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Clean Coal Technology: A Review of Present Practices in India

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Abstract

India ranks third largest coal producing country in the world and is also the fourth largest importer of coal in the world. The aim of this study is have a review of adaptation of CCT in the context of Indian coal based power value chain, with the goal of reducing the negative impacts associated with coal mining. The study also attempts to provide an overview of Indian coal based power value chain and its three pillars: coal mining, coal logistics, and coal power plants. The quality of Indian coal is poor and is worsening since the higher quality resources have already been exploited. Coking coal accounts for around 18-20 percent, of which only a small percentage is of prime coking quality. The rest of the Indian coal is characterised by high ash content. This is due to the fact that majority of coal in India in Gondwana sediments, which are characterised by seams intertwined with mineral sediments. Further Indian coal has high moisture content, while sulphur content and calorific values are low. Coal in India commonly belongs to D, E and F categories which have low calorific value. In India Clean Coal Technology is to be studied in reference to long term planning. The benefits of Clean Coal Technology may not appear in shorter duration but on a longer time framework it appears that India can gain competitive advantage only by adhering to norms and procedures prescribed by Clean Coal Technology. Clean Coal Technology is a broad based concept which is aimed at achieving higher productivity and greater benefits to the users of coal.

Keyworld: burgeoning, contamination, deforestation, emission, sediments

Introduction

India ranks third largest coal producing country in the world and is also the fourth largest importer of coal in the world. The abundant availability of coal and its affordability makes it a major contributor for generation of electricity in our nation. Coal accounts for around 69 per cent of the country's electricity output. In the days to come coal as a fossil fuel will continue to play a dominant role in meeting ever-increasing energy demands of the nation. Thus managing the negative consequences of coal mining must be viewed as continued priority.

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Over the past several decades, advancements in clean coal technology (CCT) have managed to reduce the coal industry's negative environmental and health impacts across the globe. The European Union (EU) remains the world leader in cutting-edge CCT, and is home to a wide array of companies specialized in reducing the environmental impact of the coal industry. Many small and medium enterprises (SMEs) from countries such as Germany, Poland and the United Kingdom, offer a range of technological and consulting solutions that could be put to good use in India, as country prepares to curb the negative side effects of its burgeoning coal sector over the coming years and decades.

The aim of this study is have a review of adaptation of CCT in the context of Indian coal based power value chain, with the goal of reducing the negative impacts associated with coal mining. The study also attempts to provide an overview of Indian coal based power value chain and its three pillars: coal mining, coal logistics, and coal power plants. These areas offer significant scope for the reduction of environmental pollution and greenhouse gas emission. The world's largest coal producing company Coal India Limited accounts for around 80 per cent of the India's coal sector has a dominant role to play in the introduction and adaptation of CCT. In coal logistics and transportation, opportunities to explore are introduction of new low emission haul trucks, conveyors, vehicle guiding software, and hydro-transport. The most promising of the three pillars is within coal power plants, i.e., introduction of supercritical, circulating fludised-bed consumption and integrated gassification combined cycle boiler technology is perfectly suited for Indian conditions. An attempt also been made by briefly addressing other two CCT innovations that are only beginning to be considered in India: Carbon Capture and Storage (CCS) and Underground Coal Gassification.

Coal Mining

Main Coal Regions and Their Characteristics: In India, coal can generally be found in two main geological horizons: Gondwana sediments (Permian) and early Tertiary sediments (Eocene). The majority of the deposits belong to first category, and are located in the eastern and south–eastern part of the country, specifically in Andhra Pradesh, Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra, Orissa, Sikkim, Uttar Pradesh and West Bengal. The tertiary coal fields are mainly located in Arunachal Pradesh, Assam, Meghalaya, Nagaland and other North-east regions. Lignite resources are available in Tamil Nadu, Gujarat, Rajasthan, J & K and Puducherry.

