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Established 1906

THE MINING, GEOLOGICAL AND METALLURGICAL INSTITUTE OF INDIA

MGMI COUNCIL FOR 2022-23

Established 1906

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MGMI NEWS JOURNAL

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&
October - December ● 2023

THEME

"Unearthing the Depths : A Journey into Underground Coal Mining"

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The Mining, Geological and Metallurgical Institute of India

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Are you up to date in paying your subscription? Please do pay it for getting the News Journal and other correspondences on regular basis and for exercising your voting right. Why not opt for LIFE MEMBERSHIP by paying a one-time subscription! This is both convenient and economical.

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The members are requested to send contributions for the columns of the MGMI News Journal, like "Technical Articles" related to the mineral industry on topics dear to the members, Articles as Case History on various mine practices in the field, interesting write ups for "Down Memory Lane", "Opinion" on burning issues of the Mining Industry. "Safety & Health" issues, research finding for "Technology Updates", etc.

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Branches are requested to send the list of members of the Executive Committee with Addresses, Telephone Numbers and Email IDs for maintaining records at MGMI Headquarters. They may also activate their Branches and send Reports for inclusion in the News Journal.

A Quarterly Publication

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EDITORIAL BOARD

PRESIDENT'S MESSAGE

UNDERGROUND MINING : A POTENTIAL CORNERSTONE FOR BALANCING ENERGY SECURITY, ECONOMIC GROWTH AND ENVIRONMENTAL SUSTAINABILITY

In December 2023, the United Nations Conference of Parties (COP28) was organized in Dubai. This event was, in my view, of great importance because it was clearly highlighted that developmental aspirations of billions in the developing world have to co-exist with aims to mitigate climate change. This was concisely summed up in the speech of the Hon'ble Prime Minister of India where he said, "Over the past century, a small section of humanity has indiscriminately exploited nature. However, entire humanity is paying price for this, especially people living in the Global South".

As a responsible nation, India has a well-articulated climate plan both in the near-term and the long-term. The near-term plan aims to reduce the emissions intensity of the economy to the tune of 45% by 2030, relative to 2005 levels. In the long-term, the Government of India has committed to reaching net-zero emissions by 2070. Both these goals highlight India's seriousness towards climate change mitigation but also the cognizance that India's historic responsibility to this issue is minimal, i.e., only 3-4%. This sentiment has trickled down to the institutional level as well. In the context of the coal sector, Coal India Limited has the aspiration of implementing a 3 GW solar capacity programme. Even at the office level, CIL's new headquarters has state-of-the-art rooftop solar panels. Needless to say, this strengthens India's goal of increasing renewable capacity.

An associated plank in the portfolio of approaches for reducing the emissions intensity of the economy is via improved forest cover. India's long-term low-carbon development strategy reiterates the goal of increasing forest carbon sequestration to 2.5-3 billion tonnes of CO_2e by 2030. During the same timeframe, restoring 26 million ha of land has also been stated as a voluntary target. This is where this special issue of the MGMI News Journal plays an important role. The role of underground mining in improving forest cover is critical as it does not require clearing forests to the extent that surface mining does. This will create many reverberating effects. For instance, the forestry sector in India employs more than 6 million people. The policy and technological issues highlighted for underground mining should, accordingly, be viewed as part of a larger roadmap to improve environmental sustainability.

In addition to the reduced impacts on forests, underground coal mining has other environmental benefits. Most notably, it emits only a fraction of criteria air pollutants compared to surface mining. This will improve the respiratory health of the communities living around

coalfield areas. Underground mines also employ 12-18 times more people per tonne of coal produced compared to surface mines. Part of CIL's UG Vision plan document also covers coking coal extraction. Needless to say, this will save critical foreign exchange via reduced import of coking coal for India's growing steel sector. Recently, the Ministry of Coal has also invited bids for commercial mining in 39 mines across five states. Our estimate is that these steps will bring us very close to minimal coal imports this decade. CIL has also placed orders with Indian manufacturers for heavy machinery for these upcoming projects in line with the "Make in India" target. Thus, India's target to produce 125 MT coal from underground mines by 2030 assumes key importance in light of energy security, environmental sustainability and industrial growth.

As an addendum to the discussion surrounding COP28, I would also like to note about the COP28 meeting was a clear focus on interrelated topics of CO_2 capture, utilization and storage (CCUS) along with climate finance. These two topics go hand-in-hand because it is not possible for countries in the Global South to pursue CCUS without international finance. The President of COP28, His Excellency Dr. Sultan Al Jaber mentioned that CCUS would have to play a role in meeting net-zero targets. This is a very holistic and balanced take. In fact, I had the privilege of addressing global climate experts at the recently organized "International Seminar on Sustainable Energy Pathways for India" at Ranchi. I mentioned that CCUS technology has been demonstrated throughout the world and that the developed economies should not shy away from providing the previously committed financial assistance for its scale-up.

I would like to profusely thank Shri P.M. Prasad, Chairman, CIL and Immediate Past President, MGMI, for his valuable insights in this special issue's interview series. I am also thankful to the Honorary Editor, Dr. Ajay Kumar Singh, editorial board members, authors and reviewers for their contributions to this special issue. I am sure that it will generate much-needed discussion and deliberation within the MGMI community in the days to come.

Let me also take this opportunity to congratulate our team of outstanding engineers, scientists and managers for putting together the tenth successful edition of the Asian Mining Congress and Mining Exhibition. The keynote lectures and contributed papers and exhibits showcased in this event, brought contemporary mining issues to the forefront. Special thanks to Shri Manoj Kumar, Chairman, 10th AMC and CMD, CMPDI, Shri Bhola Singh, Chairman, 10th IME and CMD, NCL, and Dr. Amalendu Sinha, Chairman, Technical Committee and Former Director, CSIR-CIMFR.

Dr. B. Veera Reddy
President, MGMI
Director (Technical), Coal India Limited
Chairman-cum-Managing Director, CCL

EDITORIAL INSIGHTS

UNEARTHING THE DEPTHS : A JOURNEY INTO THE WORLD OF UNDERGROUND COAL MINING

Coal plays a crucial role in India's energy sector as it remains the primary source of energy for power generation, contributing significantly to the country's electricity supply. The abundance of coal reserves in India provides a reliable and domestically sourced fuel, reducing dependence on foreign imports and ensuring energy security. Coal-fired power plants offer a cost-effective solution, making electricity more affordable and accessible, especially in a country with a rapidly growing population and increasing energy demand. Despite efforts to diversify the energy mix and promote renewable sources, coal remains indispensable in meeting the baseload requirements and bridging the intermittent nature of renewable energy for at least the next few decades.

The history of coal mining in India dates back to the 18th century, when exploitation began in the Raniganj Coalfield in West Bengal. British colonial rulers were instrumental in the establishment of coal mining operations to fuel their expanding industrial empire. The coal industry played a pivotal role in the economic development of the region, providing a cheap and abundant source of energy for railways, factories, and other industries. While production experienced a marginal increase during the pre-independence period, the British regime and subsequent private producers demonstrated a little awareness of the environmental impacts of mining and resource conservation. Over the years, coal mining expanded to other coalfields such as Jharia, Bokaro, Godavari River Basin, Sohagpur, Sonahat, Pench Kanhan and Talcher etc., turning India into one of the world's leading coal producers. Post-independence, the nationalization of coal mines in the early 1970s led to the formation of Coal India Limited (CIL) in 1975, bringing the majority of coal mining under government control. In recent decades, there has been a push towards reforms in the coal sector, through commercial mining. These changes aim to boost production, attract private investment, and address environmental concerns through the adoption of cleaner technologies.

The coal mining sector in India experienced not just economic changes but also confronted persistent challenges in reconciling energy requirements with sustainable and responsible resource management.

In consideration of the nation's energy demands, there was a requirement to identify an efficient mining approach suitable for producing power-grade coal for the energy sector, superior non-coking coal for industries, and coking coal for steel plants on a large scale. Surface mining emerged as the preferred method to meet the increasing demand for coal. Almost all coal companies adopted surface mining to boost coal production within short time frames, leading to significant and rapid expansion. In the fiscal year 2022-23, out of the total coal production of 893.19 million tonnes, surface mining contributed 858.34 million tonnes, constituting 96.10% of the overall coal production. In contrast, only 34.85 million tonnes were extracted from underground mines, representing a mere 3.90% share. The output per manshift (OMS), a key efficiency metric and performance indicator for economic units, was notably high for surface mines but suboptimal for underground mines. India's coal statistics for the year 2022-23 reveals that the OMS for surface mines was 16.11 tonnes for CIL and 22.08 tonnes for SCCL., while underground mines registered an OMS of 1.05 tonnes for CIL and 1.38 tonnes for SCCL. Consequently, surface mining emerged as the preferred choice for enhancing both production and productivity.

In the context of coal production, the rapid depletion of shallow deposits, coupled with challenges such as surface land acquisition issues, land degradation, and environmental concerns such as air and water pollution associated with surface mining, necessitates a substantial increase in coal production and productivity from underground mines in India. It is crucial to recognize that the environmental impact of surface mining, including land degradation and air and water pollution, presents formidable challenges. India is confronted with the ongoing task of harmonizing the demand for energy security with the imperative to transition towards cleaner and more sustainable alternatives, underscoring the significance of responsible and strategic energy policies to navigate the intricate dynamics of the nation's energy sector. While underground mining holds promise in addressing these concerns, the considerably lower Output per Manshift (OMS) compared to surface mining highlights that the equipment productivity norms adopted in India are suboptimal. Technology emerges as a critical and enduring factor influencing mine productivity, with technical advancements being a key driver behind productivity growth in surface mining. To enhance the efficiency of underground mining, there is a need to leverage technological progress and implement innovative mining techniques tailored to the specific geo-mining conditions of the country.Beyond mining technologies, the Coal Industry should welcome contemporary advancements and integrate emerging trends like Artificial Intelligence (AI) and Machine Learning (ML) to redefine the landscape of underground mining, ensuring enhanced business operations in the age of digital transformation.

Globally, China's coal production amounts to 4.2 BT, with the predominant share exceeding 90% from underground mines. Nearly half of the total coal production in the world is extracted from underground mining operations. Notably, Europe has ceased surface mining practices and predominantly relies on underground methods for coal production. Underground coal mining in India stands as a pivotal force in shaping the nation's energy landscape while concurrently addressing critical environmental concerns. It is crucial to reverse the declining trend in underground coal production over the next decades to ensure energy security, protection of ecosystems, promote environmental sustainability, and minimize disruptions to forest lands and surface features. Given the current technological capabilities, underground coal mining is feasible for deeper coal deposits, leaving India with no alternative but to transition toward underground mining. The Government of India has set a production target of 125MT coal from underground mining by the fiscal year 2030. In alignment with this

goal, Coal India Limited aims to achieve 100MT by 2027-28.

Policy interventions are needed to address the pricing mechanism for coal extracted through environment-friendly underground mining. This method offers the added advantage of assured quality, emphasizing the need to streamline surface rights acquisition and promote mass production technologies. It is imperative to incorporate methane drainage from gassy coal seams concurrently with coal extraction to enhance operational safety, promote commercial utilization of this clean energy resource, and align with decarbonization targets.

In the recent past, the Hon'ble Minister of Coal, Government of India spoke at a conference focused on Underground Coal Mining – Way Forward for Sustainable Energy Security. During the event, the minister unveiled Coal India's UG Vision Plan, which outlines a strategic roadmap to achieve a production milestone of 100 million tonnes from CIL's underground mines by the fiscal year 2028. This visionary plan underscores CIL's dedication to sustainable development, technological progress, safety, and environmental stewardship. CIL's UG Vision Plan also indicates that some of this coal will be coking-grade, meaning it could help reduce import dependence for the growing steel sector.

In this issue of MGMI News Journal, we feature a special interview with Shri P M Prasad, Chairman, Coal India Limited and Past President, MGMI. The interview delves into the technological advancements and innovations that Coal India Limited is actively pursuing to enhance the sustainability and environmental friendliness of underground coal mining, to align with the Government's net-zero target. We bring forth three technical articles delving into the historical aspects, sustainability, challenges, and opportunities related to underground coal mining in the Indian context. The contributors of these articles are internationally renowned mining engineers from the academia and the industry. Besides these articles, CMPDI has contributed two insightful articles that explore key facets of sustainable coal mining and evaluation of the environmental effects of sand extraction shedding light on crucial aspects of these subjects. These contributions not only showcase CMPDI's commitment to advancing knowledge within the mining industry but also underscore the importance of responsible mining practices and the imperative need for comprehensive evaluations of the environmental repercussions associated with activities such as sand extraction.

I would like to express my heartfelt gratitude to all the contributors, with special appreciation for our esteemed Immediate Past President, Shri P. M. Prasad, Chairman of Coal India Limited, for participating in an interview. I am also grateful to President of MGMI, Dr. B Veera Reddy, for suggesting the theme and commissioning special features for this issue. Their constant inspiration has been a driving force behind our efforts to enhance the standards of our publications. The invaluable contributions from authors have empowered us to present this issue, introducing new strategies for the benefit of our readers. I extend sincere thanks to the reviewers and members of the Editorial Board for their persistent support. A special note of gratitude goes to several esteemed individuals who played pivotal roles in the success of the National Seminar on "Green Mining and Net-Zero" and the MGMI biennial event, the 10th Asian Mining Congress and Exhibition, and for their valuable contributions to this edition.

In closing, on behalf of the Editorial Board and on my own behalf, I convey heartfelt wishes for a joyous New Year in 2024 to our cherished readers and the esteemed MGMI family.

Ajay K. Singh
Honorary Editor, MGMI

MINUTES OF THE 899th MEETING OF THE COUNCIL

(Held through Hybrid mode in Physical and Virtual Platform through Zoom)

Date & Time : Saturday, 29th July 2023 at 3:00 P.M.

The report of the **899th Council Meeting** (5th meeting of the 117th Session) at **MGMI Building,** GN-38/4, Sector-V, Salt Lake, Kolkata- 700 091 on **Saturday, 29th July 2023 at 3:00 P.M.** (duly approved in the 900th Council Meeting held on 2nd September 2023).

Present : Dr B Veera Reddy, President in the Chair on Virtual. The meeting was attended by Prof. S P Banerjee, Prof B B Dhar, Dr N K Nanda, S/Shri N C Jha, R P Ritolia, R K Saha, J P Goenka, Rajiw Lochan, Prasanta Roy, Dr Singh Chandra Shekhar, Dr. Mandal Prabhat Kumar, V K Arora, Prof. Bhabesh Chandra Sarkar, Awadh Kishore Pandey, Dr Peeyush Kumar, T K Nag , Dr Amalendu Sinha, Prof. (Dr) G P Karmakar, N N Gautam, Prof. N C Dey, Dr J P Barnwal, Prof Ashis Bhattacherjee, Anup Biswas, P S Upadhyay, G.S. Khuntia, I P Wadhwa, D B Sundara Ramam and Ranajit Talapatra.

ITEM No. 0 Opening of the Meeting

Honorary Secretary welcomed all members present physically as well as virtually and requested the President to call the 'meeting to order' and address the council members.

The President welcomed all those present physically and virtually in the meeting.

Regretting not being able to attend in person as he had to be in Ranchi on the day as CMD, CCL, President stressed on membership drive and increase in the activities to utilize MGMI for a bigger cause in national level. President briefed that in a seminar in Delhi held on 28th July, there were suggestions that Mining and associated Organisations may think of organising events in the newly opened Bharat Mandapam Conference Venue in Delhi. He suggested organisation of a conference in Delhi sometime next year. Thereafter, he requested Honorary Secretary to conduct the meeting.

Honorary Secretary took the permission of the President to break the sequence of Agenda items to let Mr Wadhwa of Tafcon present the progress of 10th IME to the Council.

Shri I P Wadhwa expressed his gratefulness for getting support from MGMI and updated that in the last two months the response was picking up and expected to get more exhibitors. He asked for help to hasten up the process to attract major players in the forthcoming meet like SAIL, ONGC, NTPC, etc.

He repeated his suggestion from last Council meeting to hold a press conference in Delhi with invitees from different Embassies and Resident Commissioners in India and suggested last week of August 2023. He said that work had already started on Buyer - Seller meet and that the process had already accelerated for getting publicity in the print and web media.

899.1.0. To confirm the Minutes of the 898th meeting of the Council held in Hybrid platform at MGMI Hqs, Kolkata on 27th May 2023.

The 898th Council Minutes were circulated to all the Council Members. As no comment was received, the Council resolved that:

Resolution : The Minutes of the 898th (4th meeting of the 117th Session) Meeting of the Council held on 27th May, 2023 at 2:30 PM on Hybrid platform, be confirmed.

899.1.1. To consider matters arising out of the Minutes.

Honorary Secretary read out the ATR (Action Taken Report) in respect of the Minutes of 898th Council meeting.

The Council considered the Action Taken Report in respect of the Minutes of 898th Council Meeting held on 27th May, 2023 in Hybrid platform and it was accepted.

899.2.0. To discuss about the 10th Asian Mining Congress and Exhibition.

Honorary Secretary requested the Convenor of 10th IME, to inform about the progress on 10th IME. He briefed that already 400 companies have responded and were expected to participate and he expected more to participate compared to last year.

Convenor of 10th AMC was requested to apprise the Council about the forthcoming 10th AMC. He highlighted that letters were already sent to different PSUs, large Organizations, Embassies and High Commissioners in India and till date two Organizing Committee meetings and four Technical Committee meetings have been held. He informed that for the first time, Technical Committee is trying to publish the selected papers through the renowned Springer Publications for worldwide reach and prestige. This will result in 10th AMC getting quality papers.

It was advertised that last date for submission of papers publishing in the Springer Published Proceedings Volume was 31st July. Others will have their papers published in the normal Proceedings volume. He said that negotiations were on with Springer about the Terms & Conditions.

He also highlighted that request letters have already been sent to Hon'ble Minister of Coal & Mines, Govt of India, to be the Chief Guest and to the Secretary Coal and Secretary Mines as Guests of Honour for the Inaugural Session. The Chief Guest for the Valedictory session also needs to be finalised quickly as there is only 3 months in between.

Chairman, Technical Committee apprised that so far 78 abstract papers and 12 Full papers have been received.

It was informed that CMD, NCL & CMD, CMPDI joined the meeting through Virtual link, asboth were travelling and could not attend physically. The President suggested that CMD, NCL and CMD, CMPDI must be requested to be present during next Council Meeting as Chairman, Exhibition and Conference respectively.

899.3.0. Mode of Election for MGMI Council Member for Session 2023-26 and onwards.

Regarding election of Metallurgy seat which had fallen vacant, it was mentioned by Honorary Secretary that during the first meeting of Scrutineers' Committee it was decided to make Sri V K Arora the Chairman of the Committee. He also requested the Council for permission to go for election in electronic mode as per Memorandum & Articles of Association Clause 38 (a) if there is more than one nomination. Past Honorary Secretary, Sri Prasanta Roy, who is also a member of the Scrutineers' Committee mentioned, that as AoA does not have a detailed provision of processes for E-voting, the total process has to be formulated in line with extant Company Law regarding E-voting procedure and the formulation has to passed by the Council before placing it in AGM for final acceptance to incorporate it in the updated AoA.

Immediate Past Honorary Secretary, Shri Rajiw Lochan briefed that during Covid, GOI has modified provisions of Company Act to allow elections in electronic mode. The council agreed to the proposal for e-voting and advised Honorary Secretary to do the necessary homework to update the AoA after getting due ratifications.

899.4.0. Discuss progress of Half day Seminar, to be held on 23.09.2023.

Shri R K Saha, Chairman, Half day Seminar requested Shri Rajiw Lochan, Convenor to apprise the Council about the progress. Shri Rajiw Lochan briefed that 4 speakers have been invited and the topic is Clean Hydrogen and Net Zero Emission. He informed that the venue for the Half Day Seminar and the AGM to be held subsequently is Crystal Banquet, Taj City Centre, New town.

He also proposed the name of Chairman, CIL and Immediate Past President, MGMI, Shri P M Prasad as the Chief Guest. President, MGMI requested to have two three speakers on environmental friendly coal mining.

899.5.0. To recommend resolution as per template required for assigning M/s Razorpayor CCA venueas the Payment Gateway for online payment in MGMI Transactions including online membership fees.

Honorary Secretary briefed the members of the Council that for finalizing online payment gateway, a duly signed resolution by the Board for taking up an Online Payment Gateway Service was a requirement. Considering the recent issues with Razorpay that came out in the media, only the template for the resolution provided by CCAvenue was read out. He requested the Council to agree to the mode of payment using the above Payment Gateway. The Council unanimously

RESOLVED THAT the consent of the Board be and is hereby accorded to enter into an agreement with Infibeam Avenues Limited, Mumbai for availing of payment gateway serviceson terms and conditions as specified in the Sub merchant agreement.

"FURTHER RESOLVED THAT Sri Ranajit Talapatra, Honorary Secretary or Dr Chandra Shekhar Singh, Honorary Joint Secretary (as Director/s) of MGMI be and hereby severally authorized to sign and execute on behalf of the Company, all agreements, undertakings and any other documents that may be necessary for availing the said services from Infibeam Avenues Limited and to do all such acts that may be necessary toimplement the foregoing resolution."

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

It was informed that between the last council meeting and this council meeting, the institute has received 58 membership applications including one who wanted to upgrade from Associate Member to Life Member. The Council queried about the eligibility of these 58 candidates and on being satisfied agreed to the membership of all 58 members.

Membership Position
(As on 29.07.2023)

	27.05.2023	Add	Trans	Loss	29.07.2023
Member	43	-	-	1	42
Life Member	2051	57	1	-	2109
Associate	18	-	-	-	18
Student Associate	06	-	-	-	06
Life Subscriber	27	-	-	-	27
Subscriber	01	-	-	-	01
Life Donor	01	-	-	-	01
Donor	01	-	-	-	01
Patron	05	-	-	-	05
Corporate	07	-	-	-	07
Life Corporate	02	-	-	-	02
	2162	57	1	1	2219

899.7.0. Any other matter with the permission of the chair.

Sri J P Goenka raised the matter of Golf tournament & MGMI President apprised that the tournament will be held in MCL Golf Ground at Sambalpur by end November.

The meeting ended with thanks to the Chair and others present both physically and virtually by Honorary Secretary.

MINUTES OF THE 900th MEETING OF THE COUNCIL

(Held through Hybrid mode in Physical and Virtual Platform through Zoom)

Date & Time : Saturday, 02nd September, 2023 at 2:30 P.M.

The report of the **900th Council Meeting** (6th meeting of the 117th Session) at MGMI Building, GN-38/4, Sector-V, Salt Lake, Kolkata- 700 091 on **Saturday, 2nd September, 2023 at 2:30** P.M. (duly approved in the 901st Council Meeting held on 3rd December 2023).

Present : Dr B Veera Reddy, President in the Chair on Virtual. The meeting was attended by Prof. S P Banerjee, Prof B B Dhar, S/Shri N C Jha, R P Ritolia, R K Saha, J P Goenka, Rajiw Lochan, Prasanta Roy, Dr Chandra Shekhar Singh, Dr Prabhat Kumar Mandal, Dr Ajay Kr Singh, V K Arora, Prof. Bhabesh Chandra Sarkar, Awadh Kishore Pandey, Dr. Peeyush Kumar, T K Nag, J.V. Dattatreyulu, Prof. (Dr) G P Karmakar, N N Gautam, Dr Kalyan Sen, Prof. N C Dey, Dr J P Barnwal, Thomas Cherian , Manoj Kumar, P S Upadhyay, I P Wadhwa, D B Sundara Ramamand Ranajit Talapatra.

ITEM No. 0. Opening of the Meeting

0.1. Sri Ranajit Talapatra, Honorary Secretary welcomed all members present physically as well as virtually and requested the President to call the 'meeting to order' and address the council members.

0.2. The President welcomed all those present physically and virtually in the meeting.

The President aired his views and laid stress on how MGMI can play a role in policy making at National Level and make it spresence felt at Government level.

Honorary Secretary took the permission of the President to break the sequence of Agenda items to allow Sri I P Wadhwa, invitee, present the progress of 10th IME.

Dr C S Singh, Honorary Joint Secretary and Convenor, 10th IME, highlighted that more than 250 companies were to participate in the exhibition and the progress is satisfactory. He requested Sri Wadhwa to update the Council about the progress.

Sri Wadhwa said that more than 20 countries are participating, Germany being the largest participant and Australia committing a good number of delegates. Request letters have been sent to the State Governments of Jharkhand and Odisha to participate and sent to MSME Sectors. He also said that letters have been sent to mining companies and he expects to get more complete response by next month. Further, request letters have also been sent to 4 PSUs – Singareni Collieries, Neyveli Lignite, MECL & Hindustan Copper. As there was no more query regarding IME, Sri Wadhwa excused himself from the meeting with permission of the Chair.

Honorary Secretary thanked Sri Wadhwa and he proceeded to go ahead with the meeting in original sequence of Agenda .

900.1.0. To confirm the Minutes of the 899th meeting of the Council held in Hybrid platform at MGMI Hqs, Kolkata on 29th July, 2023.

The 899th Council Minutes were circulated to all the Council Members & the Council resolved that:

Resolution : The Minutes of the 899th (5th meeting of the 117th Session) meeting of the Council held on 29th July, 2023 at 3 PM be confirmed.

900.1.1. To consider matters arising out of the Minutes.

Honorary Secretary read out the ATR (Action Taken Report) in respect of the Minutes of 899th Council meeting.

The Council considered the Action Taken Report in respect of the Minutes of 899th Council Meeting held on 29th July, 2023 held in Hybrid platform and concurred.

900.2.0. To discuss about the 10th Asian Mining Congress and Exhibition.

Honorary Secretary requested Chairman Conference, Shri Manoj Kumar to kindly air his views. Shri Manoj Kumar talked about the progress of the conference and mentioned that letters of invitation have been sent to various Embassies of different countries and Iran has expressed interest. Letters were also sent to PSUs, organizations, private companies followed by reminders. He laid stress on sponsorship. He also shared that sponsorship have been received from NLC, Tata Steel & CMPDI till date. It was informed that till date 39 papers and 8 keynote addresses have been received and been sent to Springer following their guidelines. Papers not yet received or not fulfilling the Springer criteria will be published in the second volume of the proceedings. He thanked the Technical Committee under the chairmanship of Dr Amalendu Sinha. He also said that the Hon'ble Minister of Coal has verbally agreed to be the Chief Guest at the inaugural session on 6th November. Secretary Coal has also agreed to be the Guest of Honour and Request letter have also been sent to Secretary, Mines for being the Chief Guest in the Valedictory Session. He said that Mines Minister from Australia may be attending the Inaugural Session on 6th November as Guest of Honour.

Convenor, Conference, Shri Prasanta Roy, aired his views that the Technical Committee is taking care of Proceedings Volume and for Sponsorship, matter is being taken up with different companies. He informed the Council that a Technical Assistant has been appointed on contract basis for Asian Mining Congress. Regarding Iran, he said that MGMI office is in touch with the Iranian counterparts and correspondence has been going on. He also opined that apart from sponsorship, delegates are a major issue in the forthcoming AMC and also shared that invitations to eminent dignitaries have been sent.

900.3.0. To select the President of the Institute for session 2023-24

The council members unanimously selected Dr V B Reddy as the President of MGMI for session 2023-24.

900.3.1. To announce the Decision of the Scrutineers' Committee for Election of one vacant Metallurgist Seat in MGMI Council for the term 2023-26

In the absence of the Chairman, Scrutineers' Committee, Sri V K Arora, Honorary Secretary requested Sri J P Goenka to read out the name of the candidate who has been selected in the seat of Metallurgy to the Council and the name of Prof. (Dr) Rajib Dey, who was elected unanimously considering that his was the only nomination received was shared with the council members. It was informed that Prof Dey will be inducted into the next Council (2023-26) and his name will be announced and confirmed in the forthcoming AGM.

900.4.0. To select the Secretary of the Institute for session 2023-25

The council members unanimously selected Shri Ranajit Talapatra to continue as the Honorary Secretary of MGMI for session 2023-25.

900.5.0. To consider and approve the Audited Accounts for financial year ended on 31st March 2023

Honorary Treasurer placed before the council members the audited income and expenditure statement and balance sheet for the year 2022-23 and it was approved by the members of the council.

900.6.0. To appoint the Institute's Auditor for the Financial year with their remuneration.

Honorary Secretary highlighted that the remuneration of the auditor M/s Jha & Associates to remain the same at Rs.15,000/- per year.

900.7.0. To consider and approve the recommendations of the Judging Committees for MGMI award of Excellence for the year 2022-23

Honorary Secretary briefed the council that for this year three awards were formed – Award for excellence in Coal mining, Award for excellence in non-coal mining and Award for excellence in Earth Science. As no nomination on non-coal mining was received the Judging Committee have nominated persons on other two awards.

In the Award of Excellence in Coal Mining- 6 nominations were received and the committee has jointly awarded two persons – Prof. Khanindra Pathak and Prof. Prem Sagar Mishra and for the Award of Excellence in Earth Science - 5 nominations were received and the committee has proposed the name of Prof. Mrinal Kanti Mukherjee, geologist to receive the award for this category. These three people will be awarded on the AGM date i.e. 23rd Sept, 2023. The Council approved the aforesaid nominations.

Sri Prasanta Roy shared his opinion that since nomination has not been received in non-coal mining, there should be awards in 3 categories – Mining, Geology & Metallurgy considering the name of MGMI. It was suggested that the earlier Committee who decided on amalgamating all previous awards into these awards, will re-convene and come out with a solution taking into account last 2 years' experience and the suggestions of Sri Roy.

President expressed his desire to re-open the Award in the category of Non-Coal mining. The Council decided to re-open nomination with 15th of September 2023 as the last date.

900.8.0. To consider applications for member ship and the membership position of the Institute.

Honorary Secretary briefed the council that MGMI has received 20 applications for life memberships, wherein, barring one candidate, 19 others are found in order. This candidate has a B.Sc degree followed by Management and M. Phil qualifications not related to earth Sciences. The council decided to allow him as Associate if he still desired so, but not as Life Member. For others the council approved for life membership.

Membership Position
(As on 02.09.2023)

	29.07.2023	Add	Trans	Loss	02.09.2023
Member	42	-	-	-	42
Life Member	2109	19	-	-	2128
Associate	18	01			19
Student Associate	06	-	-	-	06
Life Subscriber	27	-	-	-	27
Subscriber	01	-	-	-	01
Life Donor	01	-	-	-	01
Donor	01	-	-	-	01
Patron	05	-	-	-	05
Corporate	07	-	-	-	07
Life Corporate	02	-	-	-	02
	2219	**20**			**2239**

900.9.0. Any other matter with the permission of the chair.

Honorary Secretary briefed the council on following points :

a) Quotations on Repair of roof shed of MGMI building have been received. The Council requested the Secretary to go ahead with a suitable agency to complete the work and make the necessary expenditure within reasonable limit.

b) Honorary Secretary shared the information that a separate website of AMC has been opened www.asianminingcongress.in.

The meeting ended with Vote of Thanks to the Chair and others present both physically- and virtually by the President and Honorary Secretary

NEW MEMBERS

As Life Member

(As approved in Council Meeting on 29.07.2023)

11014 -LM, Shri Pradeep Kumar Singh, Diploma (Mining), Sr. Manager (Mining), Aurobindo Realty & Infra Structure Pvt. Ltd, Durami, Post-Rampur Karkhana, Dist – Deoria Sader, Uttar Pradesh – 274405, (M) 8839062828,
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11015 -LM, Shri Madasu Akhil Rao, Mining Engineering (Mining), Asstt. Manager, Aurobindo Realty & Infra Structure Pvt. Ltd,18-4-92/2, Sagara Veedhi, Godavarikhani, Dist – Karimnagar, Telengana - 505209, (M) 9966836113 (O) /6265808119 (R), Email : madasuakhilrao@gmail.com

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11018 - LM Shri Arvind Kumar Bokhad, BE (Mining), Chief Manager, Western Coalfields Ltd, Coal India Ltd, Type-V/4, WCL Colony, Pathakhera, Dist - Betul, Madhya Pradesh – 460449, (M) 8959552397, Email : ak.bokhad@coalindia.in, bokhad_arvind@yahoo.com

11019 –LM, Shri Surya Prasad RaoVenkata Jayanti, Diploma (Mining Engg), General Manager (Mining), WCL,Coal India Ltd., O/o Sub Area Manager, Chhatarpur Sub Area, P.O. Pathakhera, Dist – Betul, Madhya Pradesh – 460447, (M) 6263751090 (O)/9340876611 (R),
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(As approved in Council Meeting on 2.9.2023)

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NATIONAL SEMINAR ON GREEN MINING AND NET-ZERO (GMANZ 2023)

The Mining, Geological & Metallurgical Institute of India (MGMI) organised a **National Seminar on Green Mining and Net-Zero** (GMANZ 2023) on 23rd September 2023. It was held at The Taj City Centre, New Town, Kolkata. The event was arranged in three sessions – inaugural and two technical sessions.

Inaugural Session

It commenced with the compere welcoming the guests, delegates and participants with a brief introduction of MGMI and inviting **Shri PM Prasad,** Chairman, Coal India Limited (CIL) and Chief Guest of the event, Prof **R B Grover,** Padma Shri, Member, Atomic Energy Commission and Founding Vice Chancellor, HBNI and Keynote Speaker of the seminar, **Dr B Veera Reddy,** CMD, CCL and President, MGMI, **Shri R K Saha,** Chairman, GMANZ2023, **Shri Rajiw Lochan,** Convenor GMANZ2023, **Shri Ranajit Talapatra,** Honorary Secretary, MGMI, on the dais. The dignitaries were felicitated with flower bouquets followed by lighting of the ceremonial lamp.

Shri Rajiw Lochan delivered the welcome address, specially welcoming the guests, speakers and delegates.

Shri R K Saha introduced the theme of the seminar mentioning the two subjects. He told that the basic concept is deliberations on pollution-free mining and hydrogen as a clean source of energy. He spoke about coal productions in the country, CO_2 emission, renewable energy, suggesting efforts are being made by companies to restrict and reduce pollution. Shri Saha remarked that according to calculations by authorities, if coal-based power generation is completely stopped, then the loss to the country would be around $900 billion. He looked forward to excellent deliberations from the speakers and interactions from the participants.

Dr B Veera Reddy spoke about the activities and membership drive of MGMI, mentioning it should expand its activities and may be in a position to provide suggestions to the Government in formulation of policies like net zero. He pointed out that CO_2 emission during coal production is hardly 1%, the main emission being in burning of coal. We have good reserves to continue with coal for energy, but in an environment friendly way. Coal India is planning to increase underground mining. He suggested all power plants should capture carbon so as to reduce its emission. Dr Reddy also thought search and exploration of critical minerals in our country should get importance. He hoped useful suggestions would come up through the deliberations of this seminar, which may be forwarded to the Government of India.

Dr Ajay Kumar Singh, Editor, MGMI introduced the keynote speaker, Padma Shri Prof R B Grover, the foremost nuclear scientist of the country, who has unparallel distinction of blending science, technology and diplomacy. He spoke of Prof Grover's role in founding Homi Bhaba National Institute as Founder Member, mentioning his contribution in nuclear diplomacy and resumption of civil nuclear cooperation including Indo-American nuclear deal.

Prof R B Grover thanked MGMI for the invitation and mentioned that he is from a discipline other than mining and geology, but that is the necessity today for all disciplines to come together for development of the country. We are talking of moving to a net zero economy, not only to net zero energy. While pondering over the history of development of technology, he pointed out that it takes time for a new technology to emerge. There is an element of science and an element of craft in it. A technology to be accepted in the society several aspects should come together – economy, public accep-

tance and its interaction with the earlier technology. Similarly for development of economy-wide net zero a total new architecture for the industry, for the society, for the economy has to evolve and it will not happen overnight. We have five decades to achieve it and for this all, R & D professionals, industry professionals, economists, and society, have to come together.

Shri P M Prasad in his speech highlighted the environmental measures that CIL is taking, like, plantation, top soil management, slope management, dump management. He talked of the enhanced energy needs of our country and to fulfil that coal will continue to play an important part. Coal India is also going for coal gasification, production of renewable energy like solar. He advised that in each mining practice, carbon emission needs to be cut down. He thanked the organisers for arranging the seminar on a contemporary and very useful topics.

Shri Ranajit Talapatra proposed Vote of Thanks. He specially thanked Shri Prasad, Prof Grover and Dr Reddy for coming in spite of busy schedule. He acknowledged all who helped in organising this event.

Shri P M Prasad, Prof R B Grover and Dr B V Reddy were felicitated with mementoes.

Technical Session I

Chairman – Dr B Veera Reddy

Dr Reddy presented brief introductions of the session's speakers. He briefed the green initiatives by CIL. He then invited the speakers. The speakers and topics presented in this session are as follows.

Prof. Ram Madhab Bhattacharya, Professor and Dean, International Relations and Alumni Affairs, IIT (ISM) Dhanbad -- ***Challenges in Sustainable Underground Coal Mining Technology and Solutions.***

Professor discussed global warming and climate change, its causes, concerns about effect of greenhouse gasses on global climate, recent announcement on Carbon Border Adjustment Mechanism (CBAM) and Impact on coal mining. He feels replacement of coal by renewables as energy sources is not simple in our country. Even coal mining can be done in sustainable and environment friendly manner. Prof Bhattacharya discussed sustainability issues in coal mining and challenges before coal industry. While reviewing scenario of coal production technologies in India, he strongly advocated for underground mining suggesting mass production methods with all out mechanisation. There needs to be a thrust on underground mining in mission mode. He highlighted the importance of stowing (in habitat areas), methane drainage, especially in gassy mines, and data analysis.

Shri N C Jha, Former Chairman, Coal India Limited and Past President, MGMI -- ***India's 2070 Net-Zero Pledge and its impact on future of Indian Coal Industry.***

Shri Jha summarised Net Zero as removing as much carbon from atmosphere as much we put in. Since it cannot be done instantly, Government of India has taken pledge to do it in 50 years, by 2070. The concept was promoted by Intergovernmental Panel on Climate Change (IPCC). The idea is to keep global warming to within 1.5^{O}C more than that of pre-industrial level. Nearly 90 countries, representing 80% of global emissions, have joined the programme of reducing carbon footprint in the atmosphere. Technologies needed for achieving net zero is available and they are gradually becoming cost effective. He discussed CO_2 emission by fuel type in India pointing out that there is a tremendous increase in last 30 years. India contributes highest amount of carbon (275 gms) in generating one unit of power mainly due to its low quality coal. At COP 26 India's commitment is to reduce total projected carbon emissions by 1 billion tonne by 2030. It would mean reduction of fossil fuel usage by 590 million tonnes of coal equivalent from the projected level of 2030. For renewable energy proper storage systems need to be developed, though that is expensive at present.

Shri Anil Kr Rana, Advisor (Mining) and Former Director (T/P&D), CMPDI -- ***Green Roadmap for Future Coal Mining and Mine Closure.***

Shri Rana mentioned Greenhouse Gas (GHG) emission during coal mining is negligible in com-

parison to burning of coal (in energy production). He feels fossil fuels including coal are in their last leg and will be phased out.There is urgent need for energy production to be replaced by carbon-neutral fuels, green hydrogen is not so distant alternative, and, nuclear fusion may be ultimate energy source. He discussed green roadmap for coal mining suggesting use of high-angle conveyors, batteryoperated trucks / shovels, hydrogen powered trucks / shovels, ethanol powered trucks / shovels, hydrogen enriched diesel trucks / shovels. A case study for converting an exhausted OC mine into a green power house by generating energy by wind solar combined system and gravity storage in old shafts was presented.

In conclusion, **Dr Reddy** summarised the presentations. The speakers were felicitated with mementoes.

Technical Session II

Chairman -- **Prof R B Grover,** Padma Shri, Member, Atomic Energy Commission and Founding Vice Chancellor, HBNI

Co-chairman **– Prof S P Banerjee,** Former Director, ISM Dhanbad & Past President, MGMI

Prof. R B Grover -- Keynote address **– *Production of low - carbon hydrogen using nuclear energy***

Prof Grover touched on the threats on current levels of energy use, which are ecological crisis, resource scarcity, geopolitical instabilities, pointing out that, despite threats, immense improvements in energy efficiency has occurred since industrial revolution. Now comes the call for decarbonising the economy. He apprised Government of India's commitments – reducing the emissions intensity of its GDP by 45% by 2030 (from 2005 level), and achieving 50% cumulative electric power installed capacity from non-fossil fuel-based energy by 2030, which is a step towards achieving net zero (economy-wide) by 2070. He then discussed what a net zero economy looks like. Prof feels fully eliminating carbon emissions from energy services is a challenge and fossil fuels cannot be fully eliminated; residual emission will have to be handled by carbon capture, use and sequestration. He presented an estimate of minimum energy requirement for transitioning to a net-zero, developed India, suggesting that in 2070, 60% of energy will be used for producing electricity and 40% for others like, electrolysis for generation of hydrogen, manufacturing of solar cells, maintaining large data centres etc. His suggestions are – India should develop low carbon technologies based on a technology-agnostic framework, pay attention to systems integration. At the end Professor discussed nuclear technologies and uranium availability.

Dr Pradip Kr Banerjee, Outstanding Scientist, CSIR-CIMFR -- ***Hydrogen and Methanol Production from Coal.***

Dr Banerjee spoke on cleaner products from coal, methanol and hydrogen, explaining why from coal. CIMFR had coal to syngas technology, but there was difficulty with Indian coals because of high ash. Work since 2009 has resulted in development of Pressurized Fluidized Bed Gasification (PFBG) technology, further up-scaled to Oxy-blown PFBG pilot plant for producing syngas to methanol / hydrogen from high-ash coal. He discussed the results from the pilot plant, syngas cleaning and hydrogen enrichment, syngas to methanol. Then he talked on methanol economy – initiatives in India, CO_2 footprint for coal to hydrogen production.

