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Abbreviations

AMD	Acid Mine Drainage
BCCL	Bharat Coking Coal Limited
BP	British Petroleum
CAG	Comptroller and Auditor General
CCL	Central Coalfields Limited
CEA	Central Electricity Authority
CGPL	Coastal Gujarat Power Limited
CIL	Coal India Limited
CMPDIL	Central Mine Planning and Design Institute Limited
CMR	Coal Mines Regulations
CO2	Carbon-dioxide
COD	Chemical Oxygen Demand
CPCB	Coal Pollution Control Board
cu. m.	Cubic Metre
CVD	Countervailing Duty
DC	District Collector
DGMS	Directorate General of Mines Safety
DM	District Magistrate
DU	Delhi University
EBTC	European Business and Technology Centre
ECL	Eastern Coalfields Limited
EIAS	European Institute for Higher Studies
EMP	Environment Management Plan
ETP	Effluent Treatment Plant
EU	European Union
FAUP	Fly Ash Utilisation Program
FICCI	Federation of Indian Chambers of Commerce and Industry
FPC	Fuel Policy Committee
FRI	Forest Research Institute
GHG	Greenhouse gas
GSECL	Gujarat State Electricity Corporation Limited
GSI	Geological Survey of India
ha	Hectares

HPGCL	Haryana Power generation Company Limited
IBM	Indian Bureau of Mines
ICC	Indian Chamber of Commerce
IEA	International Energy Agency
IMTF	Inter-Ministerial Task Force
INR	Indian National Rupee
IWAI	Inland Waterway Authority of India
IWT	Inland Water Transport
km	Kilometre
kWh	Kilowatt hour
MBR	Maternity Benefits (Mines) Rules
MCDR	Mines Conservation and Development Rules
MCL	Mahanadi Coalfields Limited
MCP	Mine Closure Plan
MCR	Mine Concession Rules
MGR	Merry-go-round
MMDR	Mines and Mineral (Development and Regulation)
MMR	Metalliferous Mines Regulations
MNRE	Ministry of New and Renewable Energy
MoC	Ministry of Coal
MoCI	Ministry of Commerce and Industry
MoEF	Ministry of Environment and Forests
MoF	Ministry of Finance
MoL	Ministry of Labour
MoM	Ministry of Mines
MoP	Ministry of Power
MoR	Ministry of railways
MoS	Ministry of Steel
MoST	Ministry of Surface Transportation
MPPGCL	Madhya Pradesh Power Generation Company Limited
MR	Mines Rules
MT	Metric Ton
MTPA	Million Tonnes per Annum
NCAER	National Council for Applied Economic Research
NCDC	National Coal Development Council
NCL	Northern Coalfields Limited

NMP	National Mineral Policy
NTPC	National Thermal Power Corporation
OB	Over burden
OC	Open Cast
OGT	Oil and Grease Traps
PIB	Press Information Bureau
PRI	Panchayat raj Institutions
PSU	Public Sector Undertaking
RPM	Respirable Particulate Matter
Rs.	Rupee
SCCL	Singrauli Colliery Company Limited
SDF	Sustainable Development Framework
SECL	South Eastern Coalfields Limited
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
sq.	Square
STP	Sewage Treatment Plant
TIFAC	Technology information Forecasting and Assessment council
TPCES	Total Primary Commercial Energy Supply
TPP	Thermal Power Plant
UMPP	Ultra Mega Power Project
USD	United States Dollar
WBPDCL	West Bengal Power Development Corporation Limited
WCL	Western Coalfields Limited

1. Background

1.1 Coal in the energy mix

Coal currently accounts for 54.5% of India's primary energy mix as compared to the world average of 30% (BP 2014) as indicated in Figure 1 below. India's energy sector is highly dependent on coal to the tune of 60% to fuel the country's power supply. The coal off-take is the highest for the Power sector with a share of 72% followed by Fertilizer which has a share of 13%. The sectoral coal demand in 2013-14 for steel and cement together is to the tune of 11.38% (Ministry of Coal 2015a) . The Integrated Energy Policy of the Planning Commission also indicates that coal will continue to have a share of 51% in electricity generation even by 2031-32 and a 47% share in total primary commercial energy supply (TPCES) when all alternative energy sources are utilised. In the case of the utilisation of the most economic sources of fuel, the provisional share of coal for 2013-14is 64% in total primary commercial energy supply (TPCES) (MOSPI 2015). With increasing demand and population, the nation is expected to become one of the top three emitters of greenhouse gases (GHG) by 2030 (IEA 2007) though in per capita terms, it will remain among the lowest emitters. In spite of carbon emissions associated with coal, it is dominant on account of its availability, relatively low cost and lower constraints as compared to other fuels. Domestic coal based power plants are also the most cost economic options at current energy levels in comparison to other primary energy sources like nuclear, gas as well as renewables (KPMG 2010).

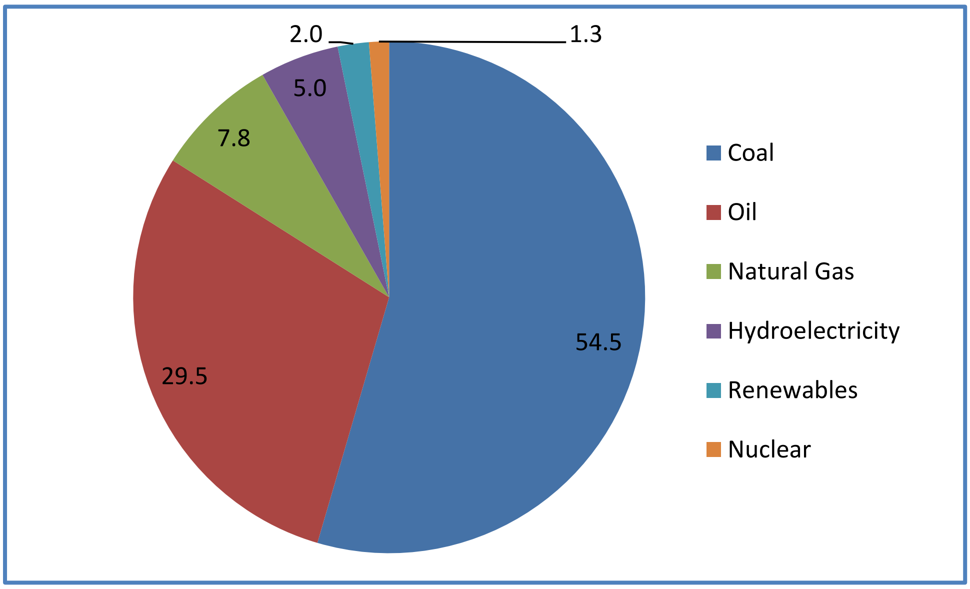


Figure1 Consumption of different fuels for energy generation in percentage for 2013

Source: BP (2014)

1.2 Key Developments

The first major step towards planned development of Indian coal industry was the setting up of the National Coal Development Corporation (NCDC) in 1956. It contributed to the task of increasing coal production and developing new coal resources in outlying areas besides introducing modern and scientific techniques of coal mining. The Fuel Policy Committee (FPC) was established in 1970 with a view to suggest a comprehensive analysis of the energy sector and decided that coal should be considered the primary source of energy for India and priority was ceded to coal relative to oil products on grounds of economic and energy security. This was followed by nationalization of coal mines in two phases the first with the coking coal mines in 1971-72 and then with the non-coking coal mines in 1973. The Coal Mines (Nationalization) Act enacted in 1973 brought coal resources under the control of public sector.

Post enactment of Nationalization Acts the coal industry was reorganized into two major public sector companies, namely Coal India Limited (CIL) and Singareni Colliery Company Limited (SCCL). SCCL was in existence under the ownership and management of Andhra Pradesh State Government at the time of the nationalization. CIL owns and manages all the old Government-owned mines of National Coal Development Corporation (NCDC) and the nationalized private mines. CIL has seven production subsidiaries which include Bharat Coking Coal Ltd., Central Coalfields Ltd, Eastern Coalfields Ltd., Mahanadi Coalfield Ltd., Northern Coalfield Ltd., South-Eastern Coalfield Ltd., and Western Coalfields Ltd. The eighth subsidiary i.e. Central Mine Planning and Design Institute Ltd. (CMPDIL) is exclusively engaged in mine planning and designing in the coal sector and rendering mining and engineering consultancy services to the subsidiaries. The Ministry of Coal is responsible for policy formulation and planning and exercises its functions through CIL and its subsidiaries and SCCL.

The nationalization of coal mines suspended all activities of mining by the private sector. However, exceptions to the policy were introduced with an amendment to the act in 1976 which permitted captive mining by private companies engaged in iron and steel production and sub-lease of private mining in isolated small pockets not amenable by economic development and do not require rail transport. Subsequent amendments in 1993 and 1996 permitted Indian companies engaged in production of power in addition to iron and steel producers to undertake coal mining for captive use. It also allowed washing of coal at pit head by private companies and production of cement as end use for captive mining of coal. In 2007, coal gasification and coal liquefaction were notified as specified end uses for the purpose of captive mining.

2. Policy and regulatory framework

The onus of management of minerals resources lies with governments both at the centre and the state. The legal framework for regulation of mines and development of all minerals other than petroleum and natural gas have been laid down in the Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act). The MMDR Act, 1957 and the Mines Act, 1952 are the general laws that are significant to governing the mining sector. The main highlight in the 2010 MMDR amendment was that it permitted foreign companies in the coal bidding process. The governments at the centre have framed guidelines with regard to Mineral Concession rules, 1960 (MCR) and the Mineral Conservation and Development Rules, 1988 (MCDR). The central government on the 21st October, 2014 promulgated an Ordinance which amends the Coal Mines (Nationalisation) Act, 1973 and the MMDR Act, 1957. The ordinance will empower end use private companies from the power, steel and the cement sectors to bid coal blocks for captive use and allot mines directly to state and central public sector undertakings (Ministry of Law and Justice, 2014). The State Governments have framed the rules in regard to minor minerals. In order to ensure that development of mineral resources is within the same wavelength as that of the national policy goals, both the central and state governments shall formulate the necessary legal measures for giving effect to the National Mineral Policy, 2008. For this, the MMDR Act, the MCR and the MCDR will be amended in line with the policy. With the objective of optimum utilization of the mineral resources while at the same time maintaining the integrity of the environment, the NMP 2008 plans to develop a Sustainable Development Framework (SDF) which will also take into account looking after the interests of the forests and displaced people. Figure 2 below describes the legal structure for mining.