The quality of Indian coal is poor and is worsening since the higher quality resources have already been exploited. Coking coal accounts for around 18-20 per cent, of which only a small percentage is of prime coking quality. The rest of the Indian coal is characterized by high ash content. This is due to the fact that majority of coal in India is located in Gondwana sediments, which are characterized by seams intertwined with mineral sediments. Further, Indian coal has high moisture content, while sulphur content and calorific values are low. Coal in India commonly belongs to D, E and F categories which have low calorific value.

Table 1: Classification of Indian Coal with Calorific, Ash and Moisture Values

Grade	Calorific Value Range (kcal/kg)	Ash & Moisture Content (%)
A	Exceeding 6200	Not exceeding 19.5
B	5600 – 6200	19.6 to 23.8
C	4940 – 5600	23.9 to 28.6
D	4200 – 4940	28.7 to 34.0
E	3360 – 4200	34.1 to 40.0
F	2400 – 3360	40.1 to 47.0
G	1300 – 2400	47.1 to 55.0

Coal Washing

Coal washing is a process of separation which uses the difference in specific gravity of coal and the impurities that are extracted along with it, such as shale, sand and stones. The purpose of coal washing is to get a relatively pure marketable coal, with a higher calorific value since non-combustible material is separated from useful combustible material. Due to the high ash content, this process is particularly appropriate for Indian coal, and it started to be adopted in the 1950s. Traditional Indian coal washeries mainly use outdated technology, but the need for coal washing is increasing and calls for an improvement of the technologies and a broadening of beneficiation. Coal washing allows the lowering of production costs through improved thermal efficiency and availability, and also reduces the amount of material to be transported, hence cutting emissions in transportation. Furthermore, coal washing increases the calorific value of the coal, lowers ash disposal, operation and maintenance costs, reducing the need for imports of higher quality coal. Coal washing also reduces land requirements, and has a social impact as well, decreasing settlement costs and effects on cultivation in the impact zone, and improving health and living conditions. In 1997, the Ministry of Environment and Forest decreed that all thermal plants located at a distance of a thousand kilometres or more from the mine (or located in very polluted urban areas) must use coal not exceeding 34 per cent ash content. This law does not apply to plants situated near mining sites, which can burn coal without beneficiating it. The regulation was meant to be operative since 2001, but has not been implemented on a large scale. In India there are currently 17 coking coal and 32 thermal coal washeries, with a total installed capacity of 130 million tonnes a year. However, the real effective utilization is rather low. The actual washing is preceded by crushing, in order to reduce the size of raw coal. While the smaller pieces are not washed, the bigger ones are beneficiated by jig, heavy medium bath or heavy medium cyclone. In some washeries inefficient barrel washers and spirals are used, and sometimes the cleaning of coal is limited to rock removal by hand picking. However, these methods are clearly not efficient.

Although the government's support and Coal India's recent investments in coal washing, obstacles for implementation and improvement of this kind of coal beneficiation continue to persist. There is widespread perception that improving coal washing would add to the cost of supplied coal, but this would be true from a very short term perspective only. In fact, in the longer term, improving these techniques would have major economic benefits.

The hurdles are not technical, but primarily political. One of the main issues in achieving a satisfying development of coal beneficiation is the need for effective coordination between the different governmental departments dealing with coal (such as the Ministry of Coal, the Ministry of Transportation and the Ministry of Railways); from extraction, to preparation, transportation, distribution and use. Furthermore, the coal pricing system should also be addressed, including the quality of coal as a factor influencing in the cost, so that there would be a further incentive to the production of quality coal.

Until 2012, coal supplied by Coal India the country's largest single supplier, was priced based on quality, grade and the amount of heat generated from a particular type of coal. This method was revised in January 2012, and made the price depend on the coal's gross calorific value, which led to an increase in prices. In April 2013 Coal India and NTPC Limited, a large state-owned power generation company, agreed on a new pricing system; the price of coal will now be calculated based on the amount of heat that can be generated by burning a particular amount of coal, with coal sampling done by a third party.

