and developing new coal-based generation technologies. These are focused on new technologies associated with carbon dioxide capture and storage, hydrogen production from coal as well as complimentary advanced power generation systems. These include IGCC, super-critical PF cycle, and PFBC systems. Through this partnership initiative, India should plan to achieve maximum benefits in the adoption of best practices and cleaner technologies in coal mining and power generation.

### *Mineral Council of Australia initiative*

The MCA (Mineral Council of Australia) is a private, not-for-profit organization and is fully resourced by its member companies that between them produce over 85% of the annual mineral production in Australia. The MCA has established an environment and social policy committee to serve its member companies that are actively engaged in the 'effective integration of the environmental, social, and wealth creation elements of mineral development' and recognize this as the key to operationalizing sustainable development. MCA aligns with the ICMM (International Council on Mining and Metals) sustainable development framework principles and the Global Reporting Initiative, and enables companies to tailor their performance reports to the needs and expectations of communities in which they operate.

### *International Council on Mining and Metals initiative*

ICMM, which was formed in October 2001, is an international body representing the interests of mining and metal industries. Its vision is 'viable mining, minerals, and metals industry that is widely recognized as essential for modern living and is a key contributor to sustainable development'. It was formed to take forward the recommendations of the MMSD (Mining, Metals, and Sustainable Development) project. ICMM has recently initiated a project titled 'Challenges of mineral wealth', with the specific aim of documenting ways in which the mining industry's socio-economic contribution could be improved.

## Conclusions

The coal industry in India has achieved significant increase in coal production over the past three decades. But its performance in all aspects of sustainable development is well below the benchmarks established in developed countries in areas like land reclamation, environmental protection, and managing community issues. While environmental management in the coal industry has improved, a lot needs to be done in the area of land rehabilitation, and land-use planning and management in partnership with the affected community. An important aspect of mine planning is the rehabilitation of disturbed lands to a stable and productive post-mining landform that is suitable and acceptable to the community. The physical rehabilitation programme should be an integral part of mine planning. The essential goal of site rehabilitation is to restore all the affected areas to their optimum economic value. The main aims of site rehabilitation are to reduce the risk of pollution, restore the land and landscape, improve the aesthetics of the area, and prevent further degradation. Through consultation with relevant interest groups (stakeholders), the mine operator can establish the required future land use and water management in the area.

Even though the industry has a number of bilateral agreements (government to government) with many coal-producing countries, it has not taken advantage of the best practices available in these countries. One such example is the Australia–India Coal and Mining Forum; the Mineral Council of Australia is a part of this Forum. The Australian Mineral Industry Code for Environmental Management was introduced in 1996 and has been highly successful and internationally acclaimed. This was the platform for the industry's continual improvement in managing its environmental impacts. Many components of this code can be adapted in the Indian coal industry with significant benefits. On the coal utilization front, since India would continue to be dependent on coal for power generation in the future, it is of utmost importance to adopt newer and better technologies to promote sustainable economic growth. The coal industry in India should minimize the environmental footprint of coal mining through measures such as mine rehabilitation, which should be treated as a priority. It is imperative that the coal industry coordinates its efforts under an industry body with greater responsibility and adequate resources, and shows strong leadership and vision on sustainability issues.

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# Centre for Research on Energy Security

CeRES (Centre for Research on Energy Security) was set up on 31 May 2005. The objective of the Centre is to conduct research and provide analysis, information, and direction on issues related to energy security in India. It aims to track global energy demands, supply, prices, and technological research/breakthroughs – both in the present and for the future – and analyse their implications for global as well as India's energy security, and in relation to the energy needs of the poor. Its mission is also to engage in international, regional, and national dialogues on energy security issues, form strategic partnerships with various countries, and take initiatives that would be in India's and the region's long-term energy interest. *Energy Security Insights* is a quarterly bulletin of CeRES that seeks to establish a multi-stakeholder dialogue on these issues.

Previous issues of this newsletter are available at **<http://www.teriin.org/div_inside.php?id=41&m=3>**.

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Pragya Jaswal
Editor
Centre for Research on Energy Security
TERI, Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003

*Tel.* 2468 2100 or 4150 4900
*Fax* 2468 2144 or 2468 2145
India +91 • Delhi (0)11
*E-mail* pragyaj@teri.res.in
*Web* www.teriin.org




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