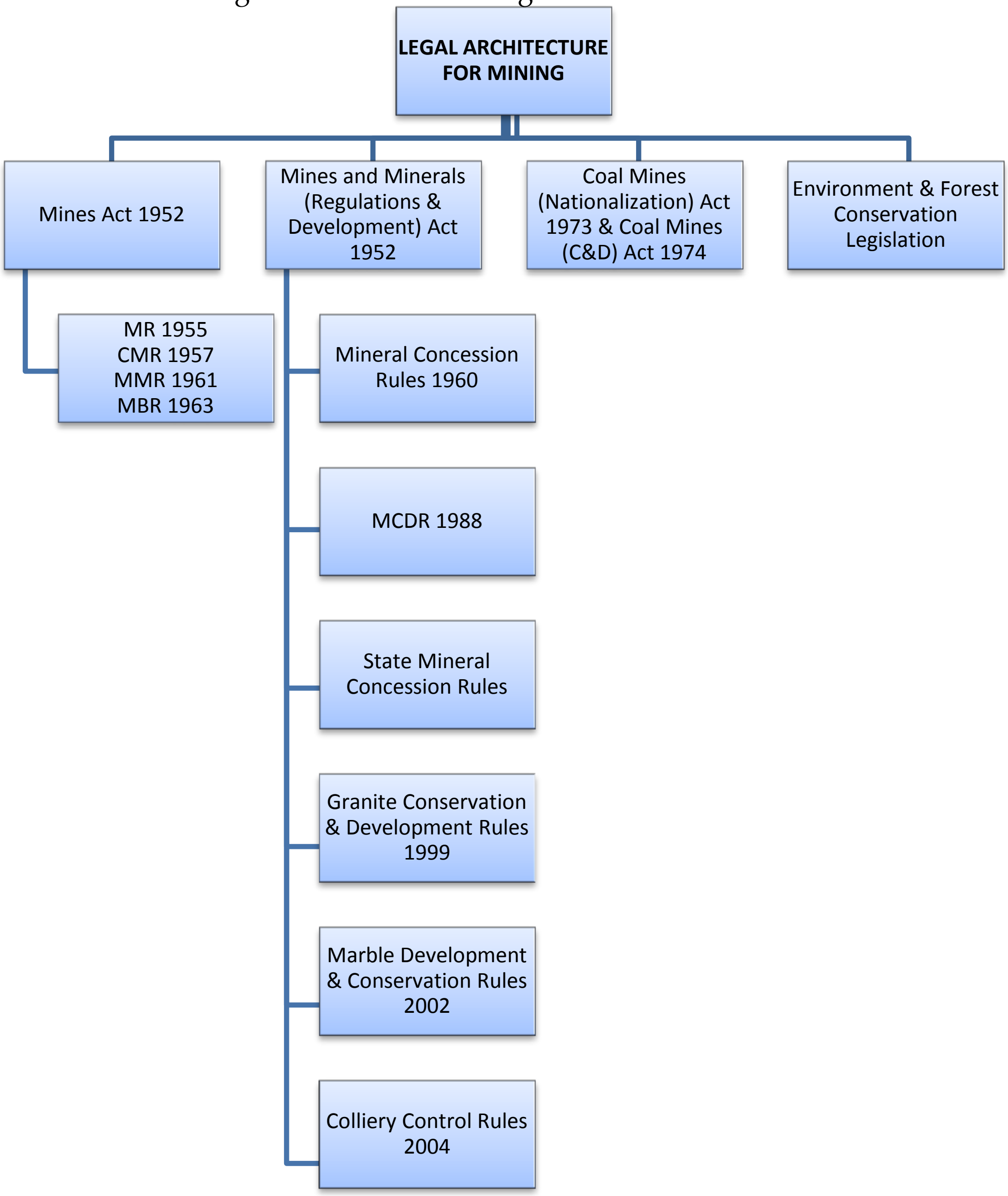


Figure 2 The legal structure for mining

2.1 Institutional Structure

2.1.1 Central level

The institutions at the centre include the Ministry of Coal (MoC), Ministry of Environment Forests and Climate Change (MoEFCC) , Ministry of Mines (MoM), and Ministry of Labour and Employment (MoL). The Ministry of Coal is involved in developing policies and plans for exploration and development of coal. These functions are administrated by the Ministry through the Public Sector Undertakings (PSUs), viz., Coal India Ltd. and its subsidiaries. The Coal Controller, the Coal Mines Provident Fund Organization and the Commissioner of Payments Office fall under the administrative jurisdiction of the MoC (MoC 2003).

The MoEFCC is in charge of legislative and regulatory measures to mitigate and control environmental pollution guided by the principle of sustainable development. The regional offices of the MoEF and Central Pollution Control Board (CPCB) complement the MoEFCC in undertaking its responsibilities. There are three subordinate offices under the department of mines, viz., Geological Survey of India, Indian Bureau of Mines and Controller of Mining Leases. The MoM is responsible for survey and exploration of all minerals, other than natural gas, petroleum and atomic minerals. It is also for administration of the Mines and Minerals (Regulation and Development), Act, 1957 in respect of all mines and minerals other than coal, natural gas, petroleum and atomic minerals. The Directorate General of Mines Safety (DGMS) which is armed within the MoL is responsible for implementing all matters pertaining to occupational safety, health and welfare of persons employed in mines. A number of other ministries which have no direct regulatory obligation on the coal sector but have a consequence on the competitiveness of the coal sector include Ministry of Railways (MoR), Ministry of Finance (MoF), Ministry of Commerce and Industry (MoCI) , Ministry of Power (MoP), Ministry of Steel (MoS) and Ministry of Surface Transportation (MoST).

2.1.2 State level

Institutions present at the state level include Department of Mining, Department of Environment, and Department of Forest and State Pollution Control Boards (SPCBs). The role of the forest department includes looking after forest clearances and compensatory afforestation while the environment department performs routine budgetary functions for SPCBs; which are responsible to enact the Water (Prevention and Control Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981 for the purpose of prevention and control of water pollution as well as control and abatement of air pollution. The SPCBs are given the task to design proactive regulatory mechanisms for environmental management and advise the state governments from time to time. The state mining department is theoretically responsible for appraising application for mineral titles, overseeing compliance with the requirements and gathering the submitted data. Other institutions include district collector (DC)/ district magistrates (DM), department responsible for issuing licenses and the department in charge of collecting royalties and taxes. The DC/ DM is vested with the executive powers of maintaining law and order in the revenue district in which the mine situated and lend assistance in the land acquisition government.

2.1.3 Local level

The municipalities and the Panchayat Raj Institutions (PRIs) at the local level have been entrusted with definite powers and functions under the legislative instruments framed by the central and state government for environmental management, however the PRIs are not able to execute their functions satisfactorily because federalization of such powers have not been complemented satisfactorily and the standing committees that are mandated to cater to matters related to natural resource management are either inactive or dormant.

2.1.4 Trade unions

Trade unions are present at an informal institutional level and are responsible for imposing restrictive conditions on the conduct of any trade or business formed mainly for the purpose of regulating the relations between workmen and employers and governed by Trade Unions Act 1926. There are five central unions in the coal industry which represent 90% of the workers in CIL (Business Standard 2013) and include Indian National Trade Union Congress (INTUC), All India Trade Union Congress (AITUC), Centre of Indian Trade Unions (CITU), Hind Mazdoor Sabha (HMS) and Bharatiya Mazdoor Sangh (BMS). A number of regional unions have political affiliations with the above unions.

2.2 Statutory clearances and land acquisition

As per the normative timeline, the coal block should commence production in 72 months from allotment date but various delays such as delay in land acquisition, environment and forest clearances, grant of mining lease, approval of mine plan and clearance of environment management plan (EMP) further add to the postponement of getting approval within the timeline. Such delays stall investment decisions and affect expansion work of existing projects. It takes 3-5 years for acquiring all the necessity forest and environmental regulatory approvals since most of the coal fields are under forest (KPMG 2013). As per CIL, in principle approval of forest clearances take as long as six years with final approvals consuming an equal amount of time (The Hindu 2011). In 2013-14 alone, around 12 million tonnes of coal was lost due to absence of regulatory clearances (The Hindu 2014). Environment clearances are the most time consuming among all statutory clearances as many departments are involved and large number of coal blocks fall under forested areas which require separate clearances. Land acquisition is also another hurdle in coal block development with the process being a fairly tedious involving 12-15 months for application approval (Issues in Coal block development in India 2009). The new land acquisition act will mandate project developers to obtain 80% consent from people whose land need to be acquired for private projects and 70% consent in the case of public-private partnership (PPP) projects (Ministry of Law and Justice 2013). This may add to the time delay in gathering and obtaining clearances but will not only ensure local level participation and also lay down the framework for inclusive growth and for social impact assessments.

2.3 Key policies around coal and sustainability

2.3.1 National Mission on Clean Coal Technologies

Under the National Action Plan for Climate Change, the government launched the Ninth National Mission on Clean Coal technologies in 2012. The missions aim is to promote work on Integrated Gasification Combined Cycle (IGCC), Advanced Ultra Supercritical technology and Carbon Capture and Sequestration (CCS) for thermal power plants including value addition among other areas. This mission will help the government to minimize coal consumption and therefore mitigate coal emissions (EIAS 2013)

2.3.2 Clean energy cess for National Clean Energy Fund

After the clean energy cess was doubled to Rs. 100 per tonne in the recent budget, the government is likely to collect Rs. 5200 crores from the industry in 2014-15 with total target in coal off-take to the tune of 520 million tonnes (MoF 2014). The MNRE, which is the nodal department for developing clean energy in the country, has only been allocated as little as over 1 per cent of the clean energy corpus of which the government has collected Rs. 40000 crores since the cess was introduced in 2010-11 and reports indicate that intended beneficiaries continue to wait for disbursement. Till date, just about Rs. 1.6 crores have been spent on clean energy projects over the past three years with a meagre amount of Rs. 57 lakhs spent on grid-connected projects since 2011 which are supposed to be a priority for the government's clean energy initiatives (The Economic Times 2014a).

3. Sustainability initiatives in the coal sector

3.1 Mining and processing

3.1.1 Controlling air pollution

Suspended particulate matter (SPM)

Particulate matter having a diameter of less than 100 microns are called SPMs. SPMs reduce visibility producing a hazy atmosphere and affects the biotic population directly or indirectly. In accordance to the notification issued by Central Pollution Control Board (CPCB) mentioned under the Environment protection rules 1986 (Ministry of Environment and Forests 1986), the norms for industrial SPM on a 24 hourly basis is 600 micrograms per cubic metre ($\mu g/m^3$) in case of existing coal fields/ mines. For Coal mines located in the coal fields of Jharia, Bokaro and Raniganj the norm is 700 $\mu g/m^3$ whereas the norm for new coal mines for concentration of SPM in ambient air is 500 $\mu g/m^3$ on a 24 hourly basis. As per the audit (CAG 2010) with respect to air quality data for 3 CIL subsidiaries, it was observed that SPM level was within norms in BCCL and ECL during the years 2008-09 and 2009-10. However, in CCL, there were 34 instances where the SPM exceeded the norm 2008-09 and 20 cases during 2009-10.