Environmental Issues with Coal Mining and Washing

Coal mining has severe impacts on the environment that go well beyond the problem of production of CO_2 generally associated with the use of coal. Mining deeply affects air, water and land resources. Due to mining, dust and methane, sulphur dioxide (SO_2), oxides of nitrogen, CO and other gases are spread in the air, thus affecting water and land resources, as well as human health. These are consequences of underground mining and, even more, of opencast operations. Another source of damage related to mining are fires in the mines, which are frequent and have severe consequences not only for the environment and the safety of the workers, but also for the production itself.

The impact of mining and associated activities on water resources is also difficult. Mining requires large amounts of water, diminishing the quantity available for other purposes. Furthermore, both underground and opencast mining disturbs aquifers and water table.

The main pollutants associated with mining are suspended solids, dissolved salts acidity and iron compounds. One of the major problems related to coal mining and water pollution is Acid Mine Drainage (AMD), the outflow of acidic water from coal mines. It contaminates drinking water and endangers the life of vegetation and water species; moreover, it also causes the corrosion of mining equipment and structures (barges, bridges, concrete materials). This issue is especially associated with opencast mining, as well as with coal washing, making necessary more adequate waste water disposals, in order to prevent the contamination of underground and surface water. Developing technologies for containment or re-use of AMD and other contaminants such as mercury that result from mining and coal washing, should become a bigger priority in the coming years. Disposing of such rejects in an environmentally-friendly manner is challenging. One option that is already used in India, but could be developed further, is greater use of these rejects in power generation. As some stil have carbon content, they can generate power through fluidised-bed combustion (FBC) or circulating fluidised-bed combustion (CFBC) units at the end of the washery.

The impact of mining activities on land is probably the most evident, with large scale excavations, removal of top soil, dumping of solid wastes, cutting of roads, creation of derelict land, subsidence and so on. Whereas the impact of opencast mining is more noticeable, the one of underground drilling might not be immediate to the eye, but it does affect the land on a large scale. Finally, noise and vibration generated by mining and related operations, such as blasting and crushing, not only affect the quality of life and work of the people working or living in the mining area, but also have an impact on the environment, as they disturb the local fauna, causing it to move elsewhere, hence misbalancing the eco-system.

The Indian government has issued legislation concerning environmental protection, with the aim of addressing these kinds of problems. The Ministry of the Environment and Forests has also started to reject some projects for new coalfields due to their environmental impact, whenever it determines that they would result in further deforestation and water pollution. Nevertheless, these measures have not had the expected outcome, as the focus on mining as a priority is stil very strong, hence implementation of laws and regulations is still rather weak. Following some comments from civil society and non-governmental organizations. (NGOs), Coal India has tried to mitigate the effects of coal mining, introducing air, water and land pollution control measures with the Environmental and Social Mitigation Project (ESMP). This project was implemented in 25 selected opencast mines, was funded by the World Bank from 1996 to 2002 and tackled both environmental and social roblems. Nevertheless, reports on CIL environmental practices found that in some cases overburden is not stocked safely, plantation density is below expectation, topsoil is not properly restored and effluent, sewage treatment is often inadequate and, in general, some mines operate without appropriate environmental systems certification. Furthermore, problems of compliance have been pointed out in the field of monitoring of implementation of environment protection performance. In general terms, it can be said that clean coal technologies and environmental concerns have to be implemented under strict monitoring and need special care to succeed in India. As new power plants are built, they do incorporate more CCT. There is also a need to renovate the older plants, as the main goal is to keep them running as long as possible, without significant regard for environmental concerns.

Main Coal Washing Technologies Currently are in India

- Coking coal:
  - Heavy media (HM) cyclones
  - Deshaling jigs, HM bath, batac jig and froth flotation
  - Deshaling jig, HM cyclone and flotation

- o HM washer, cyclone and flotation
- o Jig (coarse coal), jig (small coal) and froth flotation
- o Jig and heavy media.

- Thermal coal:
  - o Rotary breaker and barrel washer
  - o HM washer, baum jig and flotation
  - o Run-of-mine (ROM) jigs, batac jigs
  - o HM washer, HM cyclone
  - o HM cyclone, hydro cyclone and spiral.

