Relevance of Implementing Coal & Lignite Power Based Technologies - UCG, CBM, CMM, into Mainstream

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In India 62% of the explored coal resources is located within 300m depth, which is the depth accessible through opencast mining. According to CMPDIL, only 52 GT (56%) out of 93 GT of proved resources are considered extractable this are only one-fifth of the total resources in the country. Furthermore, at least 8 GT has already been depleted due to past mining, leaving only about 44 GT as a tentative estimate of coal reserves in India.

Coal as Mainstay Energy Resource

As per the government's own estimates, production will lag behind demand by about 100 MMT as of 2011-12 and by 250MMT by 2019-20. Without improvements in coal technology and economics, the existing power plants and the new plants added in the next 5 to 10 years might consume most of the currently estimated extractable coal in the country over the course of their 40- to 50-year lifespan. The relatively short lifetime projected for India's coal reserves is in sharp contrast to the general assumption that Indian coal will last more than 100 years an assumption predicated on extracting all of the resources without accounting for technology or economics. Coal Mining in India has been associated with poor employee productivity also. The output per minute per annum in India varies from 1500 to 2650 tonnes companied to an average of around 12,000 tonnes in the US and Australia.

According to the Ministry of Coal (MoC), the power sector gets about 70% of total coal produced in the country at a government-regulated and affordable price, thus despite having high ash content and low calorific value the preference is always for domestic coal vs imported. The thermal coal demand in India will increase by 810-million tons, or 137%, by 2025, driven by a 158% increase in coal-fired power capacity. "The thermal-coal market will remain tight as strong demand from emerging markets, particularly China and India. Supply is anticipated to be constrained in key producing regions such as China, Indonesia and Australia. Prices at Australia's Newcastle port, a benchmark for Asia, rose to $114.50 a ton in the Dec.2010, according to IHS McCloskey. India already imports 10% of its coal for electricity generation, and the figure is projected to increase to 16% by 2011 end.

As per Central Electricity Authority (CEA) presently the coal to gas based power generation in the ratio of 6:1 and hence highly in favor of coal which is expected to shift slowly in favor of gas with coming of Reliance's KG Basin at present along with Turkmenistan-Afghanistan-Pakistan-India (TAPI) & Shale gas in future. But at same time the large scale coal based power plants will still be generation far more green house gases than gas based project, hence the need is to also actively look for carbon capture, coal beneficiation, coal gasification technologies, etc. to explore the potential of coal reserves in India in environment friendly manner. Considering the huge initiate of Ministry of Power (MoP) under UMPPs, there is lot of catching up to do by Gas based Power Generation Sector to be competitive with coal sector project in terms of scale & size of projects in order to shift this balance in its favor.

Currently mining activities account for about 4% of total coal emissions in the country and predominantly done from opencast mines (about 85% of total production). But, future coal requirements will be met from underground mines as opencast mining potential has mostly been exploited. Developing underground mines will lead to more methane release due to gassiness of underground mines. And hence, the percentage of emissions from coal mining activities will also increase from the current 4%.

Super Critical & Ultra Super Critical Technologies in Coal Power Generation

The Green House Gas (GHG) emission of various sectors as per Ministry of Environment & Forest (MoEF) are transportation sector accounts for 7½% of our GHG emissions. 38% is electricity, 23% is industry, 17% is agriculture and 7½% Emission is from residential sector. The average net efficiency of the entire fleet of coal power plants in the country is around 29%. The older units (less than 200 MW) have the worst efficiencies. However, in spite of poor efficiencies and low PLF, these power plants continue to operate because they supply electricity at low costs. The best power plants at present with 500 MW subcritical units operate with a net efficiency of about 33%. Increasing efficiency by one percentage point in a power plant can reduce coal use, and corresponding air pollution and CO_2 emissions, by 3%. The Integrated Energy Policy suggests that if the thermal efficiency of power plants is

raised by 4%-5%, this could save 200 million tons of coal each year.

In terms of capital cost, supercritical plants would cost only about 7% more than subcritical ones; however, the addition of Flue Gas Desulphurization unit would increase the total plant cost significantly. An important caveat about the use of supercritical technologies in India: coal washing to reduce ash content might become an issue for supercritical boilers in India, as erosion of boiler tubes would likely increase with increased temperature and pressure. Therefore, the prospects for ultra-supercritical technologies might be limited by the high ash content of Indian coals.

Power Generation Alternatives from Coal: UGC, CBM, CMM, etc.