Respirable Particulate matter (RPM)

Dust particulates having a diameter of less than 10 microns and can be inhaled and enter respiratory tract of humans are termed as RPM. Diseases associated with RPM include asthma, pneumoconiosis, bronchitis, allergic disorders etc. As per the notification by CPCB, (Ministry of Environment and Forests 1986) the norms for industrial RPM on a 24 hourly basis is 300µg/ m3 for both existing as well as old coal fields/ mines whereas it is 250 µg/ m3 for new coal mines. As per the CAG audit, (CAG 2010) it was observed that RPM levels was within the norms for BCCL and ECL during 2008-09 and 2009-10 whereas in the case of CCL, it was reported that there were 34 cases where RPM levels exceeded the norms in 2008-09 and 15 cases in 2009-10.

Dust suppression measures

Indian coal is known to be of drift origin (Singh 1997) and have a high ash content of 45% (ICC 2012) which requires further beneficiation of the raw coal. Coal washing enhances the calorific value and separates the useful combustible material from the non-combustible material (METSO 2013). The entire process which involves crushing of raw coal, coal washing handling and transportation etc generate a substantial amount of dust and gaseous pollutants and thus require mitigation techniques to suppress the dust especially at dust generating points which include the screening plant, receiving hopper of feeder breaker, truck loading hopper, ground stocks, haul and transportation as well as road and railways sidings. The existing dust suppression systems in thermal power stations across India is the use of a wet dust suppression system where wetting agents are added to the water so as to improve the rate at which spray droplets wet the dust particles. The 2002 MoEF mandate that requires coal shipped more than 1,000 kilometres (revised to 500 in 2012) from the mine should be washed and have less than 34% ash is a move in the right direction (World Bank 2008).

The CAG (CAG 2010) evaluated the adequacy of dust suppression measures at railway sidings undertaken by four subsidiaries, viz., BCCL, CCL, NCL and MCL. Wet suppression measures such as water spraying arrangements were absent or inadequate at all railway sidings of BCCL and in Sonpur Bazari and Mugma railway sidings of ECL. This was also observed at Talcher, Bharatpur, Belpahar and Lakhanpur railway sidings of MCL. However, railway sidings at NCL were well equipped with rapid loading system with inbuilt silo therefor ensuring minimal dust generation during loading of coal. Other wet suppression measures such as sprinklers and water tankers were found to be inadequate at feeder breakers, truck loading points, haul and transportation roads at Block II of BCCL, Urimari of CCL and Lajkura of MCL.

The CIL management have indicated that Block II of BCCL will be further supplemented with mobile tankers so as to minimize air pollution in haul roads and coal transportation roads and dust suppression measures are being reinforced for railway sidings at BCCL and proposed at ECL. Action for adequate dust suppression arrangements have been initiated at three other railway sidings at MCL.

3.1.2 Effluent and sewage treatment plant

Effluent Discharge

The norms prescribed by CPCB for maintaining quality of water for re-use is indicated below in Table 1, (Ministry of Environment and Forests 1986)

Table 0 Parameters and standards for water quality

Parameters and standards	**Standard-concentration in milligram/litre (mg/ltr) except pH (not to exceed)**
pH	5.5 to 9.0
Total suspended solids	100
Oil and grease	10
Nitrate Nitrogen	10
COD	250

Source: CPCB (2011)

As per an audit undertaken by CAG in 2010 (CAG 2010) for three CIL subsidiaries (CCL, ECL and BCCL), it was observed that the effluent discharge levels in the case of water quality were within the prescribed norms for ECL and BCCL while CCL had exceeded the norms for both Suspended solids and chemical oxygen demand (COD).

Effluent and sewage treatment plant

This measure is relevant to open cast mines. As per the notification by the MoEF (Ministry of Environment and Forests 2003), effluent treatment plants (ETPs) should be installed so as to treat the discharged water from industrial waste. The CPCB have also prepared guidelines for water quality management (CPCB 2008) including maintenance of sewage treatment plants (STPs) so as to minimize the degradation of water quality. The ETPs and STPs should include proper oil and grease traps (OGTs) to contain the oil and grease from the effluents. It was noted in the CAG audit (CAG 2010) that two[1] out of the sample of 18 open cast (OC) mines did not have ETPs while four[2] of the OC mines did not have STPs.

OGTs were absent in two[3] mines while two[4] other mines did not have adequate capacity to contain the used oil and grease from the discharge. On the other hand, all the 10 OC mines at NCL were equipped with ETPs and STPs.

The CIL management had indicated that action has been commenced for the installation of OGTs in all major OC projects wherever it is non-existent. Two settling tanks are proposed to be installed at Jamuna OC mine while Jarangdih mine is on the verge of closure.

[1] Jarangdih (CCL) and Ghanoodih (BCCL)
[2] Urimari and Jarangdih (CCL), Lajkura (MCL) and Block II (BCCL)
[3] Jamuna (ECL), Jarangdih (CCL)
[4] Samaleshwari and Lajkura (MCL)

Acid mine drainage (AMD)

When pyrites which is commonly present in coal deposits and overburden (OB) material are weathered and leached hence causing Acid Mine Drainage. It is a function of the geology, hydrology and mining technology employed at the mine site (Acid Mine Drainage: An overview of indian Mining Industry 2011). The characteristics of AMD include low pH value with sulphate rich water, presence of toxic metals and metalloids and high amounts of acidity. This causes a lot of environmental problems ranging from water contamination and unfit for desired uses (The impact of acid mine drainage on the stream ecosystem in Pennsylvania 2002) (Acid drainage from mines 1995), disrupted growth and death of flora and fauna (Negative pH. Efflorescent mineralogy, and consequences for environmental restoration at Iron Mountain Superfund site, California 1999) including that of indigenous populations and resulting in reduced biodiversity (Acid Mine Drainage(AMD): Causes, treatment and case studies 2006). For instance, the Damodar River has become one of the most polluted rivers in India on account of intensive coal mining in the coal mining belt (Environmental Pollution from Coal Mining Activities in Damodar River Basin, India 1994).

There were few mines where such instances were noticed by CIL management as per the audit. The planning and design arm of CIL, CMPDIL has undertaken an R&D study for bio-treatment in one of the selected areas of WCL. The audit recommended that CIL and its subsidiaries undertake measures to abate the issue of AMD and to continuously work towards keeping the effluent levels in check so as to avoid any environmental problems arising from AMD. Legislation with regard to addressing such issues have been raised by the MoEF (Fennel, et al. 2006) and they have also started to disallow projects for new coal fields on account of the environmental impact including but not restricted to water pollution and deforestation. Such measures however have not met their desired results on account of feeble implementation of laws and regulations (EIAS 2013).

3.1.3 Disposal of slurry and rejects

The contaminated processed fluid that is generated during the process of coal washing which consists of solid and liquid wastes is known as coal slurry. It contains elevated levels of chlorides, sulphates, arsenic, lead, mercury, and selenium. They are dumped in slurry ponds usually near the washeries. Over stock piling of slurry is detrimental to the environment and pollute land and water near the washeries especially during the rainy season. As against the norms of one to three months' prescribed by the CPCB, the audit (CAG 2010)found that the stock of slurry and rejects as on 31st March, 2010 was equivalent to 95.04 months and 85.07 months of production respectively at BCCL and CCL. In a sample of four washeries, it was found that stock of slurry as on 31st March, 2010 for Kathara washery of CCL was more than 122.19 months production while Nandan washery of CCL lacked any identified location for disposal of rejects. CIL management have indicated that action has been taken for disposal of existing stock of slurry and rejects.

India accounts for the world's largest concentration of coal fires with the coal fields of Jharia, Raniganj and Singareni converted into wastelands due to rising surface temperatures and increase in toxic by-products in soil, groundwater and air (Krajick 2005) (Greenpeace 2008). Spontaneous coal fires during the summers not only causes air pollution but also spread to nearby regions destroying floral and faunal habitat (Coal fires burning around the world:

Opportunity for innovative and interdisciplinary research 2007) and severe health and environment impacts (Health Impacts of Coal: Facts and Fallacies 2007). A paper (Coal Fires burning out of control around the world: Thermodynamic recipe for environmental catastrophe 2004) listed major coal fires from around the world caused by spontaneous combustion, viz., Xinjiang coal field in Northern China, Rujigou coalfield in Ningxia, China including that of Jharia Coalfield in Jharkhand in India.

3.1.4 Mine closure

The MoC had prepared guidelines for preparation of mine closure plan which stated that all coal and lignite mining operations both new and existing should incorporate the progressive and final mine closure plans (MCPs) in the mining plan/ project report and subsequently approved. These guidelines take effect from 27th August, 2009 and with mine owners yet to comply with the guidelines, the government intends to penalise mine owners who do not obtain the approval of the MCP within a period of 1 year from the date in effect. (MoC 2013). Mine closure preparations was found to be absent as per the audit (CAG 2010). CMPDIL reported that during 2010-11, MCPs for 26 mines have been prepared and sent to the subsidiaries while MCPs for 69 mines are under preparation (CAG 2010).

3.1.5 Fly ash utilization

Large quantities of ash are generated by thermal power stations and with the strong dependence on coal for generating electricity, the quantum of thermal power generation will increase which will result in larger production of fly ash. Indian coal has a high ash content of 35 –50% with a low calorific value of 3,000 – 4,000 kcal/kg. Fly ash disposal and handling is one primary concern faced by thermal power plants. The annual generation of fly ash has increased from 1 million tons in 1947 to about 69 million tons during 1996-97 and to about 131 in 2010-11 million tons (CEA 2011). As per an estimate of Fly Ash Utilization Program (FAUP) and Technology Information Forecasting and Assessment Council (TIFAC, India) the annual fly ash generation figures are expected to reach about 225 million tons by 2017 (Kumar, et al. 2005).