Dr Arnab Dutta, Associate Professor, Department of Chemistry, IIT Bombay -- ***Renewable Energy Driven Hydrogen Production from water.***

Dr Dutta started by talking about ways to mitigate CO_2 emission and storing natural energies in chemical bonds. Hydrogen is not new and is being used for multiple resources since long in Indian market. We are using hydrogen for refineries, ammonia production for food security. He discussed the colour spectrum of hydrogen, grey, blue, green and their sources, mentioning that for net zero green variety that comes from electrolysis of water is important. Dr Dutta explained the principle of hydrolysis, laboratory-scale pilot plant and the indigenous electrolyser prototype developed to generate green hydrogen at a low cost from industrial grey water and also from sea water. He discussed green H_2 Carbon Capture Utilization and Storage (CCUS) technology and mentioned that IIT Bombay has initiated a clean tech start-up for industrial solutions.

Shri Ranjan Kr Sinha, Chief Procurement Officer and Chief Group Shipping, Tata Steel -- ***Maritime Sustainability towards Net-Zero Emission.***

Shri Sinha explained scope 1, scope 2 and scope 3 emissions, green mining as operations that generate less and less of GHG and it generates hardly 10% of the total emission. He discussed the target set by IMO, mentioning alternate fuels, biofuel, ammonia, methanol, hydrogen are the key to decarbonize. He talked of green corridor, which is a framework where people collaborate with the policy makers to provide a level playing field and infrastructure to have a zero-emission trial, and Harit Sagar initiative by Government of India. Finally **Shri Sinha** presented the strategy and road map Tata Steel has planned for 2030 to 2045.

The papers were thrown open for interactions. Dr Ajay Moitra enquired on solutions to probable problems in conversion of fossil fuel to other energy, and, Hydrogen storage safety. Prof Grover replied that nothing concrete has been established so far. Dr Dutta suggested hydrogen may be used in form of ammonia and methanol, where risk is much less. Research is on but not at a commercial level yet. Shri Sudip Bhattacharya from GSI suggested other uses of coal, besides thermal power, like coal to oil and extraction of critical minerals from coal. Dr Banerjee told coal to oil project is in pilot plant stage at CIMFR, current scenario being not economical.

Prof Banerjee and Prof Grover concluded the session with a short sum-up and a few comments.

The seminar was followed by 117th Annual General Meeting.


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THE NATIONAL SEMINAR ON GREEN MINING & NET ZERO
(GMANZ 2023)
23rd SEPTEMBER 2023
CRYSTAL, TAJ CITY CENTRE, NEW TOWN, RAJARHAT


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HIGHLIGHTS OF 117th ANNUAL GENERAL MEETING

The 117th Annual General Meeting of MGMI was held on 23rd September 2023 at 4.00P.M. at Crystal Banquet of Taj City Centre, New Town, Kolkata. The meeting was chaired by Dr B Veera Reddy, President, MGMI. The office bearers and members, who joined the meeting are Dr B Veera Reddy, S/Shri N K Jha, Prof S P Banerjee, R K Saha, R P Ritolia, T K Nag, Prasanta Roy, Dr P K Mandol, Dr Chandra Sekhar Singh, R N Biswas, Smarajit Chakrabarti, P R Mandal, G C Mukhopadhyay, Dr Subir Majumder, J K Das, Subrata Ghosh, Rajiw Lochan, Bhaskar Chakraborti, Anil Karmakar, Asit BaranBhol, S K Ray, Ranjit Datta, Biswajit Basak, Debdulal Sarkar, Sanjoy Mukhopadhyay, Dr S M Kolay, S Chakravarty, Dr Kalyan Sen, Ajit Singh Choudhary, P K Mukhopadhyay, Amitava Das, D K Mitra, Sudipta Saha, Subrata Biswas, M K Bhattacharya, K K Mishra, J K Hota, Dr Hemant Agarwal, T K Mishra, G G Nair, Anjani Kumar, Anup Biswas, R M Bhattacharyee, Khanindra Pathak, Praveen Sharma, Dr Lingampally Sai Vinay, Dr Santanu Kr Banerjee, Kamal Ghosh, Madhav Singhal, Pankaj Kumar, Sanjay Kumar, Bijetry Kar and Ranajit Talapatra.

Shri Ranajit Talapatra, Honorary Secretary, MGMI welcomed the members present and requested Dr V R Reddy, Dr P K Mandol, Hony Treasurer, Chandra Sekhar Singh, Hony Joint Secretary and Dr A K Singh, Hony Editor to come on dais. Then he read out the names of the members who left for their heavenly abode during the last one year and one minute silence was observed for the departed souls.

Late R H Sawkar, T V S Rao, Dr Shyamal Chakraborty, K P Kapai, Mahendra Pratap Singh, Dr Kamal Nandi, Lab Kr. Bose, Tapodhir Bhattacharjee, Sujoy Kr Gupta, Aparaesh Chandra Bagchi, M N Mehta, Dr R R P Verma, Asit Kumar Ghosal, Ardhendu Sekhar Banerjee.

Next the Secretary proceeded with the agenda of the meeting as follows.

1. He read the Notice convening the 117th Annual General Meeting, which he said was already circulated by email earlier and in hard copy there in the hall.
2. The minutes of the 116th AGM held in Kolkata on 25th September 2022 was passed by voice vote.
3. The Council's report, Audited balance sheet and Statement of accounts for the year ending on 31st March 2023, circulated by email earlier and in hard copy there in the hall, were adopted by voice vote.
4. Dr P K Mandol read out a short account of the income and expenditure incurred by MGMI during the last year.
5. M/s Jha & Co was reappointed the Institute's Auditor for the year 2022-23 with a remuneration of Rs of 15,000/-.
6. The recommendations of the Judging Committees for 3 MGMI awards and medals for 2022-23 were announced and presented to the recipients by the President. MGMI Award of Excellence for **Coal Mining for outstanding contribution in Coal** awarded to Dr Prem Sagar Mishra CMD, SECL and Prof Khanindra Pathak, Professor, IIT, Kharagpur. Dr Prem-Sagar Mishra CMD, SECL donated the cash amount to MGMI with the request to purchase books for the library.

   MGMI Award of Excellence for **Non-Coal Mining for outstanding contribution in Mining other than Coal** is awarded to Shri Praveen Sharma, Head, COE (Mining) Hindustan Zinc Limited and Shri Sabyasachi Mohanty, Director Operation, Odisha Mining Corporation Limited.

MGMI Award of Excellence for **Earth Science/Mineral Engineering** for outstanding contribution in Earth Science awarded to Prof Mrinal Kanti Mukherjee, Associate Professor, Indian Institute of Technology (ISM).

7. The Student' Awards for 2021-22 were announced and the awards were presented by the President.
   a) Pickering Medal for the Best Student in B.Tech Final of Mining Engineering to **Shri Madhav Singhal** of IIT (ISM), Dhanbad.
   b) Hayden Medal for the Best Student in M.Sc/M.Tech. in Applied Geology to **Smt Sakshi Sharma** of IIT (ISM) Dhanbad.
   c) Yule Medal for the Best Student in B.Tech. Mining Machinery to **Shri Pankaj Kumar** of IIT (ISM) Dhanbad.
   d) McNally Bharat Medal for the Best Student in B.Tech. Mineral Engineering to **Shri Sourav Prasad** of IIT (ISM) Dhanbad.
   e) Dr. Hari Narain Medal for the Best Student in M.Sc (Tech.) Applied Geophysics to **Km Shiwani Verma** of IIT (ISM) Dhanbad.
   f) Oil India Medal for the Best Student in B.Tech. Petroleum Engineering to **Shri Shashank Shekhar of** IIT (ISM) Dhanbad.
   g) Chandrakala Medal for Mining Engineering to **Miss Anjaly Kumari** of IIT, Kharagpur.
   h) S Lal Award for Mining Engineering to **Shri Sachin Paul** of IIEST, Shibpur.
   i) Dr. J. Coggin Brown Memorial Cash Award to **Smt. Sujata Majhi** of Presidency University.
   j) Indranil Award for B.Tech. in Metallurgy to **Ms Bijetry Kar** of IIEST, Shibpur.
   k) SCCL Gold Medal for the Best Student in Mining Engineering to **Shri Vinay Gade** of Kakatiya University.
   l) Nava Bharat Ferro Alloys Medal for Mining Machinery to **Shri Vinay Gade** of Kakatiya University.
   m) Roberton Medal for Mining Engineering to **Shri Sanjay Kumar** of BHU.
   n) Hadfield Medal for Metallurgical Engineering to **Shri Swarnendu Das** of BHU.
   o) La Touch Medal for Geology to **Shri Shashank Tripathi** of BHU.

8. Shri Dr B Veera Reddy, President, MGMI delivered the presidential address. Hard copies of the address have been circulated to the members present in the hall. Welcoming the participants at the august gathering, Dr Reddy deliberated upon the evolving landscape of India's mining, minerals and energy sector. He felt proud to affirm that MGMI continued to flourish pursuing its objectives. He spoke of India's present standing at world's fifth largest economy, and poised to ascend to the third position by 2031. He mentioned the transformative phase of our nation commenced when India embraced economic liberalization and global integration. Our nation, endowed with a diverse array of mineral resources, harnessed its mining sector to fuel industrialization, constructed critical infrastructure and propelled economic growth. Then he pointed out some significant ways that India's economic progress benefited from the minerals and mining industry – Resource base, Infrastructure development, Energy production, Employment generation, Export revenue.

   Dr Reddy mentioned India is world's second largest producer of coal, largest producer of sheet mica, fourth largest producer of iron ore and fifth largest producer of bauxite. For 'Make in India' to succeed, we must 'Mine in India' first. He discussed the energy consumption growth in India vis-à-vis the world. The energy options for India is limited. Our dependence on oil and gas imports is increasing. Coal is the main source of energy in our country. In FY23 India produced 893 MT of coal.

   A key component of India's ambitious effort to achieve net-zero emissions is significant increase of renewable energy sources, which is being done rapidly. India is now the top so-

lar energy producers worldwide with a total installed capacity of 70,096 MW. Our abundant wind resources are being utilized by increasing number of wind energy projects. India is also looking into the possibility of nuclear energy to charge up the energy balance. It has the potential to be a reliable and low-carbon source of electricity but with issues of public perception. In conclusion, he said it is the responsibility of our mining geological and metallurgical community to come forward to drive innovations and required policy changes.

Dr Reddy praised the editorial board of MGMI led by Dr A K Singh for the quality, contents and timely publication of the MGMI News Journals. He thanked Ranajit Talapatra and Prasanta Roy for their yeomen services in smooth organizing various events of MGMI. Also thanked numerous organisations and individuals who had helped to make his tenure gratifying and successful. He wished a bright future for the organization.

9. The Secretary announced that in the last Council Meeting it was decided that Dr B Veera Reddy will continue to be the President of MGMI during the next year. Members congratulated Dr Reddy.
10. Since no post of Council Member, except one reserved for metallurgists, fell vacant this year, no general election was held. For the reserve post, nominations were invited and only one was received. Dr Rajib Dey, the sole nominee, has been selected as a Council Member of MGMI.
11. The Secretary placed before the audience that the AoA of MGMI requires modification / amendment to include provisions of e-voting and remove bar on educational qualification which is hindering induction of new members from industry. For this committees will be formed at the Council Meeting. The proposal was accepted by members.
12. Themeeting concluded with Vote of Thanks by C S Singh. He thanked the President, Secretary, Council Members, all the members who helped in MGMI activities and also the staff members of the Institute.


117th
ANNUAL GENERAL MEETING (AGM)
OF
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HIGHLIGHTS OF 10th AMC AND IME

The 10th Asian Mining Congress (10th AMC) organised by The Mining, Geological and Metallurgical Institute of India (MGMI), at the Taj Taal Kutir Convention Centre , New Town, Kolkata on 6th – 9th November, 2023 was the latest milstone in a series of biennial events of Asian Ming Congress (AMC) and International Mining Exhibition (IME) since 2006. Central theme of the Congress was **"Roadmap for Best Practices vis-à-vis Global Transformation".** The Congress witnessed a participation of nearly 550 registered delegates including executives, practicing engineers, planners, policy makers, equipment manufacturers, regulators, scientists, researchers and other professionals from various organizations from India and abroad, who shared expertise and broad experience, through lively and dynamic presentations and discussions. To encourage students' participation in the Congress students were supported to attend through subsidized registration costs.

A total of 58 technical presentations on varied topics covering exploration, policies, mine planning, safety and surveillance, processing of minerals, sustainable green mining and oil and gas sectors were presented and discussed in one Plenary and ten technical sessions. In addition seven CEOs from PSUs and private enterprises expressed their views on improving productivity and efficiency in mineral industries based on the theme of the Congress. The Congress Proceedings Volume was published by the internationally reputed publishing house "Springer". A Supplementary Volume and Souvenir were also published and were provided to the delegates in their kit.

The following companies were the sponsors during the 10th AMC 2023 :

- Principal Sponsor : Coal India Ltd.
- Platinum Sponsor : NMDC
- Gold Sponsor : OIL
- Delegate Kit Donor : CCL
- Dinner Host : MCL & NCL
- Lunch Host : SECL & WCL
- Associate Sponsors : Tata Steel, NTPC, BEML, Essel Mining, SAIL, SCCL, NLC India, GMMCO.
- Hi Tea Hosts : CMPDI, BCCL & ECL

INAUGURAL SESSION

The Hon'ble Chief Guest on the occasion was Shri Pralhad Joshi, Hon'ble Minister of Coal, Mines & Parliamentary Affairs, Government of India, who could not come due to other pressing engagement. The Guests of Honour and dignitaries in the inaugural session were –

- **Shri Amrit Lal Meena,** IAS, Secretary, Ministry of Coal, Government of India, Guest of Honour
- **Dr Janardan Prasad,** Director General, Geological Survey of India, Guest of Honour
- **Shri P M Prasad,** Chairman, Coal India Limited, Guest of Honour
- **Ms Rowan Ainsworth,** Consul General, Australian Consulate, Kolkata, Guest of Honour
- **Shri Manoj Kumar,** CMD, CMPDI, Chairman, Organizing Committee
- **Shri Bhola Singh,** CMD, NCL, Chairman, Exhibition Committee
- **Dr B Veera Reddy,** Director (Technical), CMD, CCL, President, MGMI

The Congress was inaugurated by the Guests of Honour and the dignitaries by ceremonial lighting of lamps.

In his welcome address **Dr B Veera Reddy** President, MGMI extended a warm welcome to the foreign and Indian guests, delegates and participants on behalf of MGMI to the City of Joy. He mentioned that India has achieved highest ever coal production and a lot of green initiatives for sustainable mining is also being promoted under the guidance of Shri Meena, Secretary, MoC.

Dr Reddy presented the background and a brief history of MGMI and its activities, the Asian Mining Congress and the International Mining Exhibition. He complemented and congratulated each and every member who contributed to the organization of the 10th AMC.

Shri Manoj Kumar, Chairman, Organizing Committee briefed the august gathering about the AMC and introduced the theme of the Congress pointing out that Asia, the largest continent, shares the largest mineral resources in the world, much of which is still untapped. The mineral industry has to gear up and accelerate the pace of sustainable development of mineral resources to meet the increased demand of raw materials. He told 56 papers would be presented in the 10 technical sessions on various lead topics, in addition to the Plenary and CEO's sessions.

Shri Bhola Singh, Chairman, Exhibition Committee briefed about the IME which is one of the largest gathering of mining equipment manufacturers and persons engaged in mining business in southeast Asia. It is expected that 400+ companies, including 20+ from foreign countries, would be participating in 10th IME. The exhibition has become the most prestigious platform for display of mining equipments, latest technologies and innovative publications of development in mining and allied industries.

Ms Rowan Ainsworth, Guest of Honour, thanked the organizers, dignitaries and specially Shri Meena for the invitation in this important Congress. She spoke mainly on relationship of the countries mentioning that Australia and India has a strong bilateral relation. She referred to the comprehensive strategic partnership signed by the prime ministers in 2020. The free trade agreement has strengthened the relationship in resources sector, particularly in areas of emission reduction, mining of critical minerals, green hydrogen. In conclusion she mentioned women's role in mining sector.

Shri P M Prasad, Guest of Honour, mentioned about expanding activities of MGMI, pointing out the large participation of leaders from mining industry in this Congress. In recent Indian Mobile Congress, CMPDI participated where application of 5G in mining practices was showcased. He feels 5G and other technologies are to come in a big way in mineral industry. Production from underground mining is to be enhanced considerably. There is a strong focus on mine closure procedure in a scientific way keeping in mind proper use of the restored land with post-mining activities.

Dr Janardan Prasad, Guest of Honour, felt honoured to join the distinguished dignitaries and congratulated MGMI for the event. He presented a brief history of Geological Survey of India (GSI), a premier geoscience institute, mentioning its invaluable contribution to the national economy. Presently it institutes thousands of projects each year across the country under different missions with major emphasis on mineral exploration, green energy and low carbon emission. GSI is putting maximum pressure on exploration of critical minerals. For search of concealed and deep-seated mineral resources, GSI has undertaken programmes like project uncover, regional mineral targeting, national geophysical mapping, national aero-geophysical mapping. National geochemical mapping of whole India has been completed which is helping in targeting areas for search of critical minerals. He wished the Congress a grand success.

Shri Amrit Lal Meena, IAS, Guest of Honour, complimented MGMI for organizing the AMC, a forum for interaction of industry and users, in regular intervals. He praised the theme of the congress as very important and informative for the mining and energy sector. He conveyed that Shri Pralhad Joshi, Hon'ble Minister has sent his best wishes for the success of the congress. Energy security is of paramount importance in our country. Our economy is growing, our power demand is growing fast. So we have to depend on the primary source of energy, coal. He congratulated coal industry players for the outstanding contribution to the energy sector. He felt happy that now the percentage of imported coal versus total coal consumption on year to year basis shows a reducing trend of late. In pursuance of 'Make in India' many Heavy Earth-Moving Machines

(HEMM) are being manufactured here because of support by Coal India. By 2030 the production from captive and private mines is expected to be 500 million tonnes and with one billion tonne from Coal India, country's demand of 1.5 billion tonnes would be met. Government is promoting the policy of coal gasification in a big way so as to gasify 100 million tonnes of coal by 2030. CMPDI is planning a pilot plant for underground coal gasification. The underground coal mining needs to be promoted in a big way for which participation of private miners are being sought. Shri Meena touched upon the mine closure framework which has been prepared in consultation with experts. There may be pump storage projects for which Coal India is identifying potential areas where hydro-power plants can be set up. Government had come out with a policy of long term lease of land of coal companies for setting up of energy related infrastructure projects. Under **'PM Gati Shakti'** Plan for providing multimodal connectivity infrastructure to various economic zones, the requirement of rail infrastructure for evacuation of coal for the period 2047 has been planned in three states of Jharkhand, Odisha and Chhattisgarh jointly by ministries of railways and coal. He requested the organizers to touch upon 5 points – (i) if as an outcome of the congress certain relevant policy inputs come, those may be compiled and shared, (ii) from the global best practices being deliberated in the congress, it may be confirmed which are best applicable in our country, (iii) the best mine closure technology from other parts of the globe may be listed. (iv) any good work done on coal gasification anywhere may be noted, (v) if some guidance on Research and Development comes out of the congress deliberations. He congratulated MGMI and wished the event a great success.

The Proceedings, published by Springer, and the Supplementary - cum - Souvenir volumes of the 10th Asian Mining Congress were released by the dignitaries on the dais.

The inaugural session concluded with a Vote of Thanks by Shri Ranajit Talapatra who expressed gratitude to the dignitaries and thanks to all, including the sponsors, associated with this event. He offered special thanks to Shri Prasanta Roy, Convener, 10 AMC.

PLENARY SESSION

Chairperson – Dr Janardan Prasad, Director General, Geological Survey of India

Coordinator – Shri Alok Lalit Kumar, Executive Director, CIL

Prof S P Banerjee, Past President, MGMI of and former Director, ISM, spoke on ***'The Impact of Recent Geopolitical Events on Supply of Critical Minerals for an Early GET'.*** The Green Energy Transition (GET) is important for mankind. The fossil fuel energy needs to be replaced by green energy. For this some special variety of minerals are needed. Certain geopolitical events in recent times has helped the GET process and also caused impediments. Adverse impact was caused by Covid-19 and Russia – Ukraine war. Positives are policy changes, improvements in technology, accelerated induction of Electrical Vehicles (EV), batteries that need supply of critical minerals like lithium, cobalt, nickel etc. The R & D efforts for improving battery technology and search for alternative elements are going on in full swing.

Shri N C Jha, Former CMD, CIL and Past President, MGMI talked on ***'Impact of 2070 Net-Zero Pledge on the Future of Indian Coal Industry'.*** In COP26, India made pledge to reduce carbon for Net Zero as 2070. Globally 90 countries have agreed to reduce carbon emission that accounts for 80% reduction. In our country coal accounts for more than $2/3^{rd}$ of the CO_2 emitted to the atmosphere. India's carbon intensity in energy generation is the highest in the world at about 275g/kWh, due to inferior grade coal. India's per capita emission is nearly lowest. The pledge of reducing the carbon by 1BT by 2030 puts a huge restriction on usage of coal. India's energy mix is set to undergo transition from fossil fuel base to non-fossil fuel base, particularly renewable Energy (RE) that requires huge investment in energy storage system (ESS). Just transition is another issue that will require to be addressed, as in India, currently most of the economic activities are dependent on coal and other fossil fuels.

Dr Kalachand Sain, Director, Wadia Institute of Himalayan Geology presented ***'AI-Based New Tool for Semi-Automatic Interpretation of Reflection Seismic Data'.*** Seismic measurements on the Earth's surface are extensively used to delineate subsurface geologic features for the exploration of geo-resources and understanding geodynamics or seismo-tectonics. Over the decades, seismic attributes (properties or characteristics) extracted from 3D seismic volume have revolutionized interpretation of subsurface geologic environment. It is the high performance computing systems that have allowed processing of voluminous data within a reasonable time, but the interpretation by human analysts still remains tedious, particularly in a complex area. This has necessitated automatizing the process of interpretation. Several work flows have been designed for merging multiple attributes related to a subsurface structure into a single 'meta-attribute' that has allowed to delineate the 3D configuration of that feature from a large volume of data, even in a complicated region. Success stories from a variety of basins across the world including India were presented.

Shri Prasanna Kumar Motupalli, CMD, NLC India Limited, deliberated on ***'The Pathways for Coal Transition and Net Zero Emission'.*** Total energy is considered as indication of development of country and the same is very less in India compared to world average. There is an urgent need to improve the same for which coal / lignite sectors must grow by mitigating the impacts of climate change. India's roadmap for net-zero emission is emphasized through Panchamrit climate action by 5 goals to reach Net zero by 2070. Even after 2047 India will continue to need coal / lignite for energy generation. At the same time to ensure proper integration of Renewable energy, coal and lignite based thermal process generation continue to play a major role as per India's vision document 2047. A balance is to be maintained to ensure development and sustainability go hand in hand. NLCIL is increasing its capacity in renewable energy to 6071 MW by 2030 through various Solar, Wind power plants and is planning to establish clean technologies like lignite to Methanol, use of electrical vehicles, battery storage systems, Lignite to Diesel, Lignite Gasification and OB to M-sand.

Prof Arvind Kumar Mishra, CSIR-CIMFR, Dhanbad, presented a paper on ***'Mass Production Technologies for Underground Coal Mining in India: Status, Challenges, and Prospects'.*** The current trend of very low coal production by underground mining is not sustainable due to environmental issues, coal quality problems, and socio-economic stresses due to opencast mining. While discussing the benefits of underground mining he suggested that the solution lies in the adoption of Mass Production Technology (MPT) in underground mining which can compete with opencast mining in terms of production rate. He presented the existing mining methods and potential MPTs for exploiting deep-seated coal deposits in India. The MPT for underground mining has been defined and the eligible technologies are presented. Finally, the prospects in R & D, testing, and policy making for smooth adoption in Indian coal mining have been deliberated.

Dr Rabi Bastia, CEO (E & P), Olimax Energy, spoke on ***'Seismic Brings Paradigm Shift in Coal Seam Resolution : Enhancing Coal Mining Efficiency and Safety'.*** This is a transformation technology that he presented with some global case histories. The significance of Seismic technology reverberates through the economic and safety dimensions of coal mines globally. Seismic data provides a continuous and detailed picture of the target coal seam. By employing seismic-derived depth surfaces and detecting faults and stratigraphic anomalies, technologists can strategically plan borehole drilling for fault assessment and grout pattern design. Recent advancements in 3D seismic interpretation and converted wave seismology have further expanded its capabilities.

Shri Pinnaduwa H S W Kulatilake, Professor Emeritus, University of Arizona, talked on ***'A Case Study on Stability and Rock Support Assessment for a Complex Underground Mine in USA'.*** He presented a short description of the mine site and the tunnel system and went through the numerical

simulation. He showed the tunnel cross sections and explained the supports installations and field instrumentations, part of which was covered by multiple point borehole extensometers. Then he spoke about numerical procedures, estimation of rock mass properties, numerical model, rock supports, continuously yielding joint model for faults, sequential excavation, back filling and delayed supporting.

CEO'S SESSION I

Chairperson – Shri Amrit Lal Meena, IAS, Secretary, MoC, GoI

Co-ordinator – Shri N C Jha, Past President, MGMI and Former CMD, CIL

Shri P S Mishra, CMD, SECL –According to him, best mining practices are policies, practices and procedures which are inclined, intended and implemented for obtaining optimal efficiency and best results in successful, stable and sustainable manner. SECL has endevoured to achieve this. Informational Technology (IT) is being integrated with Operational Technology (OT) and some mines are running digitally. Shri Mishra pleaded industry – academia interface. SECL has taken steps to successful closure of mines like repurposing of mines, ecotourism, solar plant installation. Underground mining is also being given importance.

Shri Ajit Kumar Saxena, CMD, MOIL – He shared the importance of manganese ore, industries in the country and also the global scenario. Out of 1,500 million tonnes of manganese ore available in the world, India is having 34 million tonnes. More than 95% of manganese ore goes in the production of steel. To achieve India's target of 300 million tonnes steel production by 2030, 11 million tonnes of manganese ore is required. Presently 7 million tonnes are used in India of which 4.5-5 million tonnes are imported. Shri Saxena presented the availability strategy and production target of manganese ores. He talked of the exploration programme by MOIL sharing some of the best practices implemented in manganese mining.

Shri I D Narayan, CMD, MECL – He spoke of global and Indian scenarios of critical minerals and MECL's role. 70% of their production are from 15 countries. That makes risk of availability and supply chain disruptions. India is moving from petro to electro in energy sector for which critical minerals are needed. Government has identified 30 critical minerals, out of which more than 30% is fully imported. There are very limited known reserves in India though we have large geological potential areas which is still unexplored. There is need for systematic exploration, sustainable mining and processing. For this R & D and new type of equipments are necessary which MECL is implementing. More than 50% of their exploration blocks are of critical minerals.

Shri Santanu Roy, CMD, BEML – He started with sectoral analysis and growth projection with respect to global market for coal and other minerals which showed a significant increase in recent years. In this, mining equipment is critical for excavation and extraction process. The key factors for growth in India are -- the demand growth, tractive opportunities, Production Linked Incentive (PLI) schemes, policy support, competitive advantage, technology and smart mining. As far as equipment is concerned, best mining practices are best maintenance practices. He presented a short outline of BEML, various areas of its activities. He talked of future strategies including Artificial Intelligence (AI) and Environmental, Social, and Governance (ESG) initiatives.

CEO's SESSION II

Chairpersons – Shri R P Ritolia, Former CMD, CCL and **Shri Binoy Dayal,** Former D(T), CIL

Co-ordinator – Dr Anupendu Gupta, Former Dy DG, GSI

Shri Thomas Cheriyan, MD, ESSEL mining – He feels whatever we use comes from two sources, one that is grown and the other mining. That is why mining is important for human prosperity. He talked of the road to Net Zero in mining. He focused on two points, technology and people. Today mining has started looking at the best technology in the world. During the entire cycle of mineral search to extraction, latest technologies like

AI are being used. Global companies now carry out many of their potentially hazardous operations from a remote location without direct human involvement at the site. Traditional practices need to be modernized.

Shri D B Sundara Ramam, Vice President, Tata Steel – Community looks at the mining industry that spoils the environment, mostly because required focus and importance was not being given to mine closure. Economy, environment and social are the three major baskets for mining industry. He talked of challenges faced by the industry and also the government in implementing proper procedures. We should improve mining processes, including mine closure. Digitalization is the keyword now and mining industry is not behind. He discussed automation in mining with eyes on safety and security, innovations happening in mining. He shared some examples of sustainable mining carried out by Tata steel.

Shri Anuj Keolia, COO, GMMCO – Mining is a very big field and HEMM, i.e., the machine is the last portion where people give concentration. The major thrust in any mining are the machineries without which mining cannot be done and how a machine is treated is very important. According to him there is not much difference between the Indian and foreign mines. In India automation has started, remote control truck dozer may be introduced next year. If we look at the machine journey, there is a complete evolution (in India). Basically the changes in mining are mine size, machinery, regulation and technology. He talked of improvements in machinery technology.

TECHNICAL SESSIONS

There were altogether 10 Technical Sessions on 7th and 8th November besides the ones mentioned earlier, where 51 papers were presented by scientists, technologists and academicians from India and abroad. The sessions with lead topics, and number of presentations are as follows.

- In Technical Session I, the lead topic was **'Exploration, Estimation, Geostatistics and Hydrogeology'** and six papers were presented.
- In Technical Session II five presentations were made under the lead topic of **'AI / ML Applications and Smart Mining'.**
- Technical Session III the lead topic was **'Mine Planning and Production'**. Four speakers made their presentations.
- In Technical Session IV six papers were read under the topic **'AI ML Applications, Digital and Smart Mining'**
- Technical Session V had **'Explosive and Blasting'** as the lead topic. Six presentations were made in the session.
- Technical Session VI had six presentations from the topic of '**Mine Health and Safety'.**
- With the lead topic '**Sustainable Mining and Mine Environment**' five speakers made presentations in Technical Session VII
- In Technical Session VIII the lead topic was '**Back Filling & Waste Management'** In this session three presentations were made.
- In Technical Session IX under the lead topic '**Coal Gasification, CBM, Mine Fire & Ventilation'** papers presented were five.
- Technical Session X had the lead topic of ' **Rock Mechanics and Ground Control**'. Five presentations were made in this session,

There were two special talks after the Technical sessions.

Shri N V K Srinivas spoke on the ***Challenges faced in Longwall Mining in SCCL'.*** One of the challenges was the huge quantity of impure slushy water coming out of the mine face. They had to deploy three pumps from underground to surface at 250m head difference such that outlet of one pump was the inlet for the other. Another issue was controlling the temperature of the mine face. Shri Srinivas explained the process by which it was controlled. Other problems discussed were the roof support, conveyor belt system etc.

Shri D.V. Pichamuthu talked on ***Amendments of Mining Legislations and their Impact on Mining Industry.*** He traced the history of mining laws, National Mineral Policies (NMP) and MMDR acts,

starting from 1939 when certain key minerals were controlled. He discussed the amendments of 1994 and 1999 that loosened the government control and the major amendments of 2015 that, according to him, was a backward step. He presented the effects of the acts and some recommendations touching critical minerals, taxation, auction process.

PANEL DISCUSSIONS

This session was held under the chairmanship of **Prof S P Banerjee,** Past President, MGMI & Former Director, ISM, and the following persons expressed their views.

Shri N C Jha pointed out the basic idea of the theme of this Congress was the best global mining practices and how to adopt it in Indian mining. Many presentations have been made here including a number of case studies. He added that mining in India should focus particularly with respect to optimization of productivity with due regard to safety, with least carbon emission technologies. We should inculcate the habit of safety. He stressed on efficient burning of coal. He advocated for attracting more people in mining profession.

Shri N N Gautam said the most important subject was how to reach Net Zero emission. Initially it was thought coal would be phased out. But the situation is more coal would be required to meet rising demand. The only way is to use coal in a cleaner manner. Coal gasification is a better process. The latest talk in energy scenario is the hydrogen economy. Hydrogen is not an energy source, it is energy carrier. Research to make it cheaper should continue.

Shri D Mohanty – NMDC, the number one mining company, secures the raw material security for the country. He presented the activities of NMDC, including opening of gold mine in Australia. He discussed safety, environment, social responsibility in mine activities. According to him new technologies have to come in the mining and energy sector.

Shri T K Nag shared his thought about safety in mining operations. In India after any accident the conventional enquiry is done and someone is penalized, as there is no system of root cause analysis. On the basis of a report of a committee (of which Shri Nag was a member) government has now asked all companies to go for risk base analysis in case of an accident. He advocated for risk analysis based safety management plan and its audit.

Dr G K Pradhan talked on height of benches in opencast mining. He praised NMDC mines.

Shri G V Reddy, Director (PP), SCCL said the future of SCCL is at stake due to the MMDR act 2015. The search for coal is now through auction route. He pleaded to MGMI to place the point to the government.

Dr Kalyan Sen told coal preparation in India gets no importance. Gasification or generation of hydrogen with high ash coal will not be easy. For that coal preparation will be needed. He does not think Net Zero can be achieved without coal preparation.

Prof Banerjee mentioned the salient points adding his thoughts in the subject after each talk.

VALEDICTORY SESSION

The concluding session of the 10th AMC commenced with the following guests and office-bearers on the dais.

- **Shri V L Kantha Rao,** IAS, Secretary, Ministry of Mines, GoI, Chief Guest
- **Shri P M Prasad,** Chairman, Coal India Limited, Guest of Honour
- **Shri A Rajkamal,** IAS, Director, Mines and Geology, Jharkhand, Guest of Honour
- **Dr B Veera Reddy,** Director (Technical), CMD, CCL, President, MGMI
- **Shri Manoj Kumar,** CMD, CMPDI, Chairman, Organizing Committee
- **Dr Amalendu Sinha,** Chairman, Technical Committee
- **Shri Ranajit Talapatra,** Hony Secretary, MGMI
- **Shri Prasanta Roy,** Convenor, 10th Asian Mining Congress

Dr B Veera Reddy welcomed the dignitaries and guests in the session. He especially thanked Shri Kantha Rao, the key man known for key reforms in the mineral sectors, for honouring the session as chief guest. He thanked Shri Prasad for his help in organizing this congress and Shri Rajkamal for his cooperation and support in CCL activities. He also thanked Dr Sinha for the good work in publication of the proceedings volume by Spriger, and Shri Kumar for leading the Congress to a great success.

Shri Manoj Kumar told that over the past three days the power of collaboration, exchange of knowledge and the spirit of innovation were witnessed. He presented a brief outcome of the 10 AMC mentioning the keynote papers in the Plenary session, CEO's perspective and insights, technical presentations from various distinguished speakers from industry, academia and research scholars in ten sessions.

Dr Amalendu Sinha expressed satisfaction that this time the scopus indexed Proceedings volume could be published by Springers, an international publisher. He thanked the President, Secretary, MGMI, Convener, 10 AMC, editors, reviewers and authors for this unique achievement. He told that recommendations from this congress will be prepared by a committee, mainly on some points suggested by Shri A L Meena, Secretary, MoC, and forwarded to the government.

Shri A Rajkamal thanked MGMI and CCL to provide Jharkhand state an opportunity to be a partner in this event. Jharkhand being a state with highest mineral resources in the country, has the responsibility to promote mining activity and also ensure a sustainable transition to fulfil net zero commitments. Policy and technical activities are taking lead in Jharkhand, technology being used in monitoring purpose in mining activities, exploration. He felt the knowledge from the 10 AMC would be of good help to Jharkhand in mineral exploration and mining domain. Jharkhand is a pioneer state that came up with a policy of sustainable energy task force that would create a road map for moving to net zero. Hydrogen economy is also an area for focus by Jharkhand.

Shri P M Prasad thanked Shri Kantha Rao on behalf of MGMI for coming to the occasion. As suggested by Shri Kantha Rao, he requested MGMI authorities to plan the next AMC at New Delhi. He talked of the success of 10 AMC with 56 papers presented, and IME with 400 stalls. He suggested MGMI should arrange a seminar on critical minerals. He thanked all for the all-round success.

Shri V L Kantha Rao congratulated MGMI for an excellent event related to mining and praised the theme and very relevant lead topics on which the deliberations were presented. He suggested there is a need to organize an event covering all the minerals sector where stakeholders from the entire mining sector may assemble, preferably at Delhi. He feels ease of doing business following ESG standard is the need of the hour. MoM is trying to simplify the procedures in mining business, with a soft touch policy for the smaller mines. He requested all stakeholders to come up with suggestions to simplify the leasing process. Shri Kantha Rao spoke of offshore economic mineral zones where exploitation could be carried out. A lot of offshore survey had been done by GSI and 32 blocks are ready for auction. Government would spent lot of money through National Mineral Exploration Trust (NMET) for encouraging exploration, especially for the critical minerals. Government would also fund R & D programme by start-ups in mining sector. He requested all to help in making India self-sufficient in mining sector.

The 10th Asian Mining Congress came to conclusion with Vote of Thanks by the Convenor **Shri Prasanta Roy.** He expressed gratitude to Shri V L Kantha Rao, Shri A Rajkamal, Shri P M Prasad, Dr B Veera Reddy. He thanked profusely to Shri Manoj Kumar, Shri Bhola Singh under whose guidance the AMC and IME have become a grand success. He thanked Springer for publishing the proceedings, the technical committee, the editors, the reviewers, under chairmanship of Dr Amalendu Sinha. He thanked all the sponsors, naming them individually, to Tafcon for organizing the exhibition, the event management team, Taj Taal Kutir. Most important parts of the

conference are the authors, delegates and participants, to whom Shri Roy expressed gratefulness. He thanked Shri Ranajit Talapatra, Secretary, Shri C S Singh, Jt Secretary, MGMI, the comperes, and all the staff members of MGMI.

Chairpersons, coordinators Congress and speakers of all sessions were felicitated with Congress mementoes.

A cultural programme was organized in the evening of 7th November 2023. A dance troupe SAPHIRE DANCE TROUPE entertained the guests, delegates and participants at the 10th AMC with their performance.

INTERNATIONAL MINING EXHIBITION (IME 2023)

The 10th edition of "IME 2023 – the Premier International Exhibition for Mining, Equipment & Minerals" held during November 6-9, 2023 at Eco Park, Kolkata, was the largest ever and brought buyers, manufacturers and visitors from 20 Countries. The Event which was spread over 42,000 square meters had participation from 447 International and domestic Exhibitors and 25,430 trade visitors.

The Exhibition was inaugurated by Chief Guest **Shri Amrit Lal Meena,** Secretary, Ministry of Coal, and Government of India on November 6, 2023 in the presence of Guests of Honour Mrs. Rowan Ainsworth, Consul General, Australian Consulate Kolkata, Shri P.M. Prasad, CMD, Coal India Ltd. The other eminent dignitaries present on the occasion were Dr. B. Veera Reddy, President MGMI & Director (T), Coal India Ltd.; Shri Shantanu Roy, CMD, BEML; Shri M. Prasanna Kumar, CMD, NLC India Ltd., Shri Bhola Singh CMD, Northern Coalfields Ltd.; Shri Rajesh Nath, MD, VDMA.

IME 2023, had the most impressive outdoor machinery display, apart from multiple halls which showcased the latest new equipment's and innovative technologies, leading to four very busy and eventful days of high level networking and exploration of new opportunities by the participants – exhibitors and visitors alike. High level Trade Delegations and Country Level Group Participation from Germany (Partner Country), Australia (Focus Country), Czech Republic, Poland and many other countries like Russia, Iran, Tehran, Turkey, UK, USA were a part of this important event, along with large participation from mineral rich states of India such as Gujarat (Partner State) & Jharkhand (Focus State) & West Bengal. IME 2023, the 10th Edition was an unprecedented success as also by the remarks and comments given by VIPs, Delegates, Exhibitors and Visitors et all.


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New Town, Kolkata (WB), India
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November 06-09, 2023 • Kolkata
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CEO SESSION 1

Late Ajit Kumar Das (MMGI, LM – 3541, 1982-83) breathed his last on 2nd October 2023. With heartfelt grief MGMI members wish his soul to Rest in Peace in his heavenly abode. May God give strength to his surviving family members and friends to bear the loss.

Late Das was a member of MGMI since 1982-83. Born on 23rd December 1939 and a former Director (Selection Grade), Geological Survey of India, he postgraduated from Jadavpur University in 1960. He started his professional career in Geological Survey of India as STA (Geology) in 1961 and was promoted to Assistant Geologist in 1963. Subsequently he was promoted to Geologist (Jr), Geologist (Sr) and finally to Director in 1992.

Late Das carried out regional coal exploration in almost all coalfields in India including systematic geological mapping in the extra-peninsular Gondwanas of Siang and Subansiri districts of Arunachal Pradesh and exploration for coal in Tertiary coalfields of the Northeastern region. He performed ground water investigation in Burdwan, Bankura and Birbhum districts of West Bengal. Since 1969 he was attached to exploration for coal in various Gondwana coalfields.

Late Das was a recipient of gold medal for his paper presented at the Mining Geological and Metallurgical Institute of India. He was a regular visitor at all events of MGMI including those in 2023. His sudden demise has left his family and friends stunned.

An able scientist and administrator, Late Das was universal 'Ajitda' to one and all. His door was always open to anyone who wanted any help or advice. A genial personality, he seldom lost his cool and his smile.

