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Theme:

Sustainable Pathway for India's Coal Sector

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THE MINING, GEOLOGICAL AND METALLURGICAL INSTITUTE OF INDIA

The DDP initiative is a collaboration of 36 in-country research teams, based in recognised and independent institutions. Their aim is to help governments and non-state actors make choices that put economies and societies on track to reach a carbon neutral world by the second half of the century. Together, they build and open to debate ambitious and realistic decarbonization pathways, country by country, showing key drivers and their effects by 2050; make their common methodology available to all, so that every government or stakeholder can build and propose its own pathways; and develop in-country expertise and international scientific knowledge. These country-driven processes involve a strong modeling component aimed at providing quantified estimates of main parameters of the transformations. Modeling and stakeholder engagement are the two complementary legs of these processes, modeling capturing insights from stakeholder consultations and being used to provide back some structured inputs to organize the stakeholder discussions around truly transformative pathways. Thus, these processes are not just an analytical exercise, they are an opportunity for collective problem solving. They provide a platform for a two-way conversation between researchers and decision makers turning qualitative aspirations into quantified scenarios and analyzable research questions suited to produce new and useful information for concrete decision making. It can allow production of actionable options while illuminating challenges around implementation at a granular level.

The DDP BIICS Initiative in emerging countries including Brazil, China, India, Indonesia, and South Africa is committed to meeting the long-term temperature goal of the Paris Agreement. Their domestic mitigation efforts focus on implementing their Nationally Determined Contribution (NDC); under the Agreement, these contributions need to be strengthened over time. Long-term low GHG emission development strategies are a crucial tool to inform priority short-term actions with the best transformative impact, both at the country-scale and through international cooperation. Developing these strategies allows actors of the political economy to be engaged in a comprehensive dialogue about the transformation, thereby increasing the mitigation capacity at the national level. If they are connected to international processes, such as global stock take and revision cycles, developing long-term low GHG emission development strategies can also boost international mitigation capacity.

DDP BIICS initiative is funded by International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

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Editorial Board

President's Message

SUSTAINABLE PATHWAY FOR INDIA'S COAL SECTOR

In 2015 the United Nations adopted "The 2030 Agenda for Sustainable Development", which provides a blueprint for peace and prosperity for the people and the planet. At the heart of this agenda are the seventeen Sustainable Development Goals (SDGs) – ending poverty and hunger, ensuring good health and healthy life for all, provision of clean water and sanitation etc. The SDG 7 is about access to affordable, reliable, sustainable and modern energy for all. Energy is the key input in pulling people out of poverty and raising their standard of living. Important initiatives of the Government of India, like boosting manufacturing under the "Make in India" initiative in order to raise the contribution of manufacturing to India's GDP from the present 16 % to 25 %, smart cities, infrastructure development etc. will be powered by cheap, reliable and sustainable electricity.

If we look at the world's primary energy consumption in 2019, China, US and India are the largest consumers of energy with primary energy consumption of 142, 95 and 34 exajoules (EJ) respectively. However, analysis of energy consumption, from energy consumption per capita point of view, presents a totally different picture: The energy consumption per capita of India is about a third of the world's per capita energy consumption, about a fourth of China and about one twelfth of US per capita consumption. For India to become a $ 5 trillion economy by 2024 and a $ 10 trillion economy by 2030, it requires a CAGR of GDP of over 10 percent in the next ten years. The double-digit growth in GDP will require almost 9 % growth in electricity generation every year.

Options available to provide energy

If we look at the energy options with India, the choices are limited. Our dependence on oil imports is over 85 % and our oil production has been declining at a CAGR of 0.5 % in the last 10 years. For natural gas also the trend is similar with production having declined at a CAGR of 0.4 % in the last ten years. The import dependence for natural gas is about 45%. In this bleak fossil fuel production scenario, coal production has been an exception. In FY20 the country produced 729 MT of coal. The CAGR of coal production in the last 10 years is about 4 %. Though the country requires a faster growth rate in coal production, given a larger reserve base, the growth has not been up to the desired level due to various reasons like delay in land possession and regulatory approvals, insufficient infrastructure for coal evacuation, poor law and order prevailing in some coal mining areas and more recently due to COVID pandemic outbreak. Coal will continue to be the backbone of India's energy sector for the next two decades. It is, hence, imperative that coal production not only be increased but also be sustained at a very high level.

Mark Twain once said "I am in favour of progress; its change I don't like". Coal is the dominant fuel as it is available in abundance and can be mined cheaply. Today the global focus is on energy transition. How can India ensure a just transition? Some stakeholders want to get rid of coal altogether, however a wiser option is to first clean it up.

Actions being taken in CIL for sustainable mining

Coal India Limited (CIL) is the largest coal producing company in the world. It also operates the largest number of coal mines in the world. Some of the steps proposed for green CIL are as under:

1. **First Mile Connectivity Projects:** The share of conveyors and MGR employed for coal transportation in India is low (MGR – 15 %, belt – 5 %). Australia, which produces one of the cheapest coals in the world, has 80 % of the coal movement by conveyors. This not only reduces air pollution dramatically but also makes mine operations safer. Pipe conveyors as they are cheaper than road transportation and offer advantages over open conveyors. First mile connectivity projects have been taken up in top 35 projects at a cost of Rs 12,000 crores. The total capacity of FMC projects is over 414 MT. By 2024 end CIL is planning to increase mechanised transportation of coal from 150 MT to 600 MT.
2. **Planning of large capacity mines:** Large capacity mines are being given priority. Magadh (51 MTY), Siarmal (51 MTY), Amrapali (25 MTY), Chandraguta OC (15 MTY), Sanghamitra OC (20 MTY) etc. are some of the upcoming mines. Large capacity mines enable deployment of state-of-the-art technology and rapid augmentation of coal production.
3. **Increased deployment of Surface Miners and continuous miners:** Surface miners eliminate drilling and blasting, enable selective mining and provide crushed coal. Surface miners have found increasing use in CIL over the years. In FY21, surface miners produced 280 MT coal (about 50% of opencast coal production) in CIL, a growth of 4 % over FY20. MCL is the leader in CIL as far as use of surface miners is concerned, with surface miners producing over 90 % of the total coal production. There is an urgent need to scale up its deployment in other subsidiaries. Continuous Miner Technology was introduced in India in 2002, though it had been introduced in the USA in the year 1948, in South Africa in the year 1958 and in Australia in the year 1950. Continuous Miner technology at Churi - Benti mine in CCL is first of its kind in India to extract coal from seam up to 5.0 m of height. Earlier CMs were able to extract up to 4.6 m height only. Continuous miners produced 7.8 MT coal in CIL in FY21, which is about 30 % of the total underground production. The growth in continuous miner production was 20 %. Use of Continuous Miners must be scaled up, as it not only enables higher production and productivity but also enhances coal recovery and safety.
4. **Diversification:**

a) **Coal to Chemicals Plants:** Methanol, the simplest single carbon compound can serve as the best alternative fuel for India. Some of the advantages of methanol include; it being a highly efficient fuel, can be blended with gasoline/diesel, emits lesser NOx, PM, no SOx, can be further converted to Dimethyl ether (DME), which is a clean diesel alternative and can be blended with LPG as well. Since, coal to methanol is a proven technology in the World, India being the 5th largest country with coal reserves, must tap its potential and produce methanol/DME. China has already leapfrogged to methanol in a big way. China accounts for 55% of the global methanol production of 85 MTPA and has been using it as a drop-in fuel for transportation vehicles and blending it with LPG. The consumption of methanol has risen sharply at a CAGR of 18% over the last decade in China. Moreover, in 2014, 10 MT of methanol was blended with gasoline against a total consumption of 105 MT in China which clearly indicates its strategy to reduce oil imports. CIL has an ambitious plan to gasify 100 MT of coal by 2030.

b) **CBM, CMM, UG Coal gasification:** Coalbed Methane (CBM) and its subsets like Coal Mine Methane (CMM) and Abandoned Mine Methane (AMM) and Underground Coal Gasification (UCG) are emerging non-conventional, clean energy resource which need to be actively exploited.

c) **Pit Head Power Plants:** The carbon footprint of pit head power plants is less than power plants set up close to the demand centres, far away from mines. The freight rate in India is very high, as there is cross subsidization of passenger fare by railways. It is seen that for coal transportation beyond 800-1000 km for thermal coal freight cost is as much as the cost price of coal. Pit head plant reduces the load on the railway network. It is suggested to transfer coal by "wire" rather than by rakes.

d) **Solar Power Plants**: India is committed to creation of renewable capacity of 175 GW by 2022 and 450 GW by 2030. Solar plants can be set up in reclaimed land. CIL and its subsidiaries have taken steps to set up solar power plants. A total of 3000 MW capacity solar power plants are to be set up. This will make CIL a net zero energy company.

e) **Monetisation of waste:**

   i. Reuse of Reclaimed Land: Reclaimed land is being used for setting up of Eco parks, and for solar panels deployment.

   ii. Overburden Waste Processing Plants: Overburden is being used in WCL for production of sand. This plant is proposed for replication in other subsidiaries of CIL.

   iii. Mine water utilisation: Through various levels of purification, treated water can be used as raw water for industrial use and potable water for local communities. Bottled mineral water is being sold as Coal Neer. It is also being used for irrigation. About 3450 lakh m^3 of mine water is planned for use in the domestic and irrigation sector by 2025-26.

Coal's position as the dominant player in the energy sector in India is here to stay. It is the only fossil fuel that is available in abundance in India. The contribution of coal to energy security is immense. Coal to liquid technology is an established technology and can be used for reducing oil imports. India has skilled manpower for coal mining and coal based thermal power generation. The transformation of China into a global powerhouse was powered by coal. Even though the per capita emission of GHG of India is well below China or even the world average and India has every right to increase its carbon footprint, it is important to mine, transport and use coal in an eco-friendly manner as outlined above. Planning and operating large capacity mega mines will enable the introduction of state-of-the-art technology like in-pit crusher and conveying systems, autonomous dumpers, large capacity draglines etc. Elimination of first mile road connectivity for coal transportation by dumpers will reduce traffic congestion in mines, substantially reduce dust generation and greatly reduce accidents due to coal transportation. This will also increase profitability. Other measures suggested for green coal mining include increased deployment of surface miners and continuous miners, coal beneficiation, rationalisation of mines. Forays into new areas like pit head power plants will not only ensure forward integration for the company but it will also reduce logistics cost and the cost of power. Solar power plants in reclaimed land will be the icing on the cake. Supply of mine water to nearby villagers after treatment for drinking and irrigation will improve the relationship between mine management and project affected persons. Setting up of Coal to Methanol plants will be a game changer as methanol is not only a cleaner fuel but will also enhance energy security of the country. India has over 300 billion tonnes of coal reserves. Adoption of the cited measures will result in swift augmentation of coal production in an environmentally and socially sustainable manner.

P. M. Prasad
President, MGMI

Know your President

Mr. P. M. Prasad, Chairman-cum-Managing Director (CMD) of Central Coalfields Limited (CCL) was elected President of The Mining, Geological and Metallurgical Institute (MGMI) of India during it's 114th AGM held on 27th December, 2020.

Mr. Prasad joined Coal India Limited (CIL) in August 1984 after completing in Bachelor of Engineering (Mining) from Osmania University in the year 1984 and since then has performed his duties at Western Coalfields Limited (WCL) and Mahanadi Coalfields Limited (MCL) in various capacities ranging from Executive Trainee to General Manager up-to April 2015. He acquired M. Tech. in Open Cast Mining from Indian School of Mines, Dhanbad in 1991. He has over 34 years of experience in opencast and underground coal mining. His various accolades of those times include reopening of underground fire area in 1994-95 at DRC mine in WCL in five stages. For this outstanding job, he was awarded a meritorious certificate as the best mines manager from Coal Secretary and Chairman of CIL in 1995.

Currently, he is serving as CMD of Central Coalfields Limited (CCL) and also holding additional charge as Chairman-cum-Managing Director (CMD) of Bharat Coking Coal Limited (BCCL).

Introduction to the Special Issue

Paris climate change agreement has set out targets to achieve global average temperature increase within 2°C since pre-industrial times until 2100 and well below 2 °C as an aspirational target. All parties to the Paris agreement have to provide their Nationally Determined Contributions (NDCs) giving their national commitments until 2030. India has provided 8 NDCs with three of these focusing on greenhouse gas emission mitigation. These are to reduce the greenhouse gas (GHG) emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level, to achieve about 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF), and to create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.

Notwithstanding the traditional argument that among the G20 countries India has the lowest GDP per capita, lowest final energy consumption per capita, lowest power consumption per capita and lowest GHG emissions per capita; India has so far met and committed to meet its future NDCs. In fact India is the only large economy compliant to 2 °C[1], that is India's NDC targets and its performance are "2°C compatible" indicating that India's climate commitment in 2030 is considered to be a fair share of global effort based on its responsibility and capability. However, India is a coal dependent economy and about half of its 3.3 billion tons national GHG emissions in 2019 were

contributed by coal mining and coal use activities. Coal provides the national energy security and energy access for vast poor population, while its upstream and downstream supply chains employ around 15 million people directly or indirectly. Over 50% of state earnings for Chhattisgarh, Jharkhand and Odisha are connected to coal royalties, and Indian railways earned 44.7% of its freight revenue in 2018-19 (about 31% of its total revenue) from coal transportation. Coal therefore has a very important path-dependency and criticality in the Indian economy.

Coal use and mitigating climate change are therefore closely interconnected, and more so for coal dependent economies like China, India, USA, Germany, Russia, Japan, South Africa, South Korea, Poland, Australia, Turkey and Indonesia. These together account for over 88% of global coal extraction and use per year. The world consumed 5.4 billion tons of coal in 2019, contributing around 40% of global GHG emissions. These numbers were 0.87 billion ton coal and 49% of national emissions for India. Reductions in coal exploration, trade and consumption would therefore adversely impact energy systems of many countries. However, since coal contributes to almost 40% of global GHG emissions and to meet Paris climate change agreement targets of 2 °C and well below 2 °C compliance for the world, the IPCC special report on 1.5 °C reported that "use of coal shows a steep reduction in all pathways and would be reduced to close to 0% (0–2% interquartile range) of electricity (high confidence)". The pace and depth of national declines would depend upon the economic-

1 https://climateactiontracker.org/countries/india/

socio-political circumstances of each country and would be different. However, one thing is certain – affordable energy for the masses for all times to come is an imperative which no government could neglect. The future of coal would depend upon these and the urgency the world agrees for coal phase down.

The Deep Decarbonization Pathways (DDP) initiative[2] is an international research collaboration of leading national research teams that aims at helping governments and non-state actors make choices that put economies and societies on track to reach the closely interrelated climate and developments objectives. In India, the research team led by the Indian Institute of Management Ahmedabad (IIMA) has proposed a set of realistic pathways to deep decarbonization to reveal the conditions that need to be met at domestic and international level. To further inform policy, the research has done an in-depth social assessment to further understand the circumstances for coal in India.

Coal accounts for 70% of India's electricity generation (Central Electricity Authority)[3]. However, coal usage could begin to decline in the long run as India is increasing capacity and generation from renewable energy. The government has already announced targets to install 450 GW of renewable energy by 2030 – almost five times than that in 2020 and more than twice the coal capacity of 206 GW currently. In terms of share of generation, Central Electricity Authority of India indicates that coal's share could decline to 50% by 2030. However, in absolute terms, the amount of coal used could continue to increase till 2035, as India's overall energy demand continues to grow. However, coal demand could begin to decline after this period. States like Chhattisgarh (third largest coal reserves in India) and Gujarat (major solar power capacity creator) have announced that they will not build any new coal generation facilities[4]. In October 2020, power minister of India Shri R K Singh announced that India would begin to replace coal fired plants with renewables and that India will have around 60 per cent of its installed electricity generation capacity from clean sources by 2030[5]. In combination with the fact that renewables are getting increasingly cost competitive with time, the long-term investments in coal in India is likely to decline[6].

Coal also causes other negative environmental externalities such as local air pollution of different types (e.g. GHG, SOx, NOx, PM), water pollution and land degradation due to coal mining activities. The air pollutants would need different policies and market mechanisms to mitigate these emissions, such as gradual coal phase out, fuel replacement from coal to gas or nuclear or renewables, strict implementation of air quality standards, carbon markets, sulfur markets, technology upgradation from sub-critical to ultra super-critical pulverized coal, flue gas desulfurization, 100% flyash utilization, coal bed methane, CO_2 capture utilization and storage etc. We have to therefore think about a "just transition" for coal in India involving all stakeholders such as miners and mine owners, power plants and other coal dependent industries, coal transporters, fly ash users, local and state governments that depend majorly on coal royalties, populations staying near coal mining and large plants using coal, financial institutions that have funded coal in the past and are worried about them becoming stranded assets, geographies that suffer from acid rains, natural gas stakeholders, nuclear power stakeholders, renewable energy stakeholders, battery and storage initiatives, and national power grid etc. In a nutshell, all those involved for a transition towards a clean energy future for India are to be brought together on a forum. This is an onerous task, requiring indulgence at the highest

2 https://ddpinitiative.org/

3 https://cea.nic.in/

4 https://qz.com/india/1709483/after-gujarat-indias-chhattisgarh-wont-build-coal-power-plants/

5 https://www.business-standard.com/article/current-affairs/india-to-have-60-renewable-energy-by-2030-power-minister-r-k-singh-120072101815_1.html

6 https://www.greentechmedia.com/articles/read/coal-king-india

level of the government system.

The financial implications must also be closely looked into and a due diligence done on these implications. For instance, Germany has allocated over USD 44 billion recently for phasing out coal by 2038 which is to be spent on compensating workers, companies and the four coal producing states[7]. Indian coal industry is about 2.5 times bigger than Germany. Eastern European countries as well, particularly Poland and the Czech Republic, still rely heavily on coal. The European Union recently created a €100 billion fund to aid their transition to cleaner fuels. Coal phasing out therefore would need substantial financial resources for India as well.

Since coal is a global concern, the solution must also be global. Individual coal dependent countries, especially developing countries, would be too much concerned with their energy security and economic-social-political compulsions and may continue with coal, to the peril of global climate change mitigation efforts. The world therefore must come together, bring such as initiative on the table and discuss global phasing out of coal in right earnest at the Glasgow summit on climate change in November 2021. Developed countries should be willing to provide technology and finance for global coal phase out. We do not have much time for discussion as the time for action is running out fast.

Amit Garg
Guest Editor of the Special Issue
Indian Institute of Management- Ahmedabad

Ajay K. Singh
Associate Editor, MGMI
Former Scientist and Head – Methane Emission and Degasification
CSIR-CIMFR

7 https://www.nytimes.com/2020/01/16/climate/germany-coal-climate-change.html

Headquaters' Activities

Minutes of 887th Council Meeting
(Held through Microsoft Teams Virtual Platform VC)
Date & Time: 16th December, 2020 at 12:00 noon)

The report of the 887th Council Meeting of MGMI held at MGMI Bldg., GN-38/4, Sector- V, Salt Lake , Kolkata – 700091 on 16th December 2020 at 12.00 noon (Duly approved in the 888th Council Meeting held on 4th June 2021).

PRESENT : Shri Anil Kumar Jha, President in the Chair. The meeting was attended by Prof Banerjee S P, Prof Dhar B B, Dr Nanda N K, S/Shri Jha N C, Ritolia R P, Saha R K, Goenka J P, Mandal P R, Talapatra Ranajit, Karmakar Anil Kumar, Arora V K, Barnwal J P, Bhattacharya Ashish, Biswas Anup, Chakrabarti Smarajit, Prof Dasgupta Sajal, Prof Karmakar G P, Dr Samantaray A K, Prof Sarkar Bhabesh Ch, Dr Sinha Amalendu and Shri Lochan Rajiw.

ITEM No. 0 Opening of the Meeting

1.1 The meeting called to order by the President, Shri Anil Kumar Jha. The President welcomed the Past Presidents and all Council Members present in the meeting.

1.1.1 Leave of absence were granted to those who could not attend the meeting.

887.1.0 To confirm the Minutes of the 886th meeting of the Council held through Google Meet Virtual Platform VC on **16th August, 2020 at 11.00 am**
The draft Minutes were circulated by mail to all the Council Members. So far, no comments were received. The Council then resolved that:

Resolution: The Minutes of the 886th (2nd meeting of the 114th Session) Meeting of the Council held on 16th August, 2020 at 11.00 am through Google Meet Virtual Platform VC be confirmed.

887.1.1 To consider matters arising out of the Minutes.
The Council considered the Action Taken Report in respect of the Minutes of 886th Council Meeting held on 16th August 2020.

Short Term Course : The Council decided that MGMI should go for a paid version of the Online Platform to be used for the Short Term Course. Council approved the Brochure drafted by Prof. Bhabesh Chandra Sarkar for the Course on Exploration Technique and suggested that a similar model to be followed and the other two courses (Sustainability Development in Mining Considering Environmental Issues and New Legislation – CMR2017) as well.

MGMI AWARD : Approved guidelines for **"MGMI Awards of Excellence"** has been uploaded on MGMI Website which will be effective from next year onwards i.e. 2021-22.

887.2.0 To consider and approve the Audited Accounts for the financial year ended on 31st March, 2020.
The Auditor's Report and Audited Accounts for the Financial year ended 31st March 2020, were placed before the Council for consideration. The Council gone through the Auditors report , Balance Sheet for 2019-20 and Income & Expenditure Report 2019-20 and approved after some clarification and adopted it for further needful.

887.3.0 To Discuss on 114th Annual General Meeting of the Institute.
A letter requesting to organise 114th AGM on 20th December 2020 instead of September 2020 was sent to ROC. A press release was published by Press Information Bureau, GOI that Ministry of Corporate Affairs has given a General order for

extension of time to hold AGM for FY 2019-20 till December 31st from September 30th, 2020.

It has been decided that 114th AGM of MGMI will be held on 27th December, 2020. Meeting will be hybrid i.e. (both in person and virtual attendance). MGMI has already approached CDSL for organising the AGM virtually following the guidelines at led down by ROC. AGM Notice has been uploaded in Website and circulated to all members by post and email and the virtual link will be circulated soon.