The MoEF notification issued on September, 1999 and subsequently amended in August 2003 and November 2009 has made it mandatory that fly ash and fly ash based building products be utilised in all construction projects including but not restricted to roads, flyover embankment and reclamation of low lying areas within a 100 km radius of a thermal power plant (TPP) (Ministry of Environment and Forests 2008). The government has also made it mandatory that fly ash be used for back filling of underground and open cast mines which are within 50 kms of a TPP. This is a healthy move by the government which is a step in the right direction. The usage of fly ash in cement and brick manufacturing as well as part substitution of cement in concrete/ mortar can help in preventing the generation of carbon dioxide by 25 million tonne, good quality lime by 35 million tonne and coal by 15 million tonne a year. Fly ash utilisation also helps in reducing degradation of top soil which is used during brick manufacturing as well as construction of roads embankments. Such utilisation including reclamation of low lying areas and mine filling etc. can conserve 20 million cubic metres soil per year (Kumar, et al. 2005). The percentage of fly ash utilization has increased steadily from 10% in 1996-97, 23% in 2002-03 to 56% in 2010-11 (CEA 2011)(Annexure 1). Fly ash utilization recorded 58.48% during 2011-12 and 61.37% in 2012-13 (Coal Insights Bureau 2014), thus showing an upward trend as indicated in figure 3 below.

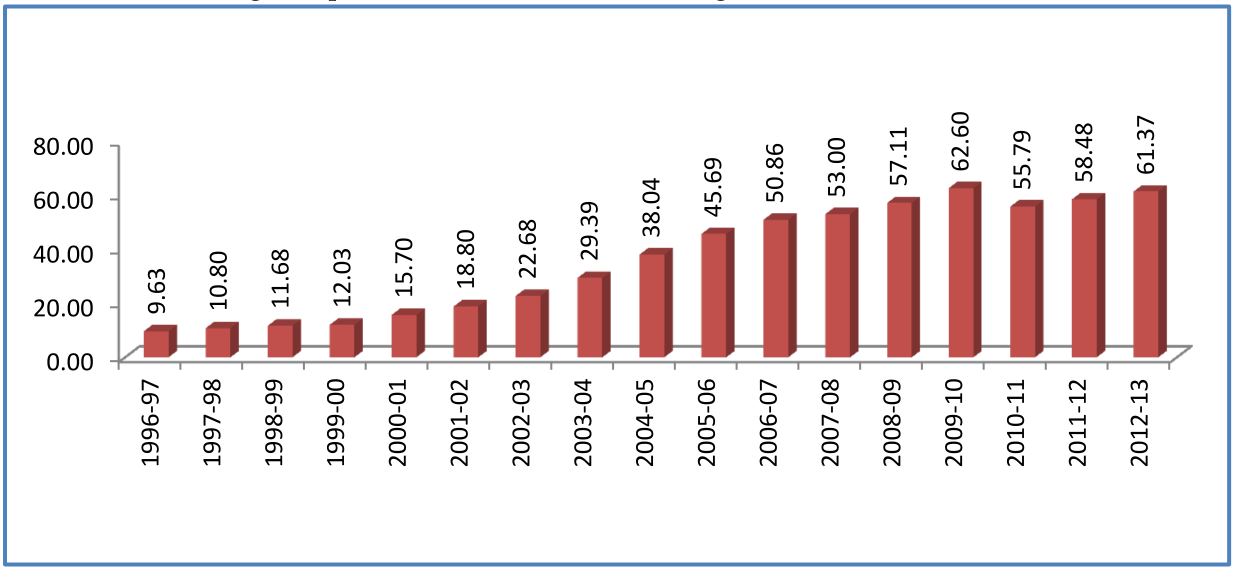


Figure 3 Fly ash utilization (in percentage)

Source: CEA 2013

3.2 Reclamation of land

3.2.1 Backfilling and technical reclamation of land

The mining of coal produces large amount of refuse material. This waste is generated at the time of extraction, beneficiation and processing of minerals. During extraction, large volumes of debris and other wastes are generated and greater the scale of mining, greater is the amount of waste generated. As compared to underground mining, open cast mining is much more pollution intensive and generates waste of around 8-10 times in quantum as compared to underground mines (Waste management in mining industry 2013). Reclamation of land will help in restoring the land to an acceptable state and make it productive for agricultural or forestry purposes etc. In brief, land reclamation involves backfilling, technical reclamation and biological reclamation. Technical reclamation involves back filling of excavated area with over burden in systematic manner by using bull dozers etc.

As on 31st March, 2010 the total land to be reclaimed in all the seven subsidiaries of CIL was 12643 hectares (CAG 2010). Table 1.2 below indicates the backlog in reclamation for all 7 subsidiaries as on 31st March, 2010 and 31st March, 2009. It can be observed that backlog for five subsidiaries, namely, ECL, SECL, MCL, BCCL and WCL had increased while a decline was observed in two subsidiaries, namely, NCL and CCL with the highest decline being CCL.

CMPDI had recently undertaken a study and it observed that other than NCL, all the other six subsidiaries have displayed an increased record for land reclamation practices for 2012 to 2013. In terms of total area under reclamation, NCL stands at the top for all the three years under observation (Annexure II) with a total reclaimed area of 87.28 sq. km which is way higher than the figure for SECL at 66.96 sq. km. The total land reclaimed overall by CIL has increased from 268.20 sq. kms in 2012-13 to 272.73 sq. kms in 2013-14 as indicated in Annexure II (CMPDI 2014). Figure 4 and Figure 5 indicates the total excavated area vis-à-vis the total area under reclamation by the seven subsidiaries for the years 2012 and 2013 respectively.

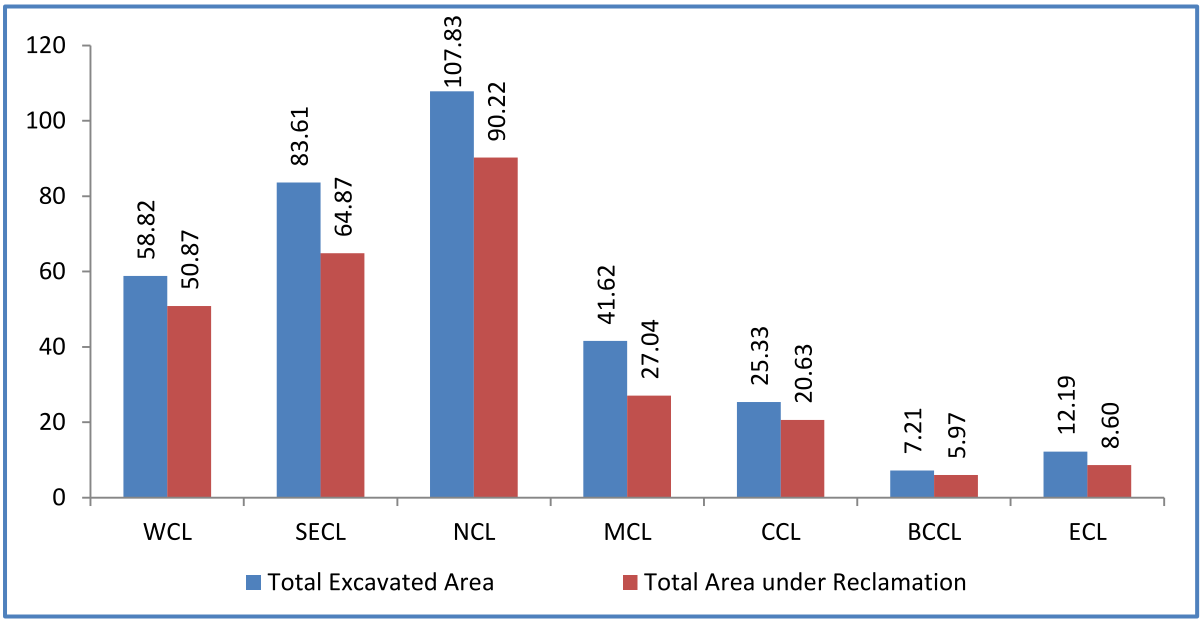


Figure 4 Excavated area versus reclaimed area of CIL subsidiaries for 2012 (km^2)

Source: CMPDI, 2014

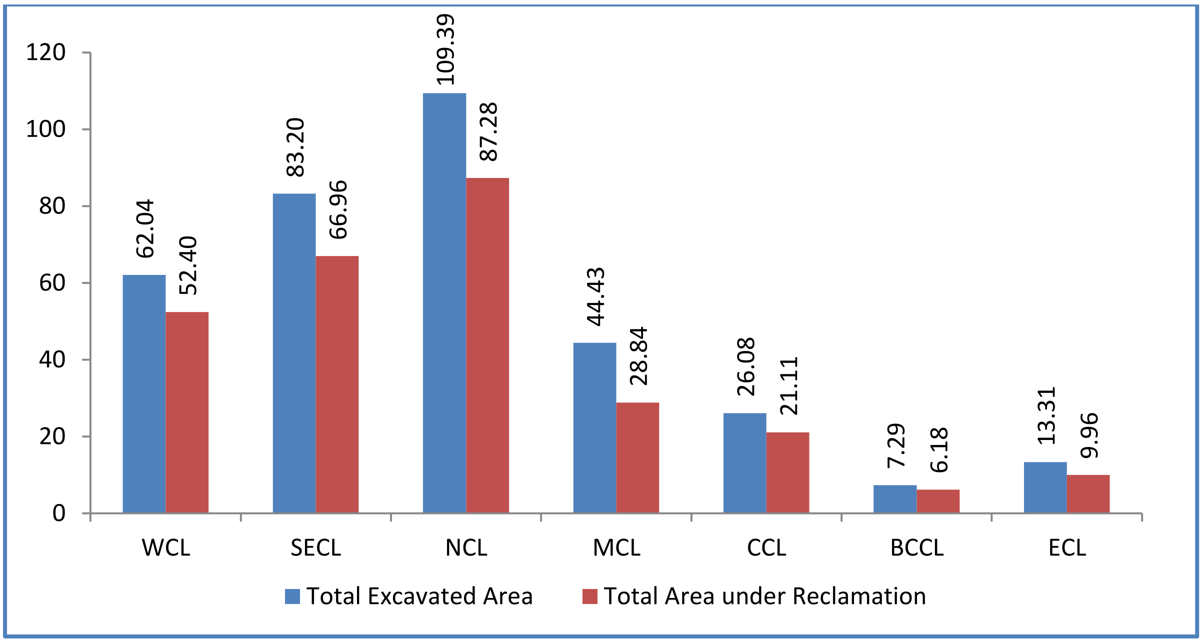


Figure 5 Excavated area versus reclaimed area of CIL subsidiaries for 2013 (km^2)

Source: CMPDI, 2014

3.2.2 Biological Reclamation of land

Post physical reclamation of land, further steps are undertaken to restore the natural flora and fauna of the land such as top soil preservation, selection of plant species for plantation which improve the moisture content, bulk density, pH and overall nutrient contents of soils and maintenance of nursery etc.