Nagpur Chapter

HIGHLIGHTS OF SEMINAR ON 'RELIABLE, AFFORDABLE & CLEAN ENERGY (RACE)'

The Mining, Geological & Metallurgical Institute of India (MGMI), Nagpur Chapter organized a one-day seminar on **"Reliable, Affordable & Clean Energy (RACE)" on December 20, 2023** at Hotel Radisson Blu, Nagpur. The seminar was chaired by Shri Ajit Kumar Saxena, CMD, MOIL Ltd. Shri J P Dwivedi, Director (Tech) Op, WCL was the Patron of the event. The Platinum Sponsor was Western Coalfields Limited.

The seminar brought together various stakeholders including mineral organizations, regulators, government bodies, academia, and activists to discuss the need for reliable, clean and affordable energy sources in India. Speakers at the seminar included reputed Directors of CIL & its subsidiaries, ex-Directors CIL, and delegates from organizations like CIL, WCL, ECL, MCL, SECL, MOIL Ltd, CMPDIL, MECL, IOCL, CIMFR-Nagpur, Satna University, Ramdeobaba College of Engineering and Management, Adani Power, Deloitte and a XYKno Capital Services Pvt Ltd.

In the face of a global energy transition, coupled with India's vast and growing population, demands a strategic focus on reliable, clean, and affordable energy sources. The MGMI seminar on RACE uniquely positioned itself as a vital forum to address this pressing need. This platform aimed to unite diverse stakeholders - mineral organizations, regulators, planners, government bodies, academia, and activists. The goal was simple - showcase achievements, share innovations, and pave the way for the adoption of new and sustainable technology in industries and households.

The speakers covered various topics related to the theme including "Renewables in the Mining Industry-Pumped Storage Hydropower Development", "Redefining Mine Closure: Harnessing Renewable energy for Sustainable Mine Closure Practices", "Role of Coal Sector towards Energy Transition", and "Importance of Critical Minerals for Green Technology & Sustainable Energy Scenario in India".

The key takeaways from the seminar were the achievements and innovations showcased by the speakers, and the insights provided by panellists on adopting new sustainable technologies in industries and households.

Overall, the seminar provided a good platform for all stakeholders to come together and discuss the vital topic of reliable, affordable and clean energy in the current global energy transition scenario.


Seminar on
RACE
Reliable, Affordable & Clean Energy
RELIABLE, AFFORDABLE & CLEAN ENERGY (RACE)
RENEWABLES IN THE MINING INDUSTRY
PUMPED STORAGE HYDROPOWER DEVELOPMENT
20th DECEMBER 2023
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CHAPTER ACTIVITIES

Odisha Chapter

MGMI Odisha Chapter has successfully organized the **1st Conference cum Exhibition on Redefining Mining Sector (CERIMS) 2023** with the theme **Transformation through Industry-Institute-Innovators Collaboration** at MCL Auditorium, JagritiVihar, Burla on 14th October 2023 with the active support of Mahanadi Coalfields Limited.

Shri Amrit Lal Meena, IAS, Secretary, Ministry of Coal, Govt of India **was the Chief Guest** and the following dignitaries were **the Guests of Honour.** Shri P M Prasad, Chairman, Coal India Limited; **Dr. P S Mishra,** Chairman-Cum-Managing Director, South Eastern Coalfields Limited;

Dr. B Veera Reddy, Director (Technical), Coal India Limited;

Shri Mukesh Choudhary, Director (Marketing), Coal India Limited;

Shri S P Singh, Director (Technical/Project & Planning), Northern Coalfields Limited;

Prof. A K Mishra, Director, CSIR- Central Institute of Mining and Fuel Research

Total no. of registrations across all categories (Delegates/Authors/Exhibitors) was 290.

Representatives from 60 different organizations comprising of Institute-Industry and Innovators have participated.

Sl. No	Academicians / Institute
1	IIT ISM Dhanbad
2	NIT Rourkela
3	NIT Raipur
4	CIMFR Dhanbad
5	NML Jhamshedpur
6	CMPDIL

Sl. No	Industry
1	MCL
2	CIL Subsidiaries
3	NMDC, NLCIL
4	Coal Consumers: Adani Power Limited, Hindalco Industries, Vedanta Limited, GMR, Jindal Power, NALCO
5	Mine Development Operators like DIlipBuildcon Limited, BCML, GangaramChak Mining Private Limited, TechnoBlast Mining Corporation
6	Explosive Manufacturing Companies IOCL, Special Blast Explosives, IDL Explosives, Deepak Fertilizers and Petrochemicals

7	Mining Outsourcing Companies
8	Engineering Projects India Limited, Hild Energy, RR Engineers and Surveyors
9	Mining Equipment Manufacturers like BEML, Propel Industries, Sandvik
10	Global Coal and Mining Pvt. Ltd.

A total of 39 technical papers have been received of which 16 papers were presented by academic institutes, research institutes and industries on the subjects ranging from Topics- Pre-Mining Methane Drainage, Oil Agglomeration, Relooking into R&R Policies, Carbon Trading, Mining 4.0, Risk Management in MDO models and other sustainable practices.

A total of 16 Exhibitors have participated showcasing electric truck, blast free cutting technology, application of drones in mining, virtual reality for enhancing training efficiency, real time health monitoring of HEMM, interactive chat GPT for mining rules, regulations, acts, etc., video analytics integrated with access control system, coal washing, AI/ML based mine illumination and smart traffic management system.

Sl. No	Innovators
1	GARUDA UAV SOFT SOLUTIONS PVT LTD
2	UCTL
3	GOTISHEEL
4	ZEON AI
5	KALINGA COMMERCIAL CORPORATION LTD
6	CHRP- INDIA
7	BIDAAL TECHNOLOGY PRIVATE LIMITED
8	Worldcon Technologies
9	PROPEL INDUSTRIES


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MCL AUDITORIUM
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4th October 2023
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TRANSFORMING COAL MINING IN INDIA

A Conversation with Shri P M Prasad, Chairman, Coal India Limited

Shri P. M. Prasad, presently holding the position of Chairman-cum-Managing Director at Coal India Limited, previously served as Chairman-cum-Managing Director of Central Coalfields Limited (CCL), Ranchi. With over 38 years of extensive experience in operations and management, he brings invaluable expertise to his current role. Beginning his journey as a mining engineer from Osmania University, he augmented his capabilities by earning an M. Tech in 'Open-Cast Mining' from IIT (ISM) Dhanbad, alongside obtaining a law degree from Nagpur University. Commencing his career as an executive trainee at Western Coalfields Limited (WCL) in 1984, Shri Prasad's journey epitomizes dedication and dynamic leadership. Notably, he played a pivotal role in reopening the DRC mines affected by an underground fire during his tenure at WCL, earning him accolades as the 'Best Mines Manager' in 1995. Throughout his career, Shri Prasad demonstrated a commitment to excellence, notably overseeing the successful opening of projects like the 'Kaniha Open Cast Project' and the diversion of nallah at Hingula Opencast Area to unlock coal reserves. His emphasis on safety garnered numerous awards for the projects he led. Shifting to NTPC in 2015 as Executive Director (Coal mining), Shri Prasad accelerated project awards and oversaw the commencement of coal mining operations at Pakribarwadih mines, Hazaribagh, winning the prestigious 'Swarn Shakti Awards' in 2016. Joining Northern Coalfields Limited (NCL) as Director Technical (P&P) in 2018, Shri Prasad's leadership was instrumental in environmental conservation efforts, earning NCL recognition at the World Environmental Conference. Assuming the role of CMD at Bharat Coking Coal Limited (BCCL) in 2019, Shri Prasad's leadership during the COVID-19 pandemic showcased his commitment and vigour. Renowned for his interpersonal skills and belief in teamwork, he is poised to guide Coal India Limited to new heights of success. The Mining, Geological, and Metallurgical Institute of India (MGMI) holds pride in his tenure as the Past President of the Institute. Dr. Ajay Kumar Singh, the Editor, extended an invitation for an interview on behalf of the readers of MGMI News Journal, to which he graciously accepted, and the interview is now featured herein.

Could you provide an overview of the current role of coal in India's energy mix and its significance in meeting the country's energy demands?

India's energy economy is predominantly coal driven. Coal accounts for half of the country's primary commercial energy and 70% of the total electricity generation. Of the total generation of 1306 Billion Units, from all sources, till December end in this financial year, coal based generation was 932 BU or 71%. Growth was 10.1% higher on a year-on-year comparison. With proven reserves of around 170 Billion Tonnes, what makes coal a preferred energy fuel is its affordability and assured supply. NITI Aayog and independent international agencies estimate that coal's use in India is set to peak by 2030 and remain there for another decade more. Coal's robust presence in

meeting the country's energy demands will not subside soon. In future even when coal demand declines it could be effectively put into use for alternative purposes like gasification etc.

With the growing emphasis on renewable energy sources, how do you see coal's role evolving in the Indian energy sector in the coming decades?

Advent of renewable energy sources is a welcome step from eco point of view. India has also made clear its firm commitment of pursuing RE at COP 28. Despite the increasing presence of renewables in India's energy basket they still cannot upstage coal at this juncture. At best they can supplement coal's role but cannot substitute it. In India's electricity generation, RE sources have grown by 10.7% to 169.43 BU till December FY 2024 over similar period last year. However, they still trail coalbased generation by 5.5 times. RE may be growing but so is the overall energy demand of the country. With green energy sources yet to catch up the raising demand, it effectively means that coal has to meet the resultant gap. So, its requirement will increase in quantum terms though its percentage in the energy share will shrink. In short and medium terms coal will continue to be India's energy growth engine, but in long term RE is bound to catch up especially solar and wind. If economically viable energy storage system (ESS) comes up it will be a game changer in the energy sector. But till then coal's role will be strong.

What technological advancements and innovations is Coal India Limited pursuing to make coal mining more sustainable and environmentally friendly?

To reduce carbon emissions in mining areas CIL is fast tracking eco-friendly mechanized coal transportation through 75 first mile connectivity projects. Their combined evacuation capacity is slated at 837.5 million tonnes per annum (MTPA) when all become operational by FY 2030. The move reduces load on road movement of coal through trucks and the consequential dust pollution. Pilot studies conducted through NEERI and CSIR in two large OC mines on this front reflected encouraging results in significant reduction in gaseous and particulate matter and savings on diesel.

To make mining operations more eco-friendly, CIL is also increasing OC production through surface miners which entail blast free selective mining with minimal damage to environment. Till December FY 2024 surface miners produced nearly 298 million tonnes (MTs) of coal which is 58% of the entire OC output during this period. Growth over last year's same period was a robust 13%. We are planning for more proliferation of surface miners. In yet another eco-friendly step, CIL is adopting blast free OB extraction through vibro-rippers which extract overburden without blasting.

Inpit crushers already operational help reduce the movement of dumpers, minimizing diesel exhaust and lessening air pollution. Our energy efficiency measures introduced in FY 2021 through use of LED electrical equipment resulted in CO_2 emission reduction to the tune of 93,200 tonnes till December 2023. For two consecutive years CIL's greening efforts through plantation exceeded the targets much ahead of the fiscal's closure in October itself. CIL's efforts for setting up 3000 MW of green energy through solar plants by FY 2027 is moving ahead at a brisk pace. Some of the major sustainable practices while mining coal include control of pollution of air, dust, noise, water, effective utilization of mine discharge water, segregation of sand from overburden material, development of eco-tourism parks etc.

As long as demand for coal sustains we shall mine it with a keen eye on environment.

What are the key advantages of underground mining compared to open-cast mining and how do you see this trend developing? What are the challenges?

UG mining offers ample advantages compared to opencast means. CIL has embarked upon an ambitious and aspirational target of producing 100 MTs of coal through underground mines by FY 2030. There are two reasons for this. Firstly, UG mining is environmentally cleaner, minimally invasive on land, avoids displacing large strips of forest cov-

er and land acquisition and its degradation. UG mining leaves agricultural land undisturbed and importantly is society friendly as it does not dislocate people en-masse which requires rehabilitation and resettlement. Traditional livelihood is not lost. Experience indicates that UG mining has minimal or no impact on water pollution, ambient noise levels are significantly lower, it leaves surface features and fertile top soil intact. Also, just transition costs of OC mines are that of UG mines. Secondly, the focus on ramping up output through UG mines, to supplement OC production in the wake of expanding energy demand, has also become a necessity. Because, some of large OC mines may reach their ultimate pit level at some point in near future. Comparatively, carbon-di-oxide equivalent emissions in UG mining are lower by around 24% than OC. Also, UG coal is qualitatively better and helps reduce imports of higher grades of coal on which the Nation is keen.

UG mining is surely challenging. But, what makes UG mining workable now is availability of domestic equipment manufacturers, well trained skilled operators, outsourcing to contractors and efficient mine developers and operators, and proliferation of mass production technologies. This includes operationally flexible continuous miners suitable for Indian coal seams, implementation of high-wall mines, that bypass land acquisition, to improve percentage of extraction and exploit idle coal which otherwise would be lost forever in the discontinued and running OC mines, planning high capacity UG mines through digitalization and punch entry method for extraction of UG coal at low cost through existing infrastructure. Paste fill technology which in contrast to conventional sand stowing uses fly ash to fill mine void in UG mines. While mining can proceed without disturbing surface contours the menace of fly ash disposal is also taken care.

Another advantage is bulk of coal deposits are amenable for UG mining. CIL is also revisiting 34 discontinued UG mines to unearth their locked up coal assets. LoA has been issued for 17 mines having 27.5 MT/year capacity and these mines will contribute from FY 2026. Others are under progress.

Could you discuss the role of Coal India Limited in facilitating the adoption of advanced mining technologies in the Indian coal sector?

With mining processes becoming more and more tech driven, adoption of advanced technologies is not merely a matter of choice but an absolute necessity for increased productivity at reduced operational costs. Also, to stay ahead of the emerging competition. CIL is precisely doing that. Digital technologies and automated process are gaining traction in the mining industry over the past few years. They offer opportunities in maximizing the output at minimized costs. They also help reduce equipment and labor costs, minimize set-up time, reduce downtime, and improve worker health and safety. In a first of its kind venture, CIL has formally engaged a consultant for complete digitalization of 7 select mega opencast mines of the company for accelerated performance using latest data analytic technique to raise mine productivity and efficiency. To address the environmental challenges, CIL is investing in research and development of innovative technologies.

Collaboration is key to meeting the challenges of modern mining industry. Association between mining companies, academic institutions and governments drives innovation in the mining ecosystem. Artificial Intelligence, drone technologies are increasingly becoming critical in an ever-changing industry. Suiting to its geo-mining conditions CIL is adopting these technologies. CIL holds the distinction of deploying India's first private 5G in coal mining at Amlohri project of NCL. Using 5G powered drones for aerial surveillance, monitoring and data collection ensures enhanced safety and operational efficiency in coal mining.

What initiatives is Coal India Limited taking in Coal beneficiation in view of environmental impact of coal?

Separating inorganic impurities from raw mined coal has a dual advantage. The process improves combustion characteristics of fuel and importantly leads to less adverse impact on the environment. In case of non-coking coal, CIL is planning Deshaling plants for quality enhancement. In an indication

of improved coal quality supplies, grade conformity has improved to 75% till December of current financial year compared to 70% of the same period year ago, as per the result of third party sampling agencies. In addition to the existing two third party sampling agencies, we have included 10 more agencies. CIL is also using mobile crushers for supply of sized coal. Online ash analysers are being procured for real time coal quality assessment.

In case of coking coal, whose resources are scarce in the country and even whatever reserves are available are of depleted quality, CIL is establishing new washeries and renovating existing ones where possible to increase washed coal production. Aligning with 'Mission Coking Coal' launched by the Government of India to boost indigenous coking coal CIL is aiming to ramp up the production of this variety of coal to 105 MTs by 2030. And also concurrently planning capacity expansion to produce around 8 MTPA of washed coking coal at 18% ash percentage by that time through 11 coking coal washeries of which 3 have already been commissioned. Of the remaining 8 washeries, 2 are under construction and others in various stages of progress.

How does Coal India Limited plan to align with India's commitment to reduce carbon emissions and transition towards a more sustainable energy future?

In addition to the measures to curb emissions which have elaborated in detailed earlier, proliferation of plantation in mining areas has been a major success. This helps in carbon sink. In October itself CIL's plantation over 2,270 Hectares, including grassing, has achieved 125% of the annual target of 1,820 Ha. This is for the third consecutive year that we have achieved this feat.

Can you please elaborate on the collaborations and partnerships that Coal India Limited is engaged in, both domestically and internationally, to enhance coal mining practices?

There are quite many but important ones are under Digi Coal. CIL has formally associated with Accenture Solutions Private Limited for complete digitalization of 7 select mega opencast mines of the company for accelerated performance using latest data analytic technique to raise mine productivity and efficiency. There are several joint ventures relating to coal gasification, setting up thermal power plant, laying railway lines etc.

CMPDI has a set of collaborations like MoU with Commonwealth Scientific and Industrial Research Organisation (CSIRO), an Australian Government agency for research cooperation; agreement with United States Environment Protection Agency (USEPA) on improving inventory approaches to Estimate methane emissions from OC mines; MoU with Jharkhand for identification, exploring and developing mineral blocks in the State with a similar tie up with Arunachal Pradesh as well. CMPDI is also associated with Mineral Exploration Corporation Limited for carrying out exploration activities in coal blocks and blocks of other mineral commodities.

As India diversifies its energy sources, what strategies are Coal India Limited implementing to remain a competitive player in the energy market?

CIL's core competence is mining and marketing of coal and this would remain its anchor role. But to stay ahead of the competition it is imperative for an organization to adopt to the changing business climate. To remain relevant in the energy market of the country, CIL is primarily focusing on thermal power plants, coal gasification projects and creation of solar power capacity. The first two endeavours have recently received the Union Cabinet's nod.

Of the two thermal power plants, one is through joint venture mode between SECL and Madhya Pradesh Power Generating Company Limited for the development of a 1 x 660 MW Supercritical Thermal Power Station at Amarkantak. The second one is a Supercritical thermal power plant being set up through a special purpose vehicle (SPV) in Sundargarh, Odisha called Mahanadi Basin Power Limited (MBPL) of 2X800 MW capacity. CIL has commenced the exercise of initiating power purchase agreements with State Discoms. The first MoU has been executed between CIL and Assam Power Distribution Company Limited for the purchase of 1200 MW of power from the proposed MBPL Power Plant.

Under coal gasification the focus is on two products. Synthetic Natural Gas (SNG) and Ammonium Nitrate (AN). CIL's surface coal gasification plans include conversion of coal-to-chemical derivatives like SNG where downstream production of value added chemicals, which are otherwise produced through imported natural gas or crude oil at enormous cost, is well established. SNG is suitable for manufacturing of hydrogen and basic chemicals such as ammonia, methanol, substitute natural gas, CTL (coal to liquid) as reduction gas in steel industry etc. It can also be used for production of electric power.

Pursuit of AN is to meet the requirement of explosives in house which CIL uses in large quantities. Under Atmanirbhar Bharat CIL is setting up a 'Coal-to-Ammonium Nitrate' Project at Lakhanpur, Odisha as a joint venture with BHEL.

As explained earlier, setting up solar power capacity of 3,000 MW lists high on CIL's diversification initiative.

Lastly, what is your vision for the future of coal in India, and what message would you like to convey to our readers among the mining community, policymakers, and stakeholders regarding the importance of coal in India's energy mix?

Coal will continue to fuel India's energy requirements for at least next three decades. India is committed to improve its renewable energy capacity and is ranked 4th globally. But till the time renewable energy sources come up in a big way, coal shall shoulder the country's energy aspirations in the foreseeable future. Like I said earlier, though renewables are increasing their share in the overall energy mix, so is the energy demand of the country. Coal meets that additional demand. Surely, coal's role in percentage terms may diminish in future but in absolute terms we may expect increase before it reaches a plateau. The argument should not be coal versus renewables but the action should be on coal and renewables as all available energy sources will be required to reach the developmental goals of the country. Especially, at a time when India's growth is upbeat and it is racing towards becoming a $ 5 Trillion Dollar economy.

PERSPECTIVE PIECE

A JOURNEY THROUGH THE PAST AND FUTURE OF UNDERGROUND COAL MINING IN INDIA

Dr T. N. Singh[1]

Historical Insights

The history of coal mining in India spans over 250 years, commencing in 1774 AD in the Raniganj Coalfield, where coal deposits were observed to occur on the surface near riverbeds. Grant Heatly and John Sumner started underground mining at locations such as Ethora and Chinakuri in the south-western part of the Raniganj Coalfield, employing the British conventional bord and pillar method to extract coal. Located north of the Damodar River, these coal mines showed minimal environmental impact, with underground operations to the south. Despite encountering weathered coal outcrops, coal extraction gradually increased with pillar formation in various mines. The introduction of steam engines for railways further increased the coal demand. The railway service commenced in 1846, connecting Bombay to Thane, followed by the East India Railways operating on the Grand Chord from Howrah to Banaras in 1862. The British Government, prompted by the National Movement of 1857, took control and recognized the pivotal role of railways in fostering rapid development. The Bengal Iron Company initiated steel production at Kulti and Ramnagar in 1896, serving as the foundation for the Burnpur plant of the Indian Iron and Steel Company. Railway line extensions were undertaken in 1894 to connect Barakar, Katras, Kusunda, and Patherdih to the mining belt. The Midnapur Bhojudih line, constructed in 1901, offered an alternative route for coal transportation. These activities relied on coal from the mines of the Raniganj coalfield. In the late 19th century, Jharia Coalfield emerged as the storehouse of superior coal quality in upper seams under shallow depth cover. While producing a modest 1500 tonnes of coal in 1894, Jharia became integral to the growing trends of industrialization and railway line development. The concentration of mining activities in the Damodar Valley basin indicated Raniganj's prominence, with Jharia coalfield poised for future growth as a source of high-quality coal.

With the advent of steam locomotives, the annual coal demand in British India surged to 1 million tonnes in 1853, escalating to 6.12 million tonnes by 1900, inclusive of 0.6 million tonnes from Jharia. Initially, the Jharia coalfield's production was amalgamated with the overall coal output. The Geological Survey of India, established in 1851 for mineral exploration, uncovered coal in Khammam district in 1871 under Dr King's leadership. Mining rights in Yellandu were acquired by the Deccan Coal Company Limited in 1886, initiating underground mining using the bord and pillar method, thereby contributing to coal production. By 1900, various companies, including British, Gujarati, Marwari, and Panjabi entrepreneurs, were actively involved in coal production. The underground mining operations, characterized by stable pillars supporting the surface and limited-size bords, continued without significant environmental disruption. Mining activities persisted beneath dwellings and forest cover until 1915. During World War I, the demand for Jharia coal surged to 12 million tonnes, surpassing the 9 million tonnes of Raniganj coalfield due to its superior quality.

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However, the reported figure was manipulated, as the government acquired prime quality Jharia coal at low prices, prompting mine owners to produce unaccounted medium-quality coking coal for the free market. This manipulation led to the first wave of slaughter mining in the Jharia coalfield, where pillars were trimmed, bords widened, and working heights increased to meet the demand of British machinery. Random mining practices were adopted in various sections underneath. After the war, coal demand dropped below 13 million tonnes in 1934. Neglect from mine owners resulted in surface subsidence, fires, and disturbances in dwellings within the coalfield.

The next surge in coal demand commenced in 1937, predating World War II, driven by urgent activities associated with steel production, ship movement, and arms manufacturing. Mining operations, ranging from small-scale leases to vast expanses covering hundreds of acres, adopted a uniform method that yielded 29 million tonnes of coal by 1942. Given the British control over high-quality Jharia coal, medium-grade coal seams were haphazardly exploited to meet local industry demands. This approach led to surface destabilization, deforestation to fulfil timber needs for supporting widened bords, and extraction of thick seams up to a height of 8 meters, causing extensive environmental and ecological damage in the Jharia coalfield. Post-war, a sudden decline in demand resulted in neglecting mine maintenance, and over 110 patches caught fire. Substantial surface subsidence occurred beneath dwellings, accompanied by widespread deforestation to satisfy the timber requirements of the mines. In other mining fields, pillars were systematically formed in most seams up to depths of 200-250 meters. During the lull period from the early 1940s, mines focused on dip drives to explore leases, resulting in limited coal recovery, and virtually no patch remained untouched by the time India gained independence in 1947.

Post-Independence Mining Scenario

Following India's attainment of independence, the coal mining sector experienced a period of stagnation due to a sluggish demand for coal. The majority of coal mines, ranging from small to large leaseholds, were reliant on manual pick mining and basket loading. This was a consequence of the financial hardships faced by mine owners, who were unable to invest in technological advancements. In 1947, the national coal production stood at a mere 30 million tonnes. The turning point came in 1954 when the nation embarked on a growth trajectory outlined in the Five Year Plans, focusing on industrialization. This surge in industrial activity led to a significant spike in coal demand. Subsequently, the bord and pillar mining technology evolved to incorporate explosive energy for coal fragmentation. Rather than employing coal cutting machines with undercutting techniques, a solid blasting method emerged. Some mines adopted innovative equipment such as side discharge loaders and load haul dumpers for loading coal into tubs. These technological advancements partially contributed to enhanced face production and overall productivity in the coal mining industry.

With the beginning of the first five-year plan, coal production experienced a notable increase of 33 million tonnes, exclusively sourced from underground pillar mining. In 1956, the National Coal Development Corporation (NCDC) was established as a Government of India Undertaking, taking control of collieries previously owned by the railways. The primary objective of the NCDC was to enhance coal production through systematic and scientific development of the coal industry. The Singareni Collieries Company Limited (SCCL), operational since 1945, transformed into a public sector undertaking through a joint venture between the Government of India and the State Government of Andhra Pradesh (now Telangana) after 1956. Between 1950 and 1953, some mines in West Bengal and erstwhile Bihar (now Jharkhand) initiated longwall operations, while others employed pick mining and timber support in the mines. In 1966-68, four longwall faces were commissioned in the Raniganj coalfield using coal cutting machines and blasting cycles in Banshimulia, Rana, and Dhemomain seams.

The XV seam of the Jharia coalfield also witnessed the introduction of several longwall faces during this period, with an average daily production of 100 to 150 tonnes. Bhanora and Jamuria mines, during the same timeframe, initiated longwall operations using the Anderton shearer with 20-ton/40-ton hydraulic support on the face, achieving a daily production rate of 200-250 tonnes. Recognizing and supporting these efforts, the Government of India established the Mining and Allied Machinery Corporation Limited (MAMC) in 1964 at Durgapur. The corporation aimed to manufacture mining equipment under the technology transfer from Dowty Mining of Britain, the primary supplier of pit props and chocks at that time. Although a prudent decision, financial imbalances hindered the sustainability of the companies, leading to a failure to enhance production. In the Chinakuri and Perbelia mines, the Dishergarh seam was worked in two slices, with the bottom employing longwall mining with stowing, while the top slice utilized the bord and pillar method. Chinakuri, a cluster of three pits, employed both pillar and longwall mining in conjunction with stowing. In the late 1960s, Chinakuri Pit 1 introduced the Anderton shearer with friction prop/bar support in the bottom slice, complemented by hydraulic stowing. The top slice, meanwhile, utilized timber props set on a sand bed with a base plate. The National Coal Development Corporation (NCDC) embarked on numerous innovative trials aimed at enhancing mining technology for both surface and underground operations, conducted in collaboration with agencies from the United States, Poland, and France. Concurrently, the Geological Survey of India (GSI) had substantially established the coal resources of the country by this point in time.

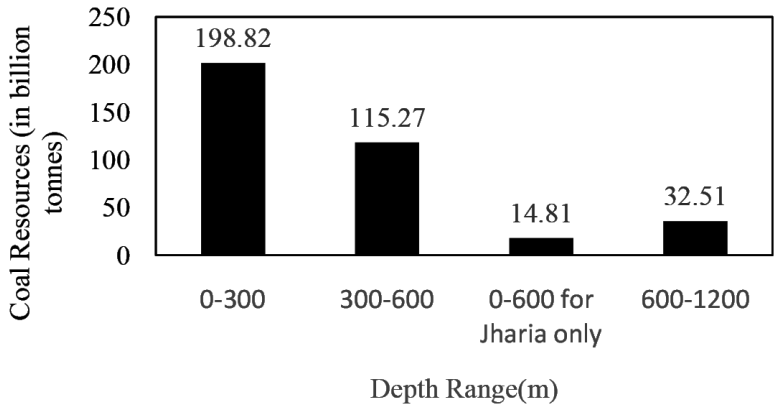


Figure 1 : Coal resources in India under different depth cover as on 01.04.2022

NCDC's Mining Strategies

NCDC aimed to extract thick, steeply inclined seams constrained by boundary faults. The ambitious Sudamdih Shaft Mine was planned in collaboration with Poland, with a targeted daily coal production of 7,000 tonnes, utilizing hydraulic sand stowing. Collaborating with France, the slicing of a 12-meter-thick seam with artificial roofing and friction prop support in the Sirka seam of Gidi Mine was planned. The first dragline in India was deployed at Kurashia Mine in the Chirimiri area in 1961 for extracting developed pillars. Churcha Mine set a production record of 100,000 tonnes per month through pillar mining. A trial was conducted to depillar coal seams beneath Kamthi aquifers in Chandrapur, addressing the concept of aquifer hazards in the coalfield. While most trials were technically successful, operational efficiency improvements were necessary to enhance production andproductivity. Table 1 outlines a summary of the mining options tested by NCDC.

Table 1 : Mining Strategies Explored by NCDC

Location	Method	Mechanization
Pillar mining in Churcha	Bord and Pillar development	Shuttle car, Gathering arm loaders
Depillaring in Bhurkunda	Depillaring with back filling+	Pneumatics Blastower
Longwall mining in Gidi	Inclined slicing in descending order	Artificial roofing and friction props under caving roof
Kazimierz Mining in Sudamdih	Horizontal slicing 22m thickIX/.X seam in ascending order	Stowing of goaf
Kamora mining in Sudamdih	Stall development	Hydraulic stowing
Yankowice Method in Sudamdih	Longwall mining of 7.5m thick seam in ascending order	Hydraulic stowing with timber support
Surface mining of pillars in Gidi Area	Developed pillars in dipping seams	Shovel dumper combination
Surface mining of pillars in Chirimiri	flat seam	Shovel dumper combination and draglines
Surface mining in Gidi mine	In dipping seams	External dumping of burden by Shovel dumper
Virgin seam	Flat deposit	External dumping of burden

Other Remarkable Initiatives

The Singareni Collieries Company Limited extended its domain of activities over Adilabad, Karimnagar, Warangal starting pillar mining of coal. Coal plough was introduced in pit 5 of Kothagudem in 1966 to extract developed pillars in conjunction with hydraulic stowing. Pioneering efforts were madefor mechanization during this period and Shuttle Cars, Gathering Arm Loaders, Conveyors, Road Headers, Load Haul Dumpers and Side Dump Loaders were tried on pillar mining face. Assam coalfield, a small pocket of tertiary coal deposit in moderate to steeply dipping thick and thin seams had its legacy of uncontrolled **"Bhaska Mining"** along with pillar mining in all the mines.

Nationalization of Coal Mines

Despite the nation's concerted efforts, coal mining faced significant challenges, with production limited to a mere 76 million tonnes and productivity stagnating at approximately 0.5 tonnes. The Jharia coalfield, the primary source of prime coking coal, grappled with extensive fires covering 17 square kilometers across 54 patches. Seams were haphazardly developed or depillared, leading to dire working and living conditions for miners. Not with standing the presence of steel plants like Durgapur, Rourkela, Bhilai, and IISCO, only the Bokaro Steel Plant was ready for steel production. Jharia's coking coal production stood at a meager 16 million tonnes. Consequently, in 1971-72, the Central Government decided to nationalize coking coal mines, excluding a few leases as captive mines for IISCO and TISCO. The stagnation in non-coking coal production was attributed to pillars developed up to 300 meters in depth, limiting the potential for depillaring technology in thick seam mining. In 1973, all mines, except for those of Singareni Coal Company and a few belonging to IISCO and TISCO, were nationalized. Amid the country's industrialization push in the 4th Five Year Plan and the looming energy crisis triggered by the Gulf War, the oil supply blockade by OPEC led to a fivefold escalation in oil prices. With coal facing various constraints, the government turned to the National Coal Development Corporation (NCDC) for guidance, exploring the possibility of increasing coal production through surface mines in short gestation periods. This became the gov-

ernment's top priority, prompting an examination of global leaders' experiences. The nation's coal priorities, considering these circumstances, were as follows :

1. Large production of powergrade coal for energy sector at the earliest,
2. Enhancement in coking coal production for steel plants, and
3. Superior grade non coking coal for meeting 4th Five-year needs.

In response to the stagnating production between 1971 and 1973, wherein an annual increase of only 2% was observed, there arose a necessity to choose a suitable mining method or option. Given that past experiences proved inadequate to address the current challenge, a careful evaluation of various mining options was imperative to overcome the crisis and boost production. To facilitate this decision-making process, a thorough analysis of resource estimates for different coal categories within the country was conducted. The findings from this exploration are briefly presented in Table 2.

Table 2 : Superior Grade Coals in Major Coalfields of India

Sl. No	Coalfield	Area (sq.km.)	Reserve (Bt)	Coal Quality
1	Auranga	250	3.0	Non coal -Superior
2	S Karanpura	195	6.0	Non coking Superior
3	N Karanpura	1230	15.9	Medium coking
4	West Bokaro	250	5.0	Medium coking
5	East Bokaro	208	7.1	Medium coking
6	Jharia	210	19.4	Prime to medium coking
7	Raniganj	1530	25.5	Medium coking-
8	Rajmahal	208	14.1	Noncoking Inferior
9	Singrauli	2202	12.9	Non Cokin Inferior
10	Sohagpur North	3000	4.5	Medium Coking
11	Sonhat	850	2.7	Semi coking
12	Bishram pur	1036	1.5	Non coking superior
13	Hansdeo Arand	154	5.0	Non coking Superiorw
14	Tata Pani	12	2.4	Non coking -superior
15	Korba	520	10.1	Non coking-Inferior
16	Mand Raigarh	506	19.3	Non coking-Inferior
17	Pench Kanhan	12	2.4	Non coking -superior
18	Wardha Valley	4130	5.7	Non Coking-Superior
19	Kamtee	95	2.0	Non coking-Superior
20	Godavari Valley	1700	17.5	Non coking- Mainly superior
21	Talcher	1813	39.6	Noncoking-Inferior
22	IB reiver	1375	22.4	Noncoking -Inferior

Table 2 reveals the presence of numerous coal blocks containing coking, medium coking, and superior-grade non-coking coal reserves, amounting to a total of 25 billion tonnes. These blocks have been extensively developed, reaching depths of up to 300 meters through pillar formation, depillaring in a random patchwork fashion, and longwall mining techniques, resulting in over 75% of the coal remaining underground. The potential for mass production through large-scale surface mining in these areas is limited due to the expansion of urban areas, clusters of residences, and the presence of infrastructure such as roads and railways, all of which have left the resources in a disturbed condition. However, certain pockets containing significant reserves of low-grade coal remain untouched. These areas offer an opportunity for rapid coal exploitation, particularly for the production of power-grade coal suitable for improved thermal power plants.

National Priority 1

The coal reserves with poor grades remained untouched till nationalization. These reserves, exceeding 10 billion metric tons, were located in barren surface conditions where land availability posed no significant challenge. The coalfields in Rajmahal, Singrauli, Korba, Mand Raigarh, Talcher, and Ib River basin were identified as having over 10 billion metric tons of coal under favourable conditions for surface mining. These coalfields contained substantial quantities of undisturbed E to G grade coal suitable for thermal power plants, and their minimal disturbance made them ideal candidates for surface mining operations, ensuring large-scale production with a short gestation period.

Surface mining was introduced in the US mines during the 16th century and experienced exponential growth, doubling every decade after 1850. By 2018, surface mining production had reached 620 million tonnes, achieving a remarkable productivity of 365 tonnes per man shift. The USSR entered the realm of surface mining in the 1860s, with the vast deposits in the Don basin in Southern Russia supplying 87% of the country's coal for the burgeoning demands of railways, and iron and steel industries. In parallel, India found itself in a similar situation and opted to initiate large-scale surface mines to meet the escalating demand for coal.

Surface Mining of Inferior Coal

The Moher basin underwent strategic planning by the P&D Division of NCDC, collaborating with Soviet experts, resulting in a master plan in 1973. The proposed mining approach involved employing a dragline and shovel-dumper combination across different blocks to extract low-grade coal from thick seams. Over the past five decades, the coal field has evolved into a robust network of mines spanning Madhya Pradesh and Uttar Pradesh, producing 70 million tons per annum and establishing the region as an Energy Capital. The Korba Coalfield, housing substantial reserves of power-grade coal in flat seams, was slated for the next trial of surface mining at the Kusmunda mine with a planned annual production of 50 million tons by 1987. The Gevra mine, initiated in 1989 and currently yielding 35 million tons annually, contributed 73.5 million tons of power-grade coal to the region's power plants in 2010. The flat seams of the coalfield favor a shovel-dumper combination for extraction, with simultaneous surface reclamation and rehabilitation efforts. Ib Valley Coalfield operates three major open-cast mines - Lajkura, Samleswari, and Lilari - with production escalating from 0.55 million tons in 1972–73 to 15.51 million tons in 2002–2003. The Rajmahal open-cast project, also known as Lalmatia Colliery, initiated in the 1980s through Canadian collaboration, presently produces 10.5 million tons annually, meeting the demands of the Farakka and Kahalgaon Super Thermal Power Stations. The Ramgundam OC III consistently produces an average of 6 million tons of coal annually. Talcher coalfield in Odisha has witnessed the establishment of several surface mines focused on producing power-grade coal. Notably, the surface mine coal production in 2021-22 reached 745 million tons, significantly contributing to the support of thermal power stations and addressing the energy crisis.

National Priority 2

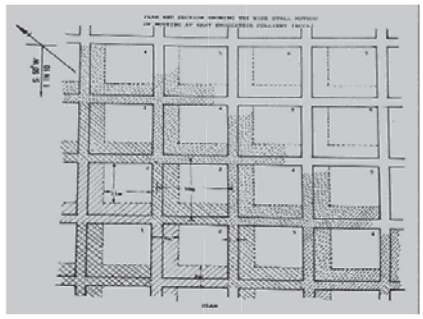
The nation's immediate focus was on meeting the demand for coking coal in steel plants and allied industries. Jharia Coalfield in India stands out as the sole repository of prime coking coal, found in the top nine seams (XVIII to IX). The Barakar formation, which serves as the primary coal-bearing stratum in the basin, exhibits a thickness ranging from approximately 1,035 to 1,250 meters, limiting exploration to a depth of 1,200m by the Geological Survey of India. The formation is exposed in the northern periphery of the coalfield, exhibiting seam gradients between 7 and 80. Notably, along the 1500m throw boundary fault, gradients escalate to 30 to 70. Consequently, coal seams extend beneath the Barren Measure, and extraction has predominantly focused on the Prime coking coal horizon, with minimal efforts to access the quality coal reserves in seams 0 to VII/VIII. Extensive development of coking coal seams on pillars covers an area of nearly 110 sq.km, extracting 10 to 15% of the total coal under specified conditions.

1.	Dwelling and industrial complex	47.06 sq.km
2.	Fire area	17,32 sq.km
3.	Under waste rock burden	6.31 sq.km
4.	Abandoned surface mined ditches	4.36 sq.km
5.	Subsided area	34.97 sq km
	Total	110.02 sq.km

Thick seams were developed on pillars along the floor or in sections and there was no technology to maximize the coal recovery from such conditions. Jharia town itself has 110 tonnes of coal per sq.m area including 54 tonnes of coking coal but the effort after nationalization was only to split the oversize pillars or heighten the bords to full seam thickness for improving the recovery from 10% to 20%. An ambitious scheme was conceptualized at this juncture to introduce large scale surface mining in Mukunda block in collaboration with USSR for extracting all the seams up to 500m depth. Despite all the efforts, the project was abandoned because of the non-availability of land.

Wide Stall Mining of Thick Seam

Pillars in East Bhagatdih mine of BCCL were developed along the floor in a section to 3m height forming 3.6m wide bord in IX/X and XI/XII seams underneath Jharia town, recovering just 10-12% of prime coking coal. An effort was made to maximize the recovery of coal in over 16m thick VIII/IX seam with minimum damage to environment, ecology, and safety of the overlying infrastructure facilities with the support of BCCL. The method "Wide Stall Mining" in conjunction with hydraulic stowing was developed by physical modelling in CMRI and was tried with 6m wide bord compared to 3.6 m bord width in slices to full seam thickness leaving the pillars of size intact (Figure 2) instead of splitting of the pillars by driving 3.6m bord and making the stooks unstable because of high slender ratio required widening of the existing bords to 9m, supporting the face with timber and steel props, and leaving the 21 m size pillar to support the burden with over 1.5 safety factor.



Plan

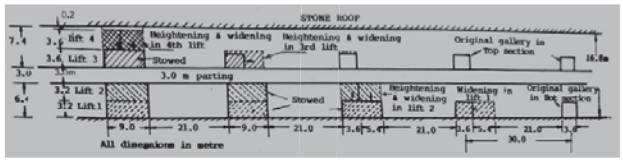


Figure 2 : Wide stall mining underneath Jharia suburb

The mining parameters of the experimental site is summarized below

Seam thickness	VII/VIII seam 16.5 m thick
Depth cover	90-120m
Pillar size	30□30m
Bord size	3.6m
Seam development	3.6m along the floor and 2.4m above the parting
Surface constraint	Office, dwellings and different infrastructure facilities

Over lying X seam, 43m above was developed in pillars and was used to monitor the subsidence if any because of the proposed stalling. The recovery from the thick seam was maximized from 12% to 45% with complete safety of the surface. Average monthly production from the panel in 1986-87 was only 892 tonnes that improved to 1556 tonnes in 1990-91 when the working in full sequence of four slices was started. All the 8 panels of the block were successfully worked with good production, safety and recovery within 4 years and the strata condition, support system and subsidence etc. were monitored by the funding from the Ministry of Coal, Government of India.