In addition to traditional mining, new options such as CBM extraction and UCG are now being considered for unmineable coal seams in India. UCG gasifies coal in-situ by injecting oxygen and water into coal seams, thereby converting the coal into a low-energy synthetic gas, in a process similar to surface coal gasification without the need of excavation of coal from under the earth. The produced syngas can then be burned in a combined-cycle gas turbine, or used for other purposes. There are significant environmental advantages of UCG like it eliminates coal mining and its attendant environmental damages, much of the ash remains underground and it produces very little SOx and NOx. Furthermore, the commercial use of deeper coal seams would significantly increase the amount of coal usable for energy purposes in the country. UCG, however, is not yet a fully commercial technology in India, although several commercial-scale plants have been proposed worldwide with Russia being the leader ship role in this technology usage. As of now, both public and private oil and natural gas companies in India are interested in pursuing UCG testing in the country. Apart from recently put to auction 2 coal blocks for UCG, nothing much has been done by the Ministry of Coal or Gas for making UCG attractive for private investment. Estimates are that UCG could increase recoverable coal reserves in the USA by 300%.

Coal seams generally contain gaseous methane adsorbed within the coal bed, and this methane can be extracted from seams through boreholes. CBM which can be used for a range of industrial purposes, including power generation is actively being considered in India by various public and private sector companies. Exploration and extraction of CBM is under the administration of the Ministry of Petroleum and Natural Gas. In 1997, India formulated a Coal Bed Methane (CBM) policy and invited global players to participate in CBM E&P activities. Till date 26 CBM blocks with a potential of covering 13,600 sq. kms have allocated under the CBM exploration policy, but apart from a CBM block in West Bengal nowhere else has commercial production started in India. Reliance Gas has carried out comprehensive geological assessment of coal & lignite basins across India, based on which about 20,000 sq. kms of area has been identified for CBM potential with an estimated in place resource of about 2000 BCM (billion cubic meters). The recoverable reserves of about 800 BCM and gas production potential of 105 million cubic meters per day over 20yrs have been estimated. Hence CBM potential is about 1.5 times the present natural gas production in India.

Underground coal mines worldwide liberate an estimated 29–41×109 m^3 of methane annually, of which less than 2.3×109 m^3 are used as fuel. Coal Mine Methane (CMM) recovery and use represents a cost-effective means of significantly reducing methane emissions from coal mining, while increasing mine safety and improving mine economics. To bring interest in CMM development, a policy is under formulation by Coal Ministry for a while, but yet to take full shape. In India, methane standards are specified in Indian Coal Mine Regulation 1957, which is based on Mines Act 1952. However, there is no regulation that specifies recovery and utilization requirements. Hence, focused action on the part of concerned Ministry is needed to make CMM utilization projects effective and profitable. MoC and Ministry of Petroleum and Natural Gas (MoP&NG) are working together to chalk out strategy so as to mine CBM and coal together. This might possibly lead to ownership issue of CMM in future and thus, this aspect must also feature while framing policy for CMM. More than 150 projects of CMM are operating worldwide at present along with 30 in development stage. There is interest in reclamation and in the past during 2007 Coal India Ltd (CIL) invited interested parties with proposals to recover methane from existing and abandoned mines (largely located in the Jharia coalfields), but till date not much progress has been made to make it attractive on larger scale.

Carbon capture in Indian power plants will require low pollutant levels in flue gas and high power plant efficiency. Capturing carbon emissions from power plants results in lower power output, loss in efficiency and higher generation costs. Installing technologies for capturing CO_2 can be considered yet another pollution-

reducing activity. However, CO_2 is not considered a pollutant in the Indian policy context, and the decision to capture CO_2 from power plants is inexorably linked to larger political decisions surrounding global climate change mitigation. There are three major carbon capture systems for power plants: post-combustion (PC, FBC); oxy-fuel combustion (PC, FBC); and pre-combustion (IGCC). Hence similar to China we can initiate working with developed countries on carbon capture technologies so as we can use them in India and reduce the GHG out of flue gases especially from older coal based projects. The process has advantages for geologic carbon storage. Combining UCG with Carbon Capture & Sequestration (CCS) technology allows re-injecting some of the CO_2 on-site into the highly permeable rock created during the burning process, i.e. where the coal used to be. Toshiba is the latest company to join the CCS fray hoping to set up a 5 MW pilot plant in JV with India's biggest power utility NTPC.

Environmental Issues: Coal Power Production & Mining

Green House Gases

Control of CO_2 emissions to mitigate climate change impacts is becoming an important challenge for the power sector. According to India's National Communication to the UNFCCC, coal contributed about 62% of India's total CO_2 emissions. Given that coal is primarily used for power generation, most of the fossil-fuel-based GHG emissions from India are from coal-based power plants. In this consideration efforts on finding alternatives using the above technologies in no-go areas as highlighted with MoEF which are coal bearing area but has high concentration of forest cover is important consideration to balance the environment aspect as the above technologies is used in harmony can effectively give more energy potential from the coal blocks in comparison to open cast coal mining and also in lesser time. Considering the potential of Methane utilization in UCG, CBM, etc. gives huge opportunity of reducing GHG to go into atmosphere in India.