887.4.0 To elect the President of the Institute for the year 2020-21.

Shri R K Saha proposed the name of Shri Polavarapu Mallikharjuna Prasad, Chairman cum Managing Director, Central Coalfields Limited as President of MGMI for the year 2020-21. The proposal of Shri R K Saha was seconded by Shri P R Mandal and Shri N C Jha. The members unanimously elected Shri Polavarapu Mallikharjuna Prasad, Chairman cum Managing Director, Central Coalfields Limited, as President for the year 2020-21.

887.5.0 To appoint the Institute's Auditor for the financial year 2020 – 21 with Their remuneration.

Council considered the proposal of M/s. Jha & Jha Chartered Accountants Company vide letter dated 15th December 2020 submitted offer to accept appointment as the Auditors of MGMI for the year 2020-21. The Council approved the appointment of M/s. Jha & Jha Chartered Accountants Company as Auditors of MGMI for the FY 2020-21 at a remuneration of Rs. 12,000/- for execution of all assignments of Audit, ROC, Annual Filling, IT Returns, GST Returns etc.

887.6.0 To consider applications for membership and the membership position of the Institute.

a) The Council approved 04 Life Membership and 01 Student Associate Membership applications.
b) The Council noted the present position of membership which is as follows:

Membership Position
(As on 16.12.2020)

	16.08.2020	**Add**	**Trans**	**Loss**	**16.12.2020**
Member	265	-	-	-	265
Life Member **Associate**	2562 41	04 -	- -	- -	2566 41
Student Associate	06	01	-	-	07
Life Subscriber	32	-	-	-	32
Subscriber	01	-	-	-	01
Donor	03	-	-	-	03
Patron **Corporate** **Life Corporate**	04 08 02	- - -	- - -	- - -	04 08 02
	2924	**05**			**2929**

887.7.0 Any other matter with the permission of the Chair.

Webinar : Consulate of the Republic of Poland in Kolkata has approached MGMI to conduct the WEBINAR on any topic of National interest related to coal in the month of January 2021. The Council unanimously agreed to the proposal and consider it as commendable achievement of MGMI.

Partner : The Steering Committee of Global Methane Initiative (GMI) agreed to make professional alliance with MGMI .
The MGMI will be partner of GMI as a voluntary Body. The Council appreciated the proposal and considered as a very good move for MGMI.

Goodwill messages for Shri Anil Kr Jha, President, MGMI

Shri J P Goenka, Vice President : It was a pleasure to work under him. His effort and dedication in arranging sponsors and hosting Golf Tournament of MGMI at MCL was highly commendable. I congratulate him for taking the initiative for installing the Lift of MGMI Building. I wish him all the best for his future endeavours.

Shri V K Arora : Shri Jha provided new leadership to CIL and played a pivotable role in improving production. Being Chairman, CIL amidst his busy schedule he has attended all the Council Meeting and events of MGMI during his tenure and has tremendously contributed to improve MGMI by devoting his valuable time and energy. He is now implementing his experiences to improve DGMS and other Committees for which he is the leader.

Shri R P Ritolia, Past President : We are feel with gratitude all the help Shri Jha extended for Organising The President Cup of Golf Tournament of MGMI held at MCL . We salute to his commitment that even during Covid Scenario he his physically attend the meeting.

Prof B B Dhar, Past President : All Past Presidents have done very good jobs . Shri Jha has left no stone unturned to take MGMI to National levels.

Prof S P Banerjee, Past President : Shri Jha has been very active and contributed tremendously for the well being of MGMI . I congratulate him for a job well done.

Shri N C Jha, **Past President :** Shri Anil Kumar Jha has contributed tremendously to raise the image of MGMI . He has taken all the initiatives to direct MGMI to new dimension. I congratulate him for all the feathers he added to the cap of MGMI.

Shri Anil Kr Jha thanked to the Past Presidents and Council for their good wishes and mentioned that the meeting has been coordinate excellently.

The meeting ended with Vote of thanks to the Chair at 1.30 p.m.

News About Members

As on 01.04.2021

Shri Debasis Biswas (9550-LM), MMGI is now Retd. General Manager (Vigilance), WCL, Flat No. 8B, Aryan Towers-II
271/B, Sodepur Road, Madhyamgra Pin: 700129, Opposite Madhyamgram Municipality
email: debasis_brunomydog@rediffmail.com

Shri Prasanta Mishra (9432-LM),
MMGI is now Dy. Director General (Retd),
GSI & Top Level Expert, WAPCOS India Limited,
Flat 1B, Vaishnu Apartment,
199, Majhepara Road, Thakurpukur,
Kolkata - 700063, West Bengal.
E-mail ID: pmishragsi@gmail.com
Mobile Nos : 9433070388 ; 9582597655

Shri Ashok Kumar Agrawal (6764-LM), MMGI is now at F-4, Nvt arcot Vaksana, Attibelle Road, P.O. Sarajapura 562125, Bangalore Karnataka. Mobile 7597347068, Landline 080-40990034.

Shri Purnendu Pandey (6973-LM),
MMGI is now at Adani Enterprises Limited.
Associate Vice President- Mine Operation
Flat No- D 101, Cape Town, Sarbahal, Opposite Utkal Continetal Hotel,
Jharsuguda, Odisha, PIN- 768201

Shri Pramod Ranjan Mukhopadhyay (10240-LM), MMGI is now at Superintendent Mines Rescue Station, Dhansar, P.O.- Dhansar, BCCL, Dist- Dhanbad, State- Jharkhand, PIN-828106.

Shri Anupam Nandi (LM-9549), MMGI is now at Shalimar Bag, Flat No 1B,Block-B,Argora Kathal More Road, Pundag, Ranchi,Jharkhand-834004.

Shri Bhaskar Chakraborti (7160-LM) is now at Premises No-23, Postal No-36, Kalitala Link Road, Mandir Para,
Behind Abhishikta Phase-I Apt,
Kolkata-700078, PS-Kasba.
Mobile No - 9477345036 / 8336990499

Shri Abhay Sharma (10401-LM), MMGI is now Dy. Manager, Mining, CH - 41, Jhingurda Project, NCL, PO- Jhingurda, Distt-Singrauli , PIN 486889

Dr. Subimal Mukherjee (8492-LM), MMGI is now Director-in-charge (Retd.), GSI, Flat No. 4B, Aspirations Orchid
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As on 30.06.2021

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(As approved in 888th Council Meeting on 04.06.2021)

As Life Member

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Interviews

Future of Coal in India : What do the Stakeholders Think?

The challenges in shaping a just and sustainable transition for the Indian coal sector are manifold. Academic interpretations of these challenges have been featured in the literature but there is an increasing need to elicit views from industry leaders. Members of the Indian team in the DDP-BIICS project (Prof. Amit Garg, Dr. Ajay K. Singh, Dr. Udayan Singh, Dr. Saritha Vishwanathan) caught up with four such stakeholders. In these interviews, a plethora of coal-related strategies were covered; ranging from policy and climate constraints, to environmental justice for coal workers. Some extracts are presented here.

In the first interview, we discussed the cost-competitiveness of renewables with the coal sector, and important policy perspectives with **Mr. Partha S. Bhattacharyya**, Former Chairman, Coal India Limited. During his tenure, a historic Coal India had record-breaking IPO with an aggregate fund flowing of Rs. 2,33,000 Crores – the highest in India's capital market.

Previous policy statements by the Ministry of Coal and Coal India mention demand of 1.5-2 billion tonnes of coal by 2030-40. Do you think that has changed in the recent years?

Yes, there have been some profound changes. The government's thrust has beenon renewables - solar and wind both - and the capacity addition in that segment has gone up in a breakneck speed. We are today already at 90 GW and we are moving at a pace, where the target of 450 GW by 2030 may not be impossible. We are really going fast, because here the policy support is very much there. Staggering investments are being committed by both Public & Private Sectors. Implicit subsidies and concessions are adding tailwinds to the growth. There are a lot of auctions, R&D and innovation happening in those sectors. As a result, the cost competitiveness of renewable power has dramatically changed over the period. I think in 2014-15, we used to talk about 15-20 rupees, per kilowatt hour. Today we're talking about Rs. 2-2.20 that includes the bit of protection given lately to the Indian manufacturers by levying some import duties.

In contrast to the tailwinds for renewable, coal based power is encountering serious headwinds. The capacity created is much in excess of the maximum demand. The GST compensation cess of Rs.400 per tonne, a very high rail freight to sustain cross subsidization of passenger fare and one of the highest tax and duty rates adds up to render the landed cost of coal uncompetitive at longer distances.

The government has already taken a decision to stop further approval of coal-based power stations. This is not only an Indian phenomenon. It is globally true and India is also falling in line. So, you will not see new capacity being created in the coal-based power space, other than, of course, those which are in the pipeline, and that is something around 35-40 GW.

Ultimately, today, we are about 205-210 GW capacity that may go up to maximum 240-245 GW and ultimately stay there. All new capacities will come on the renewables space. So, this is definitely going to make a difference to the long-term coal demand.

- Mr. Partha S. Bhattacharyya

So, I think that coal will reach a plateau at that level of 1.2-1.3 billion tonnes and stay there for a while and then commence its downhill journey. In any case, it is inevitable that coal will go away some day.

Do you see climate change constraints (such as the coal cess) as becoming a limitation to CIL revenue at some point?

Naturally, because climate change is a live problem. The world is serious about it, and we have no option either. We have to be also serious, and there are some fallouts of that which are happening. You may be aware that international investment bankers have stopped doing due diligence of coal assets. If you want to buy a coal asset and want to get a due diligence done in any part of the world, you will face a challenge in getting an investment banker ready to do it. Today it has come to that situation. So therefore, the chain reactions of climate change initiatives are impacting development of coal and then coal cess, or GST compensation cess, which is about a third of average coal price, is actually discouraging coal consumption, and making coal uncompetitive with respect to others. And that is definitely one of the factors as a result of which coal will be phased out earlier than later.

What are the key policy reforms that you would wish to see in the Indian coal mining industry?

I think the biggest reform was the commercial mining, which has already happened. That, I would say is definitely the big thing. The other thing that must happen is looking at the issues on Coal India Limited exercising its right to increase prices, you know, because the consumer base is so big, there's the power sector there, there is always a clamor for a regulator. So maybe we should consider a strong regulator to come. And that will mean laying down the ground rules for private commercial miners because the commercial miners have to be regulated. So, if that happens, then the pricing can be made much more constructive. Pricing has to be modified in a way that quality improvement can be taken up as profit-centric and not as the cost-centric. The moment anything is a cost-centric, it doesn't happen efficiently. The best way to save money is by not making it happen. But whenever quality control becomes profit-centric, you do quality improvement and then you gain out of it. So, I think changing quality improvement as an activity from cost-center to profit-center is very important, and that has to come through a proper grading and pricing which will apply both to Coal India, as well as to the commercial miners.

Could coal co-exist with net zero carbon target?

This is a very good question and in fact, I was expecting this. There is an article that I wrote for *Millenium Post* titled "Towards carbon neutrality". There we say that coal usage will definitely lead to emission of greenhouse gases. Projections indicate that use of coal in India may not disappear by 2050 or even by 2060. Hence gross emissions will be there, the capturing of which will enable the country to reach net zero. This will require cost effective technology for Carbon Capture & Sorage or Utilization (CCS/CCU). But these involve expensive advanced technology, which we can rightfully expect the advanced nations to develop for use by developing nations like India to help World fight climate challenge collectively. This needs to be duly factored into the Indian road map for moving to net zero.

But one activity that CIL does for carbon capture whose impact is not appreciated fully is afforestation. Coal India Limited has a great track record as far as afforestation is concerned. In fact, I was also not knowing that we do have such a track record, despite having worked in the company for all these years. It became apparent only when the IPO was done. At the time of IPO, we had to collect all information. And we found to our pleasant surprise that for every acre of forest land that we have subsumed into mining, we have given back 2.5 acres. In terms of quality much of these artificial forests were categorized as high density forests based on a satellite survey carried out by MOEF&CC.

If India goes for a carbon market and creates a trading system where everybody has to pay a carbon price, then maybe coal use will be very grossly hit because it will increase the price of power and it will change the game altogether. What is your opinion?

See the GST compensation cess of Rs.400 pt is effectively making that happen already. The withdrawal of that cess, is, in my view, a pre condition for a market determined carbon price to evolve. Also a holistic view on the other headwinds against coal based power as well as tailwinds in favor of renewable must be taken so that disadvantages at multiple points on coal usage is phased out in favor of one market determined carbon price. I agree that some form of carbon pricing has to be there. I also want my grandchildren to breathe clean air and use sustainable clean power etc and a carbon price may expedite the transition. But in any case it should not be a multiple whammy against coal. It needs to be recognized that coal accounts for over 70% of affordable and stable power generation and its replacement will never be an overnight affair.

We also discussed the key technological and regulatory perspectives with **Mr. N.C. Jha**, Former Chairman, CIL and Past President, MGMI.

What have the limitations been for India to effective coal production increase to reach the billion tonne target?

The government has been thinking of producing coal to the maximum extent for generation of power and basically with the passage of time in the last decade or so imports have grown tremendously. In the last 20 years it has grown to the level of more than 250 million tonnes in a year. So, the government was concerned about this and that's why it planned for increasing the domestic coal production to 1 billion tonne by 2019, but somehow it has not picked up, so now it is revised voluntarily. Now, the question is, what are the limitations? Government is generally concerned, but let us first talk about who has the right to produce coal in India? Until very recently, only central government companies had the right to produce and sell coal in the market by virtue of the Coal Mines Nationalization Act. In 2014, a landmark decision was taken by the Honourable Supreme Court of India and almost all coal blocks allocated for captive mining were cancelled and another group of coal producers brought as a captive miner were made ineligible for producing coal. So that was the situation in 2014. This was a setback that reduced the domestic coal production and the imports increased to meet the demand.

The government of that time came up with modifications in the Statute by enactment of Coal Mines Special Provisions Act in 2015 allowing private mining of coal through introduction of the concept of commercial mining. Subsequently, the MMDR (Mines and Minerals Development and Regulation) Act was also modified in 2019 or so to allow allocation of coal blocks without having detailed drilling or detailed exploration. So that was for allowing investors for prospecting any explorations through bidding route. Nowadays, coal blocks are allocated under these two acts with the defining of different sets of milestones. The whole process of policy modifications has taken nearly six years for allotment of coal blocks to commercial miners.

Coal production is greatly dependent on how fast the statutory clearances are given by the government for functionalization of a coal block. The process of getting clearances and the number of clearances required for starting a project is very large and cumbersome. Almost in all the approvals, both the Central and the State governments are involved, and it takes a lot of time before any clearance is reached. The time for bringing a coal project to production varies from five years for an open cast mine to about seven years for an underground mine. However, in practice, it is much more and depends on how much co-operative the two government agencies are.

Though the central government has declared to set up a single window clearance system for coal blocks, it only provides for mining plan approval so far in this system, which involves only Central government. Major obstacles are in the land acquisition, forest land clearance, environmental clearance and a number of other clearances where positive support of both Central and State governments and other agencies are required. In the last five years, the captive miners who got the coal blocks allocated under the CMSP (Coal Mines Special Provisions) Act, have just been able to reach a production level of around 55 million tonnes. I mean, these were the mines, which were actually producing before cancellation of the blocks and because of cancellation, these mines got stopped. So, now in last five years, they have been able to come up only to that level. So, that was a great setback.

Could coal co-exist as part of a net-zero emissions target?

See, coal is the largest emitter of CO_2, through its spontaneous combustion and through its usage. They are the two factors. This spontaneous combustion comes at the producer's end and the larger amount of coal gets converted into carbon dioxide at the coal user's end, and that is largely in the power sector. And it also contributes to CH_4 emissions during the production stage.

Meeting the net zero emission task for the coal sector in my opinion, will be a difficult task, although coal sector is already doing a lot in this regard, through plantation of trees of different varieties in its mined-out areas. Also, the efforts of coal producers to set up solar power plants could lead the sector to a net zero emitter status.

- Mr. N.C. Jha

But a major effort has to be made by the coal users and unless this system of carbon capture and storage technologies are developed to economically compete with non-renewable energy sources, getting a net zero emitter status for coal chain i.e producer and user, appears to be a big challenge.

Is there a chance, say after two decades, where coal from India could be exported to developing countries which may not have coal as a source. Is there talks about that as well?

You have to see what quality of coal India has. We have around 320 billion tonnes of coal resources. This is again an estimate, made a long time, made on the basis that no coal has depleted, so if you take the depleted coal that has been used already, then it will be around 300 billion tonnes or little less. Now majority of this resource is of inferior grade coal with ash percent above 30 percent. So, when we look at the international trade of coal, coal is traded at much lower ash, because people would not like to transport dirt and then use it. Therefore, coal beneficiation is a must. And if you want to export coal from India abroad, then it needs to be beneficiated. What we have noticed is that, if you wash non coking coal, it is economical only when the ash is reduced to 34% or 32% because the coal has a level of ash content, ranging from few percentages, which is very less to as high as 55%. So, in order to make it usable, we have to reduce the ash by washing or beneficiation to a level of 32%, which is economically viable currently, and this coal cannot be exported because exported coal is available at much lower ash which may be around 20%, 25% to the maximum.

It also depends on what other components of coal are there, like moisture. If you look at Australia, they generally export coking coal, because thermal coal is not profitable for them for export. But thermal coal, we import from Indonesia, South Africa and some other countries also. Indonesian coal has got high moisture, but ash is as low as 3%. So, when you use it, ash does not become a burden for the user because the moisture gets evaporated. So, the residue to be handled at the power plant end is very less. All this background I am giving you, just to impress that the ash percent in Indian coal is a very negative point for export, and if we want to be able to maintain the level of coal as per the internationally traded quality, it will be economically unviable. So, it has to be used to the maximum extent domestically.

All our coal is not of very poor quality, we have some good quality coal also, but its quantity is so limited, and these are linked to some old power plants which can use only high heat intensity coal, so they cannot be spared for export.

Would a focus on coal-based alternatives such as coalbed methane and underground coal gasification provide sustainable sources of revenue for Coal India in the future?

Well, let me first talk about the coalbed methane. You see, coalbed methane is a concept that was developed about two decades ago and blocks for CBM was identified, initially 26 blocks were allocated, later the number of blocks increased. But if you look at what happened to those blocks, you will find that there are only three blocks currently operating. Coalbed methane is an inherent quality of coal. The Indian coal generally occurs at shallow depth and that too with very poor quality, I mean high ash content. Coal formations are subjected to lots of faulting and other geological activity. So, what has happened, even if there was coalbed methane, i.e CH_4 gas, entrapped into the coalbeds, they have generally escaped. And the two coalfields that generally have coalbed methane or methane, the Jharia coalfields and the Raniganj coalfields have been subjected to more than 200 years of exploitation. So, if you gave an exposure to the methane, it would escape to the atmosphere. The concept of CBM has come only two decades ago but CBM found its way to the atmosphere a long time ago. The fact of the matter is that the reserves of CBM is very limited and Coal India Limited can base some of its businesses in CBM in limited areas, like you know the eastern and western part of Jharia coalfield and whole of Raniganj coalfield where actually not CBM but CMM (coal mine methane) will play a bigger role. But across the other coalfields, these other coalfields do not have the gas content, largely you know they are degree one gassy, they don't have methane content.

On the underground coal gasification also, we tried several times to have a project but underground coal gasification has not been a success around the world. The Chinchilla project which is not talked about much, was a pilot project in Australia and then subsequently closed down. I personally visited that project, but then at that time it was closed down, not working. There are some coal gasification plants in the Russian bloc countries and some means a few, not many and some in China. But then coal gasification in India is fraught with danger of polluting groundwater and because we have limited surface area and high population, the environmentalists will have a tooth and nail opposition to this concept. So, Coal India can go on pilot scale. It has identified a couple of projects for underground coal gasification, it has to be only seen after its success is reported. But as a general rule, because of the large revenue base of Coal India through coal production, coal gasification will be only a very small drop in the ocean, and it cannot be a step to be fully dependent on for revenue generation.

So, does it also mean coal to chemicals is one of the big waves where Coal India Limited could go in future?

Yeah, that is true, surface gasification of coal has been involved in India, for a long time. The earlier FCI (Fertilizer Corporation of India) plants used to have coal-based gases for their fertilizers. And those got subsequently closed because of maybe other economic reasons. Now, the government has again put thrust and government is trying to revive those 2-3 plants, the Talcher, Sindri and one more plant with partnership from Coal India Limited, NTPC and a couple of other companies, GAIL etc. So that is for coal based gas generation, surface gasification. JSPL has come up with a good gasification plant at Angul and they are generating different chemicals and gases through that plant. Unfortunately, they don't have coal, the block that was given to them got deallocated. So, they are buying coal from Coal India Limited and the MD of JSPL said that if coal blocks are given to them, then they can produce syngas at the comparable market rate of 3.5 dollars per MMBTu. Currently they are producing at 5.5 dollars per MMBTu. But, if they can be given the right to mine coal themselves, they can reduce the cost in the vicinity of the plant and then it will be comparable to the imported gas price. So, it is an area where Coal India Limited should definitely take a leap forward and try to set up these plants, surface gasification plants on its own or I would advocate that they should outsource to the private agencies who can economically produce gas at a much more competitive rate.

With the increasing relevance of the private sector, we also caught up with **Mr. Vinay Prakash**, CEO, Adani Natural Resources on his perspectives about coal futures in India and the role of workers in this transition.

Previous indicative policy statements of the Government of India indicate use of 1.5-2 billion tonnes of coal by 2030-40. Do you think that has changed in the recent years?

I personally feel that, going forward, coal is going to remain there. The share which is currently around 72-73% in terms of the total energy mix will come down to 50%. You will see growth of 12 to 15% in renewables, which is good and also in line with our objective and target to achieve and what we have indicated to the world. The coal sector growth is going to be less, 3 to 4%. But on an overall basis, you will find that coal is going to remain there for at least next two to three decades. You will have a balance, where coal percentage in a total will come down to 50%, but I feel it is going to remain there, the requirement of coal is going to go from the current level of 1 billion tonnes to 1.5 or 1.6 billion tonnes and that's what I feel.