The wide stall mining option was subsequently tried for mining thick seam underneath Barunga Hill of Chirimiri, where the seam was developed on 4m bords in two sections along the floor and roof. The bords along the roof were widened to 8m and the roof was supported by rope stitching. The coal from the bottom bord was blasted to full seam thickness. The pillar side was supported by rope stitching and the coal was hauled by load haul dumper. The stall safety was monitored with the remote recorded convergence meters and working was under safe condition with high support from the stall. It appeared very promising, but the trial was terminated midway because of the damage of the roof stability monitoring system.

Hydraulic Mining of Developed Pillars

Many options of hydraulic mining of coal havebeen successfully employed in USSR and China and one of them was successfully adopted for soft coal mining in Germany. The same equipment was transferred in collaboration with Germany for depillaring of thick hard X seam at Gopalichak colliery, BCCL (Figure 3) as an alternative to the con-

ventional system. In the method, fragmentation and transport of the coal is possible by a water jet of 5000psi (351.535kg/cm2) for fragmentation and flow of coal in hopper conveyor by water flowing from the district. The compressive strength of X seam coal was over 270 kg/cm^2. The experimental extraction was carried out in three phases. In the first phase of trial, the pillar was split into two parts to be recovered on retreat with monitor on either side of the stooks. The monitor failed to cut coal even up to 3 m distance and flushing of blasted coal was not possible beyond 5-6 m. The roof convergence was up to 5mm, load on support was nearly 10 tons and recovery was up to 40%. In the second phase, the pillars were split in three stooks of less than 5 m thickness. The proposal was to blast the coal and flush out loosened coal by the monitor. The stooks at this stage were under pressure and started yielding. Maximum convergence up to 102 mm and load on hydraulic props set in different split galleries reached up to 40 tonnes during this trial. The level of recovery remained below 20% due to stress concentration over the stooks. In the third phase, the panel was developed in virgin patch by forming four rectangular pillars. In this experiment, the maximum convergence was within 12 mm and load on supports was within 14 tonnes whereas level of recovery improved to 65%.The method in respect of high quantity of water, energy and other constraints was not acceptable and was abandoned.

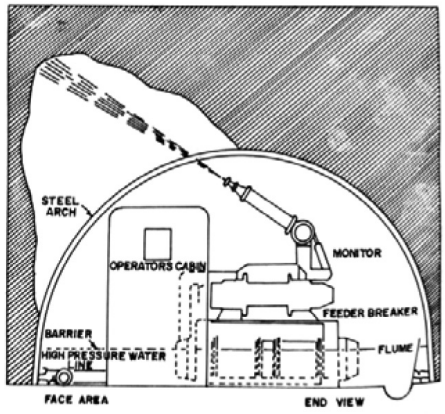


Figure 3 : Hydraulic mining trial in BCCL

Blasting Gallery Method

The basic principle of this method was to recover the coal of thick seam by drilling and blasting around galleries (rooms) located in the bottom of the seam at regular intervals and recover the coal by Remotely Controlled Load Haul Dumper. This technology was developed by Cartonnage de France for extracting coal blocked in between a set of faults. The soft coal was loosened by ring hole blasting and hauled by load hall dumper in Aquitaine Coalfield. The method was further improved by the development of the remote-controlled Load Haul dumper for hauling the blasted coal.

This method was first introduced in East Katras and Chora Mines in India. Nearly 7.5m thick X seam was developed on pillars in two sections 2.8m along the floor and 2.10 thick section under the roof with bord 4m and pillars of 23m x 23m. The pillars were splitted in two halves by 4.2m wide bord of 3m height, the bords supported by 40 ton friction props. Pillars were extracted on retreat by ringhole blasting, extracting blasted coal by remote controlled LHD feeding to armored chain conveyor. Jumbo drills were used to drill 3 to 6 rings of holes of 5m length. The galleries were supported by 40 ton hydraulic props at 3m interval and cogs with steel cross bars. The layout of the face is shown figure 4.

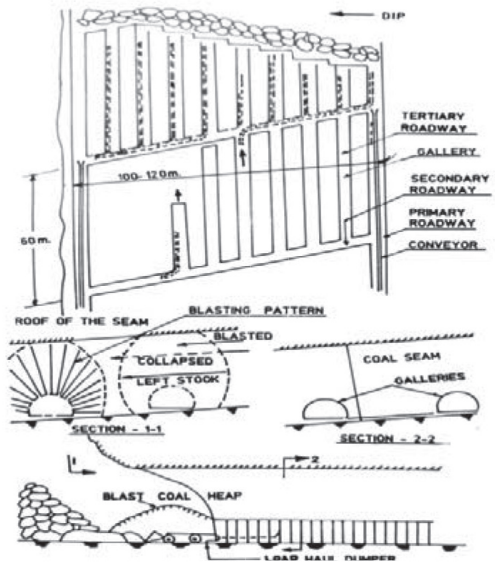


Figure 4 : Blasting Gallery Trial at East Kataras Colliery, BCCL

Production from each set of blasting was 125 tonnes, recovered on average 100 tonnes. The option had frequent stoppage due to LHD malfunction and strata control problems and was terminated without proving its future prospect.

Longwall Mining in East Kataras

In East Kataras colliery, a fully mechanized longwall panel was introduced for mining of 7.5 m thick seam under 147 m depth cover in collaboration with France. The face of 100m length and 210m long panel was equipped with shield support amenable for sub-level caving. The panel was divided in three phases for studying the feasibility of sub-level caving and integral caving. The working was 1) Longwall mining of 2.5 m thick top section along the roof for the first 90 m, 2) Extraction of the 2.5 m bottom section along the floor for the 90 m for sub level caving of the remaining 2.5 m thick middle section coal lying below broken overlying strata, and 3) Extraction of a 2.5 m thick bottom section for the remaining 120 m length with an integral caving of the 5.0 m thick top coal bed under intact strata. Caving of sub-level coal had mixing of stone while during the integral caving, coal flow was normal.

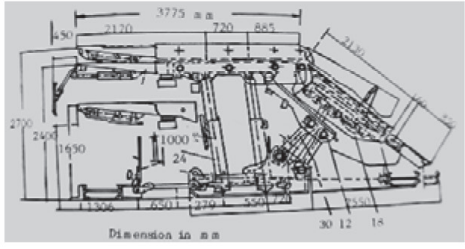


Figure 5 (a) : Shield support used in East Kataras

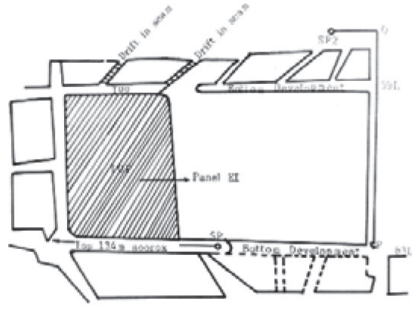


Figure 5 (b): Longwall panel development

Surface Mining in the Jharia Coalfield

Despite these trials, the performance of BCCL was not satisfactory because of thick seam, surface constraints and the production was stagnated at 16 mt with productivity around 0.41. The company incurring heavy loss thought of a large scale surface mining and Mukunda Project, Block IX was selected for the purpose in collaboration with USSR for extracting all the seams within 500m depth cover,

with concurrent reclamation and rehabilitation of the mining area.

Mukunda Surface Mining Project

The project was planned for the extraction of 313 mt prime coking coal, 273 mt medium coking coal and 634 mt superior quality non-coking coal from a block of 13 sq.km area, extensively developed thick seams on pillars, randomly depillared in patches and a few patches on fire. It was planned to decoal the area concurrently back filling the void, reclamation and rehabilitation with due care to environment and ecology and with annual coal production of 12 million tonnes. As per the experience of surface mining in Singrauli and other fields, it was likely to ease the problem of coking coal scarcity with high production and productivity within a short gestation period. The project required land free of dwellings by rehabilitation of 43,825 villagers and 13,901 employees of the company living in 13 villages and a few clusters within 13.6 sq.km area. The problem could have been solved by shifting the employees to newly coming up company township, and the villagers could have been rehabilitated taking the land from the private dwellers on lease for a definite period of 15 years, compensating their survival during the period and rehabilitating them thereafter. The alternative was compensation in terms of employment on land basis that was a common practice for depillaring underneath farms etc. None of them could be accomplished and the project despite the preparedness of the World Bank, Collaborators and the Government failed to make a start.

Scope of Small Surface Mines

Disparately looking for some way to improve the production of coking coal, BCCL thought of surface mining in and around some underground mines, where the land acquisition one to one was a common practice. Taking into account all the conditions and the experience of Mukunda mine planning, the following mines in different blocks (Table 3) were identified for small scale surface mining to improve the production of quality coal including coking coal. These mines were proposed to work to 250m depth cover extracting developed pillars and virgin seams of non-cokingcoal with concurrent internal dumping of the burden and reclamation of land.

Table 3 : Surface mining planned in different blocks of BCCL

Sl. No.	Name of the Mine/Area	Area (sq.km.)	No. of villages	Quality wise coal reserve in mt		
				Prime coking	Medium coking	Total
1	Mahuda basin	6.0	---	0.5	12.0	12.5
2	Madhuban, Keshargarh, Benidih, Nadkarki	9.6	5	15.0	0.3	15.3
3	Maheshpur, uraidih,Barora, Dumara Khas, Sinidih	14.0	6	17.0	1.0	18.0
4	Gobindpur, Kuridih, Agardih, Teturia, Dharmabandh	11.0	8	35.0	17.0	52.0
5	Kustore, Rajapur, E Bhaggatdih, Dobari, Kukurthopa, Fatehpur, N Kujama	13.0	4	31.0	39.0	70.0

Nearly 400mt coal could have been extracted from these mines including over 250mt of coking coal. Unfortunately, most of the mines are working within 100m following coking coal seams and with external dumping the burden, creating blots on the face of the coalfield.

Caution

These blocks were planned to decoal major portion and reclaim the land by extracting all the seams irrespective of coking or non-coking coal but in the interest of quick result in favor of the company facing financial challenge confined their working to coking coal horizon and improving the production from lowest 16 million tones to 36 mt of coking coal and productivity from 0.4 to an average productivity above 1.5. The depth was wisely decided with a view to decoal a section and concurrent backfilling at minimum cost and without looking for land outside for burden dumping but decrease in depth that resulted in leaving some seams underneath for mining in future. As a result, life of the surface mining blocks is reduced to half, acquisition of land nearby became necessary and the possibility of winning lower quality seams underneath has become difficult.

Scope of Prime Coking Coal Underground Mining

While thinking of an alternative mining option the resource position was to be perused where intensive mining had been in progress since last 100 years. The working zone limited to 210 sq. km, had 326 mines, 5 towns including Jharia and Katras and large concentration of villages in the mining areas, cultivated land, fire and infrastructure like rails and roads. The surface mining is helping in controlling fire, which is now claimed to be within 9.5 sq.km but the fire in shaly burden dump is showing distorted picture of the area. The surface occupation for dwelling was however increasing, posing serious problem in the field. First effort to control urbanization within the coalfield was made in early 1960's when the directives came not to allow any new construction within Jharia Town. It remained on the papers and the urbanization all around over Kusunda, Kataras, Sijua, which was completely ignored. Despite decrease in forestry and farming, the obstruction has increased with increased urbanization because of the prosperity of the mine workers. Even the Gugnanai Committee constituted by the government after the nationalization suggested restricting urbazination and housing in the active coalfield, but nothing could be done. Under by the condition the way out is underground mining - a) partial extraction of the coal from the pillars under the surface features, b) extraction of thick seam with sand stowing and c) exploitation of deep seated coal below 300m depth cover, possible by longwall mining.

The future of the coalfield after the exercise of surface mining has the following reserve of coal within 300m depth cover under following constraints. For improving the coking coal production, mainly XV to IX seams were extensively worked even up to the date of nationalization. In most of the mines 11774 mt medium coking coal was normally left underneath. Even the coking coal seams were randomly worked, leaving major portion below different constraints.

Coal locked due to technical reasons	18%
Coal locked under fire	9.4%
Coal locked under surface constraints	31.3%

The coalfield has well developed 18 seams out of which 9 were developed to thickness and many by coalescing formed combined thickness to 35m. Extraction of such thick seams posed technical challenges and were worked in sections invariably in conjunction with stowing under surface features. Seams up to 8m were worked by timber props and cogs during 1930's with mass production during the World War crisis. Leaving aside these efforts; treated as a part of "slaughter mining", following experimental trials were undertaken during 1980's after the nationalization of the coal mines.

Methods for mining thick seams

Three trials for mining of thick seams were initiated in BCCL during 1980's, covering domain of protected surface features, caving of developed

pillars and longwall mining, sublevel caving and integral caving of thick seam. None of the options survived for next trial with improvement/ modification because of the lack of initiatives of the management.

1. **The wide stall mining of 12m thick VII/VIII seam.**

   It was a technical success, and 8 panels were worked without any surface movement. It required improvement/ modification to improve production and productivity by using improvised coal cutting machines and support. But no effort was made in this direction because underground mining as such was taken as the technology of the past by the planners.

2. **Blasting gallery trial**

   While the trial demonstrated technical success, its failure was attributed to operational deficiencies.

3. **Hydraulic mining technology**

   It failed due to shortcomings in the planning phase, specifically in the selection of a low-pressure jet.

4. **Fully mechanized longwall mining**

   It was a failure because of the defective experimental site.

Until the nationalization pillar mining was effectively confined to depths of up to 250 meters, with the exception of Sudamdih Shaft and Moonidih mines. No incline or shafts extended beyond 300 meters in depth, leaving substantial untapped reserves of coking coal within the 300-600 meter depth range.

Extraction of Coal Below 300m Depth

The seams in Jharia coalfield have tendency of thinning with depth and within 300-600m depth cover all the coking coal seams below XVIII are present to workable thickness with estimated 2415mt prime coking coal and 2154mt medium coking coal. Prime coking coal below 600m is very limited; proved 89 mt and indicated 653 mt. Obviously, major reserve of prime coking in virgin seams within 300-600m depth should be the zone for active mining to meet the demand of the prime coking coal. This zone is geologically very disturbed in respect of frequent intrusion of dolerite/lamprophyres dykes and also disturbed under the influence of Madhuban, Jamadoba, Kapuria and Sudamdih faults.

Longwall Mining in Moonidih Area

Moonidih area is an extension of the Barakar Formation in the western part of BCCL where the quality seams are overclaimed by Barren Measure because of 7° dip of the beds. The mining in the area was projected by NCDC in 1964 and 545m deep shaft was completed before the nationalization of the mines. First longwall in the mine was started in 1.8m thick XVIII seam in 1973 under depth cover of 400m in collaboration with Poland. The face was supported by 40 ton friction props, coal blasted on the face conveyor to bunker for hauling to surface in tubs. The mine had the first fully mechanized longwall face of 150 m length in 1980's used Dowty chock shield support of 280 ton capacity ranging drum shear and armored face conveyor. The system was performing well, producing just 400 tonnes of coal per day, being the training period for the technical man power. Subsequently Kopex 6-legged chock shield of Polish design with ranging drum shearer and AFC was also introduced in the mine.

The coalfield is traversed by intensive faults and faces had to cross two such faults of 0.8m and 1.2m throw which was an experience in itself when the face worked just in stone, which was drilled and blasted and another face had serious problem while crossing agallery in front of the face.

Seeking the permission of the officials I refer the remark of the face In-charge when apprehending the problem because of the excessive convergence with the thining of the coal rib. His reply was very encouraging "Sir this support is an elephant, capable to cross any hurdle". The hurdle was real within a week when 22 chocks surrendered because of the increase of load with liquidation of the rib. Next was the remark of the General Manager of the mine when the retrieval of the supports was in

progress in the presence of DGMS officials,"these supports are very valuable and not able to recover them will prefer to resign and go out". In fact the type of problem and low face production was faced by the US Mine operators when initiated longwall technology in 1950's but without getting-disheartened they tried and succeeded in the customization of the longwall technology. The result of their progress is summarized in table 4.

Table 4 : Average performance of US Longwall faces

Year	Number of faces	Average daily production (tonnes)	Productivity per man shift
1950	4	100	4
1960	10	300	8
1975	50	601	30
1985	115	2320	64
1990	72	4350	120

In the year 2010 CONSOLE Co. operating 16 longwall faces in No 8 seam in Pittsburgh area produced 2.8 to 3,5 million tonnes per face by increasing the cutting power of the shearer to 1100 hp and capacity of the shield support to 975 tons. At a time, the technology was challenged by the surface mining when they introduced continuous miners with mobile conveyor and mobile bolting machine and increased the number of headings optimized to 3 for panel preparation. The experience of the British mines was nearly the same when the production starting from 743 tonnes in 1982-83 increased to 1570 tonnes in 1989-90.

Contrary to this the only fully mechanized longwall face of Coal India in Moonidih mine within last 30 years, worked in 15 longwall panels, at a time deployed two units. The panel-wise production starting from 400 tonnes a day in the first Dowty equipped face in 1980's has reached to 0.5mt annual production.

This is not the only case, Sudamdih Shaft mine was prepared at the same time in collaboration with Kopex, Poland for mining steeply dipping thick seams in conjunction with stowing with targeted production of 7,000 tonnes per day by Kazimierz, Kamora and Yankowice method miserably failed to achieve the goal.

Relevance of Depth for Longwall Mining

Longwall mining has been adopted in shallow mines to the deepest in the world for coal mining as that has been the only method in European mines. US entered in the mining field by longwall in 1958 and only 4% coal was produced from the longwall faces in 1975. The mining record of the European coalfield of the year 1958 shows that even in those days, longwall mining was adopted up to 805m depth. A summary of longwall mining in European countries is presented in table 5.

Table 5 : Long wall mining in European countries

Country	**Average depth (m)**	**Share of long-wall faces**	**Average face length**	**Production from thin seams (<1.5m)**
UK	320	92.6 %	132 m	74.4%
W Germany	698	94.9%	147m	59.1%
Belgium	829	100%	172 m	60,2%
USSR	227	41.6%	96 m	39.1%

Number Matters in Adopting the Technology

Longwall mining with pit props AFC and shearer was adopted in 1960's when the government came forward and established MAMC to support the private mine owners to sustain, improve and customize the technology. After a few trials, the entrepreneurs backed out, and with that the demand of mine machinery came to an end leaving MAMC as an ill organization today. In fact, no business house can come forward unless there is regular demand of the same and for every spare the mine has to depend on import. I recall my experience of 1989 in Belgium, where had discussion with the Chinese team in a conference on Mine Mechanization. The team was headed by the State Minister who gave the following strategy in the mission of longwall mining in state owned deep mines, which may be an eye opener for us.

- Select the best model of equipment suitable to the mining condition
- Try a few in collaboration for satisfaction of the mine operator
- Place order for bulk purchase of the system -20 as he defined
- Condition for import should be with the technology transfer
- Get a large group of technicians with the background of the like for on hands on training in plants and mines of the suppliers.

He concluded that with this strategy, by the time the equipment were supplied, the country was prepared with like fabricating units, the technicians were prepared to operate them, repair, maintain and improve on the basis of experience. In 1980's, 19 such units started operating in the state mines, producing annually 64 mt including three faces with record production of 3 mt in a year. By 1990, 30 mines became operative with befitting equipment manufactured by the China National Coal Mining Corporation, adding 74mt coal in a year. As on date China is exporting the equipment including powered support of own design. India on the other hand has been shy in initiating aggressive technology, trying it on experimental basis and importing coking coal from different countries.

Geotectonic problems faults, folds, sills and dykes are the natural obstructions and cannot be removed and for improving production from underground mines. Inclines are preferred with main conveyor the capacity and number of which may be increased as per production. Continuous system-cutting of coal to transport up to surface by AFC from the face to gate road conveyor and main belt conveyor to surface. This required inclines: one fully dedicated to coal transport. The system for the modification, improvement in capacity and availability of spares require in house manufacturing plants, which is possible only if there is increased and ensured long period demand, as continuous operating with continuous system. A study conducted in India in 1994-95 revealed the total effective operation of the face in Moonidih mine was only 30% of the time and even in that time operation was not efficient because of the equipment capacity. The effect is measured in terms of production and productivity and for comparison, poor production and productivity of the pillar mining in the field has justified the poor performance of 0.50 million tonnes from a fully mechanized longwall face in 2022.

Pootki Balihary Shaft

After the nationalization, Pootki Balihary areawas formed by amalgamation of Gopalichak, Kacchi Balihari, Kenduadih and Bhagaband collieries a few of them working since 1930. There were 6 patches on fire within this lease with mineable reserve of 570 mt. In the year 1982, a shaft sinking was started at Balihary to 521m depth and another in 1982 to 490m depth. During sinking the shaft had to cross seams on fire. It was planned to extract moderately thick seam by longwall using powered support, AFC Shearer assembly in consultation of the British Mining Consultant. During the development of the panel, a dyke came midway and the project was dropped forever. It was a fact that coal seams are disturbed and therefore panel of expensive powered support assembly longwall face required rigorous planning in

advance including selection of multifaced shearer that could cut hard dykes and stone roof mass for convenient crossing of these hurdles. Instead. every proposal of longwall mining was dropped.

Longwall Mining Proposal in Kapuria Area

Kapuria geological Block with an area of about 6.4 sq.km and located in north-central part of Jharia Coalfield is completely virgin. Underground longwall mining of quality coking coal from XV to XVIII seams under depth cover of 235 to 850 m with powered support, shearer assembly with annual production target of 2.5 mt was planned. Nine normal faults are deciphered within the lease including eight strike and one oblique fault with throw varying 10 m to 290 m. The reserve within the lease up to XV seam is 146.17mt. The access of the seams was proposed through two reverse drifts from surface with cross-section of 6m and 4m and gradient of 1 in 5 for material transport and man riding. They were planned to touch XVIIIA and XVIB seams. A shaft of 6.5 m diameter was also planned to sunk for a depth of 520 m for providing main return airway. A Proposal of this nature suited the mining condition and should be accepted and large number of faces operating in similar other mines at depth below 400m cover may follow same to ease the National priority of prime coking coal demand.

NATIONAL PRIORITY 3 : Coal for Industrial Growth

Good quality coal was in demand from 1957 from the mining activities in all the coalfields. Medium grade coking coal to superior grade non coking coal was available practically in all the active coalfields from Damodar basin to Godavari basin. The priority of the fourth five year plan (1969-1974) was – self-reliance and improvement in GDP to 5.5% against 3.5% in the previous five year plan. This was the time when the mines were nationalized and industry came under pressure to meet the burgeoning demand of industrial grade coal with targeted growth of 8 to 10% per annum. The distribution of these sources and reserves is summarized in the table 6.

Table 6 : Quality coal distribution in different coalfields

Sl. No.	Coalfield	Area (sq.km)	Reserve (Bt)	Coal Quality
1	Raniganj	1530	25.5	Medium to superior grade
2	Jharia Coalfield	445	16.5	Medium to superior grade
3	Sohagpur North	3000	4.5	Medium Coking
4	Bishram pur	1036	1.5	Non coking superior
5	Hansdeo Arand	154	5.0	Non coking superior
6	Tata Pani	12	2.4	Non coking superior
7	Pench Kanhan	12	2.4	Non coking superior
8	Wardha Valley	4130	5.7	Non coking superior
9	Kamtee	95	2.0	Non coking superior
10	Godavari Valley	1700	17.5	Non coking superior

Quality Coal Mining in Jharia Coalfield

Mines of Jharia coalfield, concentrating on prime coking coal mining available in XVIII to IX/X seams were worked in these seams up to the date of nationalization, leaving a fraction of medium coking coal and total superior grade non-coking coal underneath. A large portion of this coal is still lying in virgin state despite dead lock before the coalfield due to non-availability of the working place, stagnated coal production and productivity. Good share of this coal will be left over even after the present surface mining programme works to 100m depth. The exploitation of over 16 Bt superior coal required by the industries has to be worked by pillar mining within 300m depth cover and longwall mining depth below 400m. There is

a need to get prepared for mining of this reserve well in advance.

Raniganj Coalfield

The Raniganj coalfield mines have been in operation for the past 250 years, consistently extracting coal and fulfilling the industry's demand. The mines of the coalfield having 1,530Bt of medium coking coal have adopted all possible mining options including bord and pillar, longwall by pit props, depillaring of thick seams in slice and longwall in conjunction with hydraulic stowing before the nationalization of mines. Surface mining in the coalfield is concentrating on the exploitation of developed pillars within 100m depth cover, leaving the reserve below for any suitable option. The domain left over with reserve within 100-400m depth cover is amenable for improvised pillar mining but except the introduction of SDL and LHD, not much have been tried so far. On date 57 mines of the coalfield are deploying 237 SDLs, 39 LHDs units. Initiation of continuous miner in the coalfield is appreciable but the system alone cannot serve the purpose unless suitable infrastructure is prepared. On date, seven sets of continuous miners with shuttle cars are operating in this field.

Exploitation of reserve below 400m is possible only by longwall mining option. A good job has been done in this direction and mines like Chinakuri, the deepest mine of the country and worked by Bengal Coal Company has gone to the deepest horizon in the country. Today it is stopped at 730m depth, waiting for a technological solution of mining good quality coal from deeper horizons. Main problems in this option are poor production and low productivity. These issues are being solved by adoption of fully mechanized longwall, which has been successfully adopted for deep seated seams with difficult roof condition in Chinese state mines.

The trial of mechanized longwall face failure in Khottadih and sheetalpur mines should not be a cause of disappointment and Jhanjhra mine success should be the example for the coalfield. The subsidiary by these minor modification has improved its performance. Total coal production from the underground was 9.4mt in 2021 registering a growth of 1.11%.

South Eastern Coal fields in Central India

The coalfield of Central India was discovered by WW Hinter in 1888 which includes Umaria, Sohagpur, Sahdol, Sonahat, Chirimiri, Pench Kanhan, Hansdeo, Lakhanpur etc. in 5,345 sq. km area with estimated reserve of 15,614mt under 1200m depth cover. The coalfield in the Wardha Valley, located in the Chandrapur district, spans an area of approximately 4,130 sq.km. It extends across the valley of the Wardha river, which is part of the Godavari basin, encompassing Bhandar, New Majri, Rajur-wani, Chandrapur, Ballarpur, and Wamanpalli.

Approximately 99% of its superior quality coal is available within 300m depth cover where the pillar miningis continuing since long but have been facing problems because of low production and productivity. The excellence of pillar mining was demonstrated in Churcha mine, where use of shuttle car, gathering arm loader in flat seam made miraculous performance by semi continuous hauling system. Access through an adit equipped with a belt conveyor carrying coal from near face to railway siding resulted in peak achievement of 100,000 tonnes coal production in a month. Around 1980, the following options were implemented to enhance both production and productivity:

1. Pillar mining with SDL and LHD
2. Depillaring by knife edge at Surakachar
3. Longwall mining in Banki Colliery
4. Mechanized longwall mining in Patha Khera colliery
5. Mechanized face with powered shield, AFC, shearer at Churcha mine

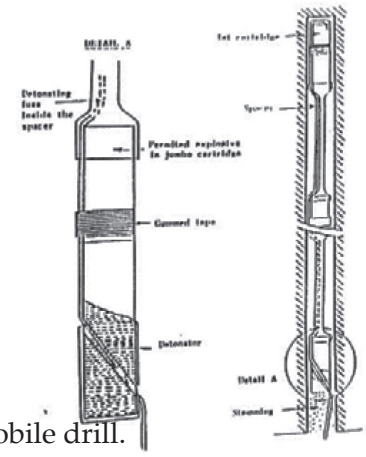
None of these options proved to be trend setter in respect of production and productivity. Thick-seams developed on pillar were the other problem of the mines. During the same period, CIMFR (erstwhile CMRI) developed the cable bolting technique for supporting high roof to ensure full recovery of coal under supported roof with the use of SDL by intermediate technology.

Cable Bolting for Depillaring Thick Seam

Depillaring of nearly 7m thick No. 3 seam of NCPH mine developed on pillars along the floor under Ponari hill was an innovative technology tried with cable bolt support. It was nearly impossible to adequately support the exposed roof during depillaring using conventional methods such as timber props, chocks, and even steel props. None of these options, designed for a 7m high roof, could provide the required 5-ton supporting strength due to their high slenderness ratio. As an alternative, an old haulage rope anchored in the immediate roof to coal band acting under tension was able to offer support capacity up to 8 to 15 tonnes. The cable used to anchor the coal and support the roof even after blasting the roof coal remained anchored to the roof and the SDL could get the blasted coal out to tub and haul the coal out up to surface. The method was initiated in Palel 15 under in october 1992 under the following condition :

Thickness of seam	6.5 m
Bord size	2.5 m× 4.5m
Pillar size	22.5m × 22.5m
Number of pillars in the panel	25
Pillar Dimension	22.5m
Depth of working	33-58m
Length of cables used for bolting	5.5m

The method required a large number of long holes (see figure 6 (a)) for cable bolting and for ensuring the safety of the workers. All the bords were bolted before the start of the depillaring in conventional mode with splitting and slicing and the slices were supported by timber props (see figure 6 (b)), while the cable bolting was being installed. The coal from the roof was loosened by blasting. The method proved very successful in respect of safety, production and productivity and coal from all the panels of NCPH Mine were extracted with record production of 65,000 tonne in a year. Recovery of coal from within the panels varied within 74.3 to 80% and productivity improved from 2.0 to 2.8. Remarkably, this was the only pillar mining alternative worked with profit in whole of the Coal India Limited during 1996-98. The method was subsequently tried at Madhujore and Khas Kajora mine of ECL and mines of SCCL successfully. Have good scope for caving of thick seam and the process might be improved using multi-role mobile drill.



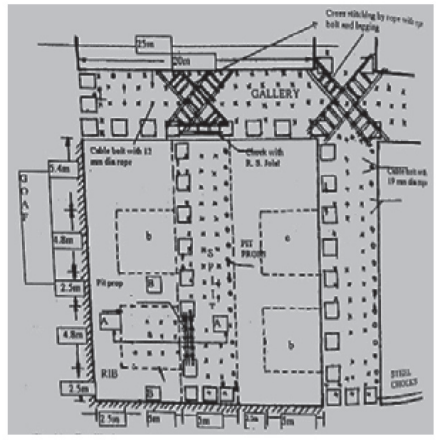


Figure 6(a) : Arrangement for full columng routing Figure 6(b) : Support during pillar extraction

Contiguous Seam Depillaring under Barunga Hill

Contiguous Zero seam under Bartunga Hill of Chirimiri was developed along the floor leaving thick section as a roof and a contiguous section with 3m thick parting above was also developed on pillars. The formation on the whole was very weak, and the bord and pillar development in both the sections was by roof bolt. This was the

first and only timberless pillar mining of CIL. A method with under pinning (figure 7), drilling hole from the floor of the top section development and installing a cable bolt with full length anchoring including parting to roof of the bottom section coal was conceived for depillaring of the full seam. The system reinforced the parting and supported the roof coal and even after the blasting of the coal from the bottom section, fragile roof remained undisturbed. The trial was initiated in panel 4 in 1997 under the following condition :

No of pillars in the panel	14
Panel dimensions	160m × 48m
Pillar size	22m × 22m
Depth cover	47m to 139m
Total seam thickness	12m
Bottom section	6m
Top section	3.5m
Bord size	2.5m x 4.8m
Achievement	
Average production/day	252tonnes
Percentage extraction	70%
oms	1.82

The method was conventional bord and pillar method, coal loosened by blasting, loaded by SDL to chain conveyor, fitting to main conveyor going out through adit. The method was successful for 5m thick bottom section and upper contiguous section mining under shallow depth. The method was implemented with little capital investment, proved to be economical in terms of productivity but was not able to improve the production level. These methods were suitable for scattered small deposits of the coalfield, where high capital investment was economically not viable. Continuous miner was thought to be the next option which is proved to be a good option for seams under depth cover with 400m depth.

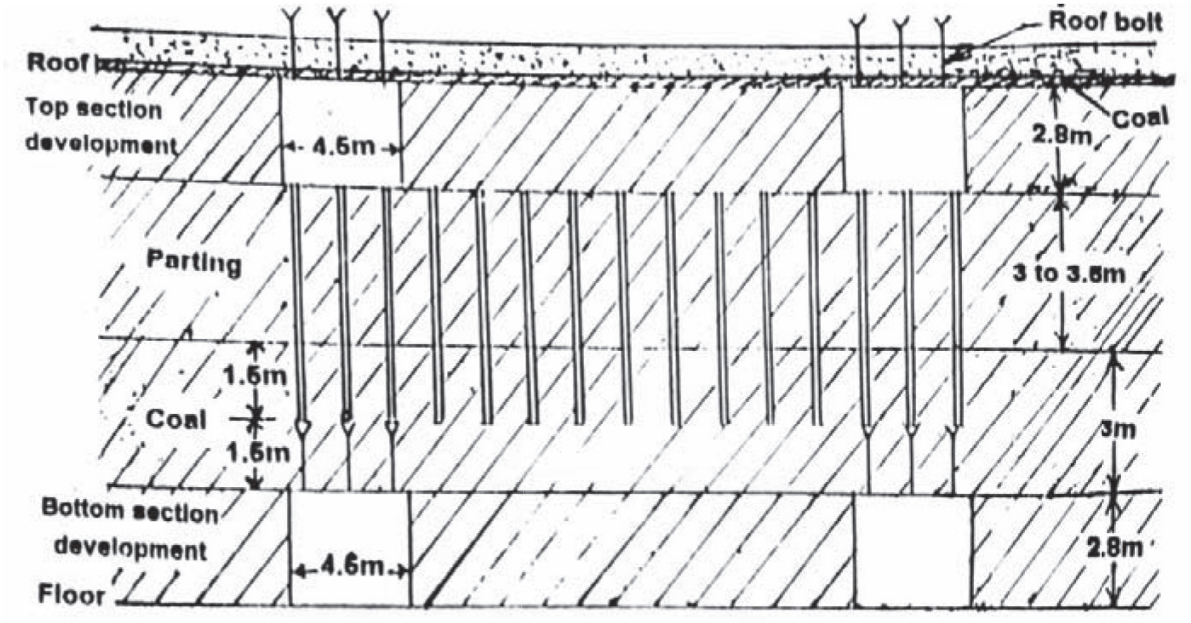


Figure 7 : Underpinning trial in Zero Seam of Bartinga Hill

Continuous Miner in Zero Seam of Anjan Hill Mine

First trial of Continuous Miner was initiated in Chirimiri area to mine Zero Seam underneath Anjan Hill. The system supplied by Dowty included two shuttle cars, a feeder breaker, and a mobile roof bolting machine. It became operative in 2003. Zero seam in Bartunga hill was a contiguous seam of total 12m thickness with 3.5 m thick fragile laminated parting in between. The problem was tackled there by Under pinning across the parting to 2.5m coal section left in the roof during bottom section development.

In Anjan Hill area top section is reduced to 1.15m and the parting is mixed stone band of nearly 2m and bottom section is 5.1m. The roof was supported by roof bolts of 2.4m length. The condition of the site where the trial was initiated is summarized below

- Pillar size center to center 33 × 33m
- Gallery width 4.8m
- Proposed extraction height 4.5m
- Width of split gallery 6.6m
- Width of slice 6.6m
- Depth 85m

The system deployed for caving of a thick seam worked very satisfactorily with the peak production of 3,450 tonnes and the average production of 2,100 tonnes per day. It encouraged the deployment of the Continuous Miners for depillaring of moderately thick seams under shallow depth cover. Next set of Dowty was introduced in Tandasi mine of Western Coalfields Limited for depillaring of 3m thick seam under 260m depth cover.

Presently the company is deploying 12 CMs (9 SHCM + 3 LHCM) in 10 mines, targeting 5.14mt additional production from Churcha, Behraband, Kurja-Sheetaldhara, Haldibari, Vijay West and Rani-Atari etc. The aggressive approach of the company has resulted in proving the scope of Continuous miner for pillar mining of superior quality coal up to 400m depth cover in thin to moderately thick seams dipping up to 1in 7.

Godavari Valley Coalfield

Singareni coalfield of Godavari valley was discovered by Dr King in 1871 in Khammam district and the Singareni Collieries Company Limited (SCCL), was incorporated in 1920. With the reorganization of states, the controlling interest of SCCL was vested with the Government of Andhra Pradesh (now Telangana) and the Government of India in 1956 with operational domain over Adilabad, Karimnagar, Khammam and Warangal districts of Telangana. An estimated 11,849mt of superior-grade coal is found within a total area of 9,000 sq.km. This includes 6,990mt within a depth of 300 m, 4,486mt within depths ranging from 300 to 600 m, and 372mt within depths of 600 to 1,200 m. The company is presently operating in 18 surface mining projects and 24 underground mines with intermediate technology to mechanized powered supported mines to customized suitable technology compatible to resource distribution. Thick seam mining has been an additional challenge for the mines of the area. The company has been improving its performance in conventional pillar mining and for thick seam mining invited collaboration of Charbonnages de France for mining 11m thick seam of Godavari khani No. 10 Incline 1989. This was infact revisiting the technology initiated by NCDC in Gidi mine.

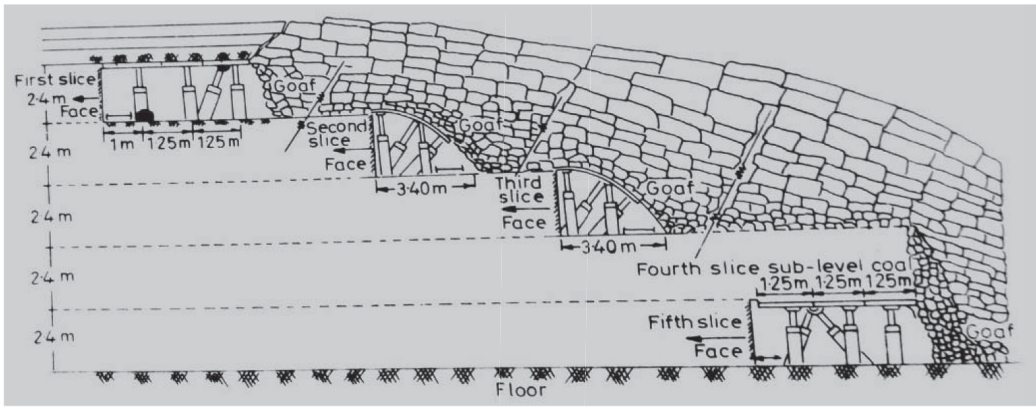


Figure 8 : Inclined Slicing of thick coal seam under artificial roofing

Subsequently, the same method was applied at GDK-8, VK-7 and GD–11A mines in 2006. The Blasting gallery method was also tried in Godavari khani No.11 Incline mine but was abandoned because of fire, strata control and maltfunctioning of the remotely operated Load Haul Dumper.

SCCL has taken a number of steps to modernize the mines by introduction of intermediate technology and was the first to introduce Load Haul Dumper to extract pillars at GDK-9 Incline. The company has added 104 side discharge loaders and 37 load haul dumpers in the fleet and is planning to add several continuous miners also in the fleet. Longwall technology was also introduced in SCCL using road headers for drivage of gate road ways for retreat longwall faces in 1978. At present road headers are working in Kothagudem, Yellandu, Mandamari, Srirampur and Godavari khani group of mines for formation of longwall faces. Fully mechanized longwall face was introduced at GDK-7 Incline in 1983 with additional twin face conveyor facility. Company has planned 12 more longwall faces in Jawahar Khani-5, Godavarikhani-llA, GDK-10A, GDK-9 Vakilpalli block, Ravindrakhani-IA, Ravindrakhani-NT, Goleti 1 and 2 and Prakasham Khani-2 Inclines. Despite all these efforts, the underground production of SCCL mines has stagnated to 11 mt since 2009-10. The performance of the year 2019-2020 was even more alarming with only 8.66mt production from underground mines compared to 55.37mt from surface mines.

Summary

The scenario of coal reserve, quality, and distribution in India shows three clear mining domain and three national priorities and prime stake holders within are Coal India Limited (CIL) and the Singareni Collieries Company Limited (SCCL). Going a step closer, the demand is also of three specific groups–inferior grade coal for thermal power plants, superior grade non coking to medium coking coal for industries and prime coking coal for the steel plants. Inferior grade coal reserve invariably in virgin belts was preferred for the power sector and superior grade coal for the industrial growth as per the national plans. Extraction of inferior grade coal started after 1973 in Singrauli, Korba and Rajmahal, to ultimate depth with concurrent reclamation and rehabilitation.

Surface Mining of Superior Grade Coal

Surface mining of superior grade coal was started in Raniganj and later started in Jharia and all the coalfields because of its capacity of quick mass production from shallow cover, often leaving some seams underneath, external dumping of the burden and causing extensive land, water and environmental pollution. They are preferred because of better production and productivity compared to conventional pillar mining. During 2021-22, the production share of surface and underground mines in some of the companies is summarized below in table 7 :

Table 7: Surface and underground production of some selected companies

Company	Surface production (Mt)	Underground production (Mt)	Total Production (Mt)
BCCL	29.71	0.81	30.52
ECL	23.43	9.00	32.43
SCCL	58.57	6.45	65.02
SECL	130.99	11.53	142.52

The coalfields where these companies operate constitute the primary repository of high-quality coal. The bord and pillar mining method has been employed in these regions for over 100 years. Until the 1970s, they had limited knowledge of surface mining; however, they are now inclined towards adopting surface mining practices. With this the very attitude of the mine operators changed ignoring the underground mining and preferred surface mining. The author had personal experience of this change while conducting a field trial for mining thick seam in fourth slice by mixed system of support. It was technically very successful, but the production was only 200 tonnes a day. The author once asked the area's management to visit the coal face, assuming that their presence might enhance production. However, the request was denied with the explanation that traveling a 2 km dip Incline to reach the face, spending an hour there, and then returning uphill might result in only a modest increase in production from 200 to 250 tonnes. On the other hand, if the management's empty car moves in the nearby surface mine, the production could see a significant boost of 500 tonnes.