The topsoil is very significant as most of the biological activity occurs and given the importance, the MoEF has stipulated stacking earmarked sites of top soil to be used for reclamation and rehabilitation measures of mined out and void areas. As per an audit conducted by CAG (CAG 2010), from a sample of 18 open cast coal mines, it was observed that top soil was preserved separately in five open cast mines[5] whereas the management claimed that the topsoil that was removed was used for biological reclamation in parallel for the remaining 13 open cast mines[6]. Table 2 below iterates the status of land reclamation across CIL subsidiaries.

Tree plantation helps in preserving the environment and is very crucial in the process of biological reclamation of land. This task as well as protection of trees is provided for the first three years by the respective state forest departments for which payments are made by the coal subsidiary concerned. 131.48 lakh trees were planted by the subsidiaries during the year 2004-05 to 2009-10 and incurred an expenditure of INR 72.76 crore (CAG 2010). There has been a fall in plantation area in 2013-14 at 163.19 sq. km from 167.71 sq. km in 2012-13 whereas the area under backfilling has increased from 100.49 sq. km in 2012-13 to 109.54 sq. km for all the 7 coal subsidiaries (CMPDI 2014) (Annexure II).

It can be observed that BCCL has an impressive record in terms of land area under reclamation as a per cent of total excavated area scoring the highest at 84.77% in 2013 (Annexure II). The company laid emphasis on "complete ecological restoration" which includes 3 tier plantation as well as preservation of bio-diversity and have tied up with Forest Research Institute (FRI), Dehradun and Delhi University (DU) for its pilot projects in Jharkhand (Coal Insights Bureau 2014).

Table 2 Status of land reclamation

Name of the company	Progressive land to be reclaimed as on 31.03.10 (Ha)	Progressive land to be reclaimed as on 31.03.09 (Ha)	Increase / decrease (-) in backlog in reclamation (Ha)
MCL	2129.36	2019.08	110.28
CCL	235	2442.38	(-) 2207.38
BCCL	930.76	812.39	118.37
SECL	1367.72	1357.81	9.91
NCL	2687	2910.88	(-) 223.88
ECL	743.19	738.22	4.97
WCL	4549.97	3507.97	1042
Total	12643	13788.73	(-) 1145.73

Source: CPCB, 2011

[5] Ghanoodih (BCCL), Rajmahal (ECL, Sonepur Bazari (ECL), Chhal (SECL) and Piperwar (CCL)

[6] Jagannath, Lajkura and Samaleshwari (MCL), Amlahri and Nigahi (NCL), Jamuna and Gevra (SECL), Ghorawari and Umrer (WCL), Urimari and Jarangdi (CCI), Block II (BCCL) and Rajpura (ECL)

The following are pictures (photo 1 & 2) of a pilot restoration site taken by the TERI team at the Tetulmari Colliery of BCCL in Dhanbad. As mentioned earlier, the company has undertaken a '3-tier' plantation that helps in restoration of biodiversity in this particular overburden.

Photo 1: Ecological Restoration site at Tetulmari colliery in Dhanbad, Jharkhand under BCCL
Photo credits: Swati D'Souza

Photo 2: 3-Tier restoration site at Tetulmari colliery in Dhanbad, Jharkhand under BCCL
Photo credits: Jonathan Donald Syiemlieh

3.3 Coal use in power sector

Sub-critical pulverises coal power plants

Presently, sub-critical pulverised coal (PC) combustion power plants form the backbone of the Indian power sector. As the name suggests, coal is pulverized into fine powder and burnt to heat water in boilers. This water then gets converted into high pressure steam which drives electrical generators. Subcritical thermal power plants (TPPs) operate at steam temperature of 538 ^{0}C and steam pressure of 170 kg per square cm. Bharat Heavy Electricals Limited provides India's total power generating utility sets.

The best subcritical plants in India equipped with 500 megawatt (MW) subcritical units operate with a net efficiency of 38%. The high ash content (40-50%) and high moisture content (4-20%) in Indian coal hinders the efficiency of the power plants as it requires additional coal to generate amount of electricity (Chikkatur, et al. 2009) recently coal-based power plants use a variety of technology to remove chemical impurities prior, during and after combustion. Technologies such as chemical washing of coal to remove impurities and minerals before combustion, scrubber technology to filer exhaust air into smoke stacks, flue-gas separation are already in operation (EIAS 2013).

But it is transparent that clean coal technology is still at a nascent stage in India. Besides renovating and modernising existing PC-based power plants, it is obvious that Indian power plants will need to explore other feasible and effective innovations and technologies.

With the intention to encourage clean thermal electricity generation, the budget has allocated Rs. 100 crores for developing "Ultra-Modern Super Critical Coal Based Thermal Power Technology" (Ministry of Finance, Government of India 2014). Another move to attract investors is the 10-year tax holiday to projects that start operations by 31 March 2017 (MoF 2014). Box 2 below indicates a green initiative by a subsidiary of Tata power Company

Box 2: Green initiative by Tata Power Company subsidiary

A subsidiary of Tata Power Company, Coastal Gujarat Power Ltd (CGPL) that operates India's first ultra-mega power project (UMPP) at Mundra, has begun using a blend of almost 20 different varieties of coal in order to keep costs down without jeopardizing efficiency of plant operations for the five states it signed PPAs with till the tariff issue is settled by the court. In comparison to any other subcritical power plant in India, this venture saves 1.7 million tonnes of coal per year, hence averting carbon emissions of almost 4 million tonnes annually. The greenhouse gas emissions per kilowatt hour of energy generated will be about 750 gm of carbon dioxide per kWh, as compared to India's national average of 1,259 gm CO2/ kWh for coal-based power plants. The choice of imported coal significantly lowers sulphur emissions. The plant will use significantly less than the stipulated 1% sulphur and 10% ash content in coal. It also generates 2.6% of the nation's power requirement with its end tariff being under Rs 3 a unit (dna 2014).

Supercritical plant technology

Supercritical units operate at a higher temperature as compared to subcritical units. This leads to higher efficiency of about 42% with lower carbon emissions. Supercritical units operate at a turbine throttle pressure of 242 bar and main steam and reheat steam temperatures of 565^0 C and 593^0 C respectively (Power Line 2013). This not only results in fuel savings of up to 5% but also includes other benefits like reduced carbon emissions, lower operating costs and greater operational flexibility. Table 3 highlights the key differences between subcritical and supercritical TPPs.

Table 3 Comparison of Subcritical and Supercritical TPPs

Input Parameters	Unit	Subcritical TPP	Supercritical TPP
Steam Pressure	Megapascal (MPa)	16.7	24.1
Steam Temperature	Degree Celsius	538/ 538	565/ 593
Plant Configuration	Unit x Rating	4x500	3x660
Plant Capacity	MW	2000	1980
EPC cost per MW	Rs million	40	46
O&M Cost	Rs million per MW	1.46	1.34
Land Required	Acres per MW	0.80	0.65

Source*:* Power Line (2013)

In the Twelfth Five-Year Plan, the Planning Commission has stated that that there will be a capacity addition of 88 GW of which coal-based capacity is about 69 GW. Of this it expects about 50% of the coal-based capacity is expected to be based on supercritical technology. (Planning Commission 2013). Adani Group's Mundra power plant in Gujarat was India's first supercritical plant. The first unit of the 2x660 MW project was synchronized in December 2010 while the second one reached the same milestone in early June 2011. Other units include a 3x660 MW unit at Sipat by NTPC, the Mundra UMPP by Tata power, the Barh plant (Stage-II) among others. Currently about 11 units with a capacity of 7400 MW have been installed and twelve more Ultra Mega Power Projects (UMPPs) are in process of being commissioned. Box 3 gives a brief idea about China's foray into super critical technologies.

Box 3: Supercritical technology in China

China began using supercritical technology only in 1990s following the procurement of 10 units from Russia. The first plant utilizing western technology was the Shi Dong Kou, commissioned in 1992 and consisting of 2X600 MW units with 5650C steam conditions. The second plant utilizing western technology was the Waigaoqiao plant in Shanghai (next to the Shi Dong Kou), which consists of two 900 MW units with steam conditions 5650C (Tavoulareas 2008). Since then, Chinese manufacturers like Shanghai Boiler Works, Harbin Boiler Group among others have teamed up with international players like Alstom, Siemens and Hitachi via joint ventures (JVs) or licencing agreements to manufacture majority of the equipment required the supercritical technology in China itself. By the end of 2010, about 27 supercritical units were in operation in China representing a total of 37.8 GW. From 2010 to 2020, new power plants with unit capacities of 600 MW and more will all be required to be supercritical and about half of the newly built power generating units will be ultra-supercritical. Consequently, supercritical units will account over 30% by 2020 ((Horbach, et al. n.d.). This offers a valuable lesson for India which now faces a situation similar to what China faced prior to 1990s.

Ultra-supercritical Technology (USC)

Ultra-supercritical boilers operate at a pressure and temperature of over 250 kg per square cm and 600 ^{0}C respectively. Research and development for this technology is already underway and is being jointly undertaken by NTPC, BHEL, and Indira Gandhi Centre for Atomic Research (Power Line 2013). An early milestone has already been crossed in this field with BHEL submitting a project design memorandum for an 800MW pilot project based on this technology to the government in April last year. Funded by the government's National Mission for Technology (an initiative to research into clean coal technologies), this project could well be over 600 crores INR and is expected to be completed in 2018 (Hindu BusinessLine 2013). Box 4 below gives an idea about Japan and Germany's entry in Ultra-super critical technologies.

Box 4: Ultra-supercritical technology in Japan and Germany

Japan and Germany continue to lead the charge in ultra-supercritical technology. The technology movement in both the countries was led by the government's commitment to advance state-of-the-art pulverized coal technology. The government supported both power plant manufacturers as well as power generation companies with funding to carry out research. The initial high cost was absorbed by consumers through tariff adjustment. Japan continues to design newer power plants with higher steam conditions. Japanese power plant major the J-Power Group constructed Japan's first USC facility in 1997 at Matsuura Thermal power plant. The Isogo Thermal power plant constructed in 2002 has the highest efficiency with steam temperature of 610^{0}C (J-Power Group 2012). Moreover, the company is also heading a consortium to build Asia's largest IPP project (1 GWx2) on the island of Java in Indonesia.