Earlier, 5-6 years back, when they were making these policies they were talking about 1.5 to 2 billion tonnes on the basis of the growth which they have seen for the earlier 5-10 years, and also on the basis of power generation growth, which they were seeing. At that time they were not taking this renewable power growth to be at the level of 10 to 12% Y-o-Y growth. So definitely, if you ask me, I don't see the thermal power requirement or thermal coal mining requirement going up to 2 billion tonne, but for sure it is going to cross 1.5 billion tonnes in coming years.

Are there any key bottlenecks on the coal utilization side (either power or industry) that could be sorted through technology or policy levers?

The biggest bottleneck is connectivity. We don't have railway connectivity with many of the mines, you don't have good policies for the connectivity. We are still working on 4000 metric tonne railway capacity. We are still struggling to transport that much amount of coal across the country. We still have to really pump up in our RSR (rail cum sea cum rail) route capacity.

So, I think first of all the needs is to build up a very robust infrastructure which can support this type of volume (1.5-1.6 billion tonnes of coal capacity). There are places where people are starving for coal and there are places where people are having coal and are sitting on coal. In today's time, Coal India says that they have 28 to 30 million tonnes of coal available at their pit head. But, there are places where people are saying that they have a stock of only 3 days' time, so why is it not matching. It is not matching because you are not having the infrastructure to link it.

We have been seeing some social initiatives for community engagement by Coal India. But some worker unions etc., are little apprehensive about the commercial mining. So, what could be the initiatives on part of the private players that could help alleviate some of these concerns from the workers side?

I think it's a very relevant question in terms that when we talk about the mining sector, the general perception is that the workers are all covered in coal dust, the mining sector is responsible for death of many people, safety concerns are there, the mining sector has a very rough way of working, there is lot of damage to the environment also. So, the general perception is that the company is not taking care of the employees and the worker community.

With this commercial mining and with a lot of players which have worked in similar areas in different infrastructure projects, I believe a sense of responsible mining is coming in India.
- Mr. Vinay Prakash

I will talk about one mine which I have personally developed in the last 10 years, the PEKB (Parsa East and KantaBasan) mines at Surguja, Chhatisgarh. In that particular mine what we have done is that we have worked out on the need of the community first, we have done a deep study of the community requirement. What we realized is that the community needs education. There is a need to have a lot of investment into malnutrition issues of the community.

Another issue we have found out is the issue of domestic violence and people getting separated. So what we have done is that, we have actually worked out the complete package and we have put in a CBSE standard school, "Adani Vidyamandir". We understood that the females are interested to work but they're not earning that much, so that they can be independent. So we have created a "Mahila Udyam" committee where we are giving the infrastructures for them to do lot of activities which would make them independent.

We created the job employment for the people for the males by getting them into the VTCs (Vocational Training courses), lot of initiatives were given to train them for the things which are required there. And with that now the particular place is a digital village first. Secondly, the education level of the kids has gone from 23% to 98% now. Kids are now aspiring to become IPS/IES/IAS officers. And this particular engagement which we have done there for the community is setting an example for people to come and work with Adani to do well as they have seen it happen in the community in Surguja. Second thing is, when we talk about the manpower, which works with us in which we have two types of manpower, one is the technical manpower which we employ to the mining activities and secondly the project affected people where we are obliged to give them employment and we engage them on a basis that we are in position to use them properly. We want to motivate them to see that their minimum salary is "X", how they can make it "X+Y". And for that motivation, we are doing a lot of other initiatives, which is actually motivating them to come forward. Initially the percentage of people coming forward was less. But over the period of 3-4 years, around 85% people came forward and are ready to continue working and we ensure that they are properly engaged.

Along with our efforts to elicit the views of industry leaders, we also interacted with **Mr. K. Lakshma Reddy**, who leads the coal wing of the Bharatiya Mazdoor Sangh (BMS), and is also BMS' National Executive Member. Our efforts were to understand the views from a labor union perspective, which have not been covered from the Indian research context in great detail.

Please shed some light on coal transition issues from a labor perspective.

What I feel is that the ecological balance and livelihood of coal workers have to go hand-in-hand; one cannot be at the cost of the other. Climate change is a serious, global issue without a doubt. But the role of developed and developing countries should not be equated in this crisis. During the last 200 years, since industrialization, western nations have been primarily responsible for climate change. They should not ask developing countries to meet steep reduction targets by a particular year. Any change should come about in a phased manner.

We see that renewable energy already forms 38% of the Indian energy mix. But if you look at what the developed countries have committed to in the Recent G7 meeting and prior to that, in the Paris Agreement, it seems they are not serious about it. There is low likelihood of these countries meeting their near-term targets on GHG mitigation, i.e., by 2030.
- Mr. K. Lakshma Reddy

How many workers are directly and indirectly linked with coal in India?

I believe there are close to 0.5 million workers in the coal mining industry itself. This includes government employees and contract workers. If you include ancillary sectors such as coal transport (through trucks), it may be close to 1 million. Upon including power plant employees, the total may be close to 2 million.

Do you see any recent changes in coal businesses, especially that effect the workers?

Definitely, there are three major changes which should be noted. The first is that coal companies are adopting the latest technologies – in terms of automated machinery and so on. This might result in job losses. The companies say that this is inevitable to maintain cost-competitiveness with other industries. The second key development is the closure of several underground mines. These closures have led to job losses. The third development is that coal mining industry may not survive in isolation due to global climate pressures and accordingly, there is a thrust on diversification. So, the companies are investing into renewables. Recently, Coal India tied up with the National Aluminum Company (NALCO) to set up aluminum smelting plants.

What are the main issues of various categories of coal workers and their families? And how do unions help them solve these issues?

The first major problem is that the coal mine workers appointed long back (3-4 decades ago) have very low levels of literacy. As such, they are not aware of their rights within the company policy as well as the government policy. Our organization tries to educate them about these. I have personally been regularly interacting with them and apprising them of the latest updates to these policies. Another key issue is the poor living facilities and other housing amenities that these workers and their families live within. More recently, during the COVID-19 pandemic, it became somewhat clear that maintaining social distancing within an underground mining context was extremely difficult. As per our estimates, nearly 500 workers died due to COVID-19, in addition to their family members as well. Recently, the Hon'ble Coal Minister announced a compensation of Rs. 15 Lakh ex-gratia for workers who died due to COVID-19. This has been disbursed and we have regularly been following up on this.

What do you think about "just transition" for phasing out coal?

Achieving just transitions is an extremely difficult challenge in context of the Indian coal industry. That was noted by the U.N. Secretary General also that some mechanism must be thought out for alternative reemployment of coal workers, who are already engaged in different stages of the coal supply chain. Until such time, the government likely cannot afford an immediate phaseout of coal. I think the coal would be around for at least the next 2-3 decades. A just transition would require inputs from everyone. For instance, Coal India subsidiaries have been largely dependent on trucks for coal transport. But there is an effort (as outlined in a NITI Aayog report) to shift to more mechanized, conveyer belt system.

For Just Transition in Indian coal sector, developed countries must supply the latest technologies. Similarly, the funding for a just transition must also be contributed to by developed countries. A just transition is necessary from the point of view of the international community, and accordingly taking the workers' welfare should be of utmost priority.

- Mr. K. Lakshma Reddy

Perspective Piece

Framing the Just Transition

Geeta Morar[1]

A Just Transition is essential for South Africa

There is significant pressure on countries to decarbonize their economies to net zero emissions by 2050 in order to contribute to mitigating the worst impacts of climate change by the end of the century. Countries committing and implementing plans to achieve net zero by 2050 are also doing so to ensure that they remain globally competitive in future low carbon markets and to develop social and economic resilience to the existing threat of climate change that is already.

While South Africa contributes only 4% of emissions globally, it is Africa's largest emitter with the bulk of electricity being generated from an aging fleet of coal fired power stations. As a signatory to the UNFCCC and to the Paris Agreement, and as an energy and emissions intensive middle income developing country, South Africa recognizes the need to contribute its fair share to the global effort to move towards net zero carbon emissions by 2050, taking into account the principle of common but differentiated responsibilities and the need for recognition of its capabilities and national circumstances

South Africa itself is also highly vulnerable to the impacts of climate change and will need significant international support to transition its economy and to decarbonize. Furthermore, given the country's high rate of inequality and unemployment and the extent of dependence on a fossil fuel-based energy system and economy.

In response to the above imperatives, the National Business Initiative, together with Business Unity South Africa and the Boston Consulting Group has worked with corporate leaders and other stakeholders representing government, labour, youth, and civil society organisations, to assess whether the pathways exist for the country's economic sectors to decarbonize by 2050.

Central to this study is to work out how this could be done in such a way as to build resilience to the impacts of climate change as well as to put the country onto a new and low emissions development path that addresses issues of poverty, inequality and unemployment. Our results to date show that this is possible.

The findings from the energy sector decarbonization pathway, so far, shows that the least cost electricity decarbonization pathway for South Africa is driven by a significant increase in the uptake of renewable energy, storage and gas (as a proxy for system flexibility and to manage peaking). Implementing this system could mitigate emissions to the extent that we have around 70 Mt $C0_2$-e left. From this point, and in order to get to zero emissions, an overbuild of renewable energy systems (to around 150 GW by 2050) along with investment into direct air capture (if gas remains in the system) would be required. An alternative would be combine the renewable energy overbuild with investment into a green hydrogen (H_2) system- with the intention being to use green H_2 to replace the gas and decarbonize further from 70MT CO_2-e.

The implication of these results is that, if South Africa wants to re-orientate the country towards a new and low emissions development path that addresses issues of poverty, inequality and unemployment, it is necessary to phase out the use of coal to generate electricity.

Coal is presently a central part of the South African economy and currently provides employment for 89,000 people in coal mining alone with an additional 76,000 jobs provided by companies in the broader value chain, including Eskom and Sasol (TIPS, 2020). Furthermore, the bulk

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of the coal transition risk lies in Mpumalanga, South Africa, because coal mining and related activity accounts for 8% of total employment in the province (TIPS, 2020). Impacts are therefore very local.

It is therefore essential to work out what a Just Transition looks like for South Africa. The transition is underway in the energy sector globally and in South Africa and it will become relevant to other sectors over time. There is therefore a real need to unpack what a Just Transition means in a developing country context, what it truly means to "leave no one behind," and to work out as a collective, what the future after the just transition looks like.

This paper offers a first attempt at unpacking what a Just Transition is based on insights offered by transitions literature in an attempt to understand the multitude of approaches and perspectives to transitions that exist. These perspectives inform approaches for the development and implementation of Just Transitions in various contexts and dictate which stakeholders need to be included as well as when and how they should be involved and the extent to which they have the power to influence the process. This paper argues that neither perspective is more correct than another but rather that all offer useful insight and knowledge that can be used to inform the development of context specific Just Transitions.

What is a just transition?

A Just Transition is a multi-stakeholder, participatory process that seeks to transition the country's economy to one that is socially inclusive, environmentally sustainable, and economically competitive on future carbon neutral markets. It is an economy-wide process of change and adaptation that also aims to promote economic recovery post covid as well as resilience in the face of climate change.

In a developing country such as South Africa, it is also essential that just transition efforts strive to acknowledge and address historical socio-economic inequality at a local and global level, and to carefully and consciously manage distribution of resources and the employment transition hand in hand with sector transition. Central to a Just Transition for South Africa are therefore issues of decent job creation, ownership, inclusion, and service delivery.

Issues of procedural justice are key. A Just Transition dialogue is ultimately a negotiation between stakeholders around what the future of our country and economy should look like. It is a question of who has the power to decide what actions, how those decisions are taken (Geels, 2014), who will be affected by those decisions and the extent to which those affected are proactively empowered (Just Transitions Initiative, 2021) and included.

Mapping approaches to Just Transitions

There are many perspectives from which this negotiation can take place- each informed by their own sets of knowledge, values, and theories of change.

In a study of language used when describing the Just transition in key international frameworks and transition and sustainable development related papers including those released by the IEA, ITUC, UN, NEF, UNEP and OECD between 2008 and 2012 highlights two main types of approach towards designing and implementing transitions: the localist approach and the technocentrist approach (Audet, 2016).

Both approaches emphasize the need for, and importance of, economic change but propose different starting points and call for different depths of transition- some for a complete economic overhaul and the robust inclusion of all affected stakeholders, and some for the option of greening current economic activity with limited levels of stakeholder engagement.

What is the localist approach to just transition?

The localist perspective departs from the premise that the economic transition needs to take place to enhance and secure social and ecological wellbeing first and foremost and that local actors are the primary initiators and drivers of change. From this perspective, local stakeholders are best placed to develop and implement climate solutions than are national governments and large corporations and value robust stakeholder engagement for decision making (Audet, 2016).

There is ambition for deep economic transition of the incumbent economic structure in a process that is procedurally just and seeks to address current and past inequality. This approach, or discourse, is further sub-divided into two theories of change: Grass-Roots Change, encompassing actions of individuals and grass-roots organisations, and Policy Change, emphasizing the central role of local governments at municipal and city level (Audet, 2016).

What is the technocentrist approach to just transition?

The technocentrist approach/discourse takes a more direct look at the economy itself and, in the context of macro-economics and development strategy, proposes that the transition needs to take place to ensure the long term sustainability and competitiveness of the economy. From this position, change is seen to be driven by economic policy, climate research and development literature, and the market, and it is assumed that social and ecological benefits will be experienced as the economy transitions (Audet, 2016).

Unlike the localist perspective, that can be categorized into the grass roots and policy change buckets, the different types of technocentric perspectives exist on a spectrum. The drivers of change include the market, new technologies, governments, business, labour, and other organisations and communities, and the degree to which they are involved in the transition depends on where the perspective lies on the spectrum. The two sides of the spectrum are indicated by the degree of institutional reform proposed (Audet, 2016).

The one side of the spectrum is characterized by a low degree of ambition for institutional reform and for limited levels of procedural and distributive justice. The market is considered the primary driver of economic transition, new technology is considered to be the solution to all climate and economy related challenges, and the role of the state is to simply incentivize and enable the uptake of renewables to reduce emissions in line with economic trends and ensure economic sustainability on global markets. There will be both positive and negative socio-economic consequences but the fundamental premise is that economic growth will eventually trickle down.

This is fundamentally informed by the neoliberal approach to development where ecological wellbeing is considered essential to the extent that it supports economic growth. Language and concepts associated with this discourse include "green economy", "blue economy", "ecological infrastructure", "green growth" (Audet, 2016)

On the other end of the spectrum is the perspective characterized by the call for much higher ambition for institutional reform. This perspective argues for much stronger involvement and cooperation of stakeholders, state, labour, and business in particular. The transition needs to be planned to pro-actively and carefully manage the socio-economic outcomes and maximse the benefit for environment and society while ensuring economic sustainability (Audet, 2016).

The underlying premise acknowledges the need for GDP growth although the definition of national and economic success and growth is considered much broader than simply a measure of GDP. Central to this perspective is the need to generate robust research to inform decision making (Audet, 2016).

Why is this useful?

Organisations have used broad transition framings like this to start categorizing just transition projects for financing to understand the degree of transition and justice that can be achieved by each and therefore, help direct funding decisions (Just Transitions Initiative, 2021). The reality of the Just Transition, especially in South Africa, with its democratic governance system, social diversity, and high degrees of socio-economic inequality, is that it must encompass a combination of approaches. The role of a nationally organized just transition effort is to work on finding and building common ground between stakeholders and fundamentally between the wide range of value positions and theories of change that exist and support in weaving a collective vision of the country's future and path to realization.

Towards a framework for finding common ground

There is a global transition underway in the electricity sector. Forward thinking countries, and those with the capacity to do so, are moving away from centralised fossil fuel based electricity systems towards more diversified and decentralized electricity mixes and systems relying on ever increasing amounts of green renewable energy. This consequent impact on coal mines creates serious socio-economic challenges for countries with entire regions and multiple communities whole livelihoods are entirely dependent on coal, and related, industries.

The 'just transition' has therefore predominantly been defined in relation to the transition from coal when, in reality, it should be much broader. While the coal industry is the first sector to face the transition, it will not be the last.

The NBI has partnered with the Boston Consulting Group (BCG) and Business Unity South Africa (BUSA) to run a collective, and transparent research process to develop and offer strong technical decarbonization pathways for each of South Africa's sectors and corresponding socio-economic impact analysis to support the national effort to craft a just transition strategy for the country. This study falls somewhere along the spectrum of technocentric approaches described above, with a bias towards institutional reform, acknowledging the social context experienced by South Africa's people (highest inequality in the world, 30% unemployment – 50% amongst the youth -, and 55% of the population living in poverty)

The state has a strong role to play in the just transition and that a level of institutional reform is necessary to truly ensure distributive justice but that the state will also need to work constructively with the private sector, civil society and other stakeholders to craft a common vision and implement action towards a just transition. The NBI is consulting widely with business, labour, government, and civil society, and the youth through various aligned organisations. In order for the NBI contribution to be useful the study needs to be as transparent and objective as possible. There is therefore great importance placed on inclusion in consultations and making assumptions and modelling approaches available for scrutiny and replication.

There are also several key concepts that must be addressed by a just transition process in South Africa in order to ensure that it is in fact just. these are: job creation and decent work, social vulnerability and protection, ecological protection, education, capacity building and re-skilling, economic inclusion and participation, ownership, infrastructure planning and roll out, service delivery, policy and governance, and potential social and geographic dislocation.

These elements have been identified through our stakeholder engagement processes and they form the basis of the approach to the socio-economic modelling component of the NBI Just Transition Pathways Project. We are currently in the process of developing a framework that can help us understand at what level of just transition implementation each of these concepts needs to be addressed (national, provincial and/or local level), and in what levels of depth, in order to develop and implement just transition solutions to the serious social, economic and environmental challenges we face.

The way forward

While the NBI is contributing a body of research on the technical decarbonization pathways and corresponding socio-economic consequences, opportunities and solutions, it is beyond the NBI's capacity and scope of work to effectively consult at the grassroots level. It is, however, essential that these stakeholders are effectively involved and engaged in concrete decision making and implementation processes. This illustrates a vital opportunity for further collaboration between organisations and individuals with views from the range of just transition perspectives. Having a common and uniting vision is essential to unlock the true potential for South Africans to once again join forces to develop a way forward from the current social, economic, and environmental crises we face today that incorporates rather than attempts to homogenize a single approach across all contexts (Blythe et al, 2018).

Conclusion:

This short paper offers a first attempt at unpacking what a Just Transition is, based on insights offered by transitions literature in an attempt to understand the multitude of approaches and perspectives of transitions that exist. These perspectives have the potential to polarize stakeholders working to craft and implement Just Transition processes and plans for their countries and it is essential that these processes be focused on finding common ground between stakeholders so they may benefit from the inclusion of a broad range of knowledge, insight, experience, approach, and skill to inform a more wholistic vision of an inclusive, equitable and resilient future and process to get there.

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Perspective Piece

Global Coal Phase Out Efforts

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Introduction

The world crossed an inflection point in 2015 when nations universally agreed to reaching global peaking of GHG emissions as soon as possible and reach net-zero or negative GHG emissions in the second half of the century. This was established in the Paris Agreement as a necessary condition to limit the temperature increase to well below 2C, and aspiring at 1.5C, and with this, to be able to protect the most vulnerable against the worst impacts of climate change. Five years later, carbon neutrality (i.e. net-zero carbon emissions) is not just a global objective, but a rapidly growing country-level end goal. To this, countries are exploring strategies to accordingly transform their economies while meeting their development priorities, identifying opportunities as well as ways to facilitate the establishment of conditions that will support them in this endeavour.

Coal-dependent countries are no exception. Six and eight countries amongst the top ten coal producing and the top ten coal consuming countries respectively are already committed to carbon neutrality: China, US, Australia, South Africa, Kazakhstan, Poland, Japan and Germany. The remainder (India, Indonesia, Russia and Colombia) are publicly considering such a commitment.

This paper provides a global perspective on the implications of the universally adopted Paris Agreement for coal use, as well as the established multifaceted links between coal and sustainable development. Next, it unpacks general implications for individual countries and current state of thinking in the face of these implications. As a major challenge, the paper discusses the risks embedded in the national coal transition actual debates and the role of domestic and international governance in supporting them.

What does carbon neutrality mean for coal, physically?

Carbon neutrality cannot be understood if we do not go massively out of all fossils, notably coal. Technology, including Carbon Capture and Storage (CCS) may change slightly the transition but not the end point.

IPCC's Special Report on 1.5°C (IPCC, 2018) describes the transformation of the global power sector in 1.5C pathways: all modelled scenarios project renewable energy sources to supply 70–85% of electricity in 2050 whereas the use of coal shows a steep reduction. Shares of nuclear and fossil fuels with CCS are modelled to increase in most 1.5C pathways compared to the current electricity system. The use of CCS would allow the electricity generation share of gas to be approximately 8% of global electricity in 2050, while for coal is reduced to close to 0%. The most recent analysis from IEA (IEA, 2021) increases this the projection of renewables to almost 90% of electricity generation, with wind and solar PV together accounting for nearly 70%, and nuclear covering most of the remainder. This IEA NetZero pathways implies that "no additional new final investment decisions should be taken for new unabated coal plants, no new coal mines or mine extensions to be approved from 2021, the least efficient coal plants to be phased out by 2030, and the remaining coal plants still in use to be retrofitted by 2040".

Although the main IPCC & IEA messages largely focus on electricity, coal needs to be drastically reduced in other sectors such as industry and

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residential. IEA precises that in addition to facilities fitted with CCUS, fossil fuels that remain in 2050 are used in goods where the carbon is embodied in the product such as plastics and in sectors where low-emissions technology options are scarce" (IEA, 2021). The transformations and strategies for each of the sectoral transition would largely vary. Whereas in electricity the key criterion may be the domestic potential of renewables and access to battery storage, in industry, massive technological and process shifts may largely depend on international innovation efforts and market developments.

How do these transformations affect SDGs and development priorities?