The emergence of this situation, despite significant challenges in land acquisition and environmental concerns, is not difficult to comprehend in the foreseeable future. The performance of underground mines had plateaued by the end of the 1960s, showing stagnation in production and productivity, despite advancements in technology such as "off-the-face blasting of coal." The Chari Committee went so far as to recommend the closure of certain mines due to their negative growth. To address this decline and revitalize underground mining, the following measures were implemented :

A. Initiation of Intermediate technology – use of SDLs and LHDs for improving the production, but the equipment so identified were mainly to minimize the drudgery of miners as a little has been done in system management of extraction, hauling and support. In techno economic perspective this may be useful for pillar mining within 1 in 7 gradient in all the coalfields but with the system modification.

B. The introduction of longwall technology, a panacea for low production and productivity was introduced in Moonidih Mine by NCDC and subsequently tried in all the fields with capital intensive modern mining technology – powered support, shearer and AFC etc. Despite deployment of fully mechanized capital intensive longwall technology and 40 years of experience, the production for the panels is still in around 0.5 million tonne annually and even the best mechanized longwall face is waiting for 1 mt production figure. This technique encountered similar challenges in U.S. mines. However, through organizational improvements, the utilization of high-powered supports ranging from 350 tons to over 900 tons, the incorporation of high-power shearers, and the implementation of continuous miners for heading drivage in longwall panel development, along with enhancements in coal quality, it has thrived successfully. Although there is no documented scientific study examining the factors contributing to the failure of this established technology in India, some key issues have been identified as follows :

- Frequent failure or malfunctioning of face equipment.
- Down time of the face because of mismanagement
- System operation, resulting in over 50-70% down time
- Discontinuous system for coal handling from face to surface
- Mismatching of the vertical hoisting system
- Long time requirement for transfer of the face equipment to other face
- Delay in preparation of the operational panels

Longwall technology is the only option for mining seams below 400m and despite these failures a concerted effort should be made to customize it. The steps adopted for the mining of deep seated coal by State Mines in China may be perused for guidance.

C. Continuous miners entered the domain of pillar mining for depillaring Zero seam underneath Anjan Hill has set an example of average 0.6 Mt annual production even during the first panel. Credit for the performance of this efficiently modified CM goes to 1) access through adit, 2) conveyor layout from the panel to surface 3) flat seam and 4) seam of ideal mineable thickness. The like system is operating in 9 mines of SECL. It is working successfully for depillaring 5m thick seam in Jhanjhra and Shyamdundarpur mines of ECL for depillaring of 4.54 to 4.8m thick seam. This may prove to be an ideal option for pillar mining within 400m depth and in seams up to 1 in 7 gradient.

Conclusion

The coal companies have the target of mining medium coking and superior grade non-coking coal in the states of W. Bengal, Jharkhand, Chhattisgarh, MP and Telangana within 100 to 1200m depth cover. These coalfields are densely populated and urbanized with infrastructural facilities like rails. roads etc. The failure of the surface mining proposal to 500m depth cover in Mukunda blocks of Jharia coalfield shows the hindrances in scientifically planned surface mining in these coalfields. Small scale surface mining is not a suitable option for extraction of superior grade non-coking to coking coal mining in the major coalfields having several seams unless it ensures decoaling of the mining area, concurrent backfilling of the burden and scientific reclamation and rehabilitation. The surface mining in case of fire hazard is an exception but that too needs reclamation of the pit after the removal of hot coal etc.

Underground mining stands as the sole method for extracting high-grade coal, with the approach varying based on deposit depth and accessibility. Drawing from a wealth of experience spanning more than a century, deposits have been categorized into shallow deposits, covering depths up to 400 meters, and deep deposits beyond this threshold. Extensive mining activities have been conducted within the 200-meter depth range across various fields, with successful exploration reaching depths of 400 meters in select areas of the Raniganj coalfield in West Bengal. Notably, deep-cover deposits remain largely untouched, with only Raniganj coalfield witnessing exploration activities in this category, presenting virgin territories across other coalfields. The following summary outlines viable options, each carrying a fair chance of success :

Mining shallow deposit

Bord and pillar mining has been done in India in seams dipping upto 30° in seams up to 30m thickness by horizontal slicing; forming pillars with drivage along the foot wall and hanging wall. Next slice underneath was developed below a 2-3m thick coal band in the same manner by forming pillars up to 150m depth cover before 1937 in Jharia coalfield. The general gradient of the seams in rest of the coalfield and other coalfields with superior grade coal varies within 1 in 7 and the coal beds of Central India are flat with 1 in 50 gradient. Pillar mining manually as such has been very popular method for centuries.

The future mechanization for mining seams within the gradient in 1 in 7 and depth 200 to 400m which is compatible to large coal reserve in all the major coalfields, Continuous Miners can be used for mass production of coal. Reserve within 300 to 600m depth and small reserve in seams below 600m depth in Jharia, Raniganj, Sohagpur, Chirimiri and Godavari basin coalfields requires customization of longwall mining technology. The plan should be prepared to extract coal from underground with mass production, high productivity with conservation of the reserve.

1) Pillar Mining under protected surface features

Development :

Development of bord with stable pillar up to 4.8m height

Development in slices with minimum 2m thick parting in between

Development in slices with packing/stowing

Wide Stall mining with sandstowing / stone packing in thick seams

Development in thick dipping seam in Horizon mining

Thick seam in slices in conjunction with sand stowing

Technology Options :

Intermediate with- SDL/LHD, drill & haulage etc

Mechanized development- Continuous miner, LHD etc

Depillaring - where surface subsidence allowed :

Caving of seam to 4.8m thickness- conventional splitting and slicing

Caving of thick seam with cable bolt, splitting and slicing

Pillar extraction by NEW Method- Non effective width of panel

Longwall mining of developed pillars

Underpinning method for thick Contiguous Seam

Thick seams – Inclined slicing under artificial roofing

Thick seam Inclined slicing in conjunction with stowing

Shortwall mining of developed pillars

Continuous Miner in seams upto 5m thick flat seams

Technology Option – Intermediate technology option with SDL / IHD etc

Mechanized mining technology

Continuous Mining layout with Powered support shearer, AFC combination

2) Mining of coal below 400m Depth Cover

Mechaanized Longwall mining of moderately thick seams

Shortwall mining of moderately thick seam

Sublevel caving and or integral caving in thick seams

Inclined slicing of thick seam in conjunction with stowing

Technology Option

Powered support, shearer, AFC on the face

Continuous miner with mobile bolter for gate road development

Deployment of fully mechanized longwall face equipment and continuous miner in combination or alone in different conditions are meant for mass production provided they are of proper capacity, deployed in suitable mines with befitting infrastructure. Past experience has revealed deployment of powered supports of under capacity, resulting in poor performance in ECL, BCCL and SCCL mines. The longwall system failure was faced by the US mines in early days of its introduction when more than 10 faces failed under different conditions. Lesson, they learnt was to deploy shield support of 500 to 1000 ton capacity and use high power shearer to cut large amount of coal and matching continuous system through adits. Indian coal measure formation of Barakar series is known to have competent roof, intrusion of dyke and faults and therefore, need detailed geological study be done in advance.

Geo-engineering Study for System Selection

Gondwana coal measure formation in India, competent in nature is extensively folded, faulted disturbed by intrusion of dykes or sills. Selection of site, and system capacity definitionis very much influenced by strata behavior. It needs advanced geo-engineering study of the formation. The author highlights the commitment of the USSR research team in meticulously assessing the feasibility of extracting coal from the bump-prone Dishergarh seam at the Chinakuri mine. This dedicated team collaborated with CMPDI and the Regional Institute in Asansol, dedicating almost a year to the comprehensive study. The author actively contributed to various aspects of the investigation conducted by the team :

1. Characteristic of the immediate roof; recovering the immediate massive roof section from 4 boreholes in two corners of the proposed panel by using double tube core barrel.
2. Detailed physico-mechanical property of the formation to identify weak horizons
3. Identification of horizons with characteristics of moisture softening
4. Inject water to the identified horizon to see the water absorption and correlate the same from the laboratory study of the core.
5. In-situ strength of the coal for defining the size of pillars around the panel.

The project was dropped after detailed study because of the reasons best known to the planners but the mining in the deepest coal mine of the country came to an end and is waiting for its revival. The longwall face of Churcha mine; working under thick massive sill with thick stratified formation as the roof. This section was not explored in depth for its characteristics and the face operating with excellent performance in collaboration of British Mining Consultant collapsed with the first periodic weighting. The destiny of Balihary project was sealed because of a few dykes crossing the face. The information is just a caution in deciding capital intensive longwall technology.

System Selection

Longwall faces in future should be equipped with higher capacity like that of Australia and South Africa. The produce by such system should be hauled to surface in continuous manner through matching face conveyor to gate conveyor, and main conveyor to surface.

As the adits are not common in India, should have a pair of inclines; one exclusively for coal hauling driven in place of shaft sinking to make the system continuous, capable to transport produced amount of coal. Inclines are more amenable to modification or handling increased production.

The pioneers of mining industry of India in 1950 conceived the idea of technology transfer along with the import of some equipment and therefore established MAMC, Durgapur to help in absorption of the technology. This is the right time to club this clause with bulk import of the shield support shearers and continuous miners to meet the rising demand of tomorrow.

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TECHNICAL ARTICLE

SUSTAINABLE COAL MINING AND MEASURES FOR ENERGY TRANSITION TOWARDS NET ZERO AT SECL

Dr. P.S. Mishra[1], Sanjeev Kumar[2]

Abstract

Coal and coal-related emissions are both critical issues as world is facing with the twin crisis of energy availability and global warming. Coal is both the largest emitter of energy-related carbon dioxide (CO_2) – 15 Gigatons (Gt) in 2021 – and the largest source of electricity generation, accounting for 36% and a significant fuel for industrial use. While integrated action plan for the de-carbonization is attracting global attention, containing emissions from coal must be given the highest priority. The recent political developments arising out of Ukraine war has led to energy crisis over large part of the globe and even those countries which had declared target dates for achieving net zero emissions are taking a fresh look at coal.

However, for country like India, it is not feasible to phase out coal in the coming decades, since it is the mainstay of the energy security of our nation since long and meets more than 55% of total energy need of the nation and accounts for more than 70% of total electricity being generated in the country. Further, considering continuous exponential surge in energy demand and non-availability of an affordable and reliable alternative source of clean energy in meeting the energy need of the country, coal is bound to remain the dominant source of energy security of our country for at least 2-3 decades more. In India coal also provides large employment and the economy of major coal producing states is largely dependent on coal. We therefore must plan our move towards transition to Net-Zero with great amount of care.

However, in alignment with the India's commitment to achieve net zero emission by 2070, there is complete consensus that the coal mining must undergo such a transformation, wherein coal mining as well as net zero both can co-exist. CIL and its subsidiary companies have already started taking voluntary actions towards decarbonization and achieving Net-Zero. SECL, which is one of the subsidiary companies of CIL is committed to achieve net zero in line with our nation and the holding company CIL and we are confident that we'll do it in a time bound manner. This Article is an effort to provide a glimpse about how SECL is planning to achieve Net-Zero.

Introduction :

Net zero, the most commonly used approach, refers to an 'equilibrium' state where all anthropogenic GHG emissions are matched by their removal (Fig. 1). A widely recognized definition of 'net zero' is given by SBTi (Science Based Target initiatives) as a credible, science-based target aiming to "achieve a state in which activities within the value chain of a company result in no net impact on the climate from Green House Gas (GHG) emissions."

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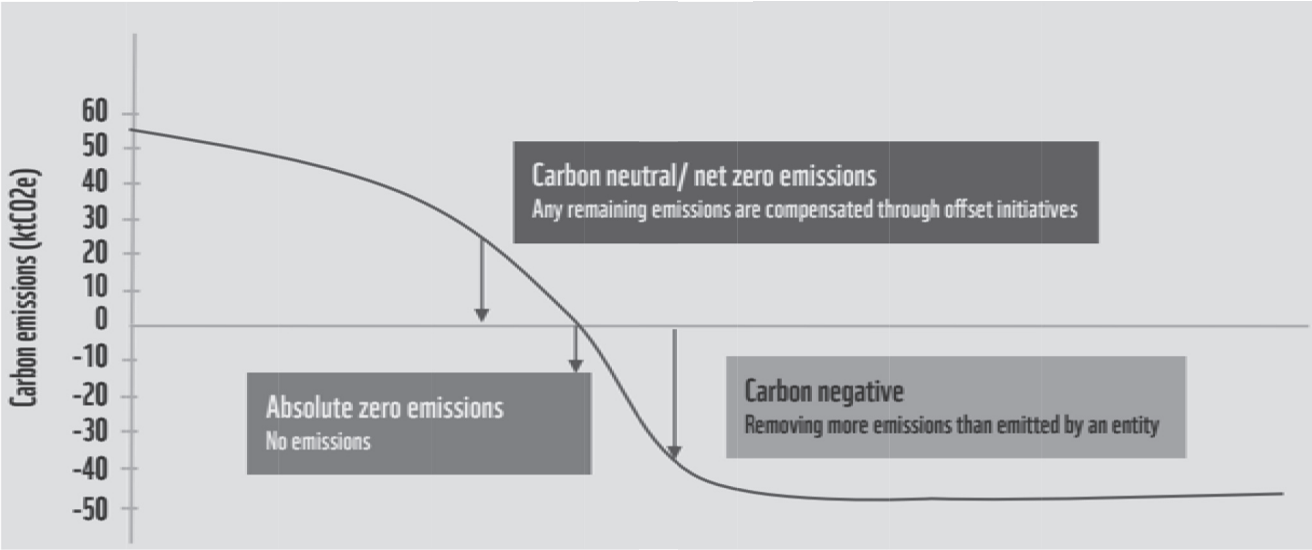

Fig.1: Net Zero equilibrium curve

Achieving net zero emissions, is an extremely complex process and requires a multipronged approach, encompassing a range of abatement options, including reduction of resource intensity, replacement of emitting sources and offsetting emissions.

South Eastern Coalfields Limited (SECL) has taken several measures for sustainable coal mining, energy transition, development and adoption of Renewable Energy, Energy Efficiency and conservation measures in its business etc., which has resulted in substantial reduction in GHG emission. Measures taken by SECL are shown below Fig. 2.

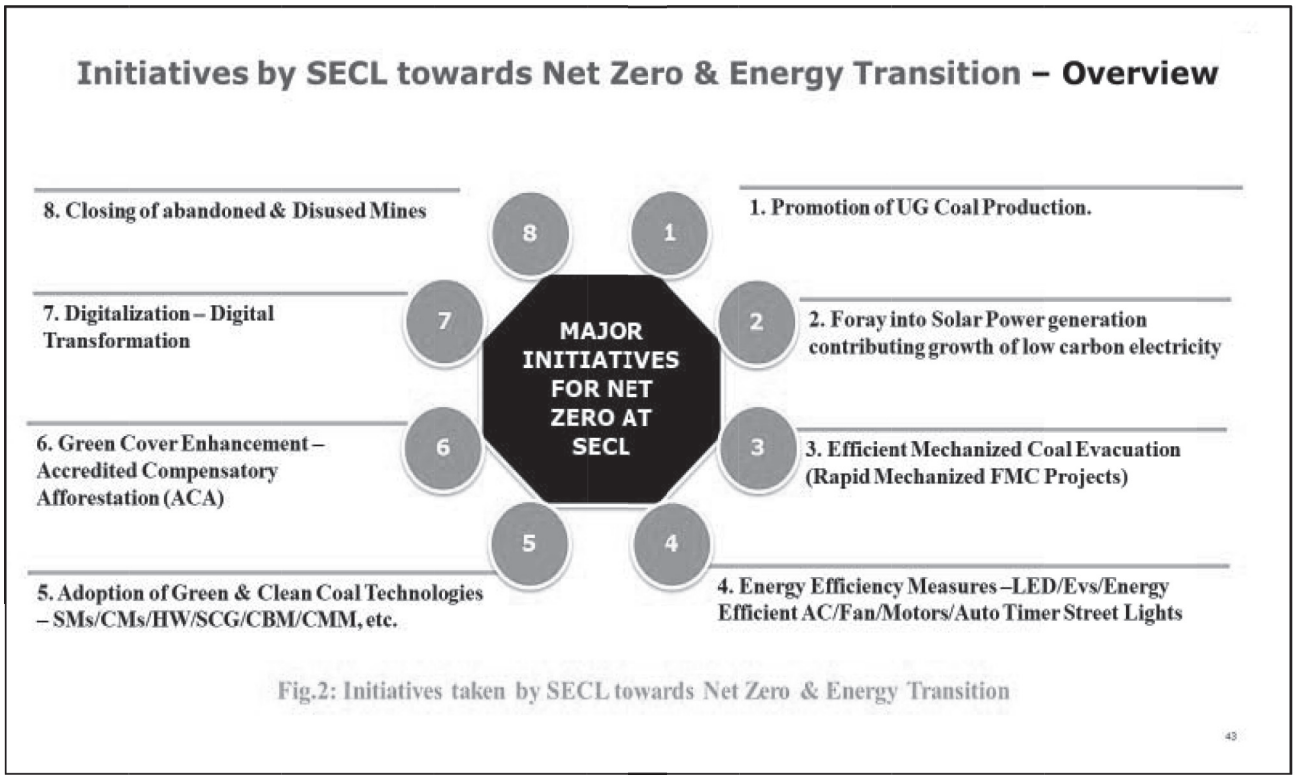

Fig.2: Initiatives taken by SECL towards Net Zero & Energy Transition

Promotion of Environment Friendly Underground Coal Mining

On the global scenario, out of the 4.2 BT of coal produced by China, more than 90% of its coal comes from underground mines. About 37% of coal in USA and 50% in South Africa are produced from underground mines. Almost 50% of the world coal comes from UNDERGROUND mines. Europe has already stopped opencast mining and has relied mostly on underground production. Percentage share of underground production in major coal producing countries in shown in table 1.

Table 1: Contribution of underground production in total coal production

Country	Production FY23 (MT)	Consumption FY23 (MT)	Share of underground production	Share of Coal In Energy Mix
India	893	1,115	4%	55%
China	4,237	4,250	90%	54%
United States	535	465	37%	12%
Australia	446	64	23%	29%
South Africa	255	159	50%	71%

It can be seen from table 1 that the contribution of underground production in India is below 4% of the total coal production. Though, the total coal production in India has increased manifold from a modest figure of 87 MT in 1974-75 (just after nationalization) to 893.2 MT in 2022-23, the percentage share of underground coal production has declined from 75% to 3.9% respectively in the corresponding period. As shown in figure 3, while the opencast and total production have increased considerably, underground coal production in India has either remained stagnant or deceased in this period. Indian coal production companies ought to reflect on the fact that if China can achieve over 90% of its total coal production from underground mines, and if half of the world's coal production comes from underground, there is no apparent reason why India cannot increase its underground production to 1 billion tonnes or more by 2030.

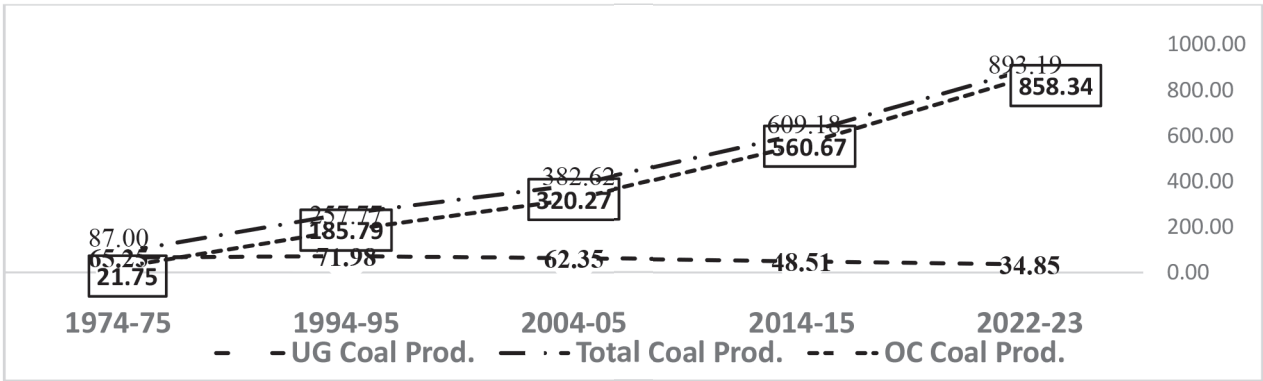

Fig.3 : Underground and opencast coal production trend in India over five decades

The underground coal production of SECL, which came into being in 28th November 1985, has also come down from 15.13 MT (44.2%) from its year of inception to just 11.64 MT (7%) in FY'23. The trend is shown in Figs. 4 and 5.

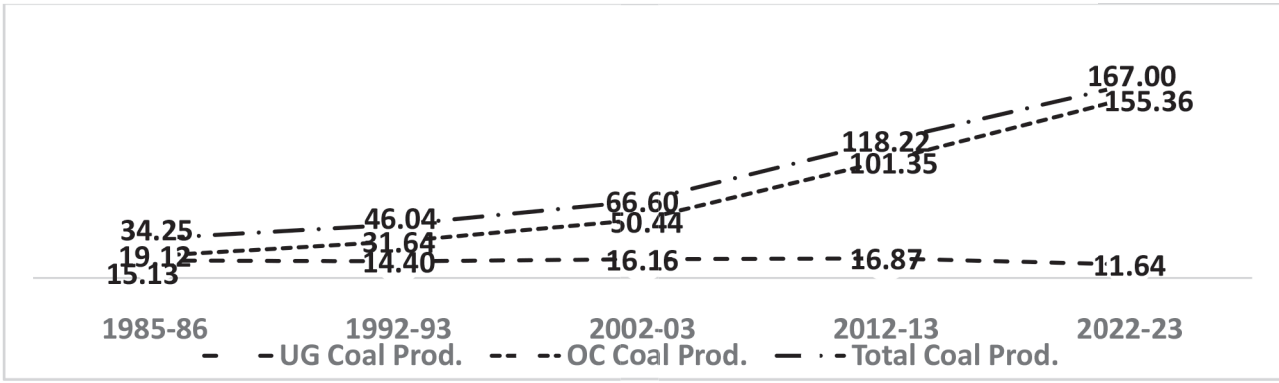

Fig.4 : Underground and opencast coal production trend of SECL over four decades

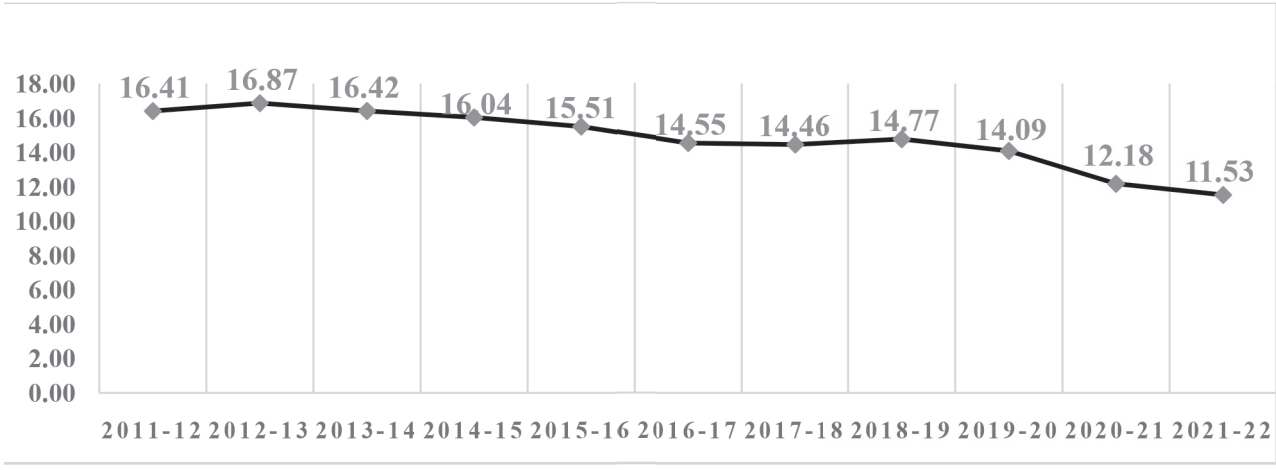

Fig 5 : Trend of underground production of SECL during past ten years

Underground coal mining in India stands as a pivotal force in shaping the nation's energy landscape while concurrently addressing critical environmental concerns. The imperative to accelerate the declining trend in underground coal production over the next two to three decades is paramount for safeguarding ecosystems, achieving environmental sustainability, and minimizing disturbance to forest lands and surface features. The significance lies not only in meeting the escalating energy demands of a burgeoning population but also in ensuring responsible resource extraction. Unlike surface mining, underground coal mining minimizes ecological challenges by mitigating habitat destruction, water pollution, and the release of harmful particulate matters. By delving beneath the earth's surface, this method offers a sustainable alternative that preserves the delicate balance of ecosystems. Further more, the minimal disturbance of the water table enhances the longevity of vital water resources, addressing a critical need for sustainable development. In the pursuit of a more sustainable energy future, the increased production of coking and superior-grade non-coking coal through underground mining becomes imperative. This strategic shift not only bolsters the nation's energy security but also aligns with global efforts to transition towards cleaner energy sources. As the world grapples with the challenges of climate change, underground coal mining in India emerges not only as a pragmatic solution to energy needs but also as a conscientious step towards harmonizing economic progress with environmental stewardship. It signifies a commitment to responsible resource management and a vision for a future where energy security coexists with ecological resilience. Fig.6 provides a brief illustration of the factors driving the increase in underground coal production in India.

Fig.6 : Justification for Advocating Underground Coal Mining

Coal demand of the nation is increasing astronomically, which cannot be met only through opencast mining. In FY 2022-23, total coal consumption in India was around 1,115 MT, while indigenous supply of coal was around 893.2 MT, necessitating import of about 237.7 MT coal, with import value of 3.84 trillion rupees (48.04 billion USD). India having the 4th largest coal reserve in the world with over 361 BT of total coal resources and about 187 BT of proved coal resource (As on 01.04.2022), cannot afford to spend such huge foreign exchange in importing of coal. Import of coking coal is some how acceptable due to non-availability of low ash coking coal in India but import of non-coking coal, especially that of power grade coal, can be completely stopped if coal production is increased. The Ministry of Coal has vision to completely stop the import of non-coking power coal by 2025-26, which can only be possible if India increases coal production, both from opencast and underground coal mines.

Further, as more than 55% coal reserves of India is amenable to underground coal mining with the present technology, we have no other option but to shift towards the underground mining.

India is an 'Energy Deficit' nation despite having a lower per capita energy consumption in the country. The per capita energy consumption in India is about 1218 KWh while it is 5985 KWh in China, 10,318 KWh in Australia, 11585 KWh in South Africa and about 13,075 KWh in USA. The per capita energy consumption of India for the year 2022 stood at 1,200 KWH, which is about 17 times lower than the world average of about 21,039 KWh. Energy consumption in India has more than doubled since 2,000 to 2,020 and the energy demand and consumption is further projected to be doubled by 2040. Further, with a projected population of about 1.64 Billion of the country by 2047, the energy security of the country shall be facing stiff challenges in meeting the energy demand.

India must increase the production of coking coal in view of the National Steel Mission 2017 to increase crude steel production from the present 125 MT to 300 MT by 2030, which is possible only through underground mining.

Pressing need for underground coal mining is also due to increasing socio-environmental and regulatory difficulties associated with opencast mining. As opencast coal mining is associated

with more negative externalities as compared to underground coal mining, opencast mining is becoming increasingly difficult due to its high socio-environmental cost and increasingly societal unacceptance. Apart from environmental aspects, land acquisition and R&R issues are also proving to be major hurdles in starting opencast coal mining projects and expansion of the existing ones. The importance and relevance of underground mines is greatly enhanced when the high environmental and social cost is considered. Underground mining is preferable due to lesser financial, social, and environmental burden and due to its wide applicability indeep seated seams.

Accordingly, the Government of India (GOI) has kept target of producing 125MT coal by FY 2030. In line with the GOI's target, Coal India Limited (CIL) has envisaged to reach 100MT by 2027-28 from the current levels of 25.5MT, in which the contribution of SECL would be 30.97MT. Table 2 displays the projected underground coal production of Coal India Limited and its subsidiaries for the next 5 fiscal years.

Table 2 : Projected underground coal production of CIL and its subsidiaries

Fiscal Year	2022-23	2023-24	2024-25	2025-26	2026-27	2027-28
	Actual (MT)	Assessed Projection (MT)				
ECL	8.97	9.50	12.17	17.32	22.10	27.75
BCCL	0.69	1.74	4.37	8.31	10.68	12.91
CCL	0.86	0.85	1.87	3.29	5.21	7.00
NCL	-	-	-	-	2.00	5.00
WCL	2.89	4.62	5.75	8.35	10.06	12.33
SECL	11.64	13.54	15.76	19.76	23.82	30.97
MCL	0.44	0.90	2.23	2.75	3.48	4.88
CIL	**25.49**	**31.15**	**42.15**	**59.78**	**77.35**	**100.84**

SECL has already started reversing the trend of underground coal production from the FY 2022-23 and is poised to cross 30 MT coal production from underground mines by FY' 28.

To enhance underground production and productivity SECL is adopting the following strategies :

- o Introduction of more and more of Continuous Miners, wherever feasible.
- o Implementing large number of Highwall Mines to improve percentage of extraction and exploit idle coal which otherwise would be lost forever in the old/discontinued/running opencast mines.
- o Planning high capacity underground mines with higher degree of digitization.
- o Revival of loss-making mines, wherever possible through introduction of mass production technologies (MPT).
- o Identifying seams amenable to Longwall mining in virgin area and within the lease-hold area of mines where upper horizons are de-coaled and where possibility exists to extract lower seams.
- o Improvement in productivity of the current mines through re-engineering and amalgamation.

SECL has presently 12 CMs (9 SHCM + 3 LHCM) running in 10 different mines with cpacity of 5.14 MTY. However, SECL has planned to commission total 57 CMs - 51 CM (18 SHCM+33 LHCM) without PFT and 6 LHCM with PFT. LOI for commissioning of 7 CMs (2 SHCM + 5 LHCM) in 3 additional mines for a capacity of 2.81 MTY has already been issued while schemes have approved for commissioning of 13 CMs (3 SHCM + 9 LHCM) in 5 additional mines for a capacity of 5.57 MTY. Out of these 13 CMs, NIT has also been floated for 11 CMs.

SECL has also plan to commission one more Highwall Miner at Sharda Mine in addition to the 02 HW Miners already in operation there. SECL is also exploring possibilities for Longwall Mining at Kewai patch of Hasdeo Area.

However, enhancing coal production from underground mines to such high level will need addressing of various challenges, which the Indian underground coal mines are facing presently. The various challenges which must be addressed are presented in Fig.7 below:

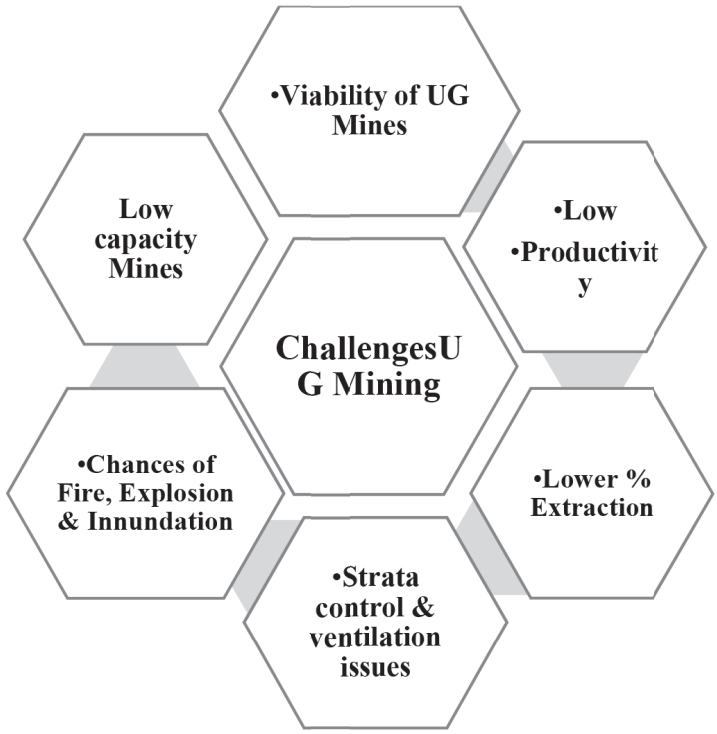

Fig.7 : Challenges of underground coal mining

Suggestions for addressing the challenges :

A. Addressing viability of underground mines :

(i) Underground Mining being an environmentally friendly method and having added advantage of assured quality, relaxation/ policy intervention is required in pricing mechanism of coal mined from underground. Composite pricing/cost-plus pricing/e-auction may be considered, as the case may suit.

(ii) Entire underground coal production to be sold in open market through auction.

(iii) For viability of the underground projects where grades are G6 and above, there is need for the review of 12% IRR criteria to encourage underground projects.

(iv) Policy intervention is also needed regarding the mandate of taking of surface rights, even if there is very little chance of subsidence due to underground mining. Permission may be granted on the basis of scientific study. Acquiring surface rights entails huge cost, which must be reviewed.

(v) Re-imbursement of Backfilling cost if the mine goes for PFT/Backfilling.

(vi) Indigenization of equipment as currently, most equipment are imported impacting project cost.

B. Addressing lower production and productivity :

(i) Introduction of Mass Production Technologies.

(ii) Planning for more longwall faces preferably in deeper seams be done.

(iii) Performance linked incentive or tax relief to the indigenous machine manufacturers.

(iv) Collaborations/Joint Venture with internationally reputed equipment manufacturers.

(v) Creating more Innovation Centers for heavy engineering.

(vi) Development of multi-skilled workforce for reduced manpower deployment

(vii) Recategorization of underground projects as Category-B2 projects.

(viii) Grant of permission for underground development after Stage-I.

(ix) More coal blocks for underground mining be put up for auction and incentivizing new coal block owners who opt for underground block.

C. Addressing lower percentage extraction :

(i) More Highwall mining should be planned in conjunction with paste-fill technology in such cases to get higher % of extraction, say 60-70% (whereas it is normally around 33%).

(ii) Back-fill/stowing technology needs big leap if the seams locked in pillars are to be extracted and UNDERGROUND production capacities are to be augmented.

(iii) CIL is saddled with around 5 BT in developed pillar for which DGMS may be perused for relaxations for possession of land. Statutory relaxations/ Policy interventions is required.

D. Addressing strata control and ventilation issues :

Policy interventions is needed to get help of overseas expertise and engaging technical consultants to address strata control and ventilation issues. For better ventilation standards, systems applied in advanced countries may be adopted and surface cooling systems, peripheral ventilation and borehole ventilation may be thought of depending upon the size of panel. Relaxation in regulation for ventilation in case of MPT may be sought.

E. Addressing fires/explosions/inundation :

(i) Developing system of pre-drainage of methane from seams, when it contains even 2-3 m^3 per tonne coal produced. This can make operations very safe, and possibilities could be explored to tap this gas for commercial use.

(i) Enforcement of compliance culture in the mines.

F. Addressing low-capacity mines:

(i) Planning of higher capacity underground Mines of more than 2 MTPA Capacity.

(ii) For MPT, bigger size panel be planned which is not the case presently due to incubation period restriction. Size of underground blocks should be 10-15 sq.km. for planning large size panels for underground mining. Incubation period can be varied with mass inertization to avoid spontaneous heating as has been followed in Australian mines.

SECL has always remained the pioneering as well as the highest underground coal producing subsidiary of CIL. The company has geared up to enhance underground coal production astronomically in line with the plan of CIL/MoC.

Foray into Solar Power

As per an internal assessment by SECL, the electricity consumption by SECL for FY 2022-23 was 988 Million Units (MU), which translates to around 626 MW of solar power generation capacity for achieving net zero against this consumption of electricity. The total solar energy generated during 2022-23 was 1,04,617 units through its installed Rooftop Solar plants in Johilla, J&K and Hasdeo Areas, resulting in reduction of about 90 Te of CO_2.

SECL is striving to achieve a solar power generation capacity of 626 MW as a crucial component of its Net Zero initiative by the fiscal year 2025-26. The company's step-by-step plan for achieving Net Zero electricity consumption is illustrated in Fig. 8.

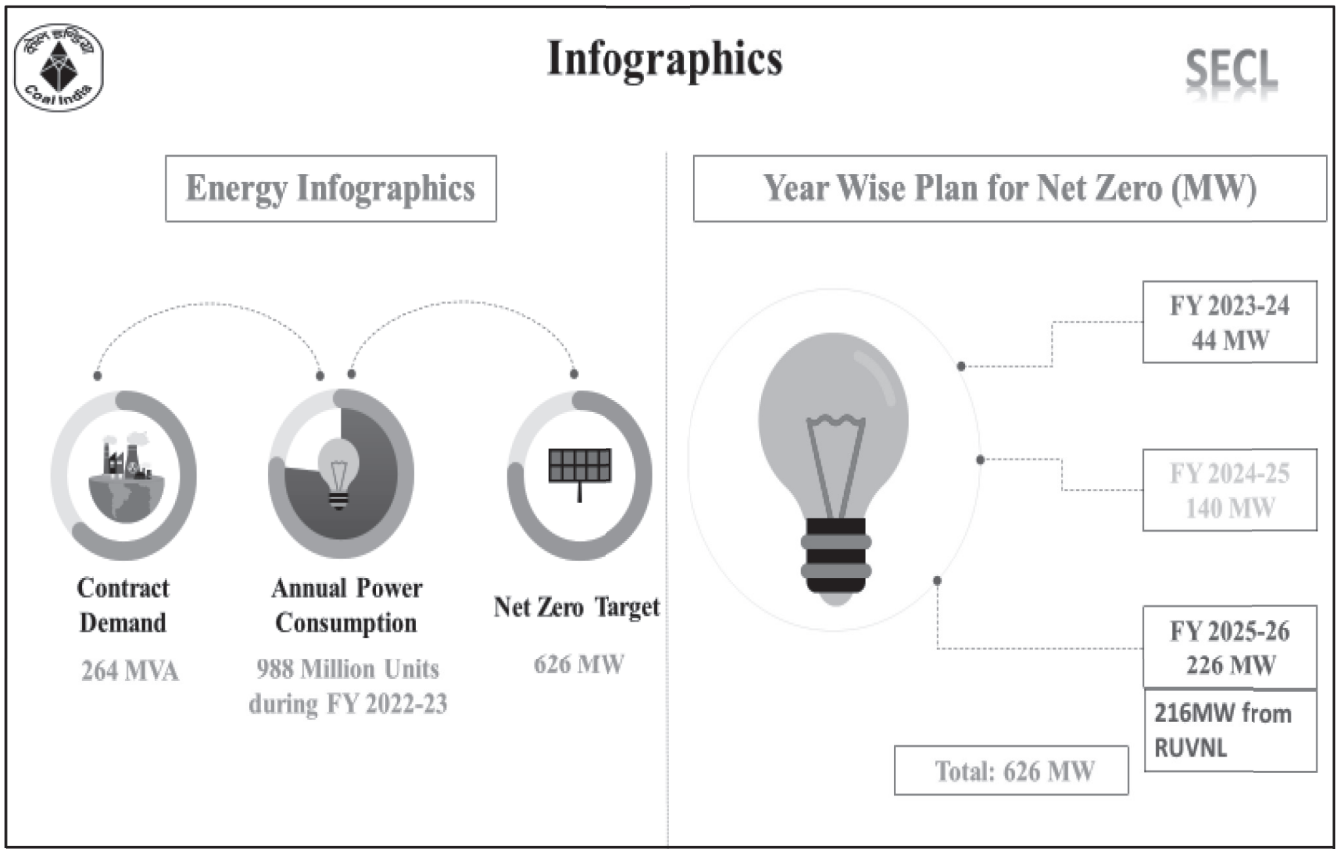

Fig 8 :Year-wise plan for Net Zero for Electricity consumption

Installation of Rooftop Solar Power Plant on Buildings of Various Areas of SECL :

Rooftop solar plant with capacity of 580 kWp was successfully commissioned in SECL and a Letter of Acceptance (LOA) has been issued for the installation of a cumulative capacity of 4000 kW grid-connected rooftop Solar PV Plant on 5th october 2023. This installation will be spread across various buildings in different areas.

Installation of 40MW ground mounted grid connected Solar Power PV Plant on SECL's own land at Bhatgaon and Bishrampur Areas under CAPEX model :

Civil work and the supply of materials/machinery are currently underway. A 20MW Solar PV module has been supplied to the site, with a 5 MW module currently in transit. Additionally, the installation of 18.5MW of solar modules has been completed at the Bhatgaon site. The 10 MW solar plant has been commissioned and is undergoing a trial run.

Installation of 40 MW (1st Phase) Ground Mounted Grid Connected Solar PV Power Plant on SECL's Own Land at Johilla Area of SECL under CAPEX model :

Detailed Project Report (DPR) of 40 MW has been prepared by M/s CNUL.

Moreover, Installation of 1.5 MW (AC) floating solar plant at Trench-1 of Sharda opencast mine of Sohagpur area, SECL is also in progress.

Environmental impact of commissioning of 626 MW of Solar Power plant are summarized in Table 3.