Integrated Gasification Combined Cycle (IGCC)

This is a means of using coal and steam to produce a high-energy gas (synthetic gas or syngas) which is comprised of carbon monoxide and hydrogen. This syngas is then burned in a gas turbine and the steam produced from heat exchanger (used to cool the syngas) is used to power a secondary steam turbine which produces electricity (Chikkatur, et al. 2007). India has some experience in IGCC since BHEL has conducted preliminary work in this technology. To date, one small IGCC plant operates in India – a 52 MW unit operates as part of the Sanghi cement plant (EIAS 2013). Meanwhile, BHEL and APGENCO, the power generating company of Andhra Pradesh are in the process of setting up a 125 MW demonstration IGCC plant in Andhra Pradesh (TERI 2013). The advantages of using this technology include increased efficiency from the combined cycle, lower costs for the clean-up technology, greater ease of capturing carbon and decreasing emissions. However, there are numerous difficulties which have to be navigated before this technology can be used on a wider scale. Primarily among the disadvantages is the high degree of complexity for using this technology. IGCC is more like a chemical plant than a power plant. Moreover, it also demands higher capital costs and lacks the technological maturity that is present in other clean coal technologies; therefore it is perceived as having higher risk. The most recent cost estimates published by the Department of Energy in the US were in mid-2007. Their capital-cost estimates for a 750 MW plant using bituminous coal are listed below:

Table 4 Different kind of technologies and its associated capital cost estimates

Technology	Capital cost estimates/kW
Subcritical	$1,548/ kW
Supercritical	$1,574/ kW
IGCC	$1,841/ kW

Source: http://www.moef.nic.in/downloads/public-information/LCGIndiaCCTjune2008.pdf

However, this technology is nonetheless one of the cheapest options for carbon capture and its development can eventually lead to deployment of pre-combustion capture technology in the power sector.

Underground coal gasification (UCG)

This technology is still in the early stages of development. This method refers to a gasifying coal seam in-situ under controlled combustion and then extract the products usually syngas, containing hydrogen, carbon monoxide and methane. This method requires less land and therefore can be used to extract energy from deep and isolated beds in India. Moreover, the government has also addressed the regulatory hurdles in the space. The Ministry of Coal issued a Gazette Notification in July 2009 which specified that production of syngas obtained through gasification (underground and surface) has been notified as an end use under the Captive Coal Mining Policy (Singh, et al. 2012) (Ministry of Coal 2009). Seven blocks (five in lignite and two in coal) have been identified by the Central Mine Planning and Design Institute (CMPDI) as suitable for commercial development of UCG. UCG can especially be used for coal deposits found beyond 300m in depth. However, there are several risks such as contamination of ground water, inconsistent supply of syngas as well as lack of control when it comes to underground combustion associated with this technology.

Circulating Fluidised-bed Combustion (CFBC)

Fluidised-bed combustion burns coal in a bed of ash and limestone particles which are suspended in flowing air. The two types of fluidized bed designs are bubbling and circulating. Circulating fluidized bed (CFB) is more common for power generation especially in plants larger than 100 MW. This technology is particularly suitable for high-ash fuels such as lignite, brown coals and Indian coals. Moreover, if sulphur dioxide regulations are implemented in the future, CFBC technology will become all the more rampant and should be taken into consideration when building new plants. Most CFBs though are designed for subcritical steam conditions. There are reported to be more than 36 CFB units in operation in India representing 1200 MW of installed capacity, most of them are relatively small with the largest unit being 136 MW (Tavoulareas 2008).

Carbon Capture and Use (CCU)

This particular technology has been a subject of intense global debate. It aims to reduce carbon dioxide emissions from fossil fuels by capturing it and transporting it to storage sites. The IEA believes that this technology will contribute significantly when it comes to decreasing emissions by 50-85% by 2050 (Viebahn, et al. 2013). Commercial availability of this technology before 2030 though seems improbable for India especially since its commercial viability has not yet been proved. But this does not mean that there is no ongoing activity in this field. Most R&D work in the field takes place under the Department of Science & Technology. Several small projects are taking place such as the National Aluminium's (NALCO) plans to set up a carbon capture unit at its coal-fired at Angul in Orissa. Even NTPC has been conducting research along with National Geophysical Research Laboratory India (NGRI) to evaluate the Deccan basalt formation as a potential long-term CO_2 storage option (TERI 2013). But India is extremely cautious on the commercialisation of this technology. One of the biggest barriers is the resulting increase in electricity costs with a net reduction in power output by implementing this technology. Moreover, lack of accurate geological storage site data also makes it unfeasible currently. Enhanced Oil Recovery (EOR) is one of the most attractive options for CO_2 storage, but few fields in India are sufficiently depleted that oil can be recovered from them using this procedure.

3.4 Others

3.4.1 Increase number of coal washeries

With the Indian coal being of drift origin which includes a mix of mineral matter along with the coal and therefore consisting high ash content. The coal ash distribution in the ores is highly interwoven and hence requires crushing so as to remove coal and ash particles. The clean coal technology adopted by coal washeries in the country looks at coal cleaning by the removal of ash from coal so as to undertake coal beneficiation. The MoEF issued a notification in 1997, which mandated the use of beneficiated coal with ash content not exceeding 34% for power plants located beyond 1000 kms from pit heads and plants located in critically polluted regions (MoEF 2010). Therefore with this in mind CIL has been asked to increase proportion of washed and crushed coal to take care of quality issues and reduce ash quantity and make it globally competitive. With this in mind, CIL plans to install 16 washeries in Chhattisgarh, Odisha, West Bengal and Jharkhand with a total capacity of 92 million tonnes per year (See Annexure III). CIL has 17 washeries of 39.40 million tonnes per annum (MTPA), (Coal India Limited 2013-14) (The Economic Times 2014b) out of which 12 are coking coal washeries with capacity of 22.18 MTPA (FICCI 2013). The yield from these washeries has reduced and performance is not satisfactory as they are very old. CIL has also been rationalizing coal linkages to minimize the transport cost of coal from mines to the consumer which has also been announced in the budget (MoF 2014).

3.4.2 Transportation and Use

More than 50% of the coal produced in India is transported by railways alone with 45% of the overall freight of the railways attributed to coal alone (FICCI 2013). A study indicated that up to 70% of the delivered cost of coal accounted for from coal transportation (World Coal Institute 2009) The 12th plan working group foresees a production target of 715MT towards the end of 2016-17 with the share of rail infrastructure for coal movement envisaged to increase to 58% by the end of the twelfth five year plan (Ministry of Coal, Government of India 2011) and the railways plan to commission three new major railway lines by 2017 in Jharkhand, Odisha and Chhattisgarh to transport coal from existing and planned mines of CIL (Reuters 2013). Albeit flexibility in coal transport via roadways, rising maintenance and labour costs make it unfeasible and expensive. Therefore CIL primarily utilise trucks for coal transport from pitheads to railheads nearby (The Hindu Business Line 2012a). Emissions from large haul trucks also create an unfavourable carbon footprint (Lieberworth 2012). A study on the emissions from the Indian transport sector in 2009 concluded that shipping accounted for the smallest amount of CO2 and CO emissions, followed by railways, aviation and road transport (Emissions from India’s transport sector: Statewise synthesis 2009). Some of the green initiatives undertaken to mitigate the issues associated with logistics of coal are mentioned below:

Rationalization of coal linkages

An Inter-Ministerial Task Force (IMTF) was formed by the MoC on 25th June, 2010 in order to evaluate the existing sources and consider feasibility for rationalization of linkages from these sources with a view to reduce the transportation cost for power utilities, cement, steel & sponge iron sector. Some of the major recommendations include rationalization of coal supplies for Sanjay Gandhi and Satpura Thermal Power Plant of Madhya Pradesh Power Generation Company Limited (MPPGCL). Rationalization of sources for Panipat and Rajiv Gandhi Thermal Power Station of Haryana Power Generation Company Limited, Mejia and Koderma Thermal power Stations of Damodar Valley Corporation and Santhaldih, Kolaghat, Sagardighi and Bakreshwar Thermal Power Stations of West Bengal Power Development Corporation Limited was also undertaken.

The IMTF also endorsed a reduction in quantity allocated to Gujarat State Electricity Corporation Limited (GSECL) from Korea Rewa fields of C/D grade coal and proportionate increase in Korba fields of South Eastern Coalfields Limited (SECL) by swapping quantities of MPPGCL. A reduction in coal allocation from Mahanadi Coalfields Limited (MCL) and enhancement in coal allocation from Eastern Coalfields Limited (ECL) for the power plants of Tamil Nadu Electricity Board was also recommended among other recommendations. In order to undertake the optimization exercise again, the MoC constituted a new IMTF in June, 2014 to review rationalization of coal linkages (PIB 2014).

As per a study, efficient linkage rationalization will enhance sub-optimal allocation of coal and help save transport cost. This can help in reducing GHG emissions with lesser fuel being consumed to operate the railways and shipping. Taking into account the information of current movement of both domestic and imported coal, linkage rationalization will lead to savings of 66,894 million tonne per km of transport which indicates savings of about INR 5,817 crores in 2010 (KPMG 2010). With the requirement of imported coal as well as rise in freight rates, the significance of linkage rationalisation is expected to intensify going forward. The success of it is however dependent on efficacious implementation of pooled pricing mechanism otherwise imported coal price cannot be absorbed by coastal power plants.

Construction of railway links

In order to better the availability of coal by about 300 million tonnes, the union budget had proposed to speed up the construction of three critical railway links of Tori-Shivpur-Kathautia, Jharsuguda-Barpalli-Sardega and Bhupdeopur-Raigarh-Mand. However only a small fraction of the total 590 km will be completed by 2016 and officials say it will take at least five years to complete the remaining projects owing to delay in environmental clearances leading to time and cost over runs. (The Economic Times 2014c) The timeline indicated by the Railways for Tori-Shivpur was December 2016 as against March 2015; for Jharsugudu-Barpalli June 2016 against December 2014 approved earlier. The indicated timeline by the Railways for Bhupdevpur-Korichapar was September 2016. The impact of the delay is envisaged at 67.16 million tonnes (MT), of which 13.6 MT will be in 2015-16 and 16.1 MT in 2016-17 in the case of Tori-Shivpur line and 12.5 MT in 2015-16 and 20 MT in 2016-17 in the case of Jharsugusa- Barpalli. In case of Bhupdevpur-Korichapar, if this line does not come up by 2015-16, the loss of production is envisaged to be at 4.96 million tonnes from the mines of CIL alone (The Economic Times 2014d)

Use of inland & coastal waterways

Inland water transport (IWT) account for less than a per cent share of goods transported within the country as compared to other modes of transport (Press Information Bureau

2012). Analysis undertaken by the National Council for Applied Economic Research (NCAER) showed that the operating cost of IWT per tonne per mile is 1 cent by IWT as compared to 2.5 cents by railways and 5.3 cents by roadways (Economic Yield and Feasibility of the Inland Waterways Mode of Cargo 2006).