Carbon neutrality must be explicitly assessed in the context of sustainable development and efforts to eradicate poverty and reduce inequalities, acknowledging that climate change and development can be considered two sides of the same coin. According to the IPCC 1.5°C Special Report, limiting global warming to 1.5°C rather than 2°C above preindustrial levels would make it markedly easier to achieve many aspects of sustainable development, with greater potential to eradicate poverty and reduce inequalities (IPCC, 2018). The same Report finds that mitigation options consistent with 1.5°C pathways are associated with multiple synergies and trade-offs across the Sustainable Development Goals (SDGs). It establishes that while the total number of possible synergies exceeds the number of trade-offs, their net effect will depend on the pace and magnitude of changes, the composition of the mitigation portfolio and the management of the transition" (IPCC, 2018).

The links between coal and sustainable development are multifaceted. Firstly, we have the risks of transitioning out of coal, namely in terms of energy security, affordability (SDG 7), and employment. The deployment of small-scale renewables, or off-grid solutions for people in remote areas has potential to counterpoise by enhancing energy access (SDG 7) (Sánchez and Izzo, 2017). As a rule, trade-offs must be scrutinized in detail to anticipate potential negative social outcomes by putting in place robust policy interventions, including through regional cooperation-building (SDG 17) and institutional capacity (SDG 16) (Labordena et al., 2017). IEA (2021) affirms that ensuring uninterrupted and reliable supplies of energy and critical energy-related commodities at affordable prices will only rise in importance on the way to net zero.

Secondly, the reduction of coal use reduces adverse impacts of upstream supply-chain activities, in particular air and water pollution and coal mining accidents, and enhances health by reducing air pollution, notably in cities, showing synergies with SDGs 3, 11 and 12 (Yang et al., 2016; UNEP, 2017 via Ch4 IPCC SR15). Reducing current city pollution is a health imperative across the urban world, becoming an in-country clear short-term motivation against coal use. Thirdly, for many countries coal phase down creates the opportunity to build a more robust macroeconomic structure, even in the absence of a climate constraint. Diversity of the energy supply translates into a reduced dependence on scarce resources and international trade -the well know natural resource curse. For critical minerals-rich countries, including minerals like copper, cobalt, manganese and various rare earth metals, the energy transition offers a significant area of growth that could support countries trade balance, with revenues from those minerals expected to be larger than revenues from coal well before 2030 (IEA, 2021).

Fourth, coal assets may represent a financial risk as international investors are progressively banning coal-related investments. Fifth, the pace of coal phase down is directly linked to the risk of negative effects on sustainable development objectives in the medium term. In the context of Paris Agreement-compatible pathways, delays in emission reductions result in the need for abrupt trend reversals and heavy reliance on negative emissions, which comes along with intensified social disruption and higher risk for development priorities associated to the availability of land, in particular food security as well as protection of habitat.

For coal transitions, both literature and public debates tend to focus on the first two arguments: the potentially negative effects on energy security and employment, and the positive effects on health and pollution. Arguably they respond to citizens' short-term concerns. However, growing risks emerging from the last three arguments, including macroeconomic diversity, finance and stability, are probably the most structurally important to ensure durable achievement of SDGs.

But what does it mean for individual countries?

In IPCC words, "whereas the benefits of adaptation and mitigation projects and funding may accrue to some and not others, responses may be costly and unaffordable to some people and countries, and projects may disadvantage some individuals, groups and development initiatives (IPCC, 2018). For individual countries, any climate policy objectives must work within their national development goals to sufficiently provide for development and equity, and so, to preserve social cohesion through the low carbon transition. This requires well-tailored policy and sectoral policies and actions that are in accordance with development goals and consider the needs and political direction (i.e. supporting or opposing) of all major stakeholders.

Above milestones on physical transformations for Paris Agreement-compatible pathways do not mean that each country should reach carbon neutrality by 2050. However, national deep decarbonisation pathways should consider that energy and land-use carbon emissions should tend to zero by mid-century or soon after, meaning in turn that each sectoral trajectory should be framed by the carbon neutrality approach. In addition, negative emissions from land-use should be enhanced, and additional net negative emissions may be needed from biomass combusted with CCS, direct air capture of CO2 with CCS, or other direct negative emissions techniques.

In-country long-term assessments illustrate very well the different challenges and options raising from specific national circumstances, including from political, economic, social, cultural, and technical feasibility perspectives. These assessments can be a very useful tool to effectively explore the articulation of socio-economic implications and stakeholders' positions. From a generation mix structure perspective, long-term assessments can reveal important variants of the energy transition depending on the physical resource potential, technology availability and acceptability or political economy structures. National reserves and path dependencies established over the years play a central role in in-country energy system scenarios. Key assumptions on solar energy, wind energy and electricity storage technologies are critical, and can also explain much of the heterogeneity across national assessments. Differences emerge from assumptions on the learning cost, cost of capital and resource availability; also technical concerns on grid stability. Last, national considerations are also connected to the needs identified for the energy system through the different sectors' energy demand as well as cross-sectoral interrelations. The transitions must be gradual and relevant to national circumstances.

These analysis, primarily techno-economic in their nature, can provide robust evidence on the energy system transformation in the context of climate change, often centred around reliable energy systems and available choices to replace fossil fuels, where they exist. If stakeholders are involved, the analysis may result in socially agreed visions of the main transformations, along with a granular understanding of underpinning technical conditions that will drive the implementation agenda (development and access to batteries, demand response and low-carbon flexible power plants, smarter and more digital electricity networks, and others). A second layer of analysis and stakeholder dialogues that may be derived from the long-term assessments, if appropriately done, concerns the actual transition story, i.e. how to tackle short-term finance, legal and infrastructure gaps and employment effects. In other words, the evidence required to plan a transition that effectively manages the main risks of triple stranding effect: stranded assets, stranded and stranded regions.

About national transitions

Pursuing the agreed transformations requires to explicitly plan to manage the main adverse risks of the transition, which in the case of coal phase down are stranding assets, people and regions. This need prevails even in contexts where medium- and long-term macroeconomic positive effects of moving away from coal have been long ago settled and embedded in both national and people's discourses. This means that transformation that make sense from an economic and social viewpoint, may still pose serious challenges to transition. These serious challenges are connected to carful design of policy packages. This transition is not about applying the right policy instrument (carbon tax) but envisaging the policy packages that can shield the poor and vulnerable in the transition without delaying necessary action to avoid risk of lock in (Sartor, 2018).

The celerity in implementing these policy packages will directly relate to the potential for mitigating the stranding risks, because research notes that coal transition are already happening (Sartor, 2018). Absolute declines in both coal and oil use since the early 2000s in Europe, in the past seven years in the United States and Australia, and more recently in China have been observed (Newman, 2017). Nevertheless, investment in coal continues to be attractive in many countries (IPCC, 2018). Rayner (2021) finds that despite their collective stance, individual G20 countries, especially China, Japan, India and Korea, continue to finance overseas coal projects. Also MDBs' fossil fuel-related funding exceeded $5bn in 2016, though strict conditions on coal mining could be found in few MDBs policies, including WBG (Wright et al., 2018). Undergoing coal transitions have been found to gain importance and momentum around the globe given the existing trends that are buffeting the coal sector, such as the rebalancing of the Chinese economy, the emergence of cheaper alternative technologies, growing air, soil and water quality concerns, declining labour intensity of mining (Sartor, 2018), besides climate policy.

Coal transitions have also happened in the past, and there is much to learn from them. Research on historical transitions shows that managing the impacts on workers through retraining programmes is essential in order to align the phase-down of mining industries with meeting ambitious climate targets, and the objectives of a 'just transition', particularly in developing countries where the mining workforce is largely semi- or unskilled (Sartor, 2018). The same research finds that pitfalls from past transitions include a propensity to "lock-in" to the incumbent industry to block the arrival of economic diversification – because actors trying to "hang on" to a dying industry or companies refusing to sell land to new investors (Herpich et al, 2018). An important finding is that regional economic regeneration can be a generational or even multi-generational process where coal is a significant part of the local economy and a major local employer (Sartor, 2018). Thus, beginning the process of economic diversification is a matter of urgency for successful transitions. A process that will need to inclusively seek the engagement of affected stakeholders – both those representing the dying and arising economic activities. A process that will be cornerstone of the planning against stranding, which will also require fine and ad-hoc adjustment of policy instruments and governance mechanism at the country level, and presumably beyond.

Governance, as a key answer to the transitional challenge

Coal transitions require multi-level governance, including from local, provincial or state governments, national governments and in some cases supra-national organisations. It is not a question of whether centralized or decentralized approaches are better (Herpich et al, 2018): the active participation, agreement and support of a range of actors with different roles is required in coal transitions. (Sartor, 2018).

In-country dialogues and fined policy packages are a must, but multilateral governance can also play a role. International treaties help strengthen policy implementation, providing a medium- and long-term vision (Obergassel et al., 2016). Plus, innovation and investment required in Paris Agreement-compatible pathways stems from assumptions on unprecedented international co-operation among governments, (IPCC, 2018; IEA, 2021), and phasing out coal is no exception. A cooperative approach to this challenge requires as a starting point an explicit composite of country perspectives to understand potential market dynamics and potential necessary correction measures that puts people and fairness at the center of this global transformation.

Specifically for coal transitions, international cooperation could facilitate the establishment of these conditions that countries identify as enablers. From a technological perspective, important enablers include international procurement of licenses as a public good, development of open-source technology, incentives for industrial development to manufacture low-carbon technologies, or incentives on technology development in larger economies (solar, bioenergy). Other forms of cooperation should materialize the increase of financial flows to fund low-carbon investments in developing economies, or support the phasing out of subsidies to domestic prices of fossil fuels, or provide legal and financial support to terminate existing stranded assets, for instance current long-term coal contracts. All these forms of international cooperation must be equipped with governance structures to be forcefully operationalized.

Rayner (2021) has studied international governance options for the main obstacles of fossil fuel transitions, including coal. A main consideration is given to subsidy reforms. Despite the key messages from scientific assessments such as IPCC and IEA about the expected significant decline in fossil fuel tax revenues, Sartor (2018) finds that major exporting countries like Australia, South Africa or Colombia, and key coal states of the USA, are still grappling with a fast-changing reality. Rayner (2021) indicates that the series of bilateral and regional economic agreements have some relevance to energy-related decisions but are not discussed in detail in the context of coal transitions.

On supply-side interventions, he finds that while national governments guard their right to govern fossil fuel development and any related transition, international institutions can nevertheless, at least in principle, influence behaviour, constrain activity, and shape expectations in potentially helpful ways (Van Asselt, 2014). The goal should be avoiding free riders in terms of mitigation effort that could benefit from cheaper fossil fuels or producers who would likely accelerate extraction to secure rents before demand falls significantly. For these, international institutions by fostering greater transparency and learning, could ease geo-political tensions provoked by radical supply-side interventions. With regards to setting targets for extraction of remaining fossil fuels, he discusses options for a global instrument that could be recognised as equitable drawing on existing literature: global-level moratorium on new coalmines, fossil fuel ‘non-proliferation’ treaties to phase out the trade in coal or global systems to allocate production rights by regular global auction. Finally, Rayner (2021) discusses the potential of minilateral ‘coalitions of the willing’ to grow to be more comprehensive in coverage once the need for supply-side interventions becomes more widely appreciated.

A distinct role for development cooperation that has been identified by in-country assessments is providing support for the study of ‘just transition’ needs. For instance, a South African study finds that initial work indicates that concessionary finance will be a requirement to achieve the necessary rate of transition out of coal while maintaining socio-economic stability/development needs, but underlines that this is an understudied area (Winkler, H 2020, forthcoming.). Similar conclusions are made in private-sector rapidly growing thought leadership on just transition (see Morar, this issue).

Final remarks

Going massively out of coal is probably one of the most critical transformations globally in the fight against climate change. Highlighting the global nature of this challenge, it is necessary to argue the need for some kind of targeted cooperation to favour learning and support for the emergence of the needed solutions. For some countries, going massively out of coal will be a tough endeavor of domestic prosperity and social cohesion during the transitional phase, but also the necessary condition for securing in-country sustainable development. The opportunity lies in planning and financing a just transition that, accompanied by all the necessary policy packages and public and private support, will avoid stranding assets, people and regions.

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Perspective Piece

Towards the Mitigation of GHG Emissions through the Integration of Circular Economy Concepts into the Operations of the Coal Mining Industry

Runa Sarkar[1]

Introduction

The role of metals in the making of a modern economy is well acknowledged, as is the concern that this development has been based on a finite minerals and fossil fuel resource base (European Union, 2016). Given the requirements of sustainable development, there is a clear understanding that, going forward, there has to be a greater thrust in reducing the extent of primary resource consumption, generally mining activities (Ayres, 1997). While the mechanisms to address this would be through recycling of end of life products and promotion of energy generation through renewable means, in the near future, mining and mineral extraction will continue to be a growing and thriving industry, and in this context, it is necessary to focus on the how to transition this industry into a sustainability era. One such approach could be to identify how circular economy principles could be applied to the mining and minerals sector, both to improve its efficiency and to find ways for technically and economically feasible recovery of currently wasted valuable minerals or by-products. Further, circular economy principles may also play a role in remediating and recovery of abandoned mining sites.

Within the mining and mineral extraction industry, the sustainable development goals of the United Nations coupled with the implementation of the Paris Agreement has led to a lot of pressure on the fossil fuel industry, which is responsible for the largest fraction of global carbon emissions. Yet, the salience of this industry for meeting India's energy demands for the next few decades is not a matter of debate, despite the increasing thrust on electricity generation from renewable sources. This paper, therefore focusses on the coal mining industry, and attempts to apply the principles of the circular economy to this industry to demonstrate how circularity could reduce the carbon intensity of coal mining.

The paper is organised as follows. We start with a discussion on the concepts of the circular economy. After developing a reasonable understanding of circularity, its evolution from the concept of industrial ecology, we discuss its application for sustainability of the coal mining industry. The specific instance of the management of coal bed methane in coal mining operations, and how the different principles of circularity could be applied to it is discussed next. We will attempt to demonstrate how the application of circularity can lead to lower GHG emissions for the coal mines, coupled with increased profitability for the firm in the process. The objective of this paper, in the context of greenhouse emissions from energy systems, is to offer you some ideas how the theoretical underpinnings of the circular economy can help in mitigation of GHGs from energy systems and coal mining in particular. The final outcomes will be arrived at in an interactive manner.

Circular Economy

A circular economy is an economic system of closed loops in which raw materials, components and products lose their value as little as possible, renewable energy sources are used and systems thinking is at the core (Webster, 2015; Bocken et

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al, 2016). The Ellen Mac Arthur Foundation has defined the circular economy as "An industrial system that is restorative and regenerative by intention and design (EMF, 2013: 14). The concept has gained immense popularity both with policy makers and industry, as is evident from the integration of the concept into national laws by Germany through the "Closed Substance Cycle and Waste Management Act" (Su et al., 2013), Japan, China and into strategic imperatives by the European Union in 2015.

Since the late 1970s, there was a realisation that the earth was a closed and circular system with limited assimilative capacity, and the linear and open ended characteristics of contemporary production systems were stressing the natural ecosystems. Thus, the concept of a loop economy emerged which envisaged the closing of different kinds of resource loops through recycling, regeneration or reprocessing. The idea was simply to ensure that industries made profits without externalising their costs of production through the creation of wastes or the misuse of energy. Other concepts that emerged in theory that influenced the circular economy included the concept of cradle-to-cradle, performance economy, regenerative design, industrial ecology, biomimicry and the blue economy.

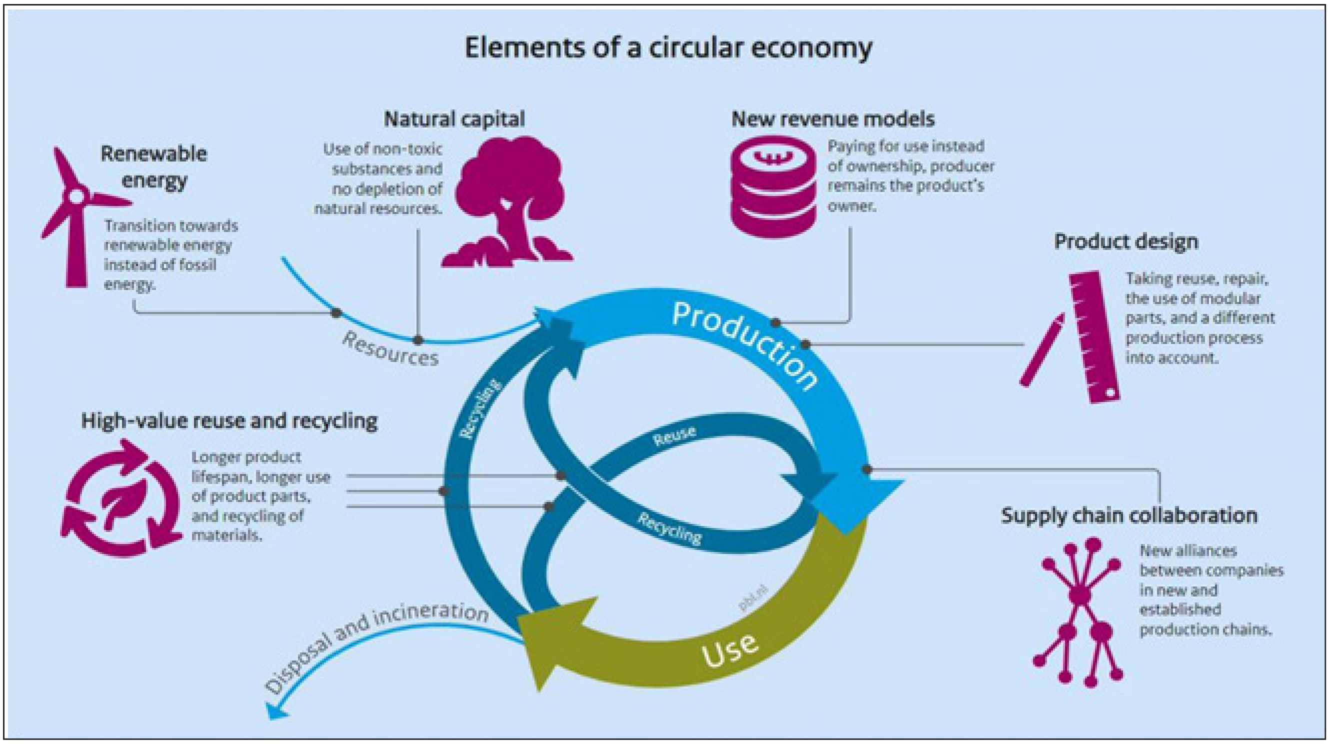

Figure 1: Elements of a Circular Economy

Source: https://kenniskaarten.hetgroenebrein.nl/en/knowledge-map-circular-economy/what-is-the-definition-a-circular-economy/

Three broad concepts of a circular economy that are relevant for an industrial system are its focus renewable energy, closed cycles and systems thinking. Figure 1 illustrates all the elements of a circular economy. As is evident from the thickness of the arrows labelled production and use, the focus, to begin with, is on waste minimization. If at all there are wastes, the wastes are to recycled back into the production process, either immediately after manufacturing or through recycling the materials. Some of the products in use may be reused or repurposed. Since the focus is on ensuring that there is complete recycling, and nothing leaves the production- use loop, the emphasis is on these closed cycles. Products are designed keeping design for environment principles in mind so as to ensure that everything is modular, has multiple uses and can either be repurposed easily of remanufactured with minimal energy loss. Supply chains have to be managed to ensure high value use and recycling with close to zero waste. This would require a systems thinking approach from the very beginning which incorporates engineering optimization exercises with the development of revenue models to support the circular economy. Such revenue models would include a shift from a propensity to sell to a propensity to rent or lease, so that the manufacturer or retailer has a greater control over the product or service and exercise responsible stewardship.

A systems thinking approach fosters system effectiveness by revealing and designing out the negative externalities from a manufacturing process. Finally, the third key concept of the circular economy centers on the use of natural capital in a manner that there is no depletion of natural resources, leading to the advocacy of using renewable energy for manufacturing and production. In the context of the fossil fuel industry this is most contentious, because the industry necessitates the exhaustion of a naturally available resource which, therefore in not renewable. However, keeping in mind the economic realities, availability and cost of producing energy from renewable resources, fossil fuels will continue to power manufacturing and consumption activities in countries like India for a long time. Thus, we will set aside this key concept driving the circular economy when discussing the mining and minerals sector and focus only on systems thinking and closed loops going forward. The focus would be on the circular or closed flow of materials and energy through multiple phases as suggested by Yuan et.al. (2008:5) and on the design of strategies that would slow, close and narrow resource loops (Bocken et al, 2016:309), as is illustrated in figure 2.