Table 3 : CO_2 avoidance through commissioning of 626 MW of Solar Power Plant (SPP)

Parameters	626 MW SPV plant
The Annual generation	Approx 1001.6 Million Units (MU)
CO_2 Emission Reduction per year	= 626*1.6*1000000*0.8 = Approx 801 Kilo tons of CO_2

A. Financial Resources and Investing in Green Energy

Total investment in installation of the 626 MW SPP will depend on the mode of installation of the solar plant (CAPEX, PPE and Revenue). In addition, SECL is also exploring to invest in other projects like, Floating Solar Plants. The investment in solar projects identified/ under execution over CIL land are presently being financed through CAPEX mode of company. Other Pan India projects are being planned to be financed through debt to be sourced from commercial banks and financial institutions.

Cost of project for installation of rooftop 4,000 kWp is around 19 crore. Total Project cost including EPC, PMC, and O&M charges (for 10 years) for Installation of 40MW ground mounted grid connected Solar Power Plant on SECL's own land at Bhatgaon and Bishrampur areas under CAPEX model comes to ₹180 crore. Likewise, total estimated cost of project for installation of 40 MW Ground Mounted Grid Connected Solar Power Plant on SECL's own land at Johilla area of SECL comes to ₹ 286 crore inclusive of 10 years O&M and GST. The estimated cost of the project as provided by CMPDI for Installation of 1.5 MW (AC) floating solar plant at Trench-1 of Sharda OC mine of Sohagpur area, SECL is around ₹14 crore.

B. Developing Skills for Clean Energy

Solar cells at subsidiary level have been developed to implement RE projects efficiently and in time bound manner. Training and development of executives of solar cells are being conducted to enhance the technical and managerial skills at reputed institutes like National Power Training Institute (NPTI) etc.

Efficient Mechanized Coal Evacuation - First Mile Connectivity (FMC) Projects

SECL is advancing its efforts to facilitate the smooth and efficient movement of coal, characterized by automated loading onto railway wagons with minimal human intervention through its FMC Projects. FMC projects offer a focussed and systematic approach for reducing carbon emissions in coal transportation. It optimizes coal transportation process by streamlining movement from mines to destinations, there by minimizing the carbon footprint per unit of coal transportation. By curbing traffic congestion and minimizing the road transport, FMC projects reduce emissions from vehicular exhausts and enhance safety. Automation and optimization of coal loading significantly reduce carbon emissions significantly.

For quicker and quality loading of coal having environmentally friendly benefits, SECL under 'First Mile Connectivity Projects', has identified 16 projects (09 projects in Phase-I, 05 in Phase-III & 02 in Phase-IV) with 206.9 MTPA.

In **Phase-I,** SECL has undertaken 9 FMC Projects, with a cumulative capacity of 145.90 MTPA. Three (03) of these projects, with a combined capacity of 70 MTPA, have already been successfully commissioned. Moreover, an additional 05 projects of 45.90 MTPA capacity, are poised for commissioning during the fiscal year of 2023-24 and 01 project of 30 MTPA is expected in FY 2024-25. The total capital investment in phase-I FMC project is around 4000 crores, including the capital investment which will be incurred in development of FMC lined sidings.

In **Phase - III,** 05 projects, including 03 MDO identified projects, namely Pelma, Madannagar and

Durgapur OCPs, with an aggregate capacity of 47 MTPA are under implementation and are planned to be commissioned by FY 2028-29.

Recently, 02 FMC projects viz. Porda Chimtapani (10 MTPA) and Rampur Batura (04 MTPA) have been identified to be commissioned in **Phase-IV.**

Post materialization of FMC projects in Phase I, III and IV, along with previously operational CHP Silos of 36 MTPA capacity, the grand total mechanized coal loading capacity of SECL will be about 242.9 MTPA by FY 2028-29.

So far, FMC projects were being commissioned in projects having capacity of 4MTPA or more. Looking ahead, SECL has plan to introduce the FMC concept into all its future mining projects, wherever they are techno-economically feasible. This forward-thinking approach underscores SECL's commitment towards sustainable growth by reducing carbon footprint.

Energy Efficiency Measures

SECL has adopted of a mix of energy efficient measures with implementation of energy efficient appliances, motors, and auto timer streetlights. These measures resulted in a reduction of 9.6 kt CO_2 emissions in FY'23. Total savings on energy was 11.82 million KWh (units) as a result for FY23.

A. E-Vehicle in CIL and its Subsidiaries

Presently, SECL is mostly hiring the services of light vehicles instead of purchasing the same. Light and medium light vehicles like Jeep, Car, and Ambulances etc. are being hired at area level and SECL HQ level. A few vehicles which are normally used by higher ups are purchased, maintained and operated departmentally.

Since 2021-22, SECL is giving special emphasis on purchasing / hiring of electrical vehicles at different Mines, Areas and SECL HQs. In FY 22-23, SECL has deployed 19 Nos. of Electric Vehicles (EVs) on hiring basis in different Areas. In FY 23-24, 11 Nos. of EVs on hiring basis has been deployed. Another 06 nos. EVs for procurement is under tendering process and 4 nos. EVs on hired basis is under tendering process.

B. Use of LED Light and Energy Efficient Appliances

Replacement of more than 1.5 lakhs high wattage lights and conventional light fittings with energy efficient LED lights for quarries, underground mines, street lights, offices, and townships is going on. This transition to LEDs has resulted in significant energy savings.

In FY 22-23, 34119 Nos. of LED lights fittings has been installed at different mines, offices and establishment of SECL. Total energy saving of 1,18,19,163 Units/year and 9692 Ton/year carbon offset created in FY 22-23 due to installation of LED light fitting and other energy saving appliances. In FY 223-24 about 4656 nos. LED lights of different wattage have been installed in different mines of SECL.

C. Energy Audit :

For FY24, energy audit conducted in 4 building of SECL for making then Energy Efficient Buildings.

Clean Coal Technologies

A. Deployment Blasting Free Green Technologies both at opencast and underground mines

SECL has been pioneer in deployment of blasting free coal mining technologies, both in opencast and underground mines, which is environment-friendly and reduces CO_2 emission. In this regard, increasing deployment of Surface Miners (SM) and Rippers at OC Mines and Continuous Miners (CM) and Highwall Miners are being done by SECL.

Deployment of Surface Miners in OCMs resulting in Major Reduction in Carbon Emissions

Surface Miner is coal-cutting machinery for opencast mining, which cuts coal while moving over the seam at a slow pace. This machine obviates the use of drilling, blasting and crushing operations in coal as the cuttings are suitably sized. Use of Surface Miner contributes immensely in energy saving and CO_2 emission reduction, as three operations viz. drilling, blast-

ing and crushing which takes huge energy, gets eliminated.

The machines are very beneficial in terms of economy as well as environment as it saves cost of production and also reduces carbon emission (Table 4). A comparative analysis of use of Surface Miner with the conventional method of drilling, blasting and crushing was done in FY 2009-10 at Kusmunda OCP, which showed excellent benefits derived due to use of Surface Miner, as the project was able to curtail 8256 Metric Tons of CO_2 through deployment of 02 Nos. of SMs having 8,000 TPD and 15,000 TPD Capacity respectively.

Table 4 : Comparison between carbon emissions through conventional methods and Surface Miner system

Sr. No.	PROCESS	CONSUMPTION	CARBON EMISSION(MT CO_2)
A1	DRILLING		
A1.1	ELECTRICAL (KWh)	1567873	1081
A1.2	DIESEL (Litres)	156034	366
A2	CRUSHING (KWh)	12930109	8916
A3	BLASTING (Kg exp)	3103666.759	1471.138044
	TOTAL- Conventional (Metric Ton CO_2)		**11834.13804**
B	***SURFACE MINER (Litres)***	1608813.518	3778
	Emission Reduction per Annum (Metric Ton CO_2)		8056.138044
	Emission Reduction (Mton CO_2/Te)		0.000719026

In view of the above, SECL has maximized the use of SMs at OC Mines. Total coal production of SECL from Surface Miners in the year 2022-23 was 113.4 Million Tonnes, which accounts for about 68% of total coal production and about 73% of total OC coal production of SECL. SECL has plan to further increase the coal production from SMs for better production and environmental sustainability.

Likewise, increasing nos. of Continuous Miners (CMs), which eliminates drilling and blasting, drastically reduces manpower and emission and improves productivity, are being deployed in mines. 12 CMs are already running while 45 more are to be commissioned.

B. Clean coal initiatives through Surface Coal Gasification (SCG) route :

SECL is also trying to take up clean coal initiatives through Surface Coal Gasification (SCG) route. For this, Pre-Feasibility Report (PFR) for setting up a C2DME [Coal to Di-Methyl-Ether (DME)] plant at Mahamaya OCP of Bhatgaon Area on LSTK (Lump Sum Turn Key) mode of implementation has been submitted by Project and Development India Limited (PDIL). For joint development of this SCG project, CIL has signed MoU with IOC on behalf of SECL. However, Coal to DME project of SECL has been kept in abeyance. But SECL is exploring option for reviving the same.

C. Development of CBM projects in CIL Lease hold areas:

SECL has identified Sohagpur CBM Block-I (Lease-hold area of 50 Km^2 of Beherab and mine in Shahdol and Anuppur Dist. MP). Project Feasibility Report is already approved and CMPDI has been engaged as Principal Implementing Agency under a MOA. The Gas-In-Place (GIP) reserve as assessed by CMPDI is 0.53 Billion Cubic Meter (BCM).

Field development model of 10 years production plateau of 56,600 m3/day has been envisaged.

Total estimated Capital cost = Rs 202.73 Crores, of which SECL's cost = Rs 15.63 Crores (land cost). MOA with CMPDIL as PIA signed on 10.12.2020 and Work Order to CMPDIL issued on 11.12.2020 for execution of the Project.

Tender was floated by CMPDI four times but in all cases no bid received. Now, it was decided that in view of non-participation of Bidders for finalization of CBM Blocks tenders, projects may be excluded from monetization Plan.

Green Cover Enhancement

SECL has undertaken extensive plantation along avenues, on OB dumps, around mines and residential colonies to maintain the ecological balance in and around its operations. In FY'23 total 8.14 lakhs of saplings were planted in over 365.57 Ha. area, which is more than +15% over FY'22. Over last five years, SECL has planted + 37.21 lakhs of saplings covering 1510 Ha. area. SECL is well positioned to cross its initial plantation target 1500 Ha coverage over a period of 5 years from 2021-22 to 2025-26.

Till FY'23, 02 Eco-parks/Eco-restoration sites namely Ananya Vatika Eco-Park, Hasdeo area and Kenapara Eco-Tourism Site, at Bishrampur area have been developed by SECL while it has plan to develop 03 Eco-parks in near future for which actions has already been taken.

As plantation/forest acts as sink for the GHG and has got huge emission reduction potential (Emission reduction of over 50 Tons of CO_2 equivalent GHG per Ha of forest land), it is one of the most thrust given area for SECL to achieve Net Zero target.

Digitalization at SECL

For achieving Net Zero, Digital transformation is very crucial. Digital transformation is all about collection of data and using these data for monitoring and controlling the emission from the activities. Just by means of digital dashboard and data visualization, process optimization, minimization of wastage, increasing of energy efficiency, reducing of downtime, improving of production, minimization of emission etc., can be achieved.

Implementation of digitalization and process excellence at 3 mega-opencast projects of SECL is being done under Digicoal with Accenture. SECL is trying hard to make the entire business digitally leaned by upgrading the technologies and developing digital culture in the organization.

Closing of Abandoned Mines

From study, it has been revealed that abandoned mines poses extreme environmental health and safety risk and are source of GHG emission. These abandoned mines can be used for afforestation, installation of solar plants, development as Eco-Park or Mine tourism, providing sites for Green Gravity's energy storage technology, etc. SECL is working in this direction as one of the measure for achieving Net Zero.

Conclusion

Net Zero is such a thing, which requires a holistic socio-environment friendly approach in carrying out all activities right from the prospecting and opening of a mine to its closure activities. It requires redefining of policies, faster technology absorption, integration of OT (Operation Technology) with IT (Information Technology) and IOT (Internet of Things), Forward Integration of Industry, Social Innovation for getting Social licencing/acceptance (need of changing the image from Earth Breaker to Earth Maker), adoption of the current best practices which are in vogue India and abroad, etc. Adoption of sustainable mining methods and coal evacuation process which have lesser carbon footprint on environment, adopting energy efficiency measures, use of clean coal technologies, transition into clean renewable sources of energy, minimization of waste by adopting circular economy (Reduce, Reuse and Recycle), doing massive plantation, digitalization of processes, proper closing and use of abandoned mines in environment-friendly way, etc. are some of the major things which are required to be done. In fact, achieving

sustainability and Net Zero requires implementation of 5Es – Engineering (for making the process sustainable), Education (Up-skilling and competence building), Ecosystem (Value based system wherein everyone acts like a change agent for bringing good things in the organization), Economics (investment of sufficient funds in building sustainable infrastructure) and Enforcement (implementation of the Net Zero road map with due diligence). SECL being a responsible corporate entity is committed to decarbonize its activities and taking environment-boosting measures for achievement of Net Zero in a time bound manner.

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You Tube, Google and Some TEDs Talk on Climate Chane and Net Zero

INDIA'S NET-ZERO COMMITMENT BY 2070 AND ITS IMPLICATIONS FOR THE FUTURE OF THE INDIAN COAL SECTOR

N. C. Jha[1]

Introduction

The United Nations Framework Convention of Climate Change (UNFCCC) in its 26th Conference of Parties (COP 26) held at Glasgow, United Kingdom desired different countries to declare their resolve for Net-Zero timelines. Notably, the United States set an ambitious goal of achieving Net-Zero by 2050 (Dafnomilis *et al.*, 2023), signaling a profound commitment to mitigating climate change. China pledged to reach Net-Zero by 2060, and India, positioning itself on the global stage, declared its intent to achieve Net-Zero by 2070. Before we proceed further on the subject, it would be prudent to understand what is meant by "Net-Zero" and what have been the pledges of India, as promised by the Honorable Prime Minister of India.

The global move towards Net-Zero has profound implications for industries, particularly the coal sector, which traditionally has been a significant contributor to greenhouse gas (GHG) emissions (May field, 2022). As India charts its course towards Net Zero by 2070, the coal industry finds itself at the epicenter of transformative changes. The transition to cleaner energy sources and sustainable practices is likely to reshape the dynamics of the coal sector, necessitating adaptation and innovation.

To comprehend the intricate challenges and opportunities that lie ahead for India's coal industry, it is imperative to evaluate the specific pledges made by the country in the context of COP 26. This article aims to provide a preliminary assessment of the potential impacts on India's coal industry, shedding light on the multifaceted aspects of the transition towards a Net-Zero future.

What is Net-Zero?

Net-Zero Emission or Net-Zero means not adding to the additional amount of greenhouse gases to the atmosphere. In other words, Net-Zero refers to the concept of balancing the amount of greenhouse gases emitted into the atmosphere with an equivalent amount removed or offset, resulting in no net increase in overall emissions (Fankhauser et al., 2022).

Net-zero emissions will be achieved when all GHG emissions released by human activities are counterbalanced by removing GHGs from the atmosphere in a process known as carbon removal. Achieving it means reducing emissions as much as possible, as well as balancing out any that remains by removing an equivalent amount. Achieving net zero can involve a combination of strategies, including increasing energy efficiency, transitioning to renewable energy sources, adopting carbon capture and storage technologies, and investing in projects that remove or offset greenhouse gas emissions, such as reforestation or carbon capture initiatives. The specific measures taken to achieve net-zero can vary depending on the entity involved and the sector in which it operates. Figure 1 illustrates the pathway to achieving net zero by eliminating carbon emissions to offset the remaiing environmental impact.

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The paper was presented at the MGMI organized National Seminar on Green Mining and Net-Zero (GMANZ 2023) in Kolkata on 23rd September 2023.

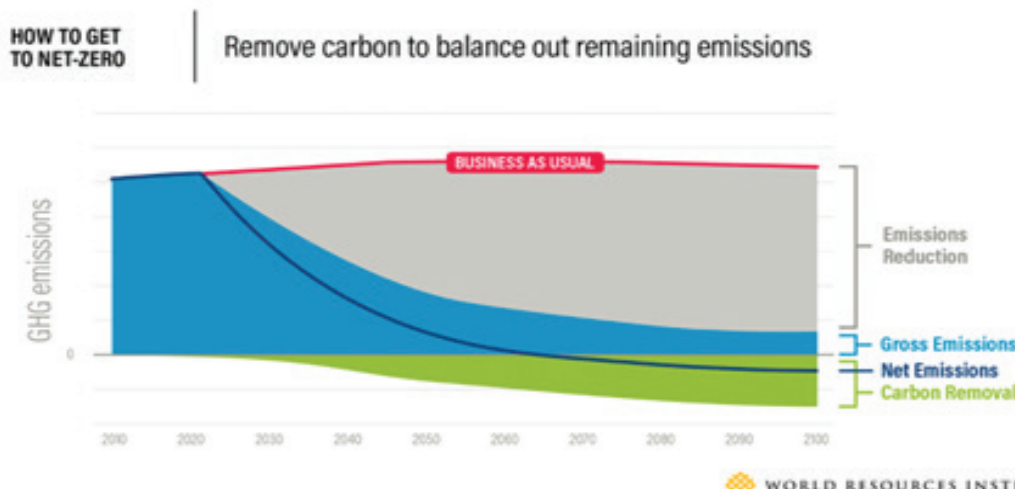

Figure 1 : Path to net zero through carbon emission elimination

Greenhouse gases like carbon dioxide (CO_2) are released when we burn combustible material, such as oil, gas, coal and biomass, for our homes, factories and transport. Methane is produced through farming, landfills, coal mining and handling activities of oil and natural gas systems. These gases cause global warming by trapping the sun's energy.

The idea of "Net-Zero" was promoted in a special report of the Intergovernmental Panel on Climate Change (IPCC) approved by the world's governments in 2018, wherein it was summarized that countries bring greenhouse gas emissions to "net-zero" by 2050 to keep global warming within 1.5°C of pre-industrial levels (IPCC, 2018). The target for achieving this was kept as year 2050, while limiting that to 2.0°C level was kept as year 2100.

Importantly, the time frame for reaching "net-zero" emissions is different for CO_2 alone versus for CO_2 plus other greenhouse gases like methane, nitrous oxide, and fluorinated gases. For non-CO_2 emissions, the net zero date is later, because models assume that some of these emissions — such as methane from agricultural sources — are more difficult to phase out. Figure 2 depicts the global timeline for achieving net zero emissions.

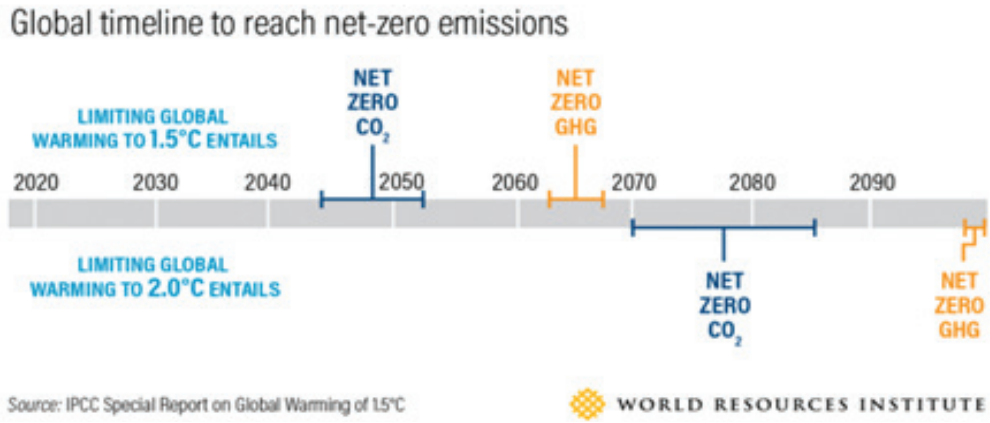

Figure 2 : Global Net Zero Emissions Timeline

All countries in the G7 - representing the world's largest advanced economies believe that the human-caused emissions from fossil-fueled vehicles and factories, should be reduced as close to zero as possible. Any remaining GHGs should then be balanced with an equivalent amount of carbon removal, which can happen through things like restoring forests or using direct air capture and storage (DACS) technology (Breyer et al., 2019).

It is also necessary that the transition from the current approach of energy generation towards net zero is done in a just manner, especially for workers tied to high-carbon industries and also the population dependent on such activities for their livelihood. In fact, the costs and benefits of transitioning to a net-zero emissions economy must be distributed equitably.

Global action for setting net-zero targets is growing fast, with major economies like China, United States, India, and the European Union making all efforts to meet such commitments. Bhutan was the first country to set a net-zero target in 2015. Now over 90 countries, representing nearly 80% of global emissions, are covered by a net-zero target.

It is pleasant to note that most of the technologies needed to reach net zero targets are already available or in advanced stages of development and becoming increasingly cost-competitive with high-carbon alternatives. Solar and wind now provide the cheapest power available for most of the world. Markets are responding to these opportunities and to the risks of a high-carbon economy, and they are shifting accordingly. Some key technologies that are considered crucial for achieving net-zero emissions are Renewable Energy Sources (RES), Energy Storage, Carbon Capture Utilization and Storage (CCUS), Electric Vehicles (EVs) and Transportation Electrification, Smart Grids and Energy Efficiency Technologies, Green Hydrogen Production and Sustainable Agriculture and Forestry Practices.

However, developing countries including India, aspiring to become advanced economy, believe that the western nations have the historical responsibility over climate change and should provide adequate financial assistance to the developing countries for climate restoration. These countries want the developed countries to provide a Climate Change Finance of $1.5 trillion to the developing countries to achieve Net Zero objective. Hence, the pledges made by the developing countries at the COP 26 summit are conditional. However, every country must make progress in this direction to stop any climate catastrophe.

CO_2 Emission in India by Fuel Type

Even though coal accounts for only 55% of the primary energy in the country, it is responsible for more than 2/3rd of the CO_2 emitted to the atmosphere. Figure 3 shows how the CO_2 emission from coal has increased over the last 30 years.

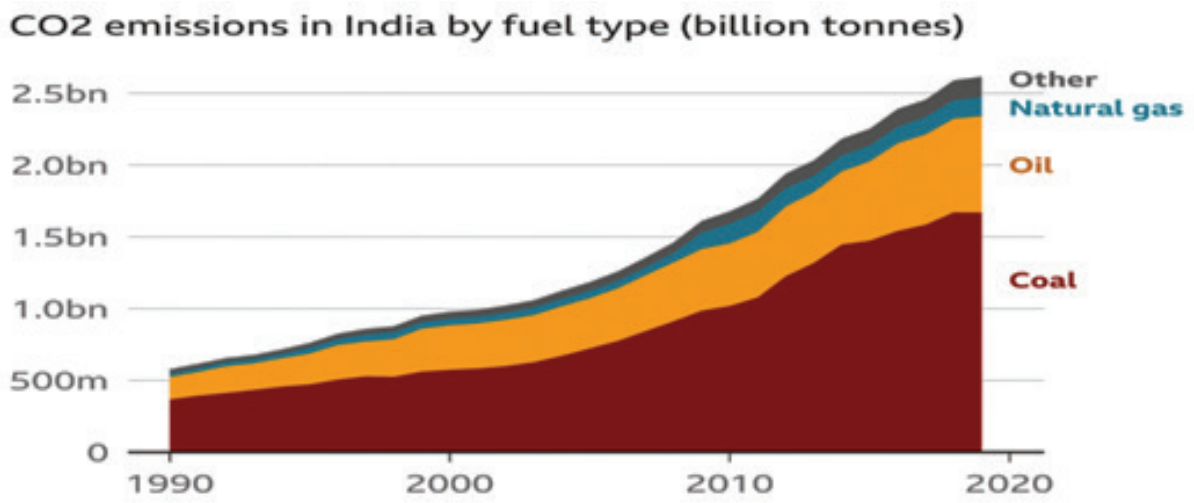

Figure 3 : CO_2 emission from various sources

Other includes flaring, cement production and other industrial emissions

Source : Global Carbon Project 2021

India's Carbon Emission compared to other Countries

In the year 2020, though India, as a country, ranked third in global carbon emission, it had contributed only one fourth that of China and nearly half that of USA. Figure 4 shows how it fits in the overall global CO_2 emission.

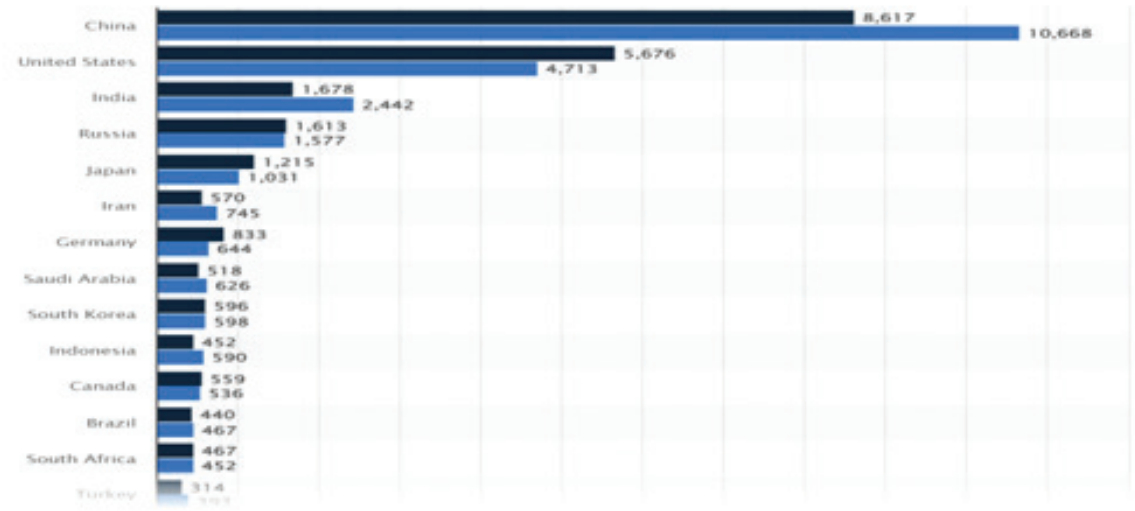

Figure 4 : Carbon Dioxide Emissions in 2010 and 2020, by Select Countries

(in million metric tons)

Source : Energy & Environment>Emissions

India's Carbon intensity of Energy Production – Highest in the world.

With the increasing use of inferior grade coal for power generation in India, the amount of carbon dioxide (CO_2) produced for one unit of power (kWh) production is the highest now, at the level of around 0.275 kg/kWh, overtaking China, which had been on the top in this category, so far. Figure 5 shows the status of different countries:

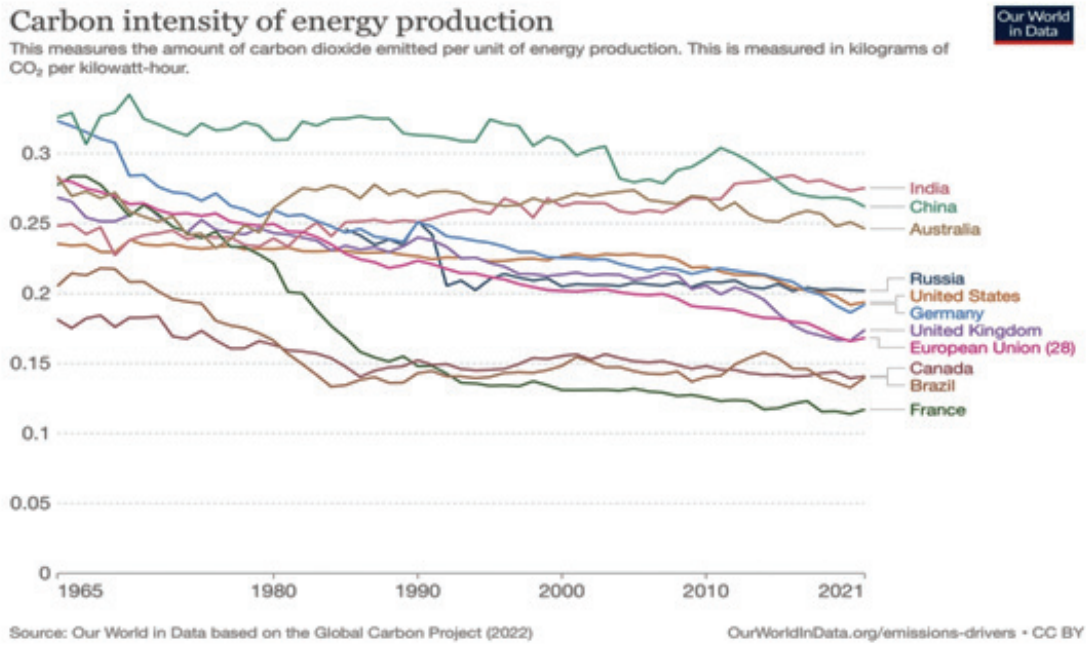

Figure 5 : Carbon intensity of energy production for different countries

India's Commitment at COP26

Hon'ble Prime Minister of India during his speech at COP 26 made the following pledges on India's decarbonisation roadmap :

1. Increase non-fossil energy capacity to 500 GW (gigawatts) by 2030.
2. Meet 50 percent of energy requirements from renewable energy (RE) by 2030.
3. Reduce the total projected carbon emissions by 1 billion tonnes (BT) by 2030.
4. Reduce the carbon intensity of the economy by less than 45 percent.
5. Achieve net zero carbon by 2070.

Impact of COP26 Pledges on Indian Coal Sector

Of the above 5 pledges, the first two relate to building up the capacity of renewable energy to 500GW by 2030, being 50% of India's total energy requirement by this time. This indicates that the total energy from fossil fuels would be around 500GW by 2030 meaning thereby that coal being the major contributor of energy intensity amongst the fossil fuels, its share in quantum as energy provider will increase at least up to 2030, but in percentage terms it is bound to reduce from the current level of 55% in the total primary energy basket. This shows that power generation from coal is projected to increase in near future terms.

In opinion of the author, the major concern for the coal sector lies in pledge No. 3, which requires the country to reduce the total projected carbon emission by 1 BT by 2030. This is a radical pledge as it promises an absolute reduction in carbon dioxide (CO_2) emissions by 2030. While the projected CO_2 emission by 2030 is not known, its reduction by 1 BT would mean reduction of fossil fuel usage by about 590 MT coal equivalent from the projected level for 2030. This is a serious threat on usage of coal as energy provider, as coal currently accounts for nearly 55% in the total source basket for primary energy sources in India.

The last pledge of achieving net zero status by 2070 gives us enough time to adhere to it. It also provides the scope of emitting or generating CO_2 and making arrangements for sequestering it through the trees and artificial processes to keep it at net-zero level.

Past trend of coal consumption in the country

The trend of total annual coal consumption in the country, including the imported coal, coke and other products is shown in the following chart. It shows that there has not been substantial increase in the coal usage in the country in the past ten years. Total consumptions in the last 5 years have been hovering between 950 MT to 1100 MT. Years 2019-20 and 2020-21 saw a slight declining trend while the past two years have seen increased usage of the solid fossil fuel in the country as shown in Figure 6.

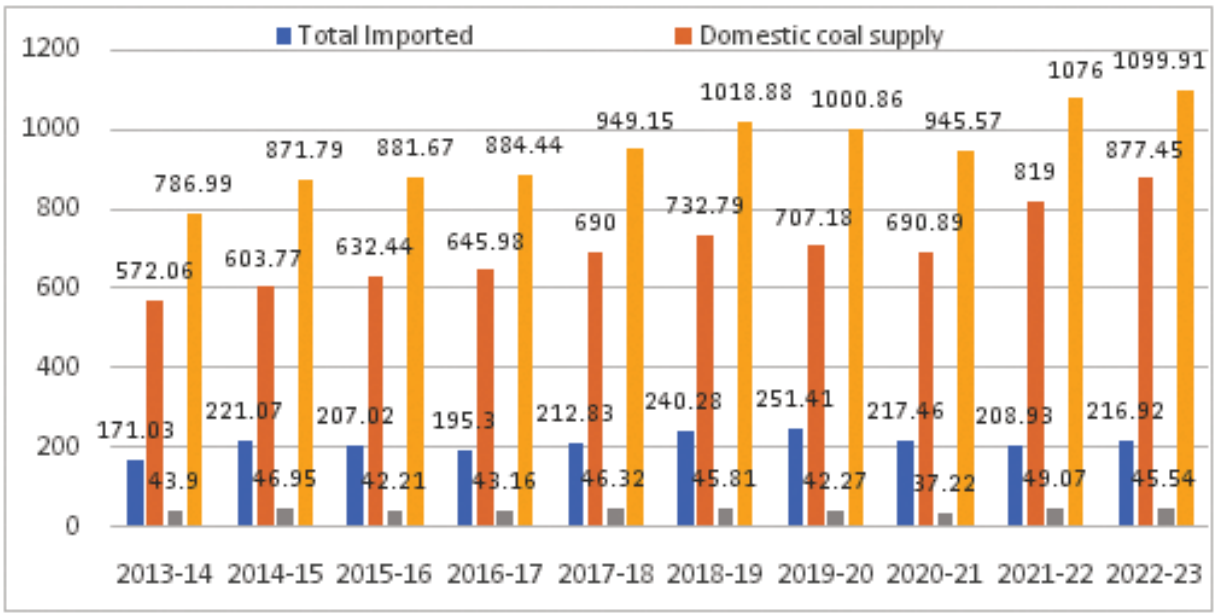

Figure 6 : Trend of coal consumption in India

Source : Data taken from Coal Statistics 2022-23

All India Power Generation Capacity and Energy Generated in June 2023

India's target for capacity creation of Renewable Energy was 175 GW by December 2022, which was missed. However, by the end of June 2023 it has surpassed that target by increasing the capacity to 176.49 GW, out of the total power installed capacity of 421.90 GW, which is 41.83% of the total. Compared to this the share of energy generation has been only 23.83% from the renewables. Installed capacity of renewable based (non-fossil fuel based) generators must be increased to 500 GW by the end of 2030 as per the pledge, which seems to be catching up.

Coal and lignite based installed capacity of power generators by the end of June 2023 has been 212.50 GW (50.37% of total of 421.90 GW) contributing 72.82% of the total energy generated in June 2023 (CEA, 2023). This indicates that even though the installed capacity of renewables-based energy generators will increase, the load on energy generation will continue to be on the coal-based generators. Figure 7 displays the all India installed capacity as of 30.06.2023 and energy generation from various sources in June 2023.

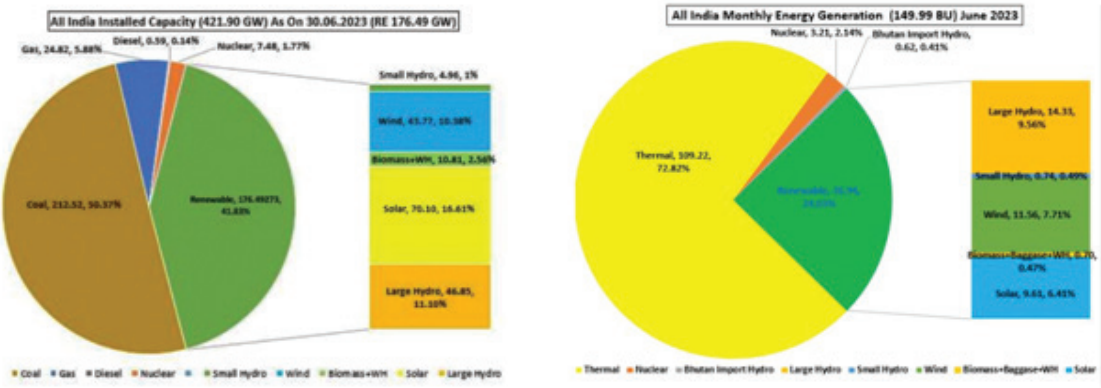

Figure 7 : All India installed capacity and energy generation from diverse sources

Source – CEA

Growth of Renewable Energy (RE) installed Capacity in last 6 Years

In the past 6 years, there has been substantial growth in the installed capacity of renewables based generating capacity creation from nearly 50 GW in January 2017 to 176 GW in June 2023, largely due to increase in solar power from 9 GW to 70.10 GW and wind from 28.7 GW to 43.77 GW (Figure 8). This is also an indicator that the target of 2030 of 500 GW can be reached safely by enhanced drive in solar and wind power.

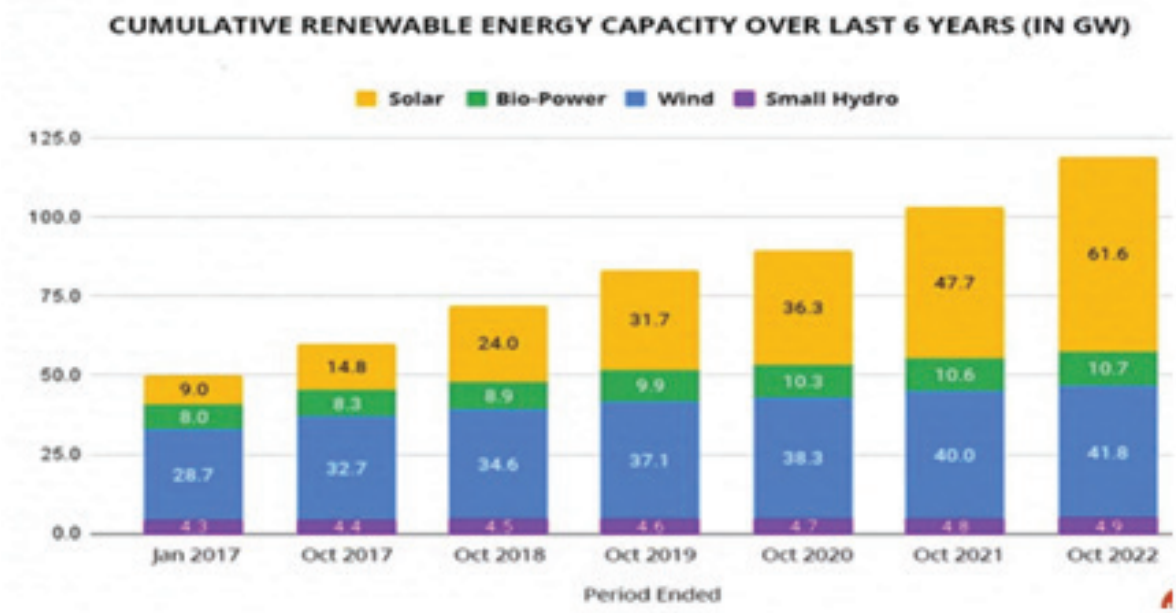

Figure 8 : Cumulative addition of renewable energy capacity over the past six years.

Source - CEA

Future projection for Coal Based Energy Plan for India

The Draft National Energy Policy of 2017, published by NITI Aayog, mentions that the large power requirement and solid fuel demand in process industries brings to fore the need for efficient coal exploitation, investment in related infrastructure, and a forward-looking regime (NEP, 2017). The large planned new coal based thermal capacity is likely to put pressure on coal resources. It further mentions that coal based power generation capacity is likely to go up to

more than 330 - 441 GW by 2040. This is likely to translate into an annual coal demand of 1.1-1.4 billion tonnes. As per this assessment, at high rates of coal demand, domestic coal supplies may plateau by the year 2035. The overall coal demand for the country was estimated to be at 1300 – 1900 MT by 2030, as per the Coal Vision 2030 document of Ministry of Coal. Figure 9 depicts the annual progression of coal production in both business as usual and aspirational scenarios.

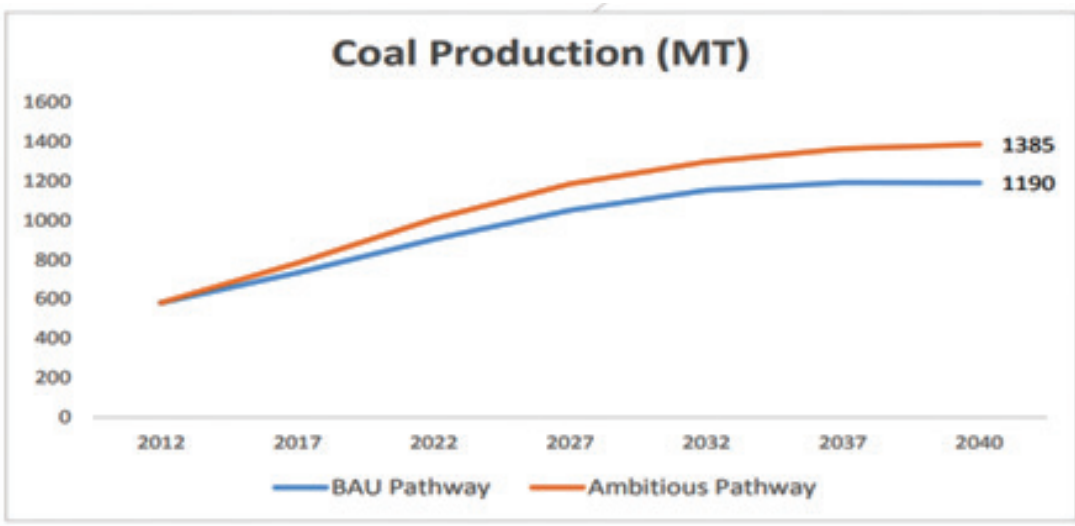

Figure 9 : Annual coal production trends in Business as Usual and Aspirational Scenarios
Source : Draft National Energy Policy, 2017

The National Electricity Policy, 2021 (NEP, 2021) also highlights the role of coal in electricity generation. On thermal generation it clarifies that while India is committed to add more capacity through non-fossil sources of generation, coal-based generation capacity may still be required to be added in the country, as it continues to be the cheapest source of generation, though compliance to stricter environmental norms remains a challenge, particularly in older stations. The Policy stresses that all future coal-based plants should only be of Super Critical/Ultra-Super Critical technology or other more efficient technology.