The Inland Waterways Authority of India (IWAI), the nodal agency with the task of developing India's national waterways along with NTPC are exploring options for coal transport via the IWT to its power projects in Barh (Bihar) and Bongagaon (Assam). A 7-year contract has been awarded to Jindal ITF Ltd by NTPC Ltd for transporting 3 million tonnes (MT) of imported coal a year from Haldia to the thermal power plant located at Farakka through the National Waterway-I of which it has invested Rs. 650 crore in various components of the project. This IWT is expected to minimise the major chunk of transport cost and save 15-20 % of the cost of transporting coal via land (FICCI 2013) for NTPC. As per the Ministry of Road transport, highways and shipping, waterways are fuel-efficient costing barely 55 paise a km compared with INR 1.50 for highways (The Economic Times 2014e). Also since inland waterway development does not involve land acquisition, the projects may come on board faster than dedicated freight corridors (The Economic Times 2014f). IWT will also ensure better fuel efficiency in relation to either rail or roadways. For instance, on an international standard, a gallon of fuel transports a tonne of freight through 827 km by a ship/ barge compared to 325 km by train and 95 km by truck (Economic Yield and Feasibility of the Inland Waterways Mode of Cargo 2006).

Ten power plants already exist along the Ganga and a similar number is expected to come up soon and the Allahabad-Haldia waterway can prove to be a boon for these upcoming TPP as they could use IWT as a means for fuel transportation. There is also a need to rationalize the movement of imported coal from port to the TPP with emphasis on optimization of "Coal-Flow". Savings estimates to a tune of Rs. 5800 crores per annum can be expected if the flow of coal can be corrected (FICCI 2013). This can only be done with efficient re-allocation of coal linkage and encouraging TPP along the coast to facilitate rationalisation of imported coal. Mechanization of major and minor ports also need to be strengthened via augmentation of necessary infrastructure like crane capacities, conveyors, silos etc and road connectivity with the ports need to be reinforced. The government's move to develop a National waterway project between Allahabad in Uttar Pradesh and Haldia in West Bengal is a step in the right direction (MoF 2014). Hydro-transport can also be seen as a viable option for transportation of coal over long distances via coal slurry pipelines (Sridhar, et al. 2012). Tata Steel is planning to capitalise on the reduced cost of transporting coal via waterways as discussed in Box 5.

Box 5 Transporting coal via waterways

As compared to China and the EU where more than 40% of the cargo is transported via inland waterways, India transports only 7% of the cargo despite having a long coastline (The Economic Times 2014g). As per the Ministry of Road Transport and Highways, waterways are also a fuel-efficient mode of transport, costing barely 55 paise a km compared with Rs 1.50 for highways (Business Standard 2014).

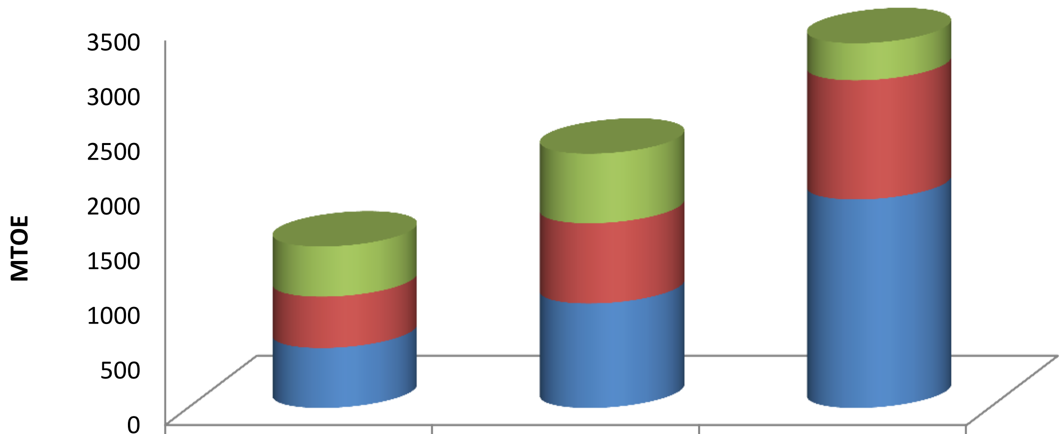
Tata Steel is setting up Rs. 40,000 crore projects in Kalinganagar, Odisha with plans to transport 15-20 per cent goods in the next three-five years by water from almost zero now. As of today, Tata Steel transports 63 per cent cargo by rail and 37 per cent by road. Tata Steel intends to transport coal from Australia through barges from ports to the Kalinganagar plant and as per a cost benefit analysis conducted by the steel giant it will turn out to be 20% cheaper with reduction in total freight costs to the tune of 3% if 20% of the cargo is transported by water in the next five years. Tata Steel India spent Rs. 2,261 crore in freight costs in the year ended March 2013, up 33 per cent from the year earlier.

Ganga inland waterway proposal

The government provided the necessary push to develop and accelerate transportation of coal from the coal belts in the northern and eastern states of the country by announcing a INR 4200 crore package to develop a National waterway project between Allahabad in Uttar Pradesh and Haldia in West Bengal over the next six years (MoF 2014). This will involve construction of river ports along the banks of the Ganga. In-spite of the country's heavy dependence on coal accounting for 55% of the energy needs, logistics in coal transport is a major obstacle as pit head coal generally lies idle for months before it can be moved to railway sidings for transportation to power plants. With close to 50% and 30% of coal is transported by Railways and Roadways respectively and about 17% by merry go round (MGR) system as per a Knowledge Paper presented by FICCI, the inland waterways can help to decongest (FICCI 2013) both railways and roadways and also minimise emissions through particulate matter. Companies can also use the route to transport coal coming from Indonesia.

4. Ways Forward

Coal will continue to remain an integral part of India's energy mix, contributing 58% of the electricity generation in 2030 as compared to 70% in 2012 (Planning Commission 2013). But this dependence will have a negative impact on India's climate change commitments, if the coal sector trajectory doesn't change from its present scenario. Fossil fuels have been a major contributing factor to climate change with combustion from them accounting for nearly 90% of the total carbon dioxide emissions. Of this, coal consumption accounts for 40% of the total carbon dioxide emissions. In India, carbon dioxide emissions continued to increase by 6.8% in 2012 making it the fourth largest CO_2- emitting country in the world (TEDDY 2013/14). This increase was mainly led by a 10% jump in coal consumption, of which coal-based power consumption which accounts for almost 70% of coal-related CO2 emissions grew by 13% in 2012, the highest annual growth ever. (European Commission 2013). As per TERI projections in a business as usual scenario or the reference energy scenario (RES)[7], India's CO_2 emissions are expected to reach 11.04 mn tn by 2051 if coal continues to be the primary commercial energy supply in India's energy mix (Figure 6). Therefore it becomes imperative to reduce our dependence on coal to curb GHG emissions. This dependence, despite our best efforts to promote renewables cannot be restricted immediately; else it will impact growth negatively. The solution would be to make coal and coal use efficient in the short-term and medium term and move away from coal in the long run. The figure below gives an indication of the different scenarios i.e. business as usual (BAU), moderate energy security (ESM)[8] and ambitious energy security scenario (ESA)[9] for projections of coal demand in the short, medium and long term.



	2021	2031	2051
ESA	458	635	339
ESM	468	732	1087
BAU	548	954	1903

Figure 6 Coal demand projections in different scenarios

Source: (TERI, 2015)

Coal demand remains high because the coal-based electricity is generally cheaper (Rs. 2/3kWh) as compared to electricity produced from most other energy sources. This makes coal use highly prevalent among different consumers (power, steel, cement and others). One aspect the government could deliberate upon is increasing the cess on coal which at present is already being used to fund cleaner technologies. Another aspect would be to slowly retire

[7] The Reference Energy Scenario (RES) is structured to provide a trajectory that shows how the nation's energy pathway would evolve if current trends in energy demand and supply are not changed. It takes into account existing policy commitments and assumes that those recently announced are implemented. But, wherever necessary, a diversion from government projections and forecasts has been assumed.

[8] Moderate Energy Security Scenario (ESM) is structured in a manner that enables one to envisage an energy trajectory of the nation that would ensure energy security in the future. This in broad terms implies that efforts are provided here for efficiency improvements both on the supply and demand sides. There is an accelerated push for diversifying the energy mix, fuel substitution, and penetration of new technologies. This is met with moderate reduction of imports.

[9] Ambitious Energy Security Scenario (ESA) is a scenario where concerns of energy security are paramount. The main objective being to drastically reduce the energy imports of the country by 2031. This entails faster implementation of efficiency measures, rapid penetration of new technologies, and increased electrification of the economy. The role of renewables is crucial in this scenario.

older subcritical plants rather than expediting renovation and modernisation (R&M) measures. It is also necessary to increase the number of coal washeries. Coal washing helps removal of ash, sulphur and other impurities and also results in lowering the carbon footprint. Moreover, mining technology in India needs to undergo a shift since pollution from opencast mining is a lot more vis-à-vis underground mining. This will need a regulatory push as opencast mining is more cost efficient for coal companies.

Another area where energy efficiency can be improved would be transportation. Coal supply via railways continues to remain the cheapest mode of transportation. However, freight transportation is not very efficient in India as compared to other countries. For example, Indian wagons have a net gross ratio of 73% which is significantly lower than the world's best of 85% (Figure 1.6). Effectively this means that we are spending a larger fraction of fuel to carry the weight of the wagons itself (NTDPC 2013) and costs for transportation constitute a large fraction of the price that the consumer finally pays.