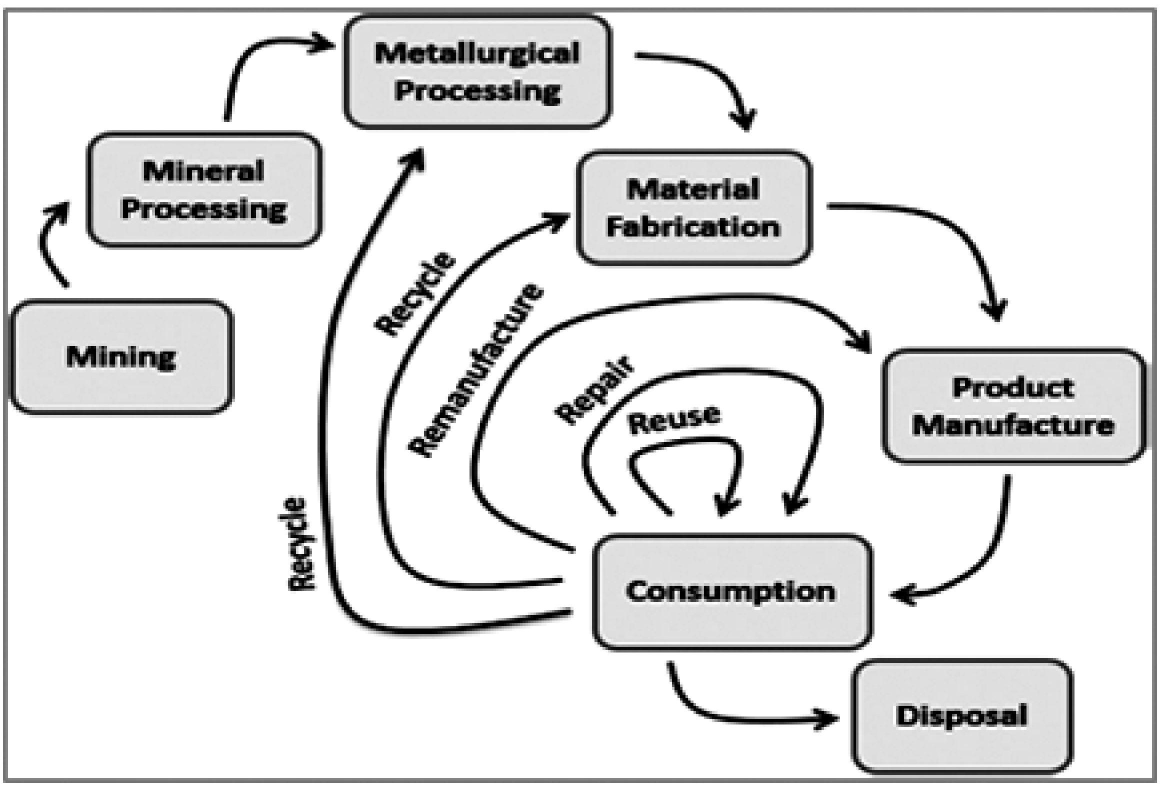

Figure 2: Circular Economy for Technical Materials, Illustrating the Closed Loops

Source: Lebre et al. (2017), The role of the mining industry in a circular economy: a framework for resource management at the mine site level

Narrowing the resource loop refers to minimizing material throughput through the six outer arrows linking mining, mineral processing, metallurgical processing, material fabrication, product manufacture, consumption and disposal. 3D printing, a prime example of additive manufacturing is an instance of narrowing the resource loop. Reuse, repair and remanufacture are processes that contribute to the slowing of resource loops. Recycling wastes and products contribute to closing resource loops. Thus, when airline seat covers are used to make carry bags, we have slowed the resource loop, and when the wastes that remain after the carry bags are made are sent back to the textile industry as raw materials to break down to cellulose and use in manufacture, the loop is closed. Evidently, any manufacturing process would need to focus on designing business models that incorporate all three actions on resource loops.

"Most circular-economy business models fall in two groups: those that foster reuse and extend service life through repair, remanufacture, upgrades and retrofits; and those that turn old goods into as-new resources by recycling the materials" (Stahel, 2016). This is primarily because optimising within the manufacturing process is considered part of the profit maximisation exercise for the firm, and the business models look beyond the firm to its links and networks with external stakeholders. Hence a circular economy is not a concept that can be restricted to a mine or an organisation, but must be understood across an industrial system.

Nevertheless, at the level of the individual firm, there are certain thumb rules that can be put in motion to operationalize the concept of the circular economy. One acronym developed for this purpose is RESOLVE, where RE stands for regenerate, S stands for sharing, O for optimising, L for loop, V for virtualising and E for exchange. The RESOLVE levers the focus on preserving and enhancing natural capital by controlling finite stocks and balancing renewable resource flows are Regenerate, Virtualize and Exchange. Similarly optimising resource yield leverages Regenerating, Sharing Optimising and Looping. The idea, therefore is, that within ones' day to day work, one must try to ensure that the prevalent practices at work regenerate materials and energy to the greatest extent possible, resources are shared to optimise their use and close the loops, material and energy intensive products and services are exchanges with those that are less material and energy intensive, and finally, if something can be consumed virtually without material use, then that should be an area of focus. The linear manufacturing concept of inputs being converted to outputs and wastes, which in turn are used to be converted into waste (some renewable, and a lot just disposed off or lost) must be replaced with a circular framework, where the manufacturer is the user of resources, which are limited in nature and hence the user uses only that part of the resource that he or she can regenerate. The focus has to shift from just efficient conversion of resources into products and services to effective conversion of resources into products and services. In other words, a take-make- dispose mindset has to be replaced by a reduce-reuse-recycle mindset. One has to think about the lifespan of his or her organisations as spanning centuries, with multiple life cycles rather than indulge in short-termism thinking of the health of the firm till the time one moves into a new job or retires. Instead of thinking of disposal of waste through recycling as an afterthought (downcycling), a systems thinking closed loop approach will lead one to think if closing the loops for all material flow, and thus, upcycle, cascade and engage in high grade recycling.

The Circular Economy in the Mining Sector

A study conducted in the European Union in 2014 illustrated that the most efficient measures for resource savings in the metal manufacturing sector are, in order of scale of investment: "eco-design (light weighting), reusing materials in a closed loop system (such as remanufacturing), waste prevention (using production processes that do not create waste), and changing procurement practices. In total, these measures would result in cost savings of €160,000 (16% of an average company's turnover), with a payback of less than 1 year (for ecodesign and procurement) and more than 3 years (for material reuse and waste prevention measures). The main two cost saving measures, eco-design and material use account for 60% of the total potential benefit, where eco-design represents 40% of the total saving" (Eurochambers, 2019). The systems thinking and focus on closed loops, and its subsequent benefits in the metal manufacturing sector is evident. This in turn puts pressure on the mining sector, as material throughput is positioned to come down in the future necessitating mines to be far more efficient. The focus on the mining sector, when discussing the circular economy is warranted because being the starting point of most product value chains, it is responsible for the losses of many non-renewable resources for the entire manufacturing sector. Towards this end, several authors have focussed on different aspects of the circular economy and its relationship to the mining industry. Golev et. al. (2016) have a comprehensive article on the contribution of mining to the circular economy as a whole, which documents the various processes through which the mining industry can close the loop. There has been a lot of work by Chinese academics on the applications of circularity in mining. For example, Zhao et. al. (2012) recommend how to construct a system of a circular economy at the level of a coal mine after illustrating how the reduce recycle and reuse principle can be applied to the development and utilisation of mineral resources. There are even more scientific papers that explore the introduction of a "negative entropy flow" into a mining operation to "promote the balance of the ecosystem and increase order in the mining area" using a case study of a specific mining company (Ru-yin and Xiao-ting, 2009).

In the context of the mining industry, a major focus of the circular economy would be in the restoration of material flows at the product level as well as at the level of the mine. This could be done using systems thinking, which could involve better product design as well as development of business models with an objective to minimise the dissipation of all non-renewable resources (EMF 2015). Thus using restorative loops implemented within a circular economy framework to manage mining wastes present in mines (whether closed/abandoned or operational) and use them as part of the stock has been an area of research. Similarly, use of scrap metal from manufacturing industry, or extending the boundaries of circular economy systems to examine wastes such as hitherto untapped coal bed methane are all ideas that are being or need to be explored. The end goal would be to reduce the requirement for the opening of new mines and from exposing and exploiting virgin ore deposits. Prolonging the use of existing mines is consistent with the "slowing the loop" principle of the circular economy. In this context, Lebre et. al. (2017) have an interesting paper exploring the "mining waste challenge" where waste rock, tailings, slag leached ore and acid mine drainage are considered as reject material as all these waste streams still contain some amounts of the material for extraction. The waste streams are characterised in figure 3, where the dashed arrows represent examples of options for mineral recovery from waste.

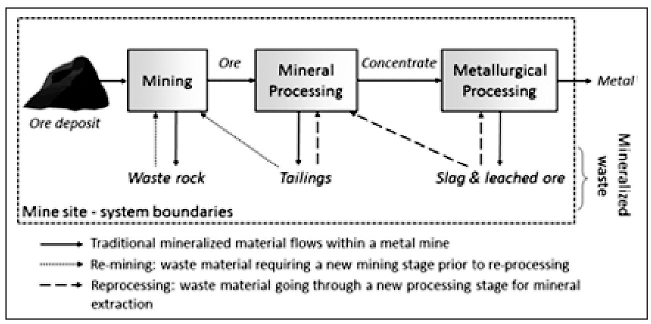

Figure 3: Simplified mining processes flowsheet exhibiting main waste streams

Source: Lebre et al. (2017), The role of the mining industry in a circular economy: a framework for resource management at the mine site level

Extraction and Use of Coal Bed Methane (CBM) as an Illustration of Circular Economy Principles

The commercial extraction of methane from coal beds is well established throughout the world, including the USA, Australia, China, India and

Canada (Moore, 2012). In India, now private organisations have also been granted permission to enter the coal mining sector, which implies that it is of utmost importance that the naturally occurring coal resources are utilised effectively and for as long as possible. CBM forms as either a biogenically- or thermogenically-derived gas, depending on whether the coal is 'under mature' (< 0.5% vitrinite reflectance) or as part of the coalification process. Thermogenically derived CBM is purely a chemical de-volatilization that releases CH_4. The CH_4 is primarily stored in coal through adsorption onto the coal surface; primarily in the micropores of the coal. The organic composition of the coal is critical in determining its porosity and permeability characteristics.

In the past, CBM was responsible for numerous explosions in underground mines, death from asphyxiation and the cause of underground coal fires especially in the Jharia coal belt. For safety reasons therefore, the gas was vented out in a controlled manner to the surface from the underground. However, CBM and its by-products are suitable for several industrial applications, most notably power generation, feedstock for fertilisers and plastics and as a raw material for transportation fuel. CBM is a much cleaner source of energy (as compared to coal) with a very high calorific value that could be used in place of natural gas (India imports natural gas) in natural gas turbines for power generation. It has uses in producing certain types of fertilisers and can also be converted into other types of hydrocarbons such as petrol and diesel. Many of India's coal fields have copious amounts of CBM which are going untapped.

Thus, in addition to the waste streams mentioned in Lebre et al (2017), CBM could be viewed as a very valuable waste in the context of the circular economy of coal mining. However, there are concerns surrounding the production of CBM as well. Besides being a technology intensive process, there are greater concerns related to the uses of water in the exploration process, as CBM exploration involves pumping large amounts of water out of the coal seams to reduce the hydrostatic pressure so as to liberate the adsorbed CBM. The water that is pumped out has high levels of salinity which in turn has adverse impacts on the soil structure in the area where it is released, if not treated. The cost of treating the water using desalination ponds, and additional wastes generated in the process also need to be considered. Moreover, the pumping of so much water also causes long term changes to the ground water system, which needs to be monitored and managed.

It is in this context that the Government of India formulated the CBM policy in 1997, carving out CBM blocks and opening them up for exploration and production by the winning parties. With the fifth largest proven coal reserves in the world, the forecasted CBM resources in the country are around 92 TCF spread across 12 states of India. Several CBM blocks have been carved out and through four rounds of bidding,

33 CBM blocks have been awarded for exploration and production. Many of them, some in the public sector and others in the private sector are already in production.

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Technical Note

Outlook for Clean Coal Technologies in India

Udayan Singh[1], Ajay K. Singh[2], Amit Garg[3]

Introduction

The government's mission for "affordable electricity for all" is based on growing coal sector expansion along with growth in the renewables capacity. The Government of India's commitments to the Paris Agreement aspire for large renewables growth and also do not entail any plan of coal phaseout. In fact, the Draft National Electricity Policy mentions that coal-fired capacity in the country will increase to 330-441 GW by 2040, which would correspond to coal combustion of 1.1-1.4 billion tonnes (NITI Aayog, 2017). In the electricity sector alone, the Central Electricity Authority estimates coal usage of 877 Mt by 2027 (CEA, 2018). This added to the large industrial consumption of coal would likely result in a requirement of 1.5 billion tonnes of coal by 2030-31.

At the same time, increasing climate ambitions by other countries might indicate growing global seriousness to mitigate climate change. Recently, China refined its national energy plan to indicate net-zero emissions by 2060. There have been concerns about increasing coal use on air pollution and human health. Some research also suggests that the COVID-19 pandemic has had a more negative impact on coal sector growth as compared to natural gas and renewables (Bertram et al, 2020). Several analyses by integrated assessment modeling groups indicate either a reduction or a complete phase-out in coal use if 1.5/2°C targets and sustainable development goals are to be realized (Vishwanathan and Garg, 2020).

Several recent developments have been relevant to coal sector development in India. First, the share of underground coal mining has gone down significantly to < 10% in the recent years. This has been due to technological and geotechnical limitations on exploration and extraction of Indian coal (Singh and Kumar, 2016). For the targets mentioned above, it is essential that underground coal mining increase significantly to meet the rising demands over the next two decades. Second, the Government of India in 2020 initiated auctions towards commercial coal mining. As part of this, bids have been invited for coal capacity over 225 Mt from which the government anticipates generation of US$4.5 billion in revenue. The government has termed the recent auction policy as fair based on the payment and land ownership policies. This could increase coal extraction and associated environmental emissions. Alternatively, healthy competition in the coal sector could also give rise to more efficient and sustainable practices. It could be noted that 14 out of 38 mining blocks were not taken up. Thus, it remains to be seen whether the coal auction strategies will pay dividends. Third, the NITI Aayog and other policy-relevant bodies of the government have placed a very high emphasis on the diversification of the end use of coal. This includes an important thrust on gasification and creation of a 'methanol economy'. The government could likely move ahead with a policy for 15% methanol blending with transport fuel which could result in cost savings of $8 billion annually (Saraswat and Bansal, 2016). Recently, Coal India Limited has indicated its intent to commission a coal-based methanol plant. In a similar vein, there have been some initial efforts to capitalize on underground coal gasification (UCG) both from CIL as well as private sector businesses. These

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plans towards diversification of coal use have been repeatedly discussed by the government. But diversification of the fossil fuel sector has been challenging as evidenced by the slowing down of such plans by Saudi Aramco, the world's largest oil producing company. Diversification of coal may be more challenging because of higher emission intensity and less alternatives available than liquid hydrocarbons (McJeon et al, 2021). Fourth, in addition to coal end-use diversification, coalbed methane or CBM extraction in India has also increased significantly. The current CBM extraction in India exceeds 45 MMSCFD largely through private players. At the same time, both ONGC and Coal India Limited have significant methane resources in their command areas. These resources (largely occurring in the states of West Bengal and Jharkhand) would be fed into the newly-inaugurated Urja Ganga pipeline (Kelafant, 2020). While these developments are at different levels of readiness, there is a need to understand their impacts on the different stakeholders in the coal sector.

This article aims to summarize the key technological facets for reduction of greenhouse gas (GHG) emissions from the Indian coal sector. It also seeks to provide the current status and future opportunities at a systems-scale for decarbonization of the coal sector in the near and medium term.

Emissions from the coal life cycle in India

In this section, we discuss the key elements of a decarbonization strategy for the coal sector. The majority of the emissions in the coal supply chain come from coal combustion for power generation. Some emissions are also attributable for coal utilization in non-power sectors. Overall, coal oxidation results in 65% of the CO_2 emissions in India (Andrew, 2020; MOEFCC, 2020). Fugitive emissions of methane during mining and handling of coal also contribute to emissions, although as discussed in the next section, the rate of emissions is highly dependent on the mining configuration. It should be noted that even though the overall share of coal in India's primary energy is 54% while that of oil and gas is 36%, the fugitive methane emissions are slightly higher for oil and gas (54%) than coal (46%) (MOEFCC, 2021). This is due to different reservoir conditions for coal, which has a highly adsorptive structure, as compared to conventional oil and gas, which have less porous structure. Other emissions also arise from transportation of coal though these are anticipated to decline if the railway and road transport become gradually decarbonized. Finally, the recent 2019 Intergovernmental Panel on Climate Change (IPCC) refinements on greenhouse gas inventories indicate that CO_2 emissions should be accounted for from the coal mining stage as well. While published analyses are limited in the Indian context, the proof-of-concept work carried out at three underground mines indicate strong correlation with the amount of ventilation air (Singh, 2019).

Table 1. Mining and post-mining emission factors for Indian coal sector (Singh and Kumar, 2016) with estimated share of methane emissions in overall coal life cycle. Assumed global warming potential of methane is 28 over a 100-year time horizon.

	Surface Mining	Underground mining		
		Degree-I	Degree-II	Degree-III
Mining emission factor (m^3/t-coal)	1.18	2.91	13.08	23.68
Post-mining emission factor (m^3/t-coal)	0.15	0.98	2.15	3.12
Total methane emissions (kg-CO_2e/t-coal)	24.95	72.98	285.71	502.77
Total methane emissions (kg-CO_2e/kWh)	0.02	0.05	0.19	0.33
Share of methane in total GHG emissions (%)	1.66	4.71	16.21	25.40

Mitigating emissions from the mining sector

Methane emissions from coal mining and handling activities depend largely from the type of mining operation (underground or opencast) as well as the degree of gassiness of the underground mine. The prior estimates of national emission factor along with the share of the fugitive emissions are shown in Table 1. The latter assumes a rate of coal consumption of 0.6-0.7 kg-coal/kWh along with a combustion emission factor of 0.8-1.0 kg-CO_2/kWh (Singh et al, 2016; Sarkar et al, 2021). It is noteworthy that the share of fugitive methane emissions may be more than a quarter of the overall GHG emissions for degree-III mines. We caveat this by stating that the share of underground mining in India, especially from degree-III mines, has been going down. That said, specific regional opportunities do exist for Raniganj, Jharia and East Bokaro coalfields.

The primary mechanism of recovering coalbed methane in India thus far has been from virgin blocks – in what is called as virgin coalbed methane (VCBM). The extraction of methane from such blocks has been ongoing with blocks being awarded since 2001. So far, 33 blocks have been awarded and the total CBM production at 2.01 MMSCMD in early 2018. In the Raniganj Block operated by Essar Oil Limited, the gas production increased from 0.15 BCF in 2011 with peaking in 2017 at 13.59 BCF (Kelafant, 2020). This entailed a compound average growth rate of 111% from the inception of the block to the peaking period. The Great Eastern Energy Corporation Limited (GEECL) is also reported to be producing 0.55 MMSCMD with the selling price of the gas estimated at $8-22/MMBTU (Singh and Hajra, 2018). The Oil and Natural Gas Corporation (ONGC) has also been producing gas at a commercial scale and its prospective peak gas production from four blocks is projected at 30,000 m^3/day/well. More recently, Coal India was also reported to have issued a letter of acceptance to a CBM developer in the Jharia CBM block.

While the extraction of VCBM does not directly intersect with the coal supply chain, it could lead to considerable decarbonization opportunities within the energy sector (Figure 1). First, the gas may be utilized at an emission factor of nearly one-third of that of an average coal combustion/conversion. Second, the Government of India has also indicated hydrogen utilization as a thrust area. The Ministry of Petroleum and Natural Gas has created a corpus fund of $13M for hydrogen research activities. As CBM is nearly pure methane, it may be utilized to produce grey/blue hydrogen using steam methane reforming (SMR), a globally proven technology at a high readiness level. Finally, as wells become mature and production begins to decline, CBM sites may also be treated as sinks for CO_2 sequestration which could also increase the overall recovery of methane.

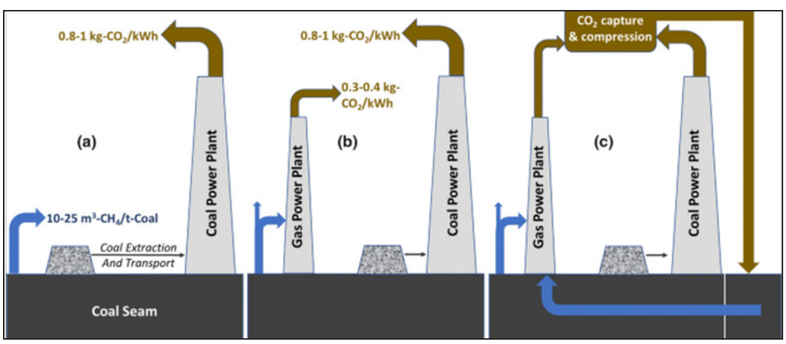

Figure 1. Schematic illustrating three-fold GHG benefits arising from CBM utilization. Case (a) shows (underground) coal mining-to-combustion route. Case (b) shows utilization of methane over the first case. Case (c) shows capture of CO_2 from electricity generation and its disposal in coal seams to produce additional methane. The brown arrows depict CO_2 flow, while the blue arrows depict methane flow. The thickness of the arrows is meant to connote the relative flux in terms of global warming potential. Source: Singh and Colosi, 2019; reproduced with permission.

While VCBM is critical in reduction of overall GHG emissions, it would not contribute to reductions in operational mines. As such, coal mine methane (CMM) recovery has been considered as a technological mechanism for simultaneous utilization of coal and methane through pre-mining drainage of methane. A demonstration CMM project was carried out with joint funding of the United Nations Development Program, the Global Environment Facility and the Ministry of Coal in the Moonidih mine of the Jharia coalfield. While there is no currently operational mine with active CMM recovery, there is high viability of CMM recovery in several existing mines in the Damodar Valley coalfields (Table 2). Utilizing this mechanism would not only lead to availability of gas and reduction in greenhouse gas emissions, it would also enhance mine safety conditions. Thus, utilization of CMM could be considered in light of several sustainable development goals.

Table 2. Important mines for CMM recovery in India (Singh and Kumar, 2016)

Name of the colliery	Name of Coal field	Degree of Mine	CMM resource (Billion cubic meter)
Kalidaspur	Raniganj	III	3.783
Ghusick	Raniganj	III	2.58
Murulidih	Jharia	III	4.98
Amlabad	Jharia	III	0.76
Sudamdih	Jharia	III	0.80
Central Parbatpur	Jharia	III	5.31
Jarangdih	East Bokaro	III	4.87
Sawang	East Bokaro	III	6.31

Recovery of ventilation air methane (VAM) may also be considered in some mines. Previous analysis at the Moonidih mine indicated a reduction potential of 0.6 Mt-CO_2e/year. It is also notable that CMM and VAM projects may be considered for incentives under the Clean Development Mechanism as they fulfill the additionality criteria (Prusty et al, 2009). Kholod et al (2020) also indicate that emissions from abandoned mines may be significant globally. However, no field-level data exists on quantification of such emissions or mitigation potential from abandoned mines in India. It is recommended that future work look at such areas.