Requirement & Pollution of Natural Resources

Considering the air pollution due to coal power generation due to flue gas emissions, particulates, sulfur oxides (SOx), nitrous oxides (NOx), and other hazardous chemicals, etc. Along with ground water getting polluted by percolation of hazardous materials from the stored flyash. Given the high ash content in Indian coals, at least one acre of land is needed for one MW of installed capacity (as per CEA); hence, there are many large power plants with more than 1000 acres of land dedicated simply for ash storage. Currently, nearly 90 MT of ash are produced annually, and there are at least 15,000 hectares of land with about 750 MT of ash in active ash ponds.

Also considering the advantage of lower land requirement for setting gas based project against coal based power projects helps in addressing the contentious issue of land acquisition faced across India by Project Developers. As gas based project straight away removes the requirement of land requirement for coal storage along with flyash storage and also using far less water in comparison to coal based projects, so they effectively conserves both land and water and finally with better pollution control gives cleaner & better option to India's growing Energy Demand.

Land acquisition is one major hurdle to expansion of coal projects or starting of new ones. The problems are basically relief and rehabilitation (R&R) issues such as delays in authentication of claims of tenants, the non–availability of valid title document, related court cases, rehabilitation and the demand for higher compensation. Learning from the examples of land acquisition done by the companies in case of coal blocks allocated for CBM extraction, the MoC can take forward similar efforts on exploring way of energy extraction using UCG, CMM, etc. as they require far less land acquisition and hence faster starting of project along with minimal damage to the natural resources in the region.

Forest Cover & Coal Bearing Areas issues concerning Coal Mining

India has 17% of the world's population, but just 1% of its forest cover and 4% of water resource. As mentioned earlier there is dilemma in India about how to approach the no-go areas as specified by MoEF considering these are the Coal Bearing areas as well have high concentration of Forest Cover as well which has been developed over many years. Hence afforestation can't be the only solution to replace the damage caused by mining in these areas but at the same time with increase in time and no clarity, desperation will lead the MoC & MoEF to facilitate mining in these areas also or worst case will be illegal mining on large scale. Hence the above technologies are better alternatives for exploitation in these areas which will causes minimal damage to the Forest Cover and the damage caused will be on minor scale and can be compensated using afforestation measures as specified by MoEF.

Coal Mining Technologies

Generally, there are two main methods for extracting coal: opencast (surface) mining and underground mining. Typically, opencast mining is used for coal seams within 300m of depth, although deeper mining is possible. In opencast mining, the coal is mined in an earth-moving operation by excavating the overburden up to the coal seams and then removing the coal using draglines, shovels, and dump trucks. Opencast mining is advantageous because of greater recovery of in-situ resources, high productivity, low costs and labor intensity, and better workplace conditions. At the same time opencast mining has enormous environmental impacts including large-scale land use, overburden disposal, disturbance of hydrology and run-off, increased erosion, acid mine drainage, noise, and possible destruction of entire ecosystems.

In contrast, underground mining, which typically is used for extracting very deep coal seams, involves constructing a vertical shaft or slope mine entry to the coal seam and then extracting the coal using board-and-pillar or longwall techniques. Underground mining is relatively more labor-intensive and it is not possible to extract all of the coal anywhere between 50 to 90% of the coal can be extracted depending on particular geological characteristics. Some of the problems with underground mining include high cost & risk, poor workplace environment, explosions, subsidence, aquifer disturbance, mine water disposal, and methane emissions.

Although underground mining was dominant in the early years of coal production in India, much of the increased production since the 1970s has come from opencast mining. Nearly 83% of total production in 2003–04 came from opencast production. Underground mining has essentially stagnated over the past decade, with annual production decreasing to below 65 MT in recent years. The increased emphasis on opencast mining has led to a faster production rate and reduced mining losses. However, it also has reduced coal quality as shale and other materials often get mixed with coal. Hence in consideration of this fact CIL has initiated drive to setup coal washeries at all its coal mines so as the quality of coal transported can be improved but at the same time has also declared it inability to handle the demand of coal by power sector through domestic coal alone. Hence there is ideal case for immediate adoption and progressively going for UCG, CBM, etc. in abandoned coal mines as well mines which are unsuitable for underground mining as well so as to increase the energy potential of India's coal reserve as the extractable coal estimates are based on existing coal mining technologies only.