Some new technologies are being introduced. For example: fine coal washing and washing of low volatile medium coking coal for enhancement of domestic met coal supply; and washery flow sheet simulation and IT applications for improved recovery and better quality control. Furthermore, dry beneficiation is also in the demonstration stage. Other new technologies could also be considered for more widespread implementation. One example is dry sorting through the use of X-ray machines, which is an affordable alternative to coal washing, which has the added benefit of not consuming (often scarce) water resources. X-ray sorting does, however, require highly-skilled personnel to operate effectively.

Coal Logistics

Logistics is a key factor in the coal supply chain, as coal transportation can account for up to 70 per cent of the delivered cost of coal. Logistical considerations begin at the coal mine proper and include the use of appropriate and economic mining and material handling equipment and the transportation of coal to stock yards and waste dump sites. On-site transportation is most commonly either discontinuous (principally by large haul trucks) or continuous (such as belt conveyors or mobile conveyor bridges).

The transfer of coal from the point of extraction to the final consumer (power plants or industry) can be done through various modes of transport. In India, the supply of coal to consumers is determined by the Standing Linkage Committee (SLC). The SLC establishes linkages between supply points, core consumers (power, cement and steel industries) as well as non-core consumers (other industries). Some 56 per cent of coal transport from the mines to consumers is based on railways, with the rest transported by road (approximately 19 per cent), merry-go-round (MGR) systems for the increasing number of power plants located near pitheads (approximately 18 per cent) and other. The share of domestic inland water transportation (IWT) is negligible, but the growing amount of coal being imported to cover India's energy needs principally reaches the country by ship. Most of India's major coal ports such as Mundra, Dahej, Magdalla, Sikka and others are located in Gujarat on the west coast, although new ports are being built in the south and east of the country to accommodate the increasing imports. Within the ports, coal is unloaded, handled and stored mainly by conveyors before it is transported further either by road or railway.

Even though transport by road offers flexibility, fuel, tyre, labour and maintenance costs make the usage of trucks costly and inefficient. As a result, large companies such as state-owned Coal India Ltd., principally utilise trucks for carrying coal from pitheads to the nearest railheads. Coal transportation by road is handled by a variety of private companies and large truck owners' associations. The share of coal transported by railway is on the rise, and India is currently planning to complete three major railway lines in Jharkhand, Chattisgarh and Odisha by 2017 in order to reach its goal of producing 615 million tonnes of coal in 2016/17. Transportation by railway is handled by state-owned Indian Railways.

The on-site discontinuous transport method consumes a considerable amount of energy and has an unfavourable carbon footprint due to emissions from large haul trucks. In contrast, continuous mining systems rely on electricity and their lower carbon emissions wil likely increase the appeal of these systems in the future. The same applies to transportation from mines to the final consumers. A study of the Indian transport sector by Ramachandra and Shwetmala shows that shipping accounts for the smallest amount of CO_2 and CO emissions, followed by railways, aviation and road transport.

Type of transport	CO_2 emissions	CO emissions
Shipping	0.6%	N/A
Railway	2.0%	1.2%
Aviation	2.9%	45.1%
Road	94.5%	53.3%

As stated earlier, coal in India is mined at a limited number of locations primarily in the east of the country, with major coalfields including Jharia, East Bakara and West Bakara which are often located far away from factories and power plants. This makes coal transport an important factor that leaves some scope for a reduction in emissions. Even though power plants are increasingly being built nearer to coal mines enabling transport through electricity-powered systems such as MGR and conveyors the scope for greater investment in such systems in India remains limited. Given the country's extensive railway network and the costs involved with building, operating and maintaining conveyors, these systems wil likely remain feasible only for distances of some 10 kilometres, replacing transportation by truck to a limited degree.