Mitigating emissions from the power sector

As discussed, coal combustion is the key contributor to India's GHG emissions. There is a risk of stranding of existing coal facilities due to their underutilization in the future due to climate constraints. Malik et al (2020) project that stranding of 133-237 GW capacity may occur post-2030 if ambitious climate policies are introduced. This risk may be somewhat alleviated by early policy strengthening. In fact, the government is already taking steps to retire old and inefficient units. Statements from the power ministry indicate that several plants have already been retired with the likelihood of retiring 29 more plants and replacement with low-carbon infrastructure. In 2020, India commissioned 2.0 GW of coal power. Taking into account 1.3 GW of retirements, India's coal fleet grew by only 0.7 GW in 2020—the lowest since 2004 and much below China's 38.4 GW new capacity additions in 2020. Coal power commissioning in India fell steeply in 2016 and shows no signs of rebounding (Global Energy Monitor, 2021). The PLFs have also been running around 60% for several years, indicating a gap in supply and demand. There have also been efforts at efficiency enhancement for coal boilers. Since 2011, the National Thermal Power Corporation (NTPC) has commissioned several units of supercritical boilers. In the last couple of years, two units of 660 MW each have also been commissioned by NTPC at their Khargone station. This power plant has an estimated efficiency in excess of 41% which is almost 10-percentage points higher than the average coal fleet in India. While the efforts to reduce emissions through efficiency enhancement, retirement of old units and reduction of transmission and distribution losses could be tangible, compatibility with the 2/1.5°C target would require near-certain deployment of CO_2 capture and storage (CCS). CCS involves capture of CO_2 from large point sources, its transportation and injection into deep geological formations. Because the concentration of CO_2 in the flue gas from a typical pulverized coal plant is only 12-14%, its separation to >90% purity involves large energy penalty. The prior analyses (Singh et al, 2017) carried out on existing facilities showed that this energy penalty could be disproportionately high in Indian subcritical units (32-53% of the gross power generation). At such levels, CO_2 capture could be deemed infeasible at these units and the retrofitting possibility with CO_2 capture would be limited. However, due to the efficiency enhancement, there may be a significant scope for CCS deployment at the supercritical and ultra-supercritical units. CO_2 avoidance costs at ultra-supercritical units with >40% efficiency could be \$30-40/t-CO_2 (Hu and Zhai, 2017) which is economically competitive with provision of CCS incentives.

An important consideration in the development of CCS is the conceptualization of so-called clusters or hubs. These are areas with large number of large point sources in close proximity with sinks of large potential. Our analysis for Indian point sources indicates the presence of eight such clusters where mitigation of 800 Mt-CO_2 could be possible (Garg et al, 2017). This existing analysis could be further evolved as and when capacity estimates for sinks that have the potential to deliver incremental hydrocarbon recovery are resolved. Our estimates indicated that the average cost of mitigation would be ~\$60/t-CO_2 but with provision of enhanced oil recovery or enhanced CBM (Figure 1), this could reduce below \$45/t-CO_2 if there is a sustained price support for such fuels. One of the prospective clusters or hubs is near the Jharia coalfield where there is a concentration of infrastructure (power, steel, cement, fertilizers and petrochemicals). As discussed in section 3, there is a scope of large-scale CBM extraction along with CO_2 injection in the latter stages of such projects. Figure 2 shows the sub-clusters that could prospectively be conceptualized in this region that could deliver overall cost reduction of \$10-20/t-CO_2 to the baseline avoidance cost of CCS in India.

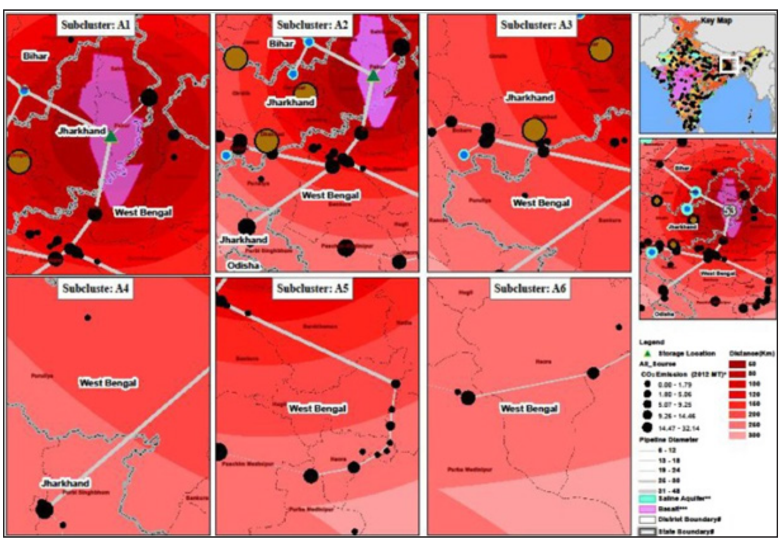

Figure 2. Sub-clustering of a prospective CCS hub in eastern India. It should be noted that the status of some ultra-mega power plants has changed since the original publication but we estimate that the sub-clustering here could still be viable. Source: Garg et al, 2017, reproduced with permission.

There are significant technological constraints for CCS deployment in Indian power plants even with efficiency improvement. For instance, water limitations are anticipated to shutdown power capacity in the order of tens of gigawatts in the United States (Liu et al, 2019). In India, there have been observed cooling water shortages during summer months for existing power plants. Implementation of CCS could further exacerbate this. Accordingly, technological development in India should focus on low-water consuming technologies. For instance, membrane-based capture could offer lower water consumption as compared to the conventional amine-based capture. CCS also requires installation of flue gas desulfurization (FGD) and selective catalysis reaction (SCR) equipment for management of SO_2 and NO_x. While the environmental regulations requirement retrofitting of existing plants with these controls by 2017, the deadline has now been extended to 2022 with provision of a penalty.

Opportunities for coal sector diversification

While the major utilization of coal in India occurs in the power sector, there is also an opportunity for diversification of coal, primarily through gasification. Two routes of gasification are being considered: underground coal gasification (UCG) - where coal is gasified *in-situ* - and surface gasification – where coal is gasified post-mining. Regardless of the where the reactor is located, coal gasification leads to formation of carbon monoxide and hydrogen. Due to the higher concentration of CO_2 (40-60%), the energy penalty associated with CCS reduces considerably. Moreover, there is a significant co-benefit in terms of reduced air pollutants. The hydrogen produced from coal gasification could provide for a blue hydrogen pathway without import dependence.

UCG could provide an opportunity to utilize deep-seated coal deposits that would otherwise be unrecoverable. Lignite reserves in Gujarat, Rajasthan and Tamil Nadu could be potentially viable for UCG because of the high reactivity of these deposits (Jain, 2017). UCG also offers the advantage of negligible fugitive methane emissions. There have been efforts for a pilot-scale project at the Vastan Mine with the joint venture between ONGC and GIPCL. Due to multiple reasons, this was withdrawn in 2016 after detailed site characterization studies were carried out. A site-selection study has also been carried out by Tata Steel and Ergo Exergy Inc at Jamadoba in the Jharia coalfield. Their pre-feasibility analysis showed availability of 400 Mt of coal resources for *in-situ* gasification (Blinderman, 2019).

The Government also has a substantial thrust on surface gasification, primarily to power the 'methanol economy'. There is a target to gasify 100 Mt coal by 2030 and the government has allotted a concession of 20% on the coal revenue for gasification. Development of the methanol pathway could be crucial for utilization of methanol as a fuel/chemical but also due to the potential of methanol to act as an energy carrier and produce synthetic hydrocarbons. Coal India has invited bids to construct a $813M coal-to-methanol plant in Dankuni, West Bengal.

Summing up

The future of coal in India would depend on multiple factors including the climate constraints and the perceived role of coal to operate in a low-carbon economy. Opportunities for decarbonization and diversification of the coal sector exist across the supply-chain as noted in this paper. While some of the technologies have been proven effective at a global scale, others are at a lower readiness level. Several of these clean coal technologies have faced technical challenges in India due to the unique geo-mining conditions, fuel quality as well as operating conditions of the power plants. The government's thrust on the methanol economy and reduction of emissions from the upstream coal sectors could be useful in creating several methanol- and methane-based co-products and aid in creating alternative streams of revenue. For long-term pathways with coal, there is a need to better conceptualize and evaluate the relevant infrastructure necessary for CCS in India. Apart from providing the current technological status, this paper also identifies key future opportunities in at least two areas, viz. CMM recovery and CCS sub-clusters in eastern India. Future analyses should focus on better incorporating the role of such infrastructure in systems-studies pertaining to long-term decarbonization scenarios for India.

Disclaimer

These results presented in this article are outputs of the academic research conducted under the DDP-BIICS project as per the contractual agreement. The academic work does not in any way represent our considered opinion for climate negotiations and also does not reflect the official policy or position of the Government of India.

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Technical Note

Coal Transitions in India?

Saritha Sudharmma Vishwanathan[1,2], Amit Garg[2]

1 Introduction

India is currently the second largest producer, importer and consumer of coal after China, and third largest power producer and consumer of electricity in the world; however, its electricity consumption per capita at 1208 KWh/capita is lower than other comparable emerging economies such as China, Brazil and South Africa (CEA 2021). Over 75% of power production is coal-based which is the dominant domestic energy resource and thus provides energy security and affordability to India. With approximately 90 million people (nearly 7% of population) still without access to electricity and given its growing population size and economic activity, India will consume more energy in coming decades to address its myriad of development challenges in addition to its rising urbanization and industrialization (SDG 2020, NEP 2017).

In 2020, India contributed to just under 10% of world's coal production. It also has the third largest proved reserves which consists of anthracite, bituminous coal (92.6%), sub-bituminous and lignite (7.4 %) variety (WEC, 2017). Coal deposits occur mostly in thick seams and at shallow depths with 93% of Indian coal extracted from surface mines (up to a depth 300m) and remaining from underground mines. Geological resources of coal in India as on April 1st, 2019 were about 326 billion tonnes (bt), where coking coal (prime, medium and semi-coking) were 35 bt, non-coking coal was 291 bt (MOC, 2021a). Global coal production is estimated to reach 8.8 billion ton (bt) in 2025 at a compound annual growth rate (CAGR) of 2.3% between 2021 and 2025 (Global Data 2021). In India, coal mining is mainly confined to eastern and southern central parts of the country.

Total annual production of raw coal during the year 2020-21 was 716 Mt (provisional) as compared to 360 Mt during 2000 registering almost twofold increase with a growth rate of 3.5% per year during 2000-2020. The production observed a decline of 2.03% over 2019-20 production (730.87 Mt) due to COVID-19. Lignite production was 45.7 Mt in 2020-21 with growth of 3% over 2019 (MOC 2021b). 91% of total raw coal consisted of non-coking coal. Indian coal is observed to have high ash content (15-45%) and low calorific value. Total coal (coking and non-coking) demand in 2020-21 was estimated to be 1085 Mt, while actual supply was 955 Mt (MoC 2021a, CIL 2021). Table 1 presents sector-wise breakup of actual supply of coal (2012-2021) and estimated demand (2020-21). The consumption in power (utilities and captive) sector increased to 534 Mt in 2019-20, while that in final energy consuming sectors (industry, building) was 352 Mt. The total projected additional demand for coal in power sector with enhanced plant load factor (PLF) and additional capacity is around 300 Mt/year resulting in the annual consumption to touch more than 1-1.5 bt by 2025/2030 (MoC 2021a).

More than 90% of the coal is excavated from open cast mines, while more than 80% of the production is done by Coal India Ltd. (CIL). India currently has 442 mines, out of which 222 are open cast mines, 195 are underground mines and 25 are mixed mines (Coal Directory, 2020). CIL's production in 2019-20 was 602 Mt, out of which the share of open cast mines contributed to 572 Mt and the share of underground mines contributed to around 30 Mt. In 2019, CIL has set a production target of 1 bt by 2024 from a combination of its active and future projects.

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The gap between demand and supply of coal has reduced over the past few years, foreign firms shun the coal mine auctions (Bhattacharjee 2021). In 2015, Minister of Power, Mr. Piyush Goyal called for zero-coal import policy. A decline of imports was observed subsequently due to improve in coal quality through third party sampling and increase in coal washeries to improve the quality of Indian coal for three years. Imports have fallen from 218 Mt in 2014-15 further to 191 Mt. in 2016-17. The trend is observed to continue in 2017-18. As domestic coal production plateaus, the imports have increased to 248 Mt in 2019-20 to meet industry needs. Most (~90%) of imports are sourced from Indonesia (48%), South Africa (24%) and Australia (18%) (Bhattacharjee 2021, CD 2020).

India, as of May 2021, has 383 gigawatts (GW) of total power generating capacity with 209 GW (~55%) of coal, 25 GW of natural gas, 46 GW of large hydro, 6.78 GW of nuclear, 39 GW of wind, 41 GW of solar, 10 GW of bio-power, and 4.7 GW of small hydro. As on March 2021, coal-based generation was estimated to be 1234 TWh with PLF of about 59.9% at a CAGR of 6.5% since 2002. The shares in power generation from these sources are 79.5% from coal and gas, 3.5% nuclear, 12.2% hydro and nearly 4.8% from remaining renewable sources (CEA 2021).

Table 1: Actual Supply of Coal (2012-2020)

#	Sector	Actual Supply	Actual Supply	Actual Supply	Actual Supply	Actual Supply	Actual Supply	Actual Supply	Actual Supply
		2012-13	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**
I									
A	**Steel – Domestic**	17	15	12	12	10	11	13	17
B	**Metallurgical coal (Import)**	36	37	44	45	42	47	52	52
	Sub Total	**52**	**52**	**56**	**57**	**52**	**58**	**65**	**69**
II									
A	**Power (Utilities)**	457	439	435	436	483	491	533	534
B	**Power (captive)**	55	54	62	62	35	44	77	77
C	**Cement**	22	12	11	11	9	6	9	9
D	**Sponge iron**	21	18	18	18	8	6	10	10
E	**Other***	108	163	240	224	235	250	256	256
	Sub Total	**663**	**687**	**766**	**751**	**770**	**797**	**903**	**886**
	TOTAL	**713**	**739**	**822**	**808**	**822**	**855**	**968**	**955**

Source: Coal Controller Organization 2017, Ministry of Coal Annual Report 2020-21

*Other includes non-coking imports, fertilizers, pulp and paper, other basic metal, chemicals, textiles and rayon, bricks.

The factors that have led to decrease in PLF include increase in coal capacity that has been built to accommodate the load for the next decade, increase in natural gas and renewables share in the energy mix (GoI 2018). The National Electricity Plan (NEP) estimates power demand growth of 6.2% and addition of about 46 GW, between 2022 and 2027. The plan forecasts PLF to be reduced to 56.5% in 2022, on account of decommissioning of 22.7 GW by 2022 on account of age and incapability to adhere to environmental norms. Subsequently, PLF rises to 60.5% due to phasing out of 25.6 GW of capacity that will complete 25 years by 2027 (NEP 2017).

Coal remains the mainstay of Indian energy systems providing for 79% of its power generation, using more than 75% of its final energy consumption and emitting 61.1% of CO_2 emissions (MOEFCC 2021, CEA 2021). Therefore, it is currently beneficial for India because it provides:

1) Energy security – coal reserves are abundant and is the cheapest source of energy,

2) Jobs – 15 million plus people depend on coal and associated businesses, and

3) Royalty - especially of the central and eastern region states get their revenue from coal mining.

Nevertheless, increased coal consumption also brings in negative production externalities such as greenhouse gas emissions and local air pollution, in addition to managing ash.

The world is rapidly embracing decarbonization with large nations and businesses committing to meet Paris Agreement Goals. India, a signatory to both Copenhagen Accord (2009) and Paris Agreement (2015), will need to restructure its entire energy infrastructure to play a crucial role in moving towards a 2°C and well below 2°C. An important aspect of this transition will involve reduction of coal demand across various sectors through numerous policy measures both by governments (federal, state, local) and businesses. These actions when implemented will have implications not only in the coal sector but also in the entire coal supply chain (which includes mining, transportation, distribution, use and disposal) and global coal trade.

The study addresses key debates held at international and national level on a) the future of coal in India, b) influences on international coal trade, c) implications of coal transitions (co-benefits and tradeoffs)

2 Model

AIM/Enduse-India model (Figure 1) has been used in the current study to capture the energy and environment systems of major sectors in India to observe the impact of multiple objectives (energy and climate security) of existing and future policies (energy efficiency, addition of renewables) energy supply (power) and enduse sectors (industry, and so on) (Vishwanathan et al. 2021, Vishwanathan and Garg 2020, Vishwanathan et a. 2018). It can provide a techno-economic perspective at the national level with sectoral granularity. The model has been developed to report primary and final energy mix, emission from the energy system, electricity generation capacity additions and related costs for various sectors. In this study, we use the model to project the future coal demand.

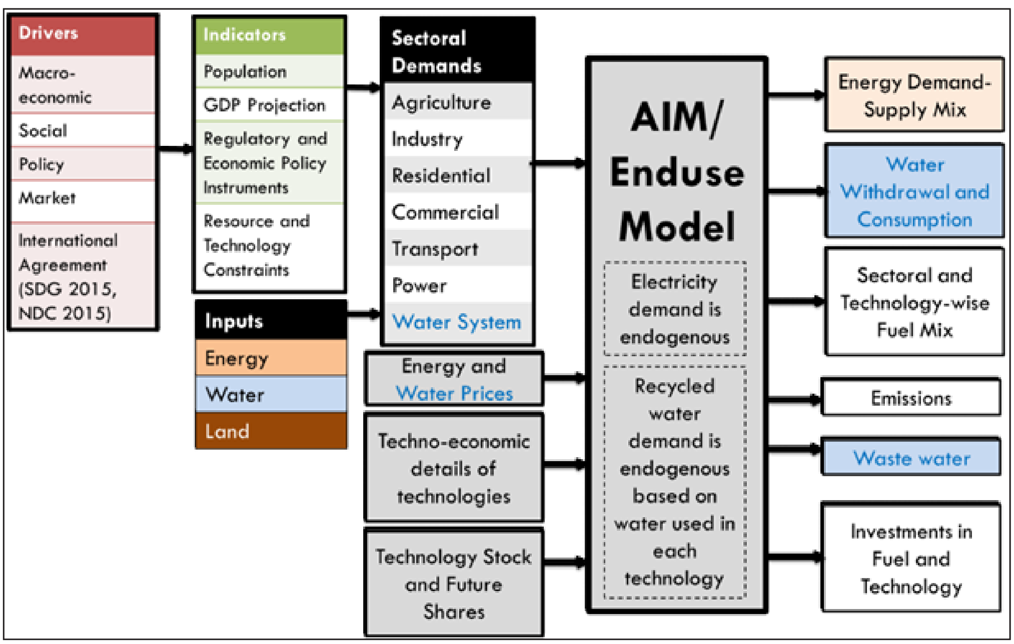

Figure 1: Modified AIM/Enduse Water-Energy-Land (W-E-L) Modelling Framework

We have analyzed four different transitions pathways to discuss alternative roadmaps to move towards a low carbon economy.

a. ***Current Policy Scenario (CPS)***: It encompasses all the on-going policies planned and implemented by government including National Determined Contribution (NDC) and Sustainable Development Goals (SDG) to be achieved by 2030. Import of coal (coking and non-coking) reduces to 235 Mt per year by 2050.

b. ***Deep Decarbonization Scenario (DDS):*** It is an attempt to capture the energy mix and coal demand required in order to move towards deep decarbonization of the Indian economy. It assumes that Indian energy systems will move towards renewables and base load for power may shift from coal to nuclear. Import of coal (coking and non-coking) may also reduce substantially.

3 Results

The results present future coal demand, carbon emissions from coal consumption and coal imports projected under afore-mentioned scenarios by the model till 2050.

3.1 Coal demand

Figure 1 and Figure 2 illustrate the coal demand by type and sector respectively. In the *current policy scenario*, the total coal demand stabilizes around 0.9 to 1 bt between 2030 and 2050 with a CAGR of 0.26% over 20 years. The coking coal demand increases to 90-120 Mt between 2030 and 2050. The share of industry sector increases to about 63% whereas as share of power sector decrease to about 37% in 2050. This is because on-going policies in power have coal as the base load, with rapid increase in share of renewables. The stabilization is due to combination of energy efficiency, shift to renewables in all sectors (power, industry, transport, residential and commercial sectors.

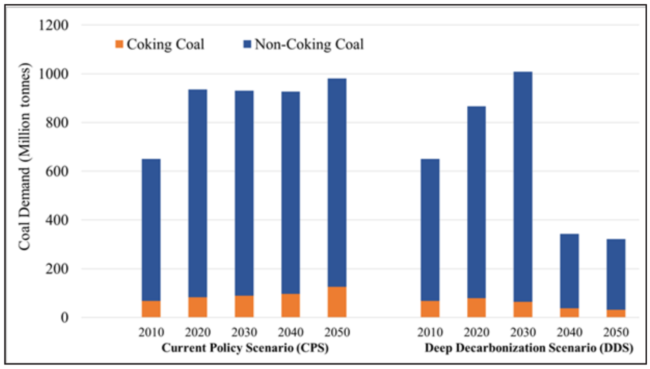

Figure 2: Coal demand by type under current policy and deep decarbonization scenarios

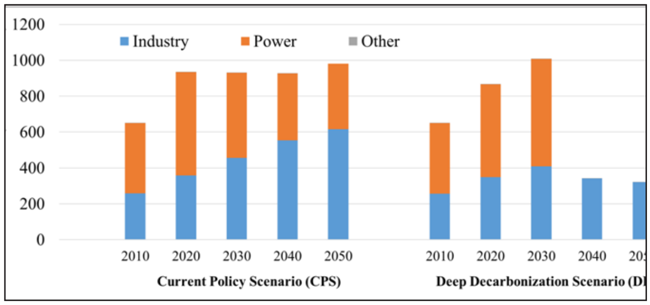

Figure 3: Coal demand by sector under current policy and deep decarbonization scenarios

In the *deep decarbonization* scenario, the total coal demand decreases to around 0.32 bt in 2050 with a CAGR of -3.26% over 30 years. The coking coal demand increase to 31-63 Mt between 2030 and 2050. The share of industry sector increases to about 100% whereas as share of power sector reduces to about 0% in 2040. This is because rapid increase in share of renewables with nuclear, large hydro and small share of gas serving as the base load after 2030. Both power and industry sectors become more energy efficient.