National Framework for Promoting Energy Storage

India's energy mix is set to undergo a transition from fossil fuel sources to non-fossil fuel-based sources dominated by Renewable Energy (RE) in the future. However, the incorporation of a significant amount of variable and intermittent RE into the energy mix poses a challenge for maintaining grid stability and uninterrupted power supply. Power generation from the conventional energy sources as coal, hydro (with storage), nuclear can be controlled and can meet any fluctuation in the power demand in no time. However, the same is not the case with Renewable Energy (RE) sources as these are to be used instantly, and in case they are not utilised they will be lost forever.

Energy Storage Systems (ESS) can be used for storing energy available from RE sources to be used at other times of the day. Storage of energy will help in bringing down the variability of generation in RE sources, improving grid stability, enabling energy/ peak shifting, providing ancillary support services, and enabling larger renewable energy integration.

A National Framework on Energy Storage System (ESS) has been issued by the Government of India in August 2023 to encourage the adoption of Energy Storage for ensuring an environmentally sustainable and financially viable power sector.

Estimation of Energy Storage Requirement

As per National Electricity Policy (NEP), 2023 the energy storage capacity requirement is projected to be 16.13 GW [(7.45 GW Pumped Storage System (PSP) and 8.68 GW Battery Energy Storage System (BESS)] in year 2026-27, with a storage capacity of 82.32 GWh (47.6 GWh from PSP and 34.72 GWh from BESS).

The energy storage capacity required for 2029 - 30 is likely to be 60.63 GW (18.98 GW PSP and 41.65 GW BESS) with storage of 336.4 GWh (128.15 GWh from PSP and 208.25 GWh from BESS).

By the year 2031-32, this requirement is expected to increase to 73.93 GW (26.69 GW PSP and 47.24 GW BESS) with a storage capacity of 411.4 GWh (175.18 GWh from PSP and 236.22 GWh from BESS).

In order to develop this storage capacity during 2022-27 the estimated fund requirement for PSP and BESS would be Rs. 54,203 Cr. and Rs. 56,647 Cr. respectively. Further, for the period 2027-2032 estimated fund requirement for PSP and BESS would be Rs.75,240 Cr. and Rs.2,92,637 Cr. respectively.

CEA has projected that by the year 2047, the requirement of energy storage is expected to increase to 320 GW (90GW PSP and 230 GW BESS) with a storage capacity of 2,380 GWh (540 GWh from PSP and 1,840 GWh from BESS) due to the addition of a larger amount of renewable energy considering the net zero emissions targets set for 2070.

Future path set in the COP26 agreement

The agreement reached at the end of the COP 26 Summit sets the global agenda on climate change for the next decade :

Emissions

- It was agreed that countries will meet next year to pledge further cuts to emissions of carbon dioxide (CO_2) - a greenhouse gas which causes climate change.
- This is to try to keep temperature rises within 1.5°C - which scientists say is required to prevent a "climate catastrophe". Current pledges, if met, will only limit global warming to about 2.4°C.

Coal

- For the first time at a COP conference, there was an explicit plan to reduce use of coal - which is responsible for 40% of annual CO_2 emissions.
- However, countries only agreed on a weaker commitment to "phase down" rather than "phase out" coal after a late intervention by China and India.

Phasing out Inefficient subsidies to Fossil Fuel

- World leaders agreed to phase-out "inefficient" subsidies for fossil fuels.
- The agreement called on all countries to accelerate the phasing-out of "inefficient" subsidies for fossil fuels - but no firm dates have been set.
- All countries in the G7 have previously committed to phase out "inefficient" fossil fuel subsidies by 2025.
- The IEA defines an "inefficient" subsidy as something that encourages wasteful consumption.

What are fossil fuel subsidies?

Fossil fuel subsidies are measures taken by governments that artificially lower the price of coal, oil, or natural gas. These take two forms :

- Production subsidies - tax breaks or direct payments that reduce the cost of producing fossil fuels
- Consumption subsidies - energy price cuts for consumers, such as setting fixed prices at petrol stations

Figure 10 illustrates an overview of consumption subsidies across various nations. In India, the subsidy on fossil fuel is on electricity and oil and gas only. Coal is rather loaded with extra taxes that make the energy cost higher, yet lowest compared to its counterparts. Transparency on fossil fuel funding is generally poor, but about three-quarters of the world's subsidies are estimated to be focused on consumers, and a quarter on producers. The following chart shows the countries with highest consumption subsidies.

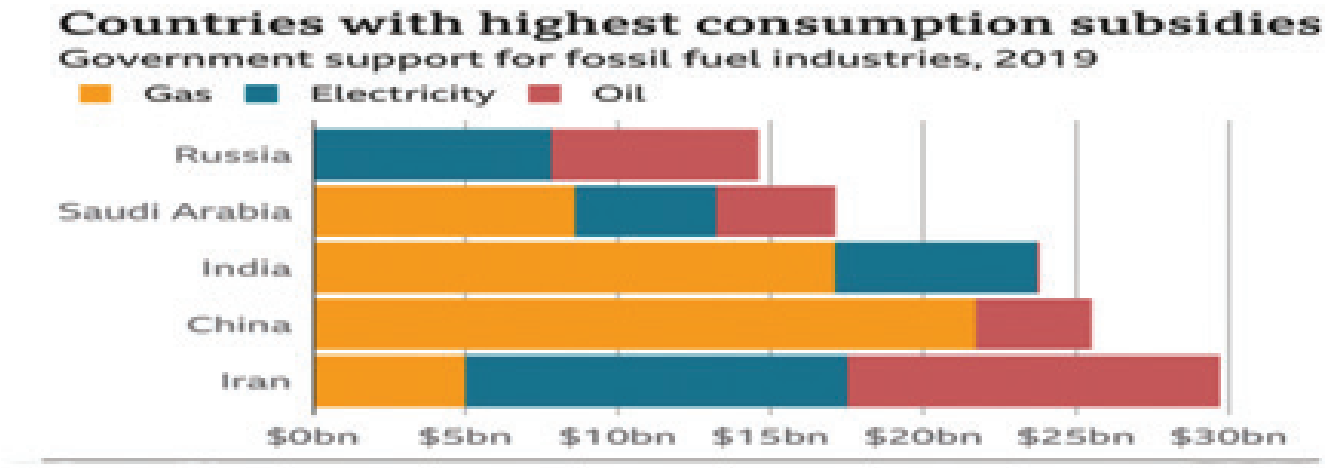

Figure 10 : Consumption subsidies in diverse countries , Source : IEA

Carbon capture and storage Initiatives in India

The greenhouse gas emission footprint of coal-fired power generation could be reduced by carbon capture, utilisation, and storage (CCUS). India has created a programme for CCS and is interested in promoting it through Mission Innovation. Several oil and gas companies, including ONGC, are investigating the potential for CO_2- based enhanced oil recovery and NTPC is interested in CCS.

R & D in CCS is being pursued by CSIR laboratories and academic institutions under the programme initiated by the Department of Science and Technology (DST). As part of Mission Innovation, initiation has been made for funding opportunity in the Carbon Capture Innovation Challenge for joint R&D in the field of CO_2 capture, separation, storage and CO_2 value-added products to be taken up jointly by Department of Biotechnology and Department of Science and Technology with member countries of Mission Innovation. Large areas of our subcontinent may not be suitable for onshore CO_2 storage due to high seismic activity and population density, and any CO_2 storage activity would need to protect subsurface aquifers, which are vital source of ground water for agriculture.

One of the actions identified in the country's National Determined Contribution (NDC) under the Paris Agreement sets out plans to create an additional carbon sink of 2.5-3 billion tonnes of CO_2 equivalent through additional forest and tree cover. NASA Earth Observatory also indicates that India is greening (Figure 11). Although, there have been replanting initiatives in the southern parts, the north-eastern region has lost forest cover in recent times. With an aim to plant enough trees by 2030, it may be possible to absorb additional 2.5-3.0 billion tonnes of CO_2 from the atmosphere.

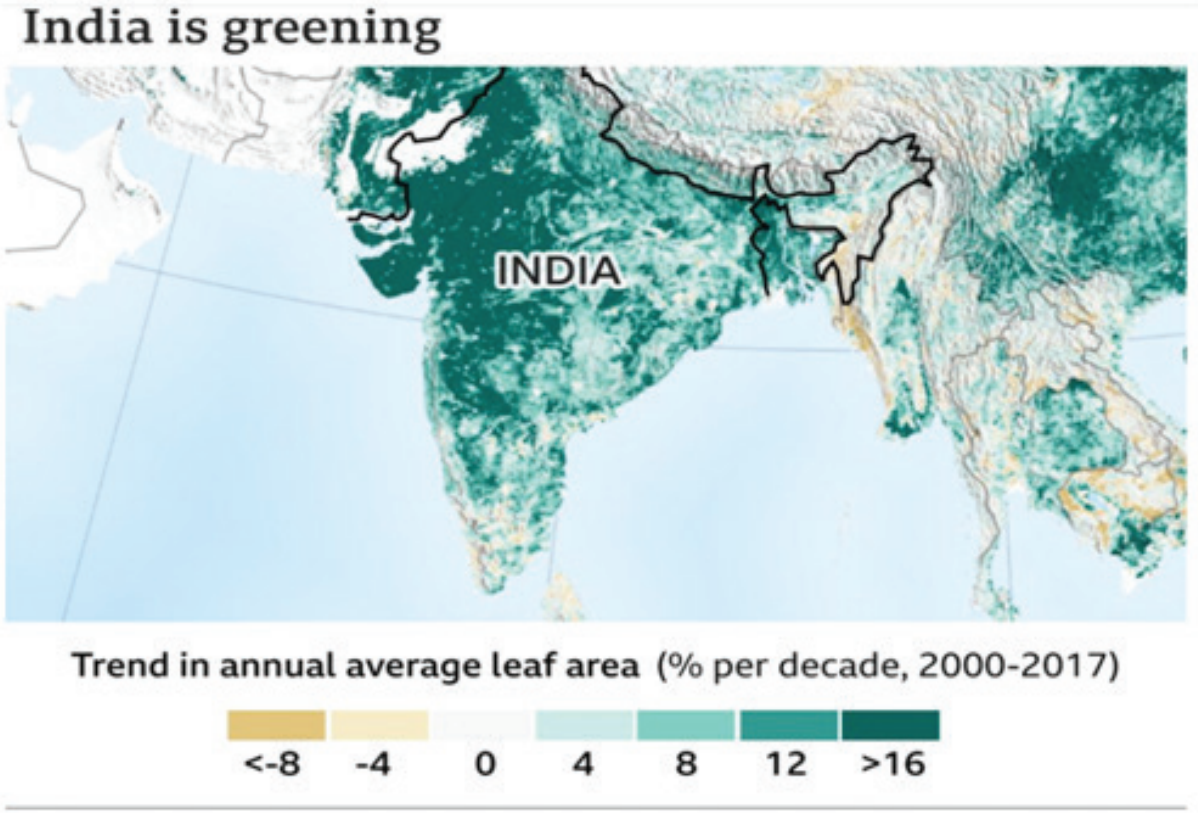

Figure 11 : Increasing green cover in India
Source : NASA Earth Observatory

Conclusions

India's energy mix is set to undergo a transition from fossil fuel sources to non-fossil fuel-based sources dominated by Renewable Energy (RE) in the future. Energy Storage Systems (ESS) can be used for storing energy available from RE sources to be used at other times of the day, for which massive investment is required. Govt. of India has issued a National Framework for Energy Storage System.

Investments in carbon removal techniques are also necessary. The different pathways assessed by the IPCC to achieve 1.5 degrees C all rely on carbon removal to some extent. Removing CO_2 from the atmosphere will compensate for emissions from sectors in which reaching net-zero emissions is more difficult, such as aviation.

Different estimates show different amount of coal requirement for the future. World pressure for making all countries carbon neutral between 2050 and 2070, puts a huge challenge on coal and other fossil fuel usage to continue for long. While in the near future terms the requirement of coal may increase by, say up to 2040, in the longer terms it all depends on the progress made in carbon capture, storage and its utilization and the extent of greening the country by massive plantation.

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Theme of the Next Issue of
MGMI News Journal

Vol. 49, No. 4

"Sustainability in Metals Minerals and Materials"

TECHNICAL ARTICLE

SUSTAINABLE UNDERGROUND COAL MINING TECHNOLOGY : CHALLENGES AND SOLUTIONS

Prof R M Bhattacharjee[1]

Prologue

Two most critical global challenges which impacted the mankind across the globe in recent times are Covid 19 and Global warming and climate change. Both the crisis thwarted the territorial boundaries across the world. Immediately after the world started recovering, the geo-political crisis due to the war between two powerful countries further aggravated the deep wound of mankind and rocked the twenty-first century civilization. But the crisis of global warming has put a big question to the existence of mankind. The fury of nature at different parts of the world in the form of extreme draught or devastating flood or huge super cyclones or the vast area bush fire has time and again given warning to the global citizens of dire consequences of being irresponsible to the nature. All these monsters are believed to be the result of one single cause of climate change due to global warming resulting from excessive green-house gas emissions over the last couple of centuries in the name of civilization totally ignoring the environment.

This article is not to discuss on global warming and climate change. However, the topic, Sustainable Underground Coal Mining Technology: Challenges and Solutions is closely related to global warming and climate change and the declaration of 26th Conference of Parties (COP 26, 2021) of the United Nations Framework Convention on Climate Change (UNFCC), held in Glasgow, Scotland, UK between 31st October and 13th November 2021, where nearly 200 participating Countries reaffirmed the Paris Agreement goal of limiting the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit it to 1.5°C and stressed the urgency of action "in this critical decade," when carbon dioxide emissions must be reduced by 45 percent to reach net zero around mid-century.

Under the overarching topic on Green Mining and Net Zero, discussions will be primarily around various initiatives of Green Energy, renewables and alternative fuels. But keeping in mind the practicality of phasing out coal from the energy basket in countries like India and China, countries with large population of 1.428 and 1.426 billion respectively out of the total global population of 8.1 billion, it is difficult to agree and commit to a policy of phasing out coal by 2050, where coal supplies around 65% of the energy basket. That is why at the 28th Conference of the Parties to the UN Framework Convention on Climate Change (COP-28, 2023) that took place in Dubai, both the countries, India and China has put their points straight that Net Zero does not mean No Coal. It is very difficult to accept that we are going to say Good Bye to coal in another 30/40 years from now. There may be another day of discussion whether coal mining or not in India, but this article is mainly on the principle of Just Transition of Indian coal industry, how to make Indian

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coal industry sustainable keeping in mind the different conflicting issues of global warming and decarbonisation, India's increasing energy demand, domestic coal reserves, coal mining eco-system and socio-economic dependency on coal industry. This article is mainly for Sustainable coal mining or rather Responsible coal mining without going into the debate of Coal Mining or No Coal Mining.

But there is no doubt that future of coal mining is in the hands of today's responsible managers of coal mining. So the primary focus will be on discussion about the challenges before Indian coal industry to supply coal as per demand and how to mitigate the challenges.

1. Impact of coal mining on global warming and climate change

Though the current article is not to discuss on global warming and climate change, there is a need to bring into certain facts of these issues in context to the subject of deliberation.

Increasing concerns about the serious effect of anthropogenic greenhouse gases on global climate have forced the international society to agree on reduction on GHG emissions by reducing use of coal in Thermal Power and other Industries. According to CSE estimates, Thermal Power Stations in India generate approximately 1.1 gigatonnes of CO_2 annually (CSE, 2020). This figure represents about 2.5 percent of global greenhouse gas (GHG) emissions, one-third of India's total GHG emissions, and roughly half of the country's CO_2 emissions related to fuel consumption. The source of supply of coal to thermal power plants is coal mining in India, and hence, impact of coal mining on global warming and climate change cannot be ignored.

Even without attempting to discuss on the future of thermal power, or alternative sources of energy, it must be accepted that coal mining in India has certainly left a huge environmental footprint over the last four – five decades by destroying the natural landscape and large scale deforestation, thereby greatly impacting the natural carbon capture and carbon storage capability and leaving a huge carbon footprint. At the same time, coal mining has also caused significant water and air pollution, millions of tons of fugitive gas emission from mining of coal and indirectly worsening the problem of global warming due to huge energy consumption to produce coal, process coal and transport of coal, etc. at various stages of coal mining life cycle.

1.1. Arguments against coal

In addition to the obvious direct relation between use of coal and global warming, certain other recent developments have further strengthened the crusade against use of coal or coal mining in India, which include :

a) **Government Policies like** Larger target of 450 GW renewables set for 2030, provision of Green Energy Corridor, Solar parks etc. to create demand for renewables and attract investors;

b) **Government policies to help renewables to become cost-competitive by** Lower corporate tax, Waiver of Inter-State Transmission System (ISTS) charges and losses, Capital subsidy, 100% foreign direct investment etc.;

c) **Falling costs of renewables challenge the economics of building new coal plants as** solar power tariff nosedived to Rs 2.62/k Wh – 20% lower;

d) **Less efficiency of thermal power plant due to low calorific value and high ash content (30 to 45%) of Indian coal,** consume about 0.7 kg/ kWh of coal whereas in United States it is 0.45 kg /kWh

e) **More stringent emission norms, and water shortages**

1.2. Arguments for coal

However, there are certain Arguments for coal also which include :

a) Population and economic growth to become 5 trillion dollar economy, urbanisation and continued industrialisation are driving India's energy appetite. India is fourth-

largest global energy consumer today, after China, United States and the European Union. India's per capita energy consumption increased from 16.3 kWh in 1947 to 1255 kWh in 2022, still very low compared to Australia – 9614, Canada – 16602, USA – 12702, UAE – 16390, Kuwait – 19433, Saudi Arabia – 11030, Sweden – 16274 kWh;

b) India's power demand is expected to grow by 80% in ten years. Central Electricity Authority (CEA) projects 2,518TWh of gross electricity generation by FY2029-30. As per some other reports it is 2,700 TWh in 2030, up from 1,500 TWh in 2020;

c) India will account for nearly one-quarter of global energy demand growth from 2019-40 in the Stated Policies Scenario (STEPS), the largest of any country. Demand for coal will reduce in % of total energy basket but absolute volume will almost be doubled by 2040;

d) By retiring older plants, the emissions intensity of the grid would improve and Coal fleet will grow more slowly, but it will be utilized much better;

Hence, at this point, we cannot stop coal mining or use of coal for energy in India – but certainly there is a strong need for responsible mining of coal in a Smart, Safe and Sustainable way.

Misconceptions about Coal

"We don't need coal. It can be replaced by renewables."

It is not that simple.

Coal cannot simply be wished out of the energy mix. All fuels and technologies are needed to meet the challenges we face and to provide opportunities for those countries looking to develop. Coal is the part of world's energy mix. It is used for affordable and reliable electricity generation, and it supports renewables, when the air does not blow or the Sun does not shine.

It is backbone of industries helping us providing everyday materials like steel and cement, and for many countries and industries, it remains the only viable choice. Most importantly, coal has underpinned growth in our modern societies, and today, many countries, seeking the same opportunity to grow and develop, have identified coal as the resources to help them out.

It is not quite true that coal use is in decline internationally. Today, coal provides 28% of global electricity and in 2040, it will fuel 25%, but of a larger pie. In reality, electricity produced from coal will continue to increase through to 2040 and it will still be the largest single source of electricity globally. The same is true for steel and cement. 70% of world steel production relies on coal. In fact, coal use in industry has almost doubled since 2000 and is set to increase through to 2040.

However, choosing coal does not mean denying climate change. Our opportunity and responsibility is to work together as industry, government and investors to get behind and use clean coal technologies. For our coal industry doing better requires collaboration amongst the stakeholders, no matter wherever they are in the coal value chain, to earn the respect and right to operate and to ensure decarbonisation in business transition journey. Transition is not for phasing out, but for carbon neutrality. COP 26 has target for Net Zero by 2050, but that does not freeze the choices of individual countries. Intergovernmental Panel on Climate Change is not for 100% renewables. And here the Clean Coal Technologies address the global emission.

2.0. Increasing Demand for energy

Global energy consumption is only going up. Since 2000, global energy consumption has increased by about a third and is projected to continue to grow in the foreseeable future. Global energy demand grew by 2.9% in 2018 and in a business as usual scenario, by 2040 global energy consumption will reach 740 million terajoules - equivalent to an additional 30 percent growth. From 2000 to 2040, this will amount to a 77 percent increase in global energy consumption. From 1980 to 2050,

global energy use could triple from around 300 to 900 million terajoules.

It's difficult to grasp the amount of energy consumed worldwide. To illustrate, the global annual energy consumption corresponds to the energy released from the Hiroshima nuclear bomb every four seconds. A Boeing 737 can cross the Atlantic Ocean on one terajoule.

Oil, coal, and gas still power the world. 83 percent of the energy we use comes from fossil fuels. Oil is the biggest energy source followed by coal and natural gas.

Continued strong growth in Asian economies offsets declines in Europe and North America, highlighting need for stronger policies and investments to accelerate growth of clean energy (World Energy Outlook 2023 : IEA)

Global coal consumption climbed to a new all-time high in 2022 and will stay near that record level this year as strong growth in Asia for both power generation and industrial applications outpaces declines in the United States and Europe, according to the IEA's latest market update.

Coal consumption in 2022 rose by 3.3% to 8.3 billion tonnes, setting a new record, according to the IEA's mid-year Coal Market Update, which was published recently. In 2023 and 2024, small declines in coal-fired power generation are likely to be offset by rises in industrial use of coal, the report predicts, although there are wide variations between geographic regions.

China, India and Southeast Asian countries together are expected to account for 3 out of every 4 tonnes of coal consumed worldwide in 2023. In the European Union, growth in coal demand was minimal in 2022 as a temporary spike in coal-fired power generation was almost offset by lower use in industry. European coal use is expected to fall sharply this year as renewables expand, and as nuclear and hydropower partially recover from their recent slumps. In the United States, the move away from coal is also being accentuated by lower natural gas prices.

After three turbulent years marked by the Covid-19 shock in 2020, the strong post-pandemic rebound in 2021 and the turmoil caused by Russia's invasion of Ukraine in 2022, coal markets have so far returned to more predictable and stable patterns in 2023. Global coal demand is estimated to have grown by about 1.5% in the first half of 2023 to a total of about 4.7 billion tonnes, lifted by an increase of 1% in power generation and 2% in non-power industrial uses.

By region, coal demand fell faster than previously expected in the first half of this year in the United States and the European Union – by 24% and 16%, respectively. However, demand from the two largest consumers, China and India, grew by over 5% during the first half, more than offsetting declines elsewhere.

The shift of coal demand to Asia continues. In 2021, China and India already accounted for two-thirds of global consumption, meaning together they used twice as much coal as the rest of the world combined. In 2023, their share will be close to 70%. By contrast, the United States and the European Union – which together accounted for 40% three decades ago and over 35% at the beginning of this century – represent less than 10% today.

The same split is observed on the production side. The three largest coal producers – China, India and Indonesia – all produced record amounts in 2022. India's economy performed very well in 2022 with growth of 6.9%, resulting in coal demand increasing by more than 8% to a total 1155 Mt, become the only country besides China to cross the 1.1 bt mark.

2.1. India's coal demand scenario

Coal is the most important and abundant fossil fuel in India. It accounts for 55% of the country's energy need. The country's industrial heri-

tage was built upon indigenous coal. Commercial primary energy consumption in India has grown by about 700% in the last four decades. The current per capita commercial primary energy consumption in India is about 350 kgoe/year which is well below that of developed countries. Driven by the rising population, expanding economy and a quest for improved quality of life, energy usage in India is expected to rise. Considering the limited reserve potentiality of petroleum and natural gas, eco-conservation restriction on hydel project and geo-political perception of nuclear power, coal will continue to occupy centre-stage of India's energy scenario.

Indian coal offers a unique eco-friendly fuel source to domestic energy market for the next century and beyond. Hard coal deposit spread over 27 major coalfields, are mainly confined to eastern and south central parts of the country. The lignite reserves stand at a level around 36 billion tonnes, of which 90 % occur in the southern State of Tamil Nadu.

After three very particular years, with the Covid-19-induced shock in 2020, the strong post-pandemic recovery in 2021, and the first truly global energy crisis after Russia's invasion of Ukraine in 2022, markets returned to more recognisable patterns in 2023: Declines in the United States and the European Union, and continued growth in Asia.

India's economy performed very well in 2022 with growth of 6.9%, resulting in coal demand increasing by more than 8% to a total 1155 Mt, became the only country besides China to cross the 1.1 Bt mark. Due to strong economic growth and coal reliance, India's coal demand grew by about 5.5% in the first half of 2023. With growth in the power sector slowing down a bit in the second half, we expect a total increase of 5% for the year, totalling 1212 Mt.

According to the NITI Aayog's anticipated coal demand projection for 2030, coal usage will be 1192–1325 MT (PIB, 2022). Below are the projected demands for coal-based electricity, coal demand estimates, sectoral demand in 2030 and medium coal demand and productions, depicted in Tables 1 through 4 :

Table 1 : Most likely demand of coal based electricity for 2030

Parameter	Lower bound	Upper bound
Electricity requirement (TWh)	2200	2400
Coal-based generation (TWh)	1150	1350
Coal for electricity (MT)	800	875
Coal-based capacity (GW)	230	260

Table 2 : Estimates of coal demand projections for 2030

Fuel	MW	Percentage of Total
Total Thermal	2,34,058	60.9
Coal	2,02,005	52.6
Lignite	6,620	1.7
Gas	24,924	6.5
Diesel	510	0.1
Hydro (Renewable)	46,322	12.1
Nuclear	6,780	1.8
RES* (MNRE)	96,956	25.2
Total	384,116	

Table 3 : Sectoral demand projections for the year 2030

Sector	2030
Utility electricity generation (MT)	800 – 875
Industrial demand (MT)	262- 310
Captive electricity generation (MT)	130 – 140
Total (MT)	**1192-1325**

Table 4 : Medium Term Coal Projections (MoC) (in MTe)

	2019-20	2020-21	2021-22	2022-23	2024-25	2027-28	2029-30
Overall Coal Demand	956	906	980	1,029	1,134	1,313	1,448
Of which							
Coking Coal	*102*	*95*	*84*	*97*	*111*	*137*	*148*
Non-Coking	*853*	*811*	*896*	*932*	*1,023*	*1,176*	*1,300*
Overall Coal Demand	956	906	980	1,029	1,134	1,313	1,448
Of which							
Demand for Coal in Power	695	621	700	735	810	938	1,034
Demand for Coal in Non-Power	261	285	280	294	324	375	414
Domestic Coal Supply	707	691	765	974	1,304	1,456	1,511
Of which							
CIL	*582*	*574*	608	700	1,000	1,090	1,130
SCCL	*62*	*49*	66	70	80	90	100
Captive and other Mines	*63*	*69*	91	204	224	276	281
Imported Coal	249	215	210	186	172	173	170
Of which							
Coking Coal	52	51	51	56	62	68	75
Non-Coking	197	164	159	130	110	105	95

2.2. Supply Road map – Challenges ahead

Based on the demand for coal, it is important to discuss how the demand for coal is going to be fulfilled domestically and not increasing burden on economy due to import of coal. Presuming demand of around 1200 - 1300 MTPA, with 30-35% of future energy basket, there is a need to prepare a road map considering the challenges before the industry having significant impact on supply road map. The challenges are

a) Mix of technology for coal production, underground and opencast
b) Technology of coal production
c) Environmental impact of production technology.
d) Socio-technical and socio-political context.

3.0. Challenges of Sustainable and Responsible coal mining

Responsibility of Indian coal mining sector is to implement **Mining 4.0** with focus on **circular economy** and **sustainability** through **smart technologies** aiming to develop autonomous mining system for **energy-efficient,** clean technologies that contribute to bulk production with due care to sustainability by **waste minimization** and **waste re-use** in an **environmentally responsible** manner. Two primary focus point is adoption of less energy intensive technology for coal production and reduction of environmental impact of production technology to the maximum possible extent. Keeping this in view, it is essential to ascertain ***is the technology mix sustainable?***

3.1 Shift in production technology after nationalization of coal mines in India

Before nationalization of coal mines in India, the ratio of coal production between OC and UG coalmining was 25% : 75%. But after nationalization in 1971 / 1973, the scenario started changing very fast due to various reasons. The ratio has reversed to almost 96% production from OC mining and only 4% from UG mining.

3.2. Reasons behind such reversal are explained below :

Scenario before nationalization (1971-73)	Scenario after Nationalization
➤ OC vs UG :: 25 : 75 ➤ Mostly underground coal mining, ➤ smaller mines owned by private owners, lack of mass production capacity, ➤ constraints of vertical hoist through shafts, manual loading, cyclic mining, ➤ lack of adequate safety, frequent occurrence of disasters, number of fatalities every year. ➤ Route of out-sourcing – more OC ➤ Reducing capability of UG production ➤ Losing focus on UG ➤ Less priority on UG production	➤ Immediate increase in coal demand ➤ Available technology not adequate to produce required quantity ➤ Poor production capacity of UG mining resulting into ➤ higher cost, poor economics, Lack of potentiality to augment production by underground coal mining. ➤ OC mining, easily amenable to mass production, readily available global technology, relatively less cost resulting into better economics. ➤ Priority shifted from underground to opencast for improving production and productivity ➤ Low cost compared to UG ➤ Cost of environment ignored by ignoring statutory and social obligations. ➤ OC at the cost of large scale damage to landscape, poor restoration of post mining land profile and land use, ➤ Pollutants load beyond carrying capacity. ➤ Late implementation of environmental laws and absence of significant penalty for non-compliance indirect motivation to opencast mining ➤ Open cast : Underground - 96:4

The scenario continued and has reached to extreme imbalance in the recent years. In last 10 years UG coal production has dropped from 10% to nearly 4%.

Table 5 : Production scenario in last 10 years

Years	Opencast		Underground		Overall	
	Production	Growth (%)	Production	Growth (%)	Production	Growth (%)
2012-13	504.195		52.207		556.402	
2013-14	516.116	2.36%	49.649	-4.90%	565.765	1.68
2014-15	560.667	8.63%	48.512	-2.29%	609.179	7.67
2015-16	592.822	5.74%	46.408	-4.34%	639.23	4.93
2016-17	613.518	3.49%	44.35	-4.43%	657.868	2.92
2017-18	633.569	3.27%	41.831	-5.68%	675.400	2.66
2018-19	686.214	8.31%	42.504	1.61%	728.718	7.89
2019-20	690.393	0.61%	40.481	-4.76%	730.874	0.30
2020-21	683.872	-0.94%	32.211	-20.43%	716.083	2.02(-)
2021-22 (Provisional)	745.007	8.94%	33.183	3.02%	778.190	8.67

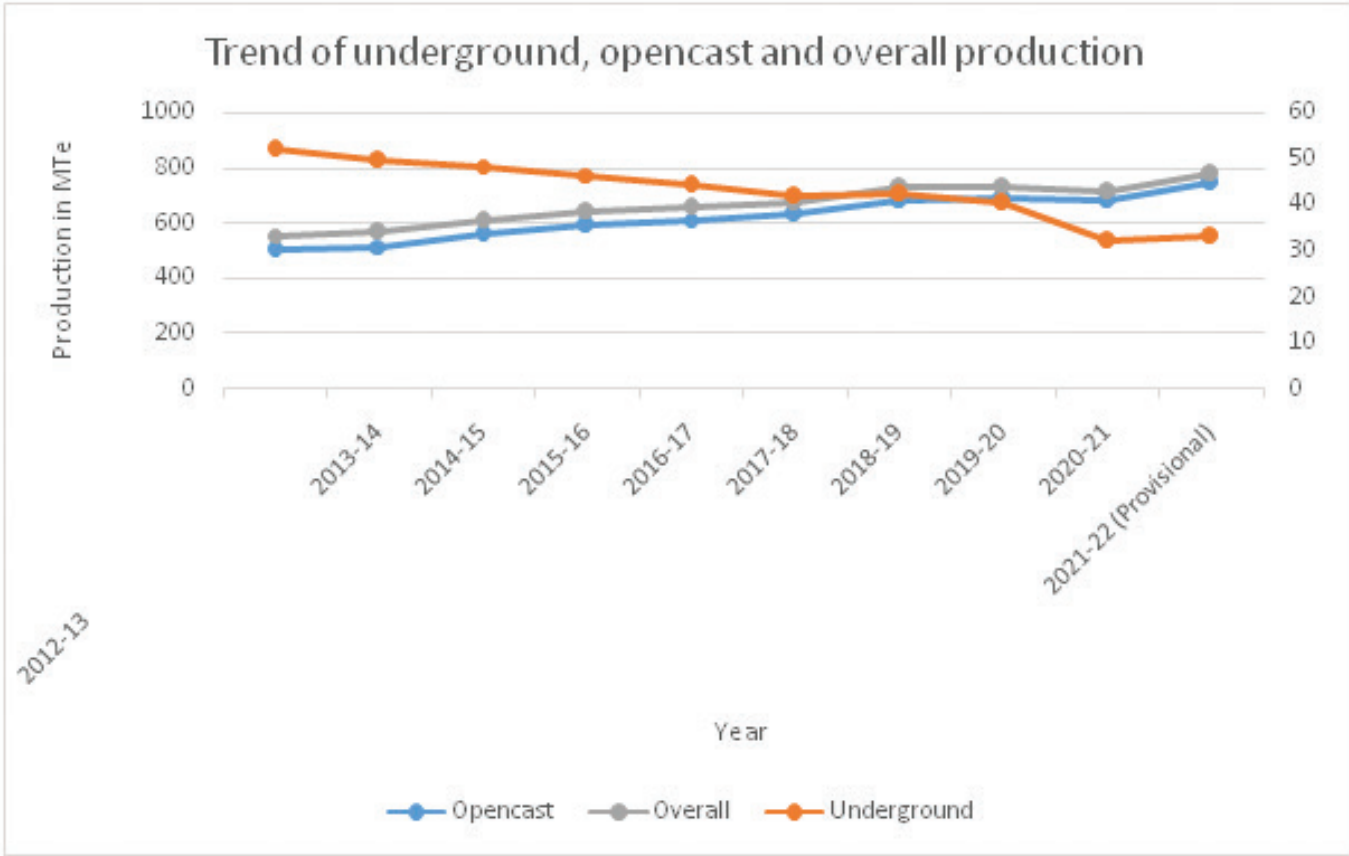

Figure 1: Trend in coal production in India

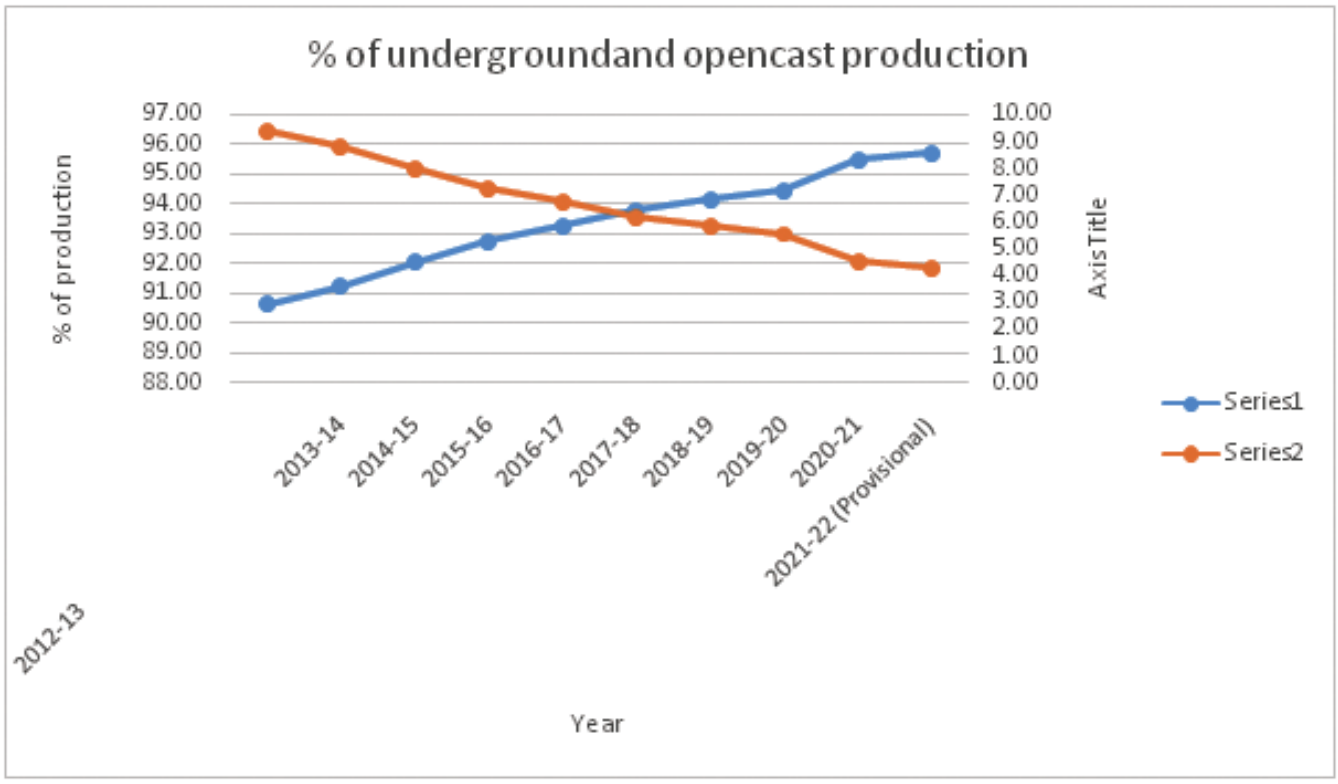

Figure 2 : Trend in share of underground and opencast coal production in India

3.3 Sustainability and technology of coal production

Sustainability of Indian coal industry primarily include the following issues :

a) Environment – Physical, Social and Economic
b) Economics of coal production technology
c) Energy intensity of coal production
d) Conservation of coal
e) Quality of coal
f) Safety of coal mining

3.3.1. Why such technology mix is not sustainable?

1. **Large Environmental foot print of OC compared to UG mining :** Environmental footprint of opencast mining is very large compared to underground mining. Opencast mining requires huge surface land, which becomes unusable for further use unless it is properly reclaimed. Experience in India is absolutely negative. There has been large scale degradation of the land after mining and due to poor mine closure practice, in most of the coalfields, social license to operate is very difficult to obtain and land procurement under the current land laws and legislative requirement, is extremely difficult. Further, as the mines are going deeper, land requirement also increases proportionately.

2. **Huge negative impact of deforestation by OC mining on carbon sink :** Large scale deforestation is needed for OC mining. This has direct impact on environmental degradation and natural carbon capturing and storage by plants and trees. In today's context of need for carbon capturing to reduce GHG effect, such large scale deforestation cannot be justified even if the provisions of compensatory afforestation is statutorily mandatory. Growth of plants is a time taking affair.

3. **Rehabilitation, re-settlement is huge socio-political challenge :** As OC mining requires huge land, there is a huge chal-

lenge of rehabilitation and resettlement of large number of project affected people. It is a very critical socio-political challenge and many Greenfield and Brownfield projects are withheld or delayed because of this problem. In a country like India with such high population density, it is going to be more problematic in future.

4. **Huge impact of OC mining on quality of air and water :** Drilling, blasting, loading and transportation of large volume of coal and rocks cause huge air and water pollution and the atmosphere around the coalmines, even at great distances, are seriously affected and become totally unhealthy to cause unacceptable level of health risk to the people living around.

5. **High energy intensity of OC due to handling OB :** Opencast mining is much more energy intensive than underground mining as in case of opencast mining, huge amount of overburden (OB), depending on the stripping ratio of coal seams, also needs to be produced at very high cost of energy. Where as in case of underground mining, waste is not mined at all. Hence, the overall energy intensity for OC mining is many times higher than that of UG mining, which indirectly causes more GHG emission due to consumption of more total energy per tonne of coal output.

6. **Technological limitation for application of OC mining at greater depth :** With the available technology, there is a limit to applicability of opencast with increasing depth. Hence OC mining cannot be technically sustainable for a long period of time. Most of the OC mines are reaching towards such critical depth and there is no other technology globally available for mining at greater depth.

7. **Poor quality consistency of OC mining :** Quality of coal is very critical for efficient conversion of coal to energy. Indian coal being inherently of poor quality due to high ash as well as low carbon content is further subject to degradation by opencast mining due to more chance of dilution by mixing with host rock by blasting and loading operations. As the future of coal is largely depending on efficiency of thermal power plant, such quality degradation is very critical. There is very less chance of such dilution in underground mining as only coal is selectively mined by UG method.

In view of the inherent deficiencies of OC mining, such technology mix of 96% : 4% is not viable for near future. Hence there is a strong need for transition from OC to UG mining of coal in India. This also needs to be kept in mind that Indian coal mining industry has lost its capability of production from UG coal mines in last four decades. Hence the transition should be prompt and gradual without further delay for maintaining sustainability of coal production as per country's demand for energy.

4.0 Future Coal mining Technology in India

As discussed above, the present mix of 96% : 4%:: OC : UG coal production technology mix is not viable. There is a strong need to reverse the trend and share of underground coal production has to increase in phases keeping the total coal demand in mind and the capability to produce from underground. But it is absolutely necessary to start the reversal without losing further time and opportunities. A clear policy and target setting is required at national level, what should be the optimum mix of production.

This is important to understand the challenges of increasing production from underground technology mainly because of the following reasons :

1. Size of mines
2. Availability of indigenous mass production technology
3. Safety challenges of deep underground coal mines
4. Geo-mining conditions
5. Skill of underground mining mass production technology

4.1. Size of mines

A recent study of sizes of underground mines in

CIL reveals that 83% of the underground mine produces less than 0.3 MTPA of coal and only 1.22 % of mines are in the range of production of 1 to 4 MTPA of coal in 2019-20. The scenario is slightly improved in 2023-24, producing 3.08% from mines of 1 to 4 MTPA capacity.