As coal in India contains a large amount of ash frequently between 40 and 50 per cent the transportation of such high amounts of inert material over long distances increases emissions in transportation. Effective coal washing can significantly reduce the amount of matter that needs to be transported. Since 2002, the Indian Ministry of Environment and Forest requires that coal shipped more than 1,000 kilometres (revised to 500 in 2012) from the mine should be washed and have less than 34 per cent ash. An analysis of one facility, the Dadri Power Plant, estimates that the use of coal washing in that plant alone reduced CO_2 emissions from transportation and combustion by over 600,000 tonnes per year. Another recent study discovered a significant reduction in emissions after dry coal sorting using X-ray sorting equipment; CO_2 emissions were reduced by four kilograms when transporting X-ray-sorted coal over a distance of 30 kilometres.

Technological Development and Potential for Sustainable Coal Logistics

The increasing share of railway transportation is making coal logistics in India more sustainable over the long term. The construction of expensive new lines is, however, proceeding slowly and the overburdened railway transport network is causing bottlenecks in the transport of coal.

Although already diminishing, coal transport by road will remain a reality in India for some time to come. As a result, procuring modern vehicles with lower CO_2 emissions and new technology such as electronic-controlled engine management and twin-speed drive axle which increases fuel efficiency should be encouraged. Such technology is already available in India and has been implemented into haul trucks by companies such as India's second largest vehicle manufacturer, Ashok Leyland.

In addition, modern information technology, such as advanced vehicle tracking and dispatch systems, can greatly increase efficiency in transportation, save fuel and reduce emissions. As with other vehicle technology, it is already available domestically: One recent example is the implementation of a radio-frequency identification (RFID) vehicle tracking system developed by the Mumbai-based company Essen. The system was introduced by the Sundargargh Truck Owners' Association, which manages a fleet of over 4,500 coal transport trucks.

Beyond improving existing modes of transportation, coal logistics in India could be made more sustainable by adopting new methods. One technological solution that is already widely available but has yet to be adopted on a large scale in India is hydro-transport, which is primarily based on coal slurry pipelines. These enable the transportation of crushed coal mixed with water over long distances while integrating coal beneficiation (such as marginal ash reduction), mitigating risks of spontaneous combustion, completely isolating coal transport from the outside environment, and enabling the dewatered coal to be readily converted into briquettes. In India, hydro-transport would be economical y feasible across distances of 10 kilometres or more. Even though hydro-transport is seeing increased investment in other coal-abundant countries, such as China, the slow and complex decision-making process in India has so far prevented its widespread adoption.

SME Opportunities in Logistics

1. Software companies specialising in RFID and Global Positioning (GPS) tracking systems could sel their products to logistics companies and truck owners' associations
2. As Indian transport companies continue to upgrade and modernize their truck fleets with more cost- and fuel-efficient vehicles, highly specialized SMEs that contribute spefic components to such trucks could play a role
3. If new modes of transportation, such as hydro-transport, become widely adopted in India, opportunities will arise for specialised SMEs

4. Indirect contribution to reducing emissions in transportation: Contributing to coal washing and dry (X-ray) coal sorting, which both greatly help reduce emissions in transportation promoting Clean technologies in India and tackling Climate Change.

Conclusion

In India Clean Coal Technology is to be studied in reference to long term planning. The benefits of Clean Coal Technology may not appear in shorter duration but on a longer time framework it appears that India can gain competitive advantage only by adhering to norms and procedures prescribed by Clean Coal Technology. Clean Coal Technology is a broadbased concept which is aimed at achieving higher productivity and greater benefits to the users of coal. In the short run this technology may appear to be expensive and infeasible but over a longer term time horizon CCT would not only help boosting coal production but also increase productivity thereby ultimately lowering the cost per tonne of coal mined. The critical mindset of managers needs to undergo a thorough change towards CCT. Coal mining in future will have to include activities such as coal washing and efficient coal logistics.

The country's continued investment in new coal mines and power plants is increasingly accompanied by investment in CCT. A major coal consumer and importer, and home to the world's largest coal producing company, CIL, India is in a promising position to become a major player in CCT, once some of the aforementioned obstacles alongside some others, such as outdated environmental legislation are overcome. With its major market share, substantial resources and state backing, Coal India is particularly well-placed to spearhead CCT innovation through direct R&D, as well as create positive ripple effects by investing in related areas, such as CSR.

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