3.2 CO_2 emissions

The reduction in emission intensity to GDP for all scenarios will be more than 33-35% (NDC Goal 3) over 2005-2030. The share of the non-fossil fuel generation capacity target will be more 40% (NDC Goal 4) under all scenarios in large hydro is also considered as 'non-fossil fuel'. The cumulative emissions between 2010 and 2050 is 134 bt CO_2, and 101 bt CO_2 for current policy scenario, and deep decarbonization respectively. The share of cumulative emissions from coal amount to 66 bt CO_2 (49% of total CO_2), and 49 bt CO_2 (49% of total CO_2) for current policy scenario, and deep decarbonization and deep decarbonization respectively.

The share of power sector emissions is observed to decrease from 60% in 2020 to around 37% in 2050 in current policy scenario, however, this share drastically decreases to almost 0% deep decarbonization in 2040. This trend is observed due to a combined impact of 1) increase in renewable share, 2) decrease in ATC losses, 3) increase in fuel and technical efficiency in thermal based power plants and 4) deep decarbonization shift of base load to nuclear and large hydro, with storage providing flexibility to the power grid.

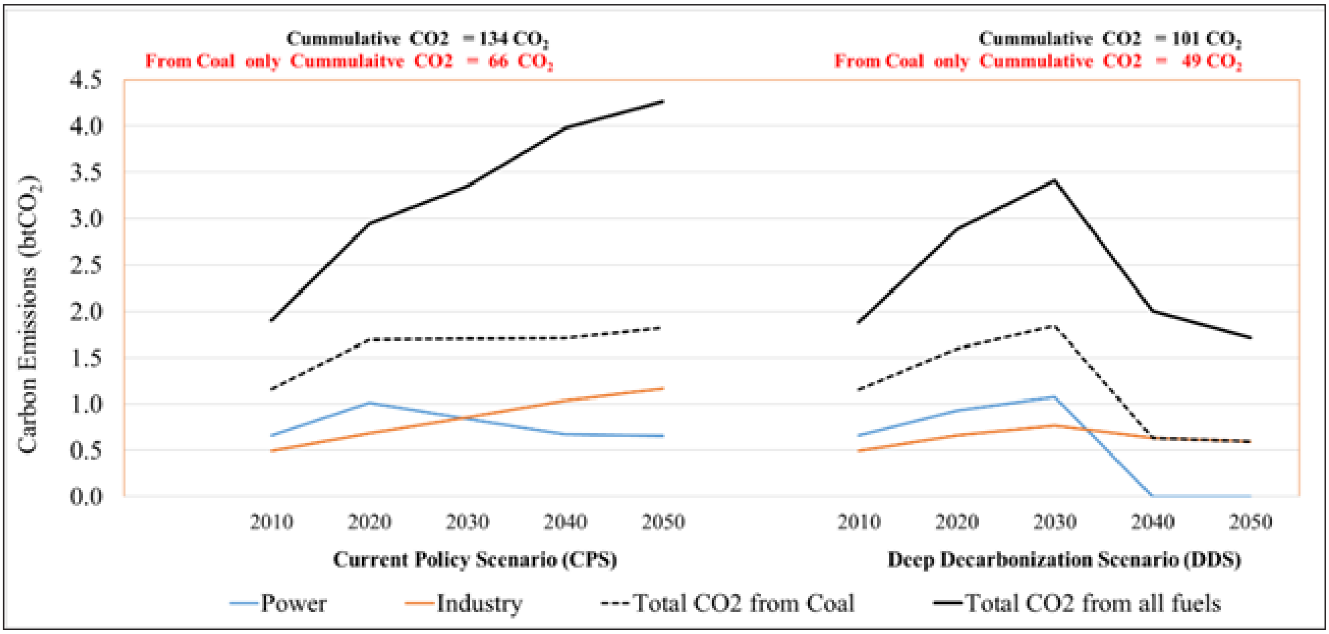

Figure 4: Total carbon emissions from coal and total carbon emissions from all fuels (including coal) under current policy and deep decarbonization scenarios

The share of industry sector is observed to shift from 41% in 2020 to 64% in current policy scenario, and 100% in DDS in 2050. This mainly in due to decrease in share of emissions from power sector. There is an overall decrease in trend of emission when deep decarbonization scenario is compared with current policy scenario. This is due implementation of energy efficient programme (PAT) under NMEEE and installation of CCUS especially in energy intensive industry like steel and cement.

4 Discussions

4.1 Future of coal

India's current NDC and on-going development and economic policies have already played a crucial role in reducing carbon emissions. Coal sector policies that have been relevant include a) improvement of coal quality to increase energy efficiency of existing production capacity, b) revising coal cess from INR 50/t (37 cents/t) in 2010 to Rs 400/t (2.95 US$/t) in 2016-17. Relevant power sector policies include a) phasing out of old, inefficient power plants with new super-critical plants, b) adjusting the power market design to more efficiently integrate renewables and thermal power generation, and c) removing existing barriers to the achieving India's current renewable energy goals in the power sector.

It is evident that the future of coal in each scenario hinges on how the development of power sector in the coming decades. It is also observed that industry sector will also become more efficient, however it will still be hard to abate emissions due to coal and industrial processes without significant investments in alternative technologies. Feasibility of deep decarbonization scenario is dependant of various factors ranging from investments, relevant technology transfers, capacity building to social acceptance. For example, in the industry sector, the emissions from coal demand can be reduced by installation of appropriate carbon capture, utilization and storage (CCUS) technologies at select locations. CCUS could be an essential component of Indian energy policy going forward with around 780 Mt mitigation possible each year at under US$60/t-$CO_2$ and around one bt at US$75/t-$CO_2$ (Garg et al., 2017). Social acceptability, geological uncertainties, and environmental risks due to leakage remain a matter of concern. For the past few years, the current gas capacity has been underutilized in the past decade. However, PSUs and private sector have been observed to switch to gas due to lack of coal supply, increasing electricity demand, and cheaper prices (especially during COVID19). In DDS, the social acceptability of nuclear may pose to be an issue depending on its geographical location.

4.2 Coal Imports and International Trade

Imports help to secure supplies when a country faces coal shortages. The main import countries for India have been Indonesia, Australia and South Africa in the past few years. So on international trade front, *if the central government retains the suggested zero-import policy for steam coal, India will still need at least a minimum of 75-100 Mt of steam coal due to demand from its import-based power plants*. Coal washing has already been discontinued in India. Figure 5 presents the estimated imports and subsequent domestic production required in the next three decades based on these assumptions. For current policy scenario, the imports are assumed to continue and increase in the range of 235 to 265 Mt in 2050. However, for DDS, the imports are estimated to be in the range of 75-100 Mt in 2050.

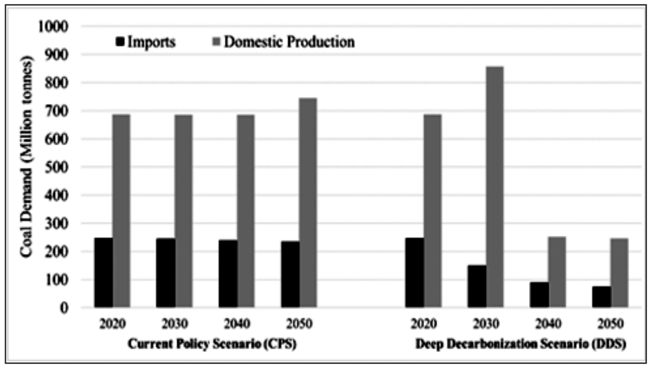

Figure 5: Coal imports and domestic production under current policy and deep decarbonization scenarios

4.3 Co-benefits: Emissions, air, water and land pollution

Emissions and pollution from mining operations are significantly less when compared to the use of fossil fuels by power and other enduse sectors. In 2020, a rough estimate from domestic coal mining amount to 20 Mt CO_2 as mining one tonne of coal emits about 30 kg of CO_2 (PTI, 2021). So, emissions from coal mining will be around 22 Mt CO_2 in current policy scenario, and around 7 Mt CO_2 in DDS in 2050.

Mining leads to environmental issues relating to deforestation, land degradation, air and water pollution. Land degradation due to mining and its reclamation has always been a challenge. Indian coal is of high ash content (up to 45%). Most of the coal occurs below forest, agriculture lands and dense population. With increasing mining activities, land acquisition, reclamation and rehabilitation (R&R) and livelihood issues have attracted serious attention of coal mining companies. CIL has already taken up large scale plantations to offset its Scope 1 emissions. It has created 2.4 hectares of plantation for every one hectare of land used for coal mining.

Power sector contributes to 60% of PM (particulate matter – of all dimensions), 45% of SOx (sulphur dioxide), 30% of NOx (nitrogen oxides) and 80% of mercury emissions. To meet the new pollution norms for SOx the plants are necessarily required to retrofit or install a technology called flue-gas desulfurization (FGD) which helps remove sulphur dioxide from exhaust flue gases of fossil-fuel power plants. CEA (2017) suggests that PM and NOx standards will be achieved by March 2019, while SOx standards by December 2020. Recently there have been extensions given by the government for FGD installations by 2022 (Reuters, 2021). Indian coal is inferior in quality and has high ash content. India generated 169 Mt of ash in 2016-17, of which 107 Mt (63%) was utilized. To increase the fly ash utilization to 100%, a mobile application "ASHTRACK" has been launched to establish link between flyash users and power plants (GoI 2018).

4.4 Tradeoffs: Stranded Assets

Stranded assets in the form coal reserves and coal based power plants will increase as consequence of selected alternate pathways. About 220 billion tonnes of coal will remain to be unutilized and the total cost of it would be roughly around 6.7 trillion USD, if we take average cost of coal at Rs.2000 per tonne (29.54 US$/t). Stranded assets in power plants have also been categorized according to physical (resource, pollution) constraints and dynamic of national and international market. Therefore, both coal and power sectors need to develop a coherent strategy for future energy systems to manage risks and avoid stranded assets.

In addition to increase of stranded assets, the feasibility of each of these scenarios reflects implicit hypotheses that could be challenged. Uncertainties will be observed at supply level depending on the type of fuels (natural gas import, nuclear fuel production/import and supply chain), future development of renewables including lack of storage, in addition to social acceptability and geological uncertainties of CCS. *Another important facet that has not been touched upon in the current study but will play an important role is studying impacts of coal transitions at social, political as well as economic level at regional, state and local levels.*

Conclusion

India is one of the key nations that is and will be looked upon to lead the climate actions by example along with Europe, United States of America and China. However, coal use and mitigating climate change are closely interconnected, and more so for coal dependent economies like China, India, USA, Germany, Russia, Japan, South Africa, South Korea, Poland, Australia, Turkey and Indonesia, which together account for over 88% of global coal extraction and use per year. Since coal is a global concern, the solution must also be global. Individual coal dependent countries, especially developing countries, would be significantly concerned with their energy security and economic-social-political compulsions and may continue with coal. There has to be an international mechanism, including providing finance and technology by the developed countries, to phase out coal use.

This study attempts to provide a snapshot on the future of coal and its implications by selecting alternate pathways. It is observed that there is still an enormous scope of improvement for India to deep decarbonization economy. Governments (federal, state, local) and private sector need to synchronize between policies, strategies and actions to look after both energy (resource and infrastructure) security, and climate security in an equitable manner.

Disclaimer

These results presented in this article are outputs of the academic research conducted under the DDP BIICS project as per the contractual agreement. The academic work does not in any way represent our considered opinion for climate negotiations and also does not reflect the official policy or position of the Government of India.

Acknowledgement

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Breaking the Restraints of Environmental Concerns on the Indian Coal and Energy Sector through Mineral Carbonation

Majid Hasan Tyeb[1], Arun Kumar Majumder[1]

Introduction

The theme for this newsletter insinuates the existence of a 'sustainable' pathway for our nation's coal sector when there clearly is no real way to sustainably use a finite amount of something which is non-renewable. Even if we wring out every last ton of coal from our proven reserves (to date), it will be extinguished in around 100 years at current production and consumption levels. If our reliance on coal for large scale thermal power generation doesn't diminish by then, we will lose our capability to quench our own energy demands and that may lead to what we can call an energy variant of a 'Malthusian catastrophe' for a country of our size.

Increasing the efficiency of our boilers, coal combustion furnaces or coal beneficiation techniques can provide temporary benefits in terms of efficient resource utilization, but it is not going to solve the issue of our impending doom. Maybe, the only real way to sustainably use our remaining coal reserves is to treat them as the last buffer energy source which will power the era of gradual, yet very essential and massive transition of our country from coal reliance to coal independence, before we hit the empty mark on our reserves. However, such an envisioned transition has always been historically associated with past periods of aggressive and unbridled technological and economic development in most of the countries which now enjoy the status of being 'developed'. The massive energy requirements for fuelling these periods of expeditious technological advancements were mostly fulfilled by unchecked exploitation of non-renewable energy sources. India too will most likely have to enter a period of turbulent development for propelling itself to the category of a developed nation and succeeding in the aforementioned transition of its energy mix. For this development spurt to bear fruit, the generation and consumption of an unprecedented amount of electrical energy will become necessary (due to the large population) and until sufficient development in renewable energy is achieved, this copious generation will have to be borne by combustion of fossil fuels; chiefly coal.

An Unseen Challenge for the Indian Coal Sector

The aforementioned strategy has worked for many developed nations and India too has the natural resource endowments to implement such a strategy for its own development. However, times are now different from when the other nations implemented such an approach. The extensive release of pollutants and greenhouse gases from the unchecked combustion of fossil fuels has had highly adverse effects on the environment and the global climate. The cumulative contribution of India in the adverse climate changes across the globe is quite small in comparison to some of the developed nations, but the fact remains that India, with the agricultural and allied industries at its heart, is one of the worst affected countries by the global climate change issues. Thus, attempting to significantly uplift thermal power generation levels to feed an era of development and technological advancement will most likely be met with dire consequences in the form of catastrophic natural calamities and irreparable damage to the ecosystem. Even if India as a country becomes willing to risk that

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kind of environmental damage for its expeditious development, ratifications to international treaties like the 'Paris Agreement' will not allow for such environmentally irresponsible behaviour. Thus, the need of the hour for India's coal sector to rise up to the occasion and help fuel the great transition towards development, is mostly snuffed out due to the concerns regarding environmental damage and climate change. The current debate is over the appropriate measures to take for sustainable use of our coal reserves while attempting to reduce emissions. However, amidst the uncertain stance adopted by us, one of the most important leverage we have (our coal reserves) in order to mount a colossal development drive on a national scale to make us ready for the future, will be gradually extinguished forever; at least for all practical intents and purposes.

However, if we do reach the counter-intuitive consensus that the conservative utilization of our remaining coal reserves will be inappropriate from a development standpoint and that the faster we develop, the faster we will be able to shake off our reliance on coal for energy production, some drastic measures for controlling the climate impact of our development drive will have to be taken into serious consideration. One such potential measure is the capturing and fixing of carbon dioxide and other greenhouse gases (GHGs) released in copious amounts from the coal fired thermal power plants. The recently emerging concept of **Mineral Carbonation** offers an attractive prospect for all around utilization of industrial wastes along with efficient and highly stable fixing of captured carbon dioxide.

Mineral Carbonation

Mineral carbonation is the artificial equivalent of the naturally occurring reaction called 'Silicate weathering', in which naturally occurring metal silicates react with atmospheric CO_2 to form carbonates over a geological time scale. In mineral carbonation, the captured and concentrated CO_2 is reacted with metal silicate or oxide bearing materials to produce stable metal carbonates in a thermodynamically favourable process at low temperatures. The oxides and silicates of calcium and magnesium are the most effective for this purpose. This process can both be in-situ and ex-situ in nature. Natural materials which are suitable for reaction in carbonation processes include silicate rocks containing olivine and pyroxene minerals found abundantly in specific igneous complexes along with serpentine bearing rocks commonly found in abundance in ophiolite complexes and belts. Industrial by-products and wastes rich in alkalinity can also be utilized for mineral carbonation. Coal ash from thermal power plants is usually rich in CaO content and can be positively considered for the carbonation process. Even the slag from the iron and steel industry is highly enriched in CaO and MgO and thus is suitable for use in mineral carbonation.

India is neither lacking the natural reserves of suitable materials for use in mineral carbonation, nor is it lacking in the suitable industrial wastes and by-products which can be utilized in mineral carbonation. Better yet, the industries which produce these suitably alkaline wastes and by-products also happen to be the primary producers of CO_2. Thus, an integrated approach can be considered where the CO_2 produced by the power generation industry and the iron and steel industry is captured and fixed using the coal ash and blast furnace slag respectively. India also possesses considerable reserves of naturally suitable materials for use in mineral carbonation, an example of which is the massive ophiolite complex of the Indo-Burman orogenic belt in northeast India.

Another lucrative prospect ties back to the fact that serpentine bearing rocks (serpentinites) are very suitable for use in mineral carbonation. Chrysotile, commonly referred to as white asbestos and utilized widely for construction and insulation purposes, is a silicate mineral of the serpentine family. Disposal of asbestos is a highly problematic issue as it can cause serious respiratory health hazards. Therefore, if the need ever arises to completely dispose of the asbestos in the country due to future enforcement of stringent laws, the use of asbestos in mineral carbonation processes can be considered for CO_2 fixing. This will take care of two environmental and health hazards in one go as after the carbonation process, asbestos will also be turned into harmless carbonates and silica by-products.

Summary

From the above discussion, it is not to be taken away that mineral carbonation is a ready to implement technology and can immediately provide us with the benefits enumerated previously. The key message is that India has everything it needs from raw materials to application opportunities and great potential benefits, for delving deep into solving the challenges associated with the industrialization of the mineral carbonation process. Mineral carbonation is not as simple as simply reacting the CO_2 with appropriate alkaline material for carbonation reaction to occur. The kinetics of the process, an efficient reaction scheme, proper material preparation, correct activation of materials and catalysis of the process, efficient recovery of the reaction catalysts, economy of the overall carbonation process and associated impact on the primary CO_2 producing industries are among the challenges standing in the way of successful application of the process.

However, if India invests its intellectual and financial resources to confront and resolve the issues surrounding immature technology of mineral carbonation and successful application is realized on a large industrial scale; then we will at least find ourselves in a position where we can harness the complete scope of our coal reserves for energy production at unprecedented levels without having to worry about the environmental impact of our CO_2 emissions. It will be a monumental industrial and scientific ordeal which will absolutely have to be undertaken for India to rise to the strata of developed nations. This will give the Indian coal sector the opportunity to become the backbone of a modern era developmental revolution; but unlike the other developed countries, we will not be staging our expeditious development at the cost of global climate and the environment.

Down the Memory Lane

From the Diary of a Geologist

Saral Sekhar Bose

With a stamp from a premier institution to work as an Earth scientist, long years have since been passed working on different fields and research assignments in state geology, GSI and private organisations. Now at the age of nearing eighty "... they flash upon that inward eye which is the bliss of solitude...". I would like to share with everyone some of the glimpses in the following lines.

My field life started in 1963 on a final year dissertation project on the eastern flank of Tattapani-Ramkola Coal field, in the densely wooded Surguja district, MP, which is now an active den of Maoist activities. Upstream of a stream deep inside the dense forest there was reported exposure of a coal seam in Barakar Formation. After a day of introductory field visit I requested the Professor, a doctorate on Gondwana from Jharia Coal Field area, to guide me sampling coal from an in-situ seam. Next day negotiating the aforementioned stream through dense jungle with pug marks of beasts along the dry stream bed, the professor suddenly stopped. He said, 'Look Bose, it is very risky to proceed further only with a guide porter. At camp I shall explain to you coal bed sampling. After my return, I shall arrange contingent provision of two coolies for your safety'. So saying, he left next day. I had to complete the project all alone ignoring the hazards of field life.

Soon after passing M.Sc in Applied Geology, I got a job that I was desperately searching because of my family financial condition, as a Field Geologist in an iron ore mine on the Gua Iron Ore Range near Barajamda. I had to join in the company's Head Quarter at Chaibasa. In those days to reach Chaibasa one has to board a Bombay bound train, get down post midnight at Rajkharswan, and avail the Rajkharswan-Barajamda passenger train in early morning which arrived Chaibasa at 8.0 AM. After joining, I was directed to report in the nearby office of N.R. Sen, Chief Mining Engineer and Manager of the Company. After preliminary introduction Mr Sen arranged my sitting arrangement in his room and gave me one progress report of the mine to prepare its synopsis. Having a cool bath and sumptuous meal after a strenuous overnight journey with no sleep, I soon dozed off keeping my head on the table! Suddenly I awoke with a jerk and stared at my boss's eyes to find a cool, assuring look focussed on me. Gently he said, 'Perhaps you were very exhausted and had no sleep last night. Go outside in the fresh air, splash your face with cold water and you will feel better'. That was my first day experience of my carrier! The company used to supply iron ore to IISCO through MMTC. Once, the overall quality of the ore depleted. Looking desperately to locate a better grade iron ore zone in the thickly wooded one kilometre long high mountain range lease hold area, I could locate within a short time a very high grade float ore deposit that could be blended and restore the required quality of the grade for the time being.

Next year I got an appointment in Directorate of Geology and Mines, Govt. of Orissa. My first year assignment was in Talcher District to explore the Talcher Coal beds for reported fireclay deposit underneath, by core drilling. To supply water to the drilling site, water had to be hauled from a river near to our camp by water tanker. One early morning when the drilling crew were about to move to the drilling site, suddenly one shouted, 'fire, fire'. Everybody looked towards the nearby Konia village where a few thatched roofs of the hutments among others lined on either side of the road, were blazing with strong wind blowing towards the village. Immediately I instructed to start the water pump and requested the inmates of the camp to move with the tanker tied to tractor to the village and help the villagers extinguish the fire. In the evening the local BDO and village head came to our camp and expressed their gratitude and profusely thanked everyone for the timely intervention taken without which the entire village would have been turned into ashes.