High Ash Content of Indian Coal

Indian coal has the general properties of the Southern Hemisphere Gondwana coal, whose seams are interbanded with mineral sediments. Run-of-mine coals typically have high ash content (ranging from 40–50%), high moisture content (4–20%), low sulfur content (0.2–0.7%), and low calorific values (between 2500–5000 kcal/kg). The low calorific value implies more coal usage to deliver the same amount of electricity. Indian coal, however, has lower sulfur content in comparison to other coals, although it has relatively high amounts of toxic trace elements, especially mercury. The ash content in Indian coal has been increasing over the past three decades, primarily because of increased opencast mining and production from inherently inferior grades of coal as per MoC. Current practices have limited coal resource assessments to within 300m, which implies that opencast mining is expected to dominate production over the next 20 to 30 years. Thus, coal quality might not improve much without additional washing and beneficiation. Hence there is urgent need for MoC to adopt new technologies as these can recover the energy out of coal blocks & mines without any requirement of bringing ash to the earth. Hence this can greatly reduce the requirement of land being wasted for ash dykes across India. For comparison, the ash content of UCG syngas is estimated to be approximately 10 mg/m^3 compared to smoke from traditional coal burning where ash content may be up to 70 mg/m^3.Along with this

Government of India also has to bring out strict guidelines for Cement Manufactures across India which compels them to maximize the usage of fly ash in their process.

Transportation of Coal

The Coal Ministry`s Strategic Plan for 2011-16 has suggested that washing of coal at the pithead makes more economic sense than to transport coal unwashed coal to the power plants. This would release a lot of railway capacity, which could be gainfully used for carrying larger quantities of better quality coal. To note, unwashed thermal coal has serious implications in terms of calorific value, ash disposal, carbon emission, cost of transportation, use of railway capacity and cost to the economy, as indigenous coal contains more than 35% of ash. Regional distribution of coal reserves makes transportation of coal very costly.

The energy consumption in pumping the gas from mine to load centers is effectively lesser than the losses happening in terms of transmission of power over high tension lines. As at present the power transmission is considered to be more economical than coal transportation, but considering huge demand and wide variation of frequency to handle along with coming of Renewable Energy into Power Grid will lead to more Decentralized Power Plants based on Renewable Energy and Gas based projects near to demand centers. These projects will be far less costly and resource intensive than building railroads along with maintenance infrastructure associated with them.

Coal Mafia & UCG technologies

A major social and operation problem affecting the India Coal Sector in terms of mining is presence of Naxalites & Coal Mafias across major coal bearing areas in Eastern India. The MoC has cited law and order problems, especially in Jharkhand, Chhattisgarh, Orissa and West Bengal, inordinate delays in land acquisition and the considerably long wait for mining lease approvals as major roadblocks for coal projects.This increases the mining cost, risk and at same time reduced the production capacity along with making the sector unattractive for private investment. One of the attractiveness of the UCG and other gas based technologies is that they make this theft of coal by coal mafia rampant across Eastern India to negligible levels considering that there will be no coal excavation but instead coal will be converted into gas under the earth and then the gas being brought up for use. Hence there will be lot of saving in terms of national coal reserves by preventing theft of coal by coal mafias along with more potential of energy extraction from coal reserves with reduced environmental losses.

Way Forward

MoP&NG has to initiate policy interventions through establishing Gas Regulator or other necessary guidelines to addresses the concerns on pricing, production, utilization issues with UCG, CMM, etc. so as to send right signals to investors & developers. Also required are efforts from CEA & MoP to have some power projects in 12th & 13th Plan for promotion on use of gas from coal using the above discussed technologies. A strategy plan submitted by the Power Ministry to the Cabinet Secretariat forecasts that the private sector will account for 62 per cent of the 75,000 MW capacity slated to come up during the coming Five- Year Plan period (2012-17), a big jump from the 20 per cent factored in for the current Plan period ending March 2012. MoC can play an important role in providing abandoned coal mines and unminable coal blocks to such projects on a time bound development manner so as to check the effectiveness of these technologies on India Coal Blocks.

MoEF can consider including the above mentioned power generation alternatives for coal based projects in mining & power generation at Term of Reference stage of Environment Clearance for 12th & 13th Plan especially for pit head projects and coal mining projects, so as the Green House Gases from these activities can be reduced and find more environmental way of generating power. Considering the savings in land and water resource by adoption of the above technologies, this effort of MoEF will help validate these technologies into Indian Power Sector.

Also more technology collaboration at Government to Government level between India and US & Europe will only help indigenous these technologies as per India Coal Sector. PSUs like NTPC, NHPC, DVC, etc can take initiative of setting up medium to large scale power project based on gas supplied using UGC, CBM, CMM, etc. with the support from IREDA, PFC, REC, etc. in financing these projects to commercial these technologies into mainstream.