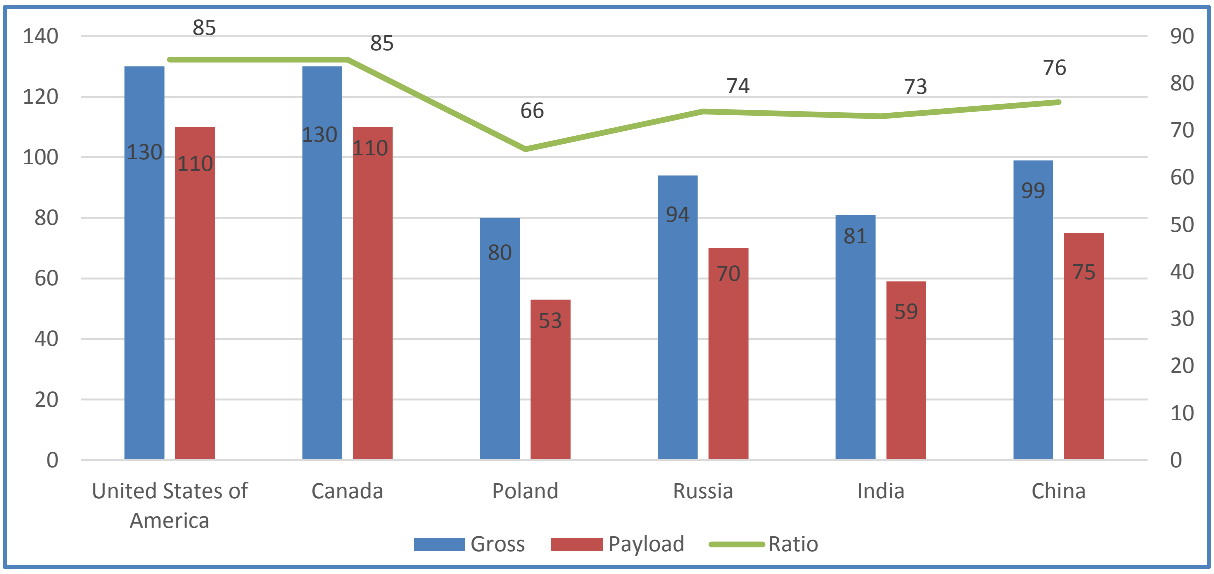


Figure 7 Comparison of wagon weight and payload to gross weight for select countries

Source: NTDPC, 2013

Railway connectivity (both for trunk and feeder routes) should be another area of focus to improve coal transportation. Coal transportation is undertaken via the main trunk routes (high density networks) which are already operating at capacity utilization of more than 100% (NTDPC 2013). This eventually leads to congestion between passenger and freight trains which end up causing massive delays and thereby losses to the power plants. The Indian Railways is already building two dedicated freight corridors (DFCs) with four more in the pipeline. However, lack of investments and interest from the private sector has already delayed these projects. These corridors must be built on a priority basis since it will save transportation costs. The railways had even proposed a new PPP policy in 2012 to boost investments by the private sector as well as allowed 100% foreign direct investment in railway infrastructure (Ministry of Railways 2012). The lack of a sustaining revenue model though is keeping the private sector away from investing in railways. This attitude must undergo a change, since the Railways cannot afford to fund infrastructural projects largely through gross budgetary support (NTDPC 2013).

The thermal plants which use coal also need to undergo massive technological changes if they are to remain sustainable. This paper has already mentioned the kind of new and cleaner technologies which can be used as a substitute for subcritical plants. However, this change will need a regulatory push since the capital costs of setting up plants with up-to-date technologies are far higher as compared to a subcritical plant. Therefore, the government needs to look into options such as providing tax holiday to plants with newer technologies, jointly funded exercises via PPP, putting in place regulations that pass on the costs to the consumer in the medium term, among others. This kind of exercise (especially the last option) will be unpalatable politically, but precedence has already been set in countries such as Germany and India could look to adopt similar measures. Adopting cleaner technologies will be an expensive proposition (especially technologies like IGCC) right now, but in the long run capital costs are expected to fall as scale economies are achieved.

4.1 Policy Roadmap for the Coal Sector

Term	Stages	Policy/ regulatory strategies	Technology needs
Short-term (2020)	Mining and Processing	Encourage shift to underground mining Frame policies for newer technologies like CBM, UCG etc Increase the number of washeries to reduce carbon footprint and enhance coal quality Mandatory disclosure of energy usage and carbon emissions in the exploration and production processes	Use of IT tools like blast logic for improving drilling and blasting efficiency in OC mines Mapping old underground workings for conversion of UG mines to OC mines and vice versa Adopt newer UG technology other than long wall mining and Continuous miner Retiring subcritical pulverized coal plants and focus on supercritical thermal plants
	Transportation	Rationalise coal linkages to cut costs and increase logistical efficiency Make revenue models that will attract private investment in logistical infrastructure	Increase wagon efficiency to bring it at par with international standards Upgrading port infrastructure such as drafts, the number of berths, crane per container among others to reduce turnaround time and augment capacity addition Creating additional dedicated freight corridors to augment the coal supply
	Coal use in power sector	Frame guidelines to retire old sub-critical TPPs rather than resorting to R&M Appropriate financial incentives to encourage and promote newer technologies	Improving energy efficiency of current TPPs by adopting CBFC boilers Enhance technological infrastructure for super critical power plants
Medium-term (2030)	Mining and Processing	Mandatory disclosure of energy usage and carbon emissions in the exploration and production processes Frame policies to maintain current efficiency levels of production	Increase number of coal washeries to adapt to newer boiler requirements

Term	Stages	Policy/ regulatory strategies	Technology needs
		Use financial instruments in the sector to power development towards renewables Regulatory push to accelerate underground mining on a large scale	
	Transportation	Regulatory push to enhance existing port and rail capacities	Creating a national coal grid on the similar lines of the national gas grid so as to meet the demands of CBM and UCG etc
	Coal use in power sector	Appropriate financial incentives to encourage and promote newer technologies Creating a tariff mechanism to levelize costs from adopting newer technologies	Retiring all the sub-critical pulverised TPPs Creating an efficient mix of super critical and ultra-super critical TPPs
Long-term (2047)		Mandatory disclosure of energy usage and carbon emissions in the exploration and production processes Creation of necessary technical and physical infrastructure to commercialise indicated coal reserves Creating policies and regulations to identify and sites that will store carbon dioxide released during IGCC and CCS Creation of infrastructure to supplement IGCC & CCS TPPs	Creating technologies that can utilise coal rejects for combustion Mass usage of IGCC and CCS TPPs which will help reduce CO2 emissions

5. Annexure I: Fly ash generation & its' utilization in the country

Sl No	Year	Fly ash generation (mtpa)	Fly ash utilization (mtpa)	Percentage utilization
(1)	(2)	(3)	(4)	(5)
1	1996-97	68.88	6.64	9.63
2	1997-98	78.06	8.43	10.80
3	1998-99	78.99	9.22	11.68
4	1999-2000	74.03	8.91	12.03
5	2000-01	86.29	13.54	15.70
6	2001-02	82.81	15.57	18.80
7	2002-03	91.65	20.79	22.68
8	2003-04	96.28	28.29	29.39
9	2004-05	98.57	37.49	38.04
10	2005-06	98.97	45.22	45.69
11	2006-07	108.15	55.01	50.86
12	2007-08	116.94	61.98	53.00
13	2008-09	116.69	66.64	57.11
14	2009-10	123.54	77.33	62.60
15	2010-11	131.09	73.13	55.79

Source: CEA Report on Fly Ash Generation and its utilization, December 2011

6. Annexure II: Company-wise land reclamation status in OC projects

Companywise land reclamation status in OC projects												
(5 million cu.m. and more Coal + OB) based on satellite data of year 2013												
Sl No	Coal Company (No. of OC projects)	Area in Sq. Kms. (% calculated in respect of total excavated area)										
		Leasehold	Plantation		Under Backfilling		Under Active Mining		Total Excavated Area		Total Area under Reclamation	
			2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
		(i)		(ii)		(iii)		(iv)	(ii+iii+iv)		(ii+iii)	
1	WCL (10)	95.01	27.44	27.88	23.43	24.52	7.95	9.64	58.82	62.04	50.87	52.40
			46.65	44.94	39.83	39.52	13.52	15.54			86.48	84.46
2	SECL (10)	159.48	42.66	42.29	22.21	24.67	18.74	16.24	83.61	83.20	64.87	66.96
			51.02	50.83	26.56	29.65	22.41	19.52			77.59	80.48
3	NCL (10)	174.52	61.70	57.65	28.52	29.63	17.61	22.11	107.83	109.39	90.22	87.28
			57.22	52.70	26.45	27.09	16.33	20.21			83.67	79.79
4	MCL (11)	86.36	14.41	14.50	12.63	14.34	14.58	15.59	41.62	44.43	27.04	28.84
			34.62	32.64	30.35	32.28	35.03	35.09			64.97	64.91
5	CCL (05)	48.47	16.33	15.68	4.30	5.43	4.70	4.97	25.33	26.08	20.63	21.11
			64.47	60.12	16.98	20.82	18.56	19.06			81.44	80.94
6	BCCL (02)	14.06	1.34	1.36	4.63	4.82	1.24	1.12	7.21	7.29	5.97	6.18
			18.59	18.66	64.22	66.12	17.20	15.36			82.80	84.77
7	ECL (02)	39.44	3.83	3.83	4.77	6.13	3.59	3.35	12.19	13.31	8.60	9.96
			31.42	28.78	39.13	46.06	29.45	25.17			70.55	74.83
TOTAL CIL (50)		617.34	167.71	163.19	100.49	109.54	68.41	73.02	336.61	345.74	268.20	272.73
			49.82	47.20	29.85	31.68	20.32	21.12	54.53	56.00	79.68	78.88

Source: CMPDI, March 2014

7. Annexure III: Subsidiary-wise and state-wise details of proposed coal washeries

Sl No	Name of the Washery	Capacity (MTY)	Subsidiary	State	Status (As on 31.3.14)
1	Kusmunda	10	SECL	Chhattisgarh	Bid under process
2	Baroud	5	SECL	Chhattisgarh	Land acquisition in progress
3	Madhuband	5	BCCL	Jharkhand	Under construction
4	Patherdih	5	BCCL	Jharkhand	Under construction
5	Patherdih	2.5	BCCL	Jharkhand	Evaluation of offers in progress
6	Dahibari	1.6	BCCL	Jharkhand	Under construction
7	Dugda	2.5	BCCL	Jharkhand	Evaluation of offers in progress
8	Bhojudih	2.0	BCCL	West Bengal	Evaluation of offers in progress
9	Ashoka	10.0	CCL	Jharkhand	Price escalation demanded by L-1 bidder which is under consideration
10	Konar	3.5	CCL	Jharkhand	Possession of land in progress
11	Karo	2.5	CCL	Jharkhand	Forest clearance (Stage-1) has been applied
12	Chitra	2.5	ECL	Jharkhand	Land acquisition in progress
13	Bashundhara	10	MCL	Orissa	RFP is under evaluation
14	Jagannath	10	MCL	Orissa	RFP is under evaluation
15	Hingula	10	MCL	Orissa	LOI issued to L-1 bidder
16	Ib-vally	10	MCL	Orissa	Land acquisition in progress
	TOTAL	92.10			

Source: Coal India Limited (CIL), 2013-14

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