I was transferred to Orissa S.Z. next year and sent to another fireclay investigation project located at Devadhara village, 35 km away from Jeypore town in Koraput district under A. K. Singh, Sr Geologist. The camping site was on a roadside open ground close to a bushy jungle and adjacent to a quartzite ridge. After a long road journey from Vizag I retired to my camp-cot placed beside Mr Singh in the same Swiss tent. At post mid-night, suddenly I woke up hearing roaring of a tiger loud and clear, appeared to be close to our camp. In a suppressed whispering tone I called out, 'Singh, Singh, can you hear a tiger's howling close by?' Half awake Singh replied, 'Oh, that tiger! Don't worry; it walks down along the ridge to a nearby water spring and returns back roaring every night. Sleep', so saying he turned around and started snoring again. I came out from the tent in the chilling wintery night with a torch in hand to find that the night guard was deep in slumber beside the almost extinguished fire. Having the tiger's roar been faded in the distance, a calm silence had dissented over the camp, occasionally broken by unison consort of crickets and the million stars blinking merrily in the overhead sky.

After qualifying for GSI job, my first field assignment was to associate myself with a large prospecting party comprising two senior geologists, a senior chemist with his mobile chemical van, surveyor and drivers camping at Belpahari, 30 km away from Jhargram Township. After about a fortnight, tension started to build up among the senior colleagues as the Director of the Division, a veteran with peevish and impervious personality had a scheduled inspection tour to the camp. All endeavours for his satisfaction, pleasure and comfort including lodging, boarding, field visit, three days excursion tour to Kankrajhore forest rest house, etc were arranged. When one week had passed with no sign of his departure, a plot was hatched and the cook was tipped to enter the dining hall with a big '*ruhu*' fish during breakfast time. Next morning the cook marched past the dining hall with a large fish dangling in his hand in view of everyone. Having no non-veg dishes both at lunch and dinner time the Director couldn't help asking, 'Why, is today a vegetarian day for all of you?' One senior colleague had a readymade reply, 'we are extremely sorry, Sir. Today's fish was totally rotten! How can we serve that to our respectable guest?' A dark shadow descended on his fair countenance. Next day after breakfast, the director left for Head Quarter.

Experimenting with vapour-phase gas geochemistry in arid regions of Rajasthan and base mental fields like Khetri, Aladahalli, Chitradurga and Kesarpur with a Sr. Colleague, establishing South-East Extension of the Singhbhum Shear zone beyond Khejurdari up to Kesarpur in Orissa, locating (for the first time) komatiite with authentic spinifex texture at SE of Banasandra in Karnataka etc. are some of my satisfying works in GSI. While working in Gaya district on the bank of Falgu River at the edge of a hill, once I encountered a real life dacoit in full 'Gabbar Singh' outfit. Appearing suddenly from behind a large boulder and aiming a double barrel gun at me in point blank range, he demanded my identity and purpose of my presence there. Having been convinced that I am not a police officer, he ordered me to leave the place forth with!

I had a rare opportunity to work at the working face of Champion Reef mine in KGF at 2900 metre depth where the temperature was above 65^0C. One day after completing work at 42^{nd} Level I waited at the lift to go down the next level to finish the day's work, but it did not stop, instead went on going up and down. When I contacted at surface over phone, my request was turned down on a plea that some mine's work was going on. Being a Senior Govt. Officer on duty, such denial hurt my prestige! I asked the telephone operator to make a contact with the Mine's Manager for a dialogue. After about thirty minutes, the telephone operator at that level summoned me saying the Manager was on the line. When I placed my complain he replied, 'Look Mr Bose. When I received the call, first thing I apprehended an accident; because when I am underground, nobody disturbs me unless there is an utter emergency. Do you know to locate me within the labyrinth of the entire mines how much the telephone system remained engaged, denying other important calls? Please Mr Bose, when you are inside the mine, do adhere the rules and regulations of the mine. Bye'. I felt very embarrassed and ashamed. It was unfair on my part to ask undue favour ignoring safety of the vast mines system and welfare of the miners.

From next day of my retirement till next sixteen years, I kept myself engaged with a private entrepreneur in mineral prospecting especially for limestone, asbestos and iron ores in different parts of India, but the KGF's memory kept me haunting till today.

Interviewees and Contributors to this Issue

Stakeholders interviewed

Mr. Partha S. Bhattacharyya | Former Chairman, Coal India Limited

Mr. Partha S. Bhattacharyya, M. Sc (Physics) from Jadavpur University and a Cost Accountant joined Coal India as a Management Trainee in 1977 and rose to become its Chairman in October 2006. In his tenure, CIL has grown from strength to strength. In his tenure, Government decided to disinvest 10% of equity in CIL. The number of shares offered were 63.16 crores to raise over Rs.15,000 crores. Under Mr. Bhattacharyya's dynamic leadership, history was created. CIL IPO, the largest so far in Indian capital market was over subscribed by 15.3 times with an aggregate fund flowing of Rs.2,33,000 crores, highest so far in the Indian Capital market. On the 4th November 2010, CIL made a spectacular debut on the bourses and at present, it is the country's fourth largest company in terms of valuation with a market capitalization of over Rs. 2 lakhs crores. The Forbes magazine has recognized him as a high achiever of the year 2010 (December 2010 issue). On October 15, 2009, he received, on behalf of CIL, the coveted 'SCOPE GOLD TROPHY AWARD' for excellence and outstanding contribution to the Public Sector Management – Institutional Category 2007-08 from the Hon'ble Prime Minister of India.

Mr. N.C. Jha | Former Chairman, Coal India Limited; Past President, MGMI

NC Jha Mr Nirmal Chandra Jha is a Mining Engineer by qualification with an M Tech degree from Indian School of Mines, Dhanbad. Professionally, he took up the job of a Mining Engineer at Coal India Limited in January 1974, worked there for 37 years and retired in January 2012 as its Director (Technical) and Chairman & Managing Director. He led the company to achieve "Maharatna" status and the "most valued company in India" in the year 2011. Post retirement from CIL also, Mr Jha has been active in the mining industry and was engaged with M/s Monnet Ispat and Energy Limited as CEO of its Mining Business, Sandvik Chair Professor at Indian School of Mines, Dhanbad and lastly with M/s International Coal Ventures Limited as the MD & CEO of its Mozambique operations. Mr Jha had steered the MGMI as its President for the period 2008-09 to 2009-10. Mr Jha has served as Director on more than a dozen Boards of PSUs as well as private companies as official, non-official and independent Directors.

Mr. Vinay Prakash | Director, Adani Enterprises and CEO, Adani Natural Resources

Mr. Vinay Prakash is among the recognised leaders in Energy and infrastructure sector. An enthusiast for energy security and sustainability, Mr. Prakash has nurtured the Natural Resources business of the Adani Group since its inception and oversees its diversification and expansion in India and abroad. Natural Resources division comprises of Integrated Coal Management, Iron Ore, Minerals, Bunkering, Mining, Cement & Aggregate Businesses. Mr. Prakash holds B.Tech (Mechanical), PG Diploma in Operations / Material Management , MBA (Finance) and he is also pursuing PhD from Indian Institute of Technology-Indian School of Mines (IIT-ISM) on Sustainable Mining Practices.

Mr. K. Lakshma Reddy | Incharge – Coal Sector, Bharatiya Mazdoor Sangh

Mr. K. Lakshma Reddy is the Former All India General Secretary of the Bharatiya Mazdoor Sangh. He has been associated with Trade Union activities for the last 45 years. He has participated in several national and international seminars of ILO,APO,FES and also International Labour Conference at Geneva

Authors of contributed papers

Ms Marta Torres-Gunfaus | Senior Research Fellow, Climate and Energy, IDDRI

Marta Torres-Gunfaus is senior researcher on climate and energy at IDDRI. Her responsibilities include bridging research and policy-making and quantitative analysis with social sciences disciplines. She is responsible for the management of the RIPPLES project, ensuring policy-relevance and impact on the ground for greater global mitigation ambition. Marta also contributes to the follow-up of the Deep Decarbonization Pathways Project, for which she will be leading the in-country policy dialogues work. She has extensive international experience leading and participating in large projects for governmental bodies such as several national administrations, the European Commission, the International Energy Agency, and the International Carbon Action Partnership. In addition, she served as Head of Climate Mitigation for the Government of Catalonia (Spain). In 2013, Marta became co-Director of the MAPS Programme, a collaboration amongst developing countries employing over hundred experts to establish the evidence base for long term transition to robust economies that are carbon efficient.

Dr. Henri Waisman | Coordinator, Deep Decarbonization Pathways Project

Henri Waisman is senior researcher within IDDRI's Climate programme, in charge of activities on long-term low emission development trajectories. He is the coordinator of the Deep Decarbonization Pathways Project (DDPP), which is working with international partners to mobilize long-term analysis as a tool to support the political process initiated by the Paris Agreement. He is also in charge of promoting the DDPP's lessons on the use of forward-looking scenarios as a tool for dialogue to support the implementation of the transition to sustainable development. After graduating from the École Normale Supérieure (ENS) of Lyon in physical sciences, Henri joined the CIRED (Centre International de Recherche sur l'Environnement et le Développement) in 2005 where he conducted modeling work for the analysis of socio-economic impacts of energy and climate issues. He holds a doctorate from the Ecole des Hautes Etudes en Sciences Sociales (EHESS) in Economics, with a specialization in Environment; his thesis focuses on the links between climate change mitigation policies, international energy markets and urban dynamics. Henri joined IDDRI in December 2013. Henri is a member of the Intergovernmental Panel of Experts on Climate Change (IPCC), as Lead Author for the Special Report on 1.5C

Prof. Amit Garg | Professor, Public Systems Group, Indian Institute of Management Ahmedabad

Amit Garg specializes in energy and climate change. He has co-authored 12 books, 25 international research reports and published extensively in international journals. He is a Lead Author for five reports of the UN's Intergovernmental Panel on Climate Change (IPCC). He is currently the Co-Chair of IPCC Emission Factor Database and Co-Editor-in-Chief of Carbon Management journal. Prof Garg was felicitated by the Prime Minister of India in 2007 for his outstanding contributions to climate change research. He was also a prominent member and contributed to the award of Nobel Peace Prize to IPCC in 2007. He received the Distinguished Young Professor Award for Excellence in Research at IIMA in 2010 and Outstanding Researcher Award at IIMA again in 2016.

Prof. Runa Sarkar | Professor, Economics Group, Indian Institute of Management Calcutta

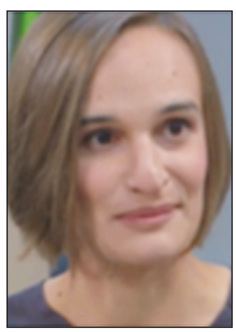
Runa Sarkar is a Professor with the Economics Group at the Indian Institute of Management Calcutta and a member of the committee for the Centre for Development and Environment Policy. Prior to this, she taught at IIT Kanpur. A chemical engineer from BITS Pilani, Prof. Sarkar pursued her Masters in environmental engineering at the University of North Carolina at Chapel Hill, USA. After spending five years as an environmental consultant in a subsidiary of Tata Steel, Prof. Sarkar completed her doctoral studies from IIM Calcutta. Her recent books include *Economics of Sustainable Development* (with Prof. Anup Sinha), *Essays on Sustainability and Management* (co-edited with Prof. Annapurna Shaw) and *Another Development: Participation, Empowerment and Well-Being in Rural India* (with Prof. Anup Sinha).

Dr. Ajay K. Singh | Former Scientist, CSIR-Central Institute of Mining and Fuel Research

Dr. Ajay Kumar Singh was a scientist at the CSIR-CIMFR and he headed the Methane Emission and Degasification Division at CSIR-CIMFR for a period of two decades. He is a Lead Author for three reports of the Intergovernmental Panel on Climate Change (IPCC). For his contributions to the IPCC, he was recognized by the Hon'ble Prime Minister of India. He has also led the chapters for fugitive emission in several reports and communications of the Government of India to the UNFCCC. The emission factors developed with his expertise have featured in the IPCC Emission Factor Database. He obtained his PhD degree from IIT Kanpur. His book on Coalbed Methane in India: Opportunities, Issues and Challenges for Recovery and Utilization, has been published by Springer in 2018.

Prof. Arun Kumar Majumder | Professor, Department of Mining Engineering, Indian Institute of Technology Kharagpur

Prof. Arun Kumar Majumder has served as a faculty member at IIT Kharagpur since 2010. Previously, he was a scientist at the CSIR-Advanced Materials and Process Research Institute. Prof. Majumder is a recipient of the MGMI's D.N. Thakur Award and R.P. Bhatnagar Award, and also the National Design Award by the Institution of Engineers (India). He received his PhD from the University of Queensland, MTech from ISM Dhanbad and Bachelors degree from (now) NIT Durgapur.



Ms Anna Pérez Català | Research Fellow, Deep Decarbonization Pathways Initiative

Anna is a Research Fellow working in the Deep Decarbonization Pathways Initiative. Prior to IDDRI, she was the Co-Director of Climate Tracker, a network that gathers and mentors climate journalists worldwide. Anna holds a Masters in Climate Change and International

Development from the University of East Anglia and a Bachelor's degree in Environmental Sciences from the Autonomous University of Barcelona.

Ms Geeta Morar | Project Manager: Environmental Sustainability, National Business Initiative

Geeta Morar is a sustainable development practitioner, with a focus on climate change as well as economic transition and social development. Geeta is currently the Project Manager for Environmental Sustainability at the National Business Initiative (NBI), where she works on core programmes of the NBI's environmental agenda: climate change, just transition, and the implementation of the Sustainable Development Goals with business. She has recently provided stakeholder engagement and research support on the NBI Just Transition Pathways project. This project aims to collectively develop a business perspective on the Just Transition in South Africa and work out what it would take, from a technical and socio-economic perspective, to transition our economy to net zero carbon emissions by 2050.

Dr. Saritha Sudharmma Vishwanathan | Postdoctoral Fellow, Social Systems Division, National Institute for Environmental Studies, Tsukuba, Japan

Saritha is a postdoctoral fellow at the National Institute for Environmental Studies (Japan). She received her fellowship (PhD) in Management, specializing in Public Systems and Public Policy. She completed her Bachelors from L.D College of Engineering (Ahmedabad, Gujarat) and Masters from Georgia Institute of Technology (Atlanta, USA) in Environmental Engineering. As an engineer, she has worked with Black and Veatch, one of the top engineering and consulting firms in USA with clients such as Environmental Protection Agency (EPA) and Department of Defense (DoD). Her current research interests include water-energy-environment systems, integrated assessment modelling, and socio-technical transitions.

Dr. Udayan Singh | Postdoctoral Fellow, Department of Chemical and Biological Engineering, Northwestern University

Udayan Singh is a postdoctoral fellow at the Chemical and Biological Engineering department at Northwestern University. He received his PhD in Environmental Engineering from the University of Virginia, where he was also awarded the Outstanding Graduate Researcher Award in his program. Udayan's research interests are in looking at decarbonization avenues for the energy sector, particularly though CO_2 sequestration and CO_2 removal. He has authored several peer-reviewed journal articles, while also serving as a Contributing Author to the IPCC's ongoing Sixth Assessment Report.

Upcoming Events

China Coal & Mining Expo 2021

26 October 2021 - 29 October 2021

Founded in the 80's, China Coal & Mining Expo (CCME) has become the nation's premier trade event, and has claimed a spot in the worldwide stage for its sector. Held biennially to showcase the latest technology, CCME is recognised as China's most important global window for the coal & mining sector.

New China International Exhibition Center (NCIEC) Beijing
88 Yuxiang Road, Tianzhu Area, Shunyi District, Beijing , 100028, China
Website: http://www.chinaminingcoal.com/

Mines and Money London 2021

30 November 2021 - 02 December 2021

Mines and Money London is Europe's largest mining investment event welcoming investors, mining corporates, and financiers to an event that is business focused, with the core goal of developing and fostering mining investments and deal-making.

Business Design Centre
52 Upper Street, London, N1 0QH, United Kingdom
Website: https://minesandmoney.com/london/

Future of Mining Australia 2022

28 March 2022 - 29 March 2022

The third edition of the Future of Mining Australia covers a vast range of content spanning the entire mining life cycle, focusing on the innovations and technologies driving the industry forward with senior representation from mining companies, service providers, government, finance and research organisations.

Sofitel Sydney Wentworth
61-101 Phillip St., Sydney, New South Wales, 2000, Australia
Website: https://australia.future-of-mining.com/

Euro Mine Expo 2022

14 June 2022 - 16 June 2022

Cutting edge technology and the latest methods in the mining industry – this is the subject of Euro Mine Expo's conference. During a few exciting days, we'll be focusing on fossil free mining, automation, battery and metals, deep rock engineering challenges, real time mining and sustainable mines among a lot of other things.

Skellefteå Kraft Arena
Mossgatan 27, 931 70, Skellefteå, Sweden
Website: https://www.euromineexpo.com/

Electra Mining Africa

05 September 2022 - 09 September 2022

The 2020 show has been cancelled. The next edition of the show will be held from 5-9 September 2022 at the same venue.

Johannesburg Expo Centre
Nasrec Road, Corner Rand Show Road, Nasrec, Johannesburg, 2091, South Africa
Website : https://www.electramining.co.za/

MGMI TRANSIT HOUSE

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Accommodation	AC	Accommodation	AC
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2. 50% discount will be offered to MGMI member for self occupancy only.
3. Full tariff will be applicable for the nominee of MGMI member.
4. Full tariff for the employees of the Corporate Member or Patron Member.
5. 100% advance has to be deposited for confirmation of block booking (three or more rooms for two or more days).
6. Caution money @Rs. 500/- per day, per room has to be deposited along with room rent in advance. This will be refunded in full or part thereof depending on the damage caused by the Guests.
7. Cancellation of confirmed booking Period Prior to date of Occupancy Cancellation fee to be deducted from advance

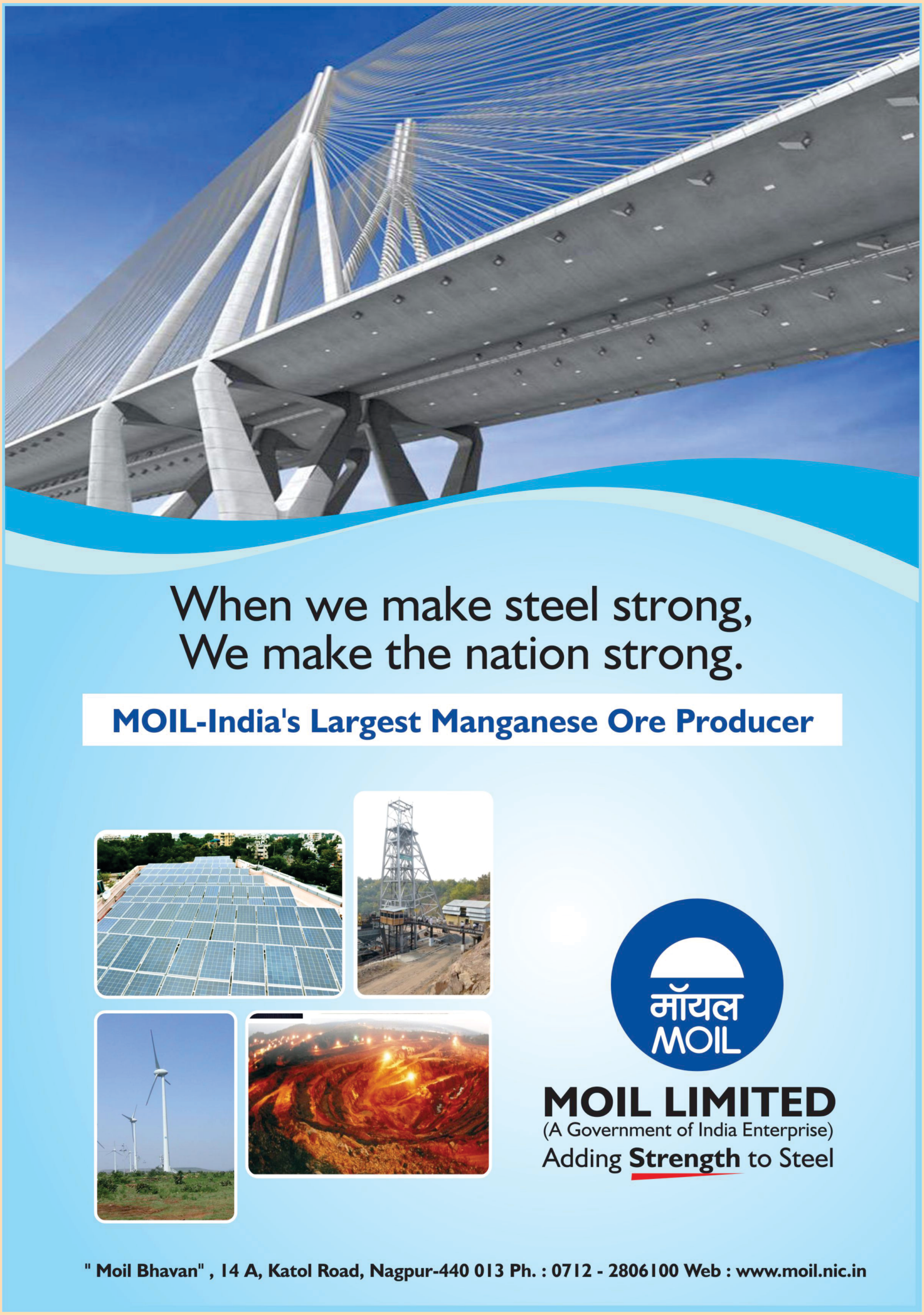
   a. Cancellation before Seven days 5%
   b. Cancellation before Three days 10%
   c. Cancellation before One day 25%

8. Check-in time 12.00 noon
9. Check-out time 11.00 a.m.
10. GST : Less than Rs. 1,000/- No GST
    Rs. 1,001/- to 7,500/- 12% (6% + 6% GST)
    Above Rs. 7,501/- 18% (9% + 9% GST)

LIFT Facility Available

For Booking Please Contact MGMI Office

Contact : +91 33 4000 5168, E-mail : secretary@mgmiindia.in, office@mgmiindia.in, Web : www.mgmiindia.in



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