Table 6 : Size of UG and OC mines of CIL in 2019-20 and 2023-24

		Production from Underground mines with annual capacity					
		-0.3 Mte	+0.3 - 0.6 Mte	+0.6 – 1.0 Mte	+1.0 – 4.0 Mte	- 4 Mte	Total Production from UG mines
FY 2019-20	Total Production	12.98	8.17	3.8	5.09	Nil	30.04
	No. of mines	136	21	5	2	0	164
	Average production per mine in M Te	0.095	0.389	0.760	2.545		0.183
	Percentage of total UG mines	82.93	12.80	3.05	1.22	0.00	
FY 2023-24	Total Production	9.13	11.99	7.06	7.4	4.2	39.79
	No. of mines	88	28	9	4	1	130
	Average production per mine in M Te	0.10	0.43	0.78	1.9	4.20	0.31
	Percentage of total UG mines	67.69	21.54	6.92	3.08	0.77	

Such small mines are not suitable for implementation of mass production technology. Hence, there is strong need to amalgamate adjacent small mines to provide larger areas for introduction of mass production technologies like Longwall mining, Continuous miner / Bolter miner technology with shuttle car of larger capacities, flexible conveyor etc.

4.2. Availability of indigenous mass production technology

No technology can sustain by importing the technology for a longer period. Technology has to be absorbed through indigenisation. Guaranteed supply of equipment and spares are very critical for success of any technology. Machineries of mass production technologies must be manufactured in the country through Make in India program, strengthening the socio-economic environment and avoiding the risk of disruption in supply chain. The machines should be enabled with smart features to perform most efficiently and safely and smart systems using cyber physical systems, sensors, IoTs, data analytic software and application of artificial intelligent tools.

4.3. Safety challenges of deep underground coal mines

Underground mining is more challenging from safety criticality point of view. The safety culture prevailing in OC mines are not adequate and effective for underground coal mining. There is a strong need to improve the safety culture by introduction and implementation of risk-based safety management system and very close and strict supervision and monitoring from various levels including the safety regulators.

There is a strong need to understand and appreciate the Human face of work-place accidents, the trauma, the economic crisis, loss of dream, the helplessness of the family etc. cannot be compensated. The basic belief is workplace accidents are preventable. Culture of risk based safety management right from top to bottom, visible commitment through policy formulation, zero tolerance to unsafe acts and conditions, go beyond compliance and come out of syndrome of human error

a) Risk-based in place of rule based safety management
b) Commitment, Consultation, Communication, Coordination
c) Risk assessment to develop PHMPs, SOPs
d) Use of TARPs
e) Risk based Emergency Response Plan
f) Root cause analysis based Accident/ Incident Management system

4.4. Geo-mining conditions

Underground mining technology is not as flexible as opencast mining with respect to geo-mining conditions. Though geo-mining conditions are beyond control, what is very critical is selection of technology suitable for prevailing geo-mining conditions and tailoring the technology to suit the condition. It requires extensive exploration before mining and use of powerful simulation and modelling technologies to assess the impact of varying geo-mining conditions on safety, production, productivity and economics. The indigenous manufacturing facilities would be handy to manufacture equipment and spares as per the requirements and thereby eliminating the technological constraints.

4.5. Skill of underground mining mass production technology

Skill and competency is one of the most critical component of any system to ensure safe production. Selection, implementation, maintenance and operation of technology requires competency at all levels. The system of ensuring competency at work place should be given top priority. There has to be a national framework of competency in core and non-core activities of every industry.

5.0 Thrust on Underground mining – strategies for improvement

Considering the above challenges, the thrust areas for consideration to augment production from underground technology should include, but not limited to, the following :

a) Mass production – amalgamation of smaller mines, Plan for bigger mines
b) Stop uneconomic semi-mechanized bord and pillar mining,
c) Longwall mining for suitable geo-mining conditions and large reserve
d) All out mechanization through continuous mining system, underground transport/ conveying of coal, material and men
e) Mass production mining methods like Room and Pillar / Wongawilli / Longwall
f) Extraction of standing pillars by shortwall or short longwall method
g) For Thick seams – Longwall top coal caving method
h) Partial extraction with stowing for built up areas
i) High speed stowing matching with rate of production
j) Mass inertization as a regular practice for dealing with spontaneous heating
k) Methane drainage for highly gassy mines

5.1 **Policy initiatives :** The National Government should take the following initiatives to improve production of coal from underground mining :

a) Thrust on UG
b) Assessment and comparison of environmental footprint due to mining
c) Incentivise UG production
d) Separate cadre-scheme for career progression
e) Introduction of global best practices for pilot mines for mass production
f) Scientific assessment of ground deformation due to UG mining through numerical modelling or simulation

g) Thrust on policy change by DGMS for exempting surface land right for UG mining under forest

h) Study of pilot area under forest to depillaring with caving

i) Implementation of mass production technology with matching stowing, dissociating extraction and filling by suitable mining method

j) Increasing stowing capacity using paste fill

k) Use of multiple stowing range

l) Getting raw materials for stowing in underground and mixing near area of stowing

m) Exploring potential reserves for application of mass production technologies using bolter miner / CM

n) Identification of reserves suitable for longwall mining

o) Starting new projects in dip-side deeper horizons, independent of existing working

p) More thrust on proper design with adequate geological data without compromising with availability

Other than policy and strategies, specific thrust should be given to the following issues:

5.2 Exploration and planning

a) Detailed exploration of coal seams at deeper horizons to avoid uncertainty

b) Use of AI tools in non-invasive detailed exploration by geo-physical methods

c) Use of 4D modelling for better understanding of mine geology, variation in geo-mining conditions, effect of geological anomalies,

d) Use of mine planning software for long-term and operational planning

e) Establishing Tech service cadre including geotechnical engineers for tech support to operation managers

f) Provisions for risk assessment due to changes in geo-mining parameters and contingency planning

5.3 Mine planning

a) Go for all out mechanization of all unit operations with available state of the art technologies

b) Systematic AI / ML based preventive maintenance

c) Remote and tele-operation wherever possible to reduce exposure to unsafe working conditions

d) Automation after mechanization, not the other way round

e) Risk assessment before introducing cyber technology and its mitigation

f) Larger panels with optimum face transfer

g) Adequate reserve for optimum utilization of equipment

h) Amalgamation of smaller units

i) Proper mine layout considering operational efficiency, coal evacuation, ventilation, stability of structures and safety

j) Reducing frequency of major overhaul necessitating equipment transport to surface between face transfer

k) Optimise development cost

l) Use of mine planning software integrating all the processes – Geological Model to Mine Design to Mine Plan to Production Schedule to Mine Reconciliation

m) •Gemcom •Minescape •Surpac • Minesight • Vulcan • Minex • Xpac

n) Application of Virtual Reality and Augmented Reality in mine planning – assessment of impact of changed geological parameters

o) Punch entry UG mines from bottom of OC mines

p) Integrated mine planning – OC to UG

q) Punch entry longwall – high capacity, simple circuit

r) Highwall mining

s) Twin entry development

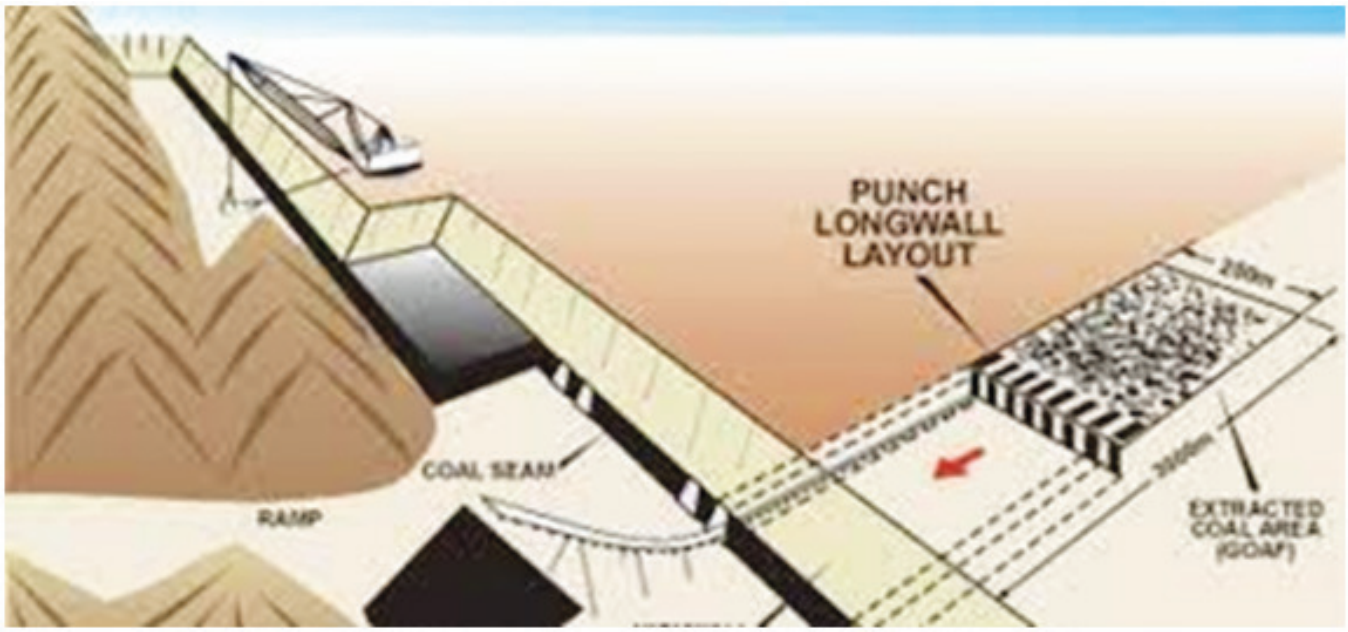

Figure 3 : Punch Entry Longwall Mining

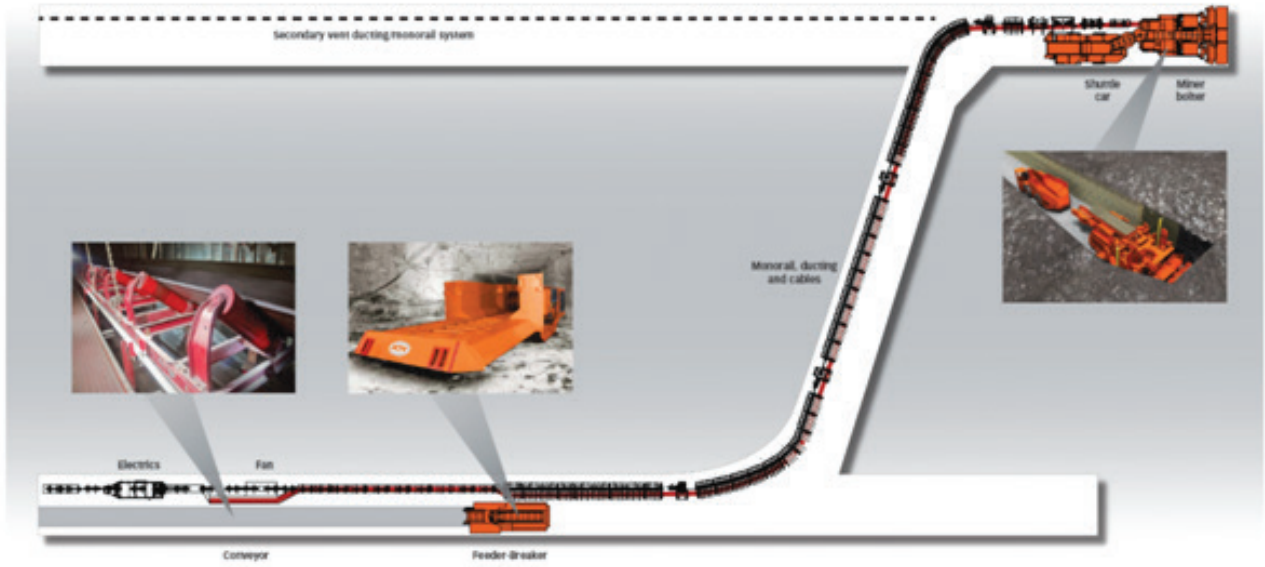

Figure 4 : Continuous miner face

5.4 Man and material transport

To go for mass production transportation of man and material including coal is very vital. Use of mono-rail, Free steered diesel vehicle, Multiple Utility Vehicles, High capacity conveyors, Flexible conveyors etc. are to be used to make transportation system efficient, quick and safe.

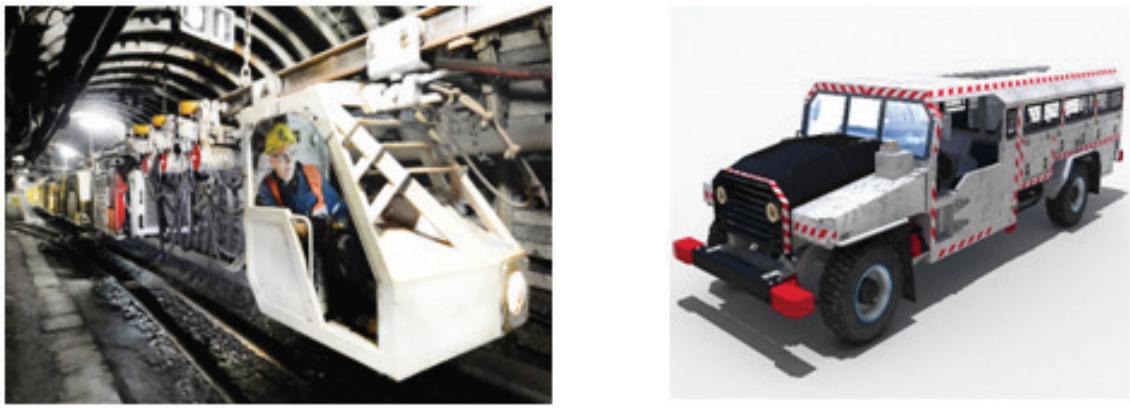

Figure 5 : Man Transportation System

5.5 Gas monitoring

In underground coal mining gas monitoring is very critical to tackle different principal hazards like fire and explosion of methane and coal dust. Real-time Continuous, reliable and precise monitoring system for toxic and inflammable mine gases, Telemonitoring, Tube-bundle and portable digital gas detectors, air analysis by Gas Chromatograph, TARP based on gas monitoring results and continuous assessment of various gas indicators may help in early detection of such hazards and initiating measures to deal such hazards will help in preventing disasters from such hazards.

5.6 Strata control and strata monitoring

Strata instability is one of the most critical challenges of underground mining, particularly for deep deposits or poor quality of roof rock. Many accidents have happened in the past due to failure of strata because of lack of adequate and effective strata control procedure. The following initiatives would help in reducing the risk of strata failure :

a) *In-situ* stress measurement
b) Mapping of geological structures and discontinuities
c) Application of numerical modelling in strata control
d) Longer roof bolts with resin capsules
e) Long cable bolting
f) Regeneration of roof rock using chemicals
g) Polimeric mesh
h) Strata monitoring – tell-tale, convergence indicator, load cells
i) Strata control TARP
j) Longwall powered supports

Figure 6 : Supervisory Control and Data Acquisition in Longwall face

5.7 Say No to Incubation Period - Mass Inertization and sealing

One of the bottleneck for mass production technologies due to spontaneous combustion is the concept of Incubation Period, which is not based on any scientific method. This is a sort of thumb rule but has a place in the statute to restrict panel size depending on incubation period, which in-turn reduces the scope of mechanization due to smaller panel sizes. There is a strong need to address the issue more scientifically and putting more thrust on control. Inertization plays a very significant role. Inertization may make incubation period infinite due to absence of oxygen. Hence provision of mass inertization in each mine by onsite installation of inertization plants of adequate capacity, underground pipe network for inert flushing, provisions for inert pipes in isolation stoppings, simulation based on Computational Fluid Dynamics for effective inertization of goaves, Risk assessment before sealing panel, SoP for sealing and construction of rated seals may go a longway in successful implementation of mass production technology in Indian coal mines.

5.8 Provision of Stone dusting and dust barrier

One of the most critical control against coal dust explosion is application of stone dust or inert material and inert barrier. With mass production technology, requirement of stone dust treatment and dust barrier become more and more critical. This is not possible to provide such huge quantity of dust effectively and installation of dust barrier with rapid progress of working faces. The following issues should be considered for ensuring adequate and effective dust treatment to prevent coal dust explosion :

a) Effective large scale general stone dusting for treatment of coal dust by using mechanized system of stone dusting using Bulk Duster, Trickle duster, Pod duster
b) Dust transport through bore holes and silos
c) Use of compressed air for spraying dust continuously with coal production
d) Use of large dust bags in returns
e) Use of explosimeter for spot analysis of roadway dust
f) Use of stone dust bag barrier in place of conventional timber frame
g) Scattered and concentrated dust barrier
h) Use of aero-dust

Figure 7 : Stone dust bag barrier

5.9 Methane Drainage :

One of the deadliest hazard in underground coal mine is methane explosion. Coal seams with very high *in-situ* gas content are vulnerable for methane explosion. Such highly gassy mines cannot be safely operated with normal or conventional ventilation system. Methane drainage prior to mining is a must to ensure reduced gas content to be handled safely by normal ventilation. Unfortunately, methane drainage system has not been introduced in any mine and the highly gassy mines are either not operated or

operated at very low level of production making it further uneconomic. Policy decision for reducing the gas content of coal seams prior to coal mining has to be taken with statutory back up in legislation to prevent explosion. Singh and Hajra (2018) have presented opportunities for the recovery and utilization of Coal Mine Methane (CMM) in some operational underground mines and undeveloped projectized blocks in India.

The crucial aspects of CMM extraction (from surface to inseam/inseam), goaf drainage, and VAM abatement are outlined below :

a) Fugitive methane is a major source of Scope 2
b) Pre-drainage of methane in coal seams having *in-situ* gas content of more than 2-3 meter per tonne
c) Surface to inseam for virgin blocks, inseam drainage for working mines to reduce gas content to below 2-3 M^3 / Te to prevent disruption of operation and reducing risk due to explosion
d) CBM extraction before mining
e) Goaf drainage

VAM abatement program

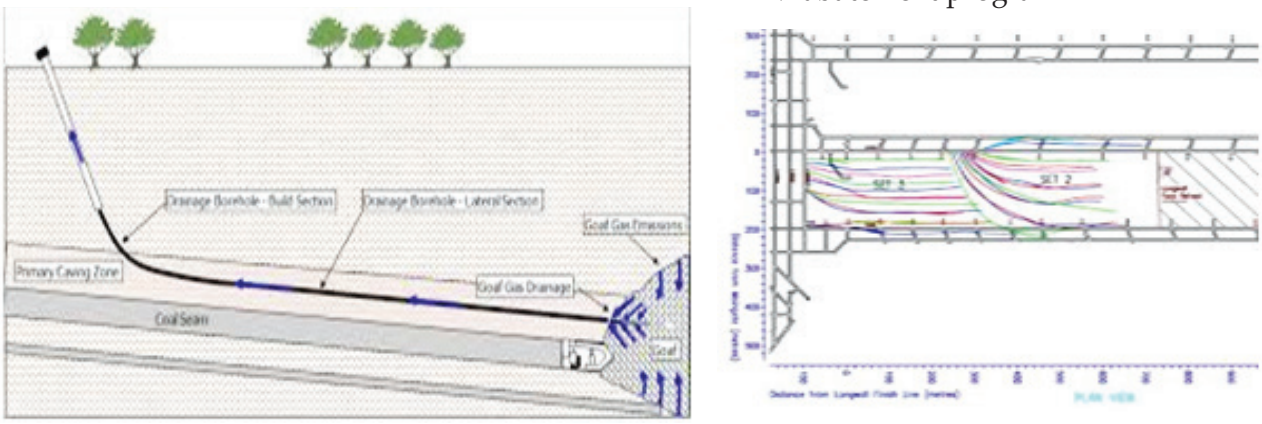

Figure 8 : Methane drainage

5.10 Decarbonising initiatives in mining – Energy bench marking

Why coal is considered as the major cause for global warming, it has two components: 1) Coal when used for thermal power generation, generates maximum GHG; 2) Energy Intensity for coal production; 3) Environmental footprint, impact on carbon capturing due to deforestation

When we talk about viability of any coal operation, we calculate the cost and sale price per tonne of output. But in today's context, when we talk about viability of a project, the question of energy consumption will play a big role, not for the cost of energy but the impact of energy consumption on GHG emission for production of coal. It is now high time to introduce the culture of evaluating the performance of energy intensity or consumption and exploring the scope of reducing the losses and improving energy efficiency which will not only reduce the direct cost of energy for producing coal but also hep in decarbonisation or optimisation of carbon emission.

Unfortunately, till today the thrust on energy consumption as a parameter of performance evaluation has taken its root. Very little study has been made globally in this regard.

As the whole discussion started from global warming, decarbonisation takes a vital role in responsible mining. How best we can mine coal with due care to decarbonisation to achieve Net Zero. There is a need to look at decarbonisation from a challenge to opportunity mind set. Decarbonisation should not be considered as a cost but overarching business strategy. There should be separate team for climate change and sustainability – this should be embedded in operations. All out efforts must be made to reduce the energy intensity of the operation, in each and every

activity by improving the energy efficiency, reducing energy wastage and regenerating energy wherever possible. Energy bench marking should be the first step for each and every activity. Second step is to explore the opportunity for using green energy as much as possible.

5.11 Remanufacturing initiatives to reduce carbon footprint

Remanufacturing components from major mining equipment can help mining companies reduce costs while also lowering their environmental footprint. Remanufacturing is a smart move to drive down waste and improve circularity in businesses while reducing operational costs. Remanufacturing is "a comprehensive and rigorous industrial process by which a previously sold, worn, or non-functional product or component is returned to a 'like-new' or 'better-than-new' condition and warranted in performance level and quality". Savings from remanufacturing when compared to new can be more than 50%. In addition, there can be a 70% or more reduction in carbon emitted in the remanufacturing process compared to the production of a new component.

Epilogue

The present discussion is not for Coal or No Coal, it is primarily how the coal mining technology be sustainable in India's perspective in the back drop of global warming, Net Zero Carbon Emission, Decarbonisation etc. However, assuming coal will be there for some more time, 50 years or more or less, how should the managers of India's coal mining industry behave in more responsible manner to address the bigger global issue of reducing the global rise in temperature, while keeping in mind the hunger for energy for countries like India having population of more than 1.42 Billion. As it emerges, there is a need to reduce environmental footprint of mining, reducing the energy intensity of our operation, keeping it within the energy bench mark, and maintaining the socio-economic sustainability goals. The discussion reinforces the need for technological optimization by increasing the share of underground coal production through adoption of mass production technology supported by extensive planning and designing with the help of simulation and modelling technologies, indigenisation of mining machinery, improving operational efficiency using automation, sensor technology, data analytics, IoTs, AI etc., supported by mass inertization, real time precise monitoring of environmental and strata deformation parameters and maintaining a high level of competency through a national competency frame work and ensuring a very high level of safety culture to ensure risk from mining operations are at an acceptable level and as low as reasonably achievable. Initiative like decarbonisation at every front and use of green energy wherever applicable, will go a long way in achieving the country's growth, meeting the energy demand in a more responsible manner.

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COMPREHENSIVE APPROACH TO SUSTAINABLE COAL MINING

A K Rana[1]

Background

The use of fossil fuels has been responsible, to a great extent, for the production of greenhouse gases. But the fact remains that the progress of mankind in any field of human activity, be it agriculture, industry, transportation, medicine, have been due to availability of energy in a very convenient form (steam engine, electric motors, IC engines etc.). So the history of progress of mankind in the last two centuries is written by the fossil fuels.

This has resulted in production of greenhouse gases, production of material which are not bio-degradable specially plastics. With the manifestation of the "dark sides" of the fossil fuels, increase in temperature, climate change, increasing of sea levels, the shift now is for green energy and bio-degradable material.

Before proceeding to the role of coal mining in the overall scheme a look at the sector wise GHG emissions will be helpful.

Sector-wise GHG Emissions in the World : A Breakdown

Sector-wise GHG Emissions : Recent Trends (2021-2023) :

1. Energy Sector : Around 73% of total global GHG emissions in 2023 (estimated).

   Electricity and Heat Production: Remains the largest source, but emissions showed a slight decline in 2022 due to increased renewable energy usage in some regions.

   Transportation : Emissions rebounded in 2022 after dipping during the pandemic, fueled by increased travel and reliance on personal vehicles.

   Manufacturing and Construction : While showing some fluctuations, emissions overall remained at an elevated level.

2. Agriculture, Forestry, and other Land Use : Estimated at around 23% of global GHG emissions in 2023.

   Agriculture : Methane emissions from livestock remain a major concern, while fertilizer-related nitrous oxide emissions have stabilized in recent years.

   Forestry and Land Use Change : Deforestation rates continue to be a problem, particularly in tropical regions, raising concerns about carbon storage loss.

3. Other Sectors : Remaining 4% of global GHG emissions.

   Examples : Waste management, industrial processes, and fluorinated gases show varying trends depending on specific activities and technological advancements.

Sources :

- *International Energy Agency (IEA) : Global Energy Review 2023, CO2 Emissions in 2022 - Analysis.*
- *Food and Agriculture Organization of the United Nations (FAO) : State of the World's Forests 2022.*
- *World Resources Institute (WRI) : CAIT Climate Data Explorer (latest data available).*
- *Inter governmental Panel on Climate Change (IPCC) : Sixth Assessment Report, Working Group III : Mitigation of Climate Change (2022).*

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The paper was presented at the MGMI organized National Seminar on Green Mining and Net-Zero (GMANZ 2023) in Kolkata on 23rd September 2023.

Fuel Source	Percentage of Global Energy Consumption (2023)	Trend
Fossil Fuels :	**83%**	Decreasing
- Coal	24%	Decreasing significantly
- Oil	32%	Relatively stable
- Natural Gas	27%	Increasing slightly
Renewables :	**12%**	Increasing rapidly
- Hydropower	5%	Stable
- Wind & Solar	5%	Growing exponentially
- Geothermal & Others	2%	Rising steadily
Nuclear :	**5%**	Relatively stable

Sources :

- *International Energy Agency (IEA) reports*
- *REN21 Renewables 2023 Global Status Report*

Fuel Source	Percentage of Indian Energy Consumption (2022-23)	Trend
Fossil Fuels :	**84%**	**Decreasing**
- Coal	57%	Decreasing
- Oil	23%	Relatively stable
- Natural Gas	4%	Increasing slightly
Renewables :	**11%**	**Increasing rapidly**
- Wind & Solar	10%	Growing exponentially
- Hydropower	1%	Stable
Nuclear :	**3%**	**Relatively stable**
Biomass :	**1%**	**Stable**

Coal has maintained a prime position in providing inexpensive energy for China and India. With increased emphasis on reducing use and phasing out of coal, need for sustainable coal mining has come to the fore.

Comprehensive approach to sustainable coal mining

The issues of sustainable coal mining need a comprehensive approach, which should start from defining the "Sustainable coal mining" itself. These requirements will be country specific as the social impacts of coal mining will be far more important than the technical aspects as coal mining is one of the major employer in at least 50 districts in India. It is important that the impact of coal mining and impact arising out of the use of coal for power generation or other industrial purposes need to be separated for any meaningful deliberations as the challenges are entirely different and respective agencies need to tackle the issues in their respective realms.

The impact on environment by coal mining can broadly be divided into the following categories :

1. Methane emissions from coal during coal mining
2. Other GHG emissions during mining
3. Impact on land including forest flora and fauna etc.
4. Impact on water bodies, water table etc.
5. Social impact arising out of loss of land, livelihood displacement from the original habitat.

Methane emissions from coal during coal mining: The release of Coal Bed Methane during coal mining operation is inevitable. Fortunately, Indian coal has less methane per tonne in comparison with European, Australian or Chinese coal.

Table : 1 Country-specific emission factors for coal mining activities

Operation (mining / Post mining)	**Methane emission factor (M3 / tonne)**			
	Surface mining	**Underground mining**		
		Degree-I	Degree-II	Degree-III
Mining	1.18	2.91	13.08	23.64
Post Mining (Handling)	0.15	0.98	2.15	3.12

Most of the Indian coal seams are classified as Degree - I gassy seams and in most of the mines the presence of methane is hardly detectable. The fugitive methane emissions attributed to Indian coal mining seems to be overstated and needs a review.

Other GHG emissions during mining : According to consulting firm McKinsey, the mining industry annually contributes up to 7% of the world's carbon emissions. This is an area where use of carbon neutral technologies can make a significant impact in the world's carbon emissions. Starting from the planning stage, selection of mining method, right sizing of the equipment will help in reducing the environmental impact of mining activities.

Inherently Underground mining seems better in terms of sustainability, but careful comparison should take into account the overall output of the coal, percentage extraction, need for land etc. Holistic approach is required for the best combination of resources.

For opencast mining, the "Safer" approach of using 1:2 slope for solid strata and 1:3 slope for overburden dump may be replaced by scientifically examined stable slopes. A small change of 2 degrees in overall mine slope (200m depth 1 Km strike length) may result in ~ 0.7 Mm^3 saving in excavation.

The latest and largest may not be the most sustainable. The use of autonomous dumpers may not be a good idea in Indian Coal Mines. So many unemployed youths may be employed with a less expenditure. "People" must be the center point in overall sustainability.

Similarly import of Mining Machinery is not sustainable in the long run. Fortunately, now we have manufacturing facilities for $10m^3$ shovel/ 100te dumper/ surface miners with matching front-end loaders and Continuous Miners covering more than 95% of geo-mining conditions.

Inefficiencies are wastage of resources. To minimize wastage, planning must be integrated with operations. Good economic practices are often the most "green".

- 1 Kwh ~ 1kg CO_2-eq
- 1 Liter diesel ~ 2.7kg CO_2-eq
- 1 Liter Petrol ~ 2.2kg CO_2-eq
- Coal 1 kg ~ 2.5 kg CO_2-eq

So, the saving in energy cost automatically results in less pollution. The recent development in India regarding Carbon Trading will further incentivize use of efficient planning, operation, monitoring of Indian coal mines. Use of remote sensing (satellite images) and Drone Photogrammetry are efficient tools for mining operations monitoring. Combined with integrated control room-based operations with 5G network can control real-time mining operations in a very efficient way.

As mentioned above, out of up to 7% of the world's carbon emissions due to mining, roughly 50% of that comes from the haulage trucks, which are used to transport overburden as well as coal in opencast mines. In Indian coal mining scenario, eighty percent of the operating cost can be attributed to fuel cost (mainly diesel) only. Obviously, a lot of innovation is targeted to reduce the use of diesel haulage trucks. Some of the alternatives are - High angle conveyors, Battery operated trucks, Hydrogen powered trucks, replacing diesel machines with electric/ Battery operated machines, use of energy efficient VFD.

High Angle Conveyors :

High angle conveying is on the up in mining – and the world's second largest installation is close to completion in the southern part of Russia's Mikhailovksy GOK iron ore open pit mine, part of Metalloinvest. It consists of 13 sections, uses a sandwich conveyor, has a 37-degree angle and a lift of 215m. It has a capacity to handle 15 Mt/y (rated at 3,000 t/h) and has been designed and installed by Metalloinvest and Ukraine-based NKMZ.

Source : https://im-mining.com/2020/08/26/worlds-second-largest-high-angle-conveyor-nearing-completion-metalloinvests-mikhailovsky-gok/

High angle conveyors can replace a large part of material handling in coal mines. There universal application to replace shovel dumper combination is not possible but in selected suitable mining conditions, their deployment can significantly reduce the use of diesel in dumpers. The trade-off of the cost component is the compromise on flexibility and cost of crushing material specially if planned to be deployed in overburden.

Battery Operated Trucks :

Caterpillar completed development of its first battery electric 793 prototype with support from key mining customers participating in Caterpillar's early learner program. participants of the program with definitive electrification agreements include BHP, Freeport-McMoRan, Newmont Corporation, Rio Tinto and Teck Resources Limited.

Source : https://www.caterpillar.com/en/news/corporate-press-releases/h/caterpillar-succesfully-demonstrates-first-battery-electric-large-mining-truck.html

These trucks are fast developing and may soon become good competitor to the diesel trucks. The real reduction in GHG can be achieved if the charging of the batteries is done by renewable energy sources.

Hydrogen Operated Trucks :

The hydrogen-powered haul truck made its official debut at the Mogalakwena mine in South Africa owned by Anglo American.

Source : https://edition.cnn.com/2022/10/06/world/hydrogen-mining-truck-first-mode-anglo-american-climate-spc-intl/index.html

Another interesting development is hydrogen operated trucks, where hydrogen is used as fuel in fuel cells which power the drives. Development of Hydrogen IC engines is also catching up. Similar to the battery-operated trucks, the real advantage in sustainability can be achieved only through green or white hydrogen.

Ethanol Operated Trucks :

Scania R 510 V8: This beast holds the title for the heaviest ethanol-powered truck currently in production. It boasts a massive 13-liter V8 engine generating 510 horsepower and a robust drivetrain capable of handling payloads of up to 76 tons. This makes it a powerful and sustainable option for heavy-duty transportation like long-haul hauling or construction materials delivery.

Source : https://www.trucksnl.com/scania-r520-v8-retarder-full-air-6x2-510-wb-night-airco-euro6-nl-truck-7634637-vd

Clear Flame

Clear Flame Engine Technologies, a company empowering rapid decarbonization for global heavy-duty industry, announced today it has successfully completed an 'on-road' demonstration of its proprietary technology that enables a heavy-duty truck diesel engine to operate on 100 percent renewable plant-based fuels. The validation of Clear Flame's technology marks a critical milestone in the company's objective to revolutionize carbon emissions within heavy-duty transportation, one of the hardest sectors to electrify and decarbonize.

Source : https://ethanolproducer.com/articles/clearflame-heavy-duty-truck-now-driving-on-100-ethanol-18988

Long haul trucks, which runs on bio ethanol are commercially available. ***The same technology has not yet been adopted for mining*** but its potential for countries like India is immense. The mixing of ethanol into normal commercial vehicles in India has already achieved a significant milestone and vehicles which runs on E98 ethanol have made an entry (although symbolic only) into Indian market. The same system can be extended to mining trucks.

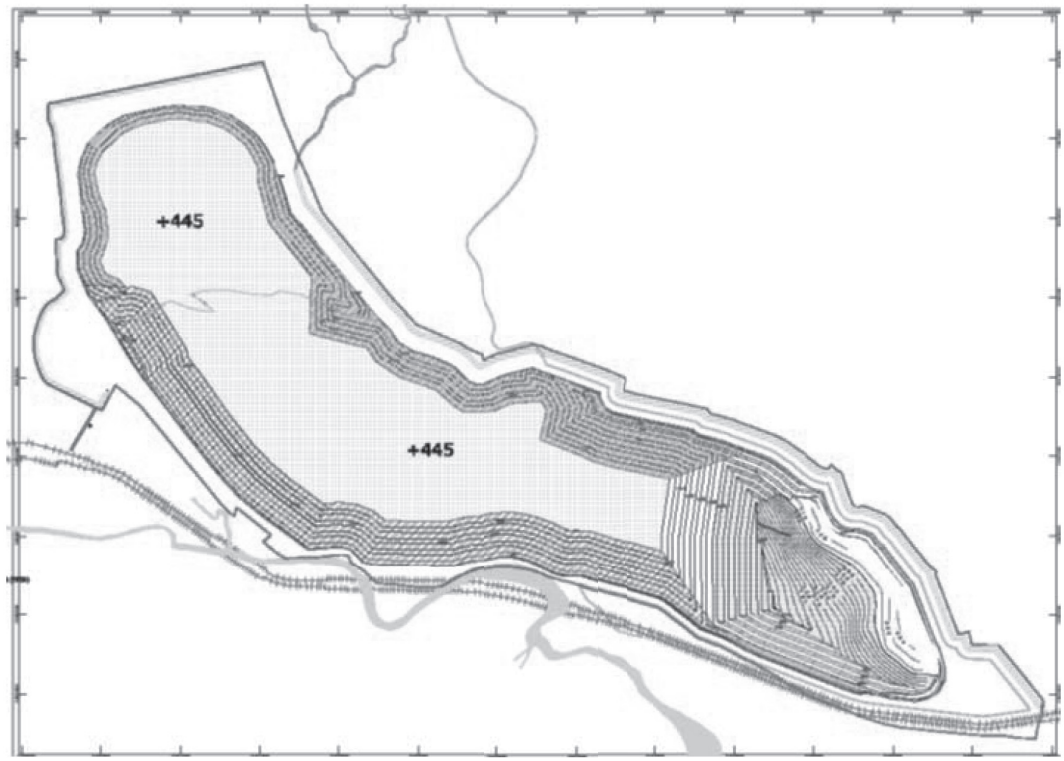
Mine Closure :

The very definition of "Sustainable" need to defined in Indian Perspective. The western notion of "Sustainable" may not be suitable for our needs. If an excavation made during mining can be used for water storage / irrigation, it may be more "Sustainable" then filing it up to its original profile. Just consider amount of diesel to be burned to re-handle say 50 or 100 million cubic meter of overburden. So such plans MUST be site specific. For broad estimation 1 lit /m^3 of rock excavation and transportation may be taken, so for every 10Mm^3 of OB 1 Cr lit of diesel will be burned along with Rs. 100 crores. Similarly a green hillock can be as environmentally sustainable as a plain land.

Technical Mine Closure

After notification of mine closure in 2009 by MoEFCC, there are defined guidelines. There is an urgent need to convert theory into practice. The "Eyesores" are more damaging to the image of the mining industry than the actual damage. It's easier to take care of these eyesores. A water filled body, a piece of broken land, a hillock of rocks need to be treated as an asset and to be managed accordingly. Innovative approach can convert these neglected assets into revenue earning either to the coal company or to the community.

Case study to convert an opencast mine into an Pump back Hydro energy storage project :



Final OB dump Proposed plantation Water Body Solar on slopes

Note :

Light yellow – OB dump top for solar panels/ Water reservoir/ Wind turbines

Green – Proposed plantation

Light blue – Water body

Magenta – Southern side batter for solar panels

In this study, data from a project report is taken and preliminary study is done to assess the scale of Pump-back Hydro energy storage project. The basis profile after mine closure is given below.

SL. No.	Particulars	Values
1	Area of Quarry km2	6.0
2	Area of OB Dump Top km2	3.5
3	Area of Waterbody km2	1.0
4	Batter Area SOUTH km2 for Solar	1.3
5	Batter Area NORTH km2 for Plantation	1.1
6	Batter Area East km2for Solar	0.7
7	Total Area (Quarry + Dump) km2	7.5
8	Volume of Water (Mcum)	74
9	Top RL of Water Body (m)	300
10	Bottom RL of Water Body (m)	150
11	Top RL of OB Dump (m)	445
12	Depth of water to be pumped out (m)	145 - 295

As per the preliminary estimates this mine, after closure can be converted into energy storage of 300 MW capacity, provided total mine is NOT covered with plantation. There will substantial amount of plantation but a practice of blanket plantation or insistence on back filling with overburden or fly-ash will be very unscientific approach. In coming days, the growth of renewables will continue to outpace the increase in energy storage capacity. Large closed opencast mines offer his opportunity, literally in platter, to coal mine companies which should not be missed. It may be appreciated that such projects will provide considerable revenue to the mine owner even after closure, will provide the nation much needed energy storage capacity and employment. The case study is done on a large opencast mine with adverse stripping ratio providing an excellent case for pump back storage project but finding a few dozen projects of fifty MW range should not be difficult.

Social Mine Closure (Just Transition)

The objective of social mine closure to provide livelihood to the population dependent on coal mining and associated business after coal mine closure. Due to social legacy and largely public Sector dominated coal mining scenario, an excellent system of providing employment, land compensation etc. is already in place. So much so that perhaps the exiting R&R policy may not be sustainable to CIL in the long run. Coal India Limited through Coal Cess, NMET and CSR is contributing over 3,000 Cr per year. We failed to find any such effort for just transition anywhere in the World. The need is to utilize these funds to the true need of the local population in a systematic manner.

The need is to set up innovative industries, as illustrated in the above case study, to provide employment to the people earlier engaged in mining operation. And the funding gap, if any, should be bridged from the funds listed above.

Disclaimer

* *The view presented in this synopsis is of the author and cannot be attributed to CMPDIL or CIL and are solely intended to initiate a meaningful discussion on the subject.*

* *Information and data is taken from various sources. In some cases, from secondary sources also, which in turn quoted the primary sources. No claim for accuracy of the data is intended. The purpose is to give an overview in support of the points presented.*

SCIENTIFIC APPROACH TO SAND REPLENISHMENT- A CASE STUDY

Nirbhaya Bhatnagar[1] , Gargi Pandey[2], Dr Vinita Arora[3], Dr Rakesh Dwivedi[3], Shankar Nagachari[4] , Dr Hemant Agrawal[5] , *

Introduction

Sand mining is a vital activity that plays a crucial role in supporting various industries and infrastructure development. The importance of sand mining lies in its multifaceted applications across construction, manufacturing, and infrastructure projects. Sand is a fundamental component in concrete production, providing the necessary structure and strength for buildings, roads, and other construction projects. It is also used in manufacturing glass, electronics, and various industrial processes.

However, unregulated and excessive sand mining can lead to severe environmental consequences, including habitat destruction, erosion, and altered riverbed morphology (Padmalal et al., 2008). To mitigate these negative impacts and ensure the sustainable use of this finite resource, replenishment studies become essential (Saviour, 2012).

Replenishment studies focus on understanding the natural processes of sand deposition and sedimentation in riverbeds. By assessing the rate at which sand is naturally replenished, scientists and policymakers can determine sustainable extraction limits (Ayyam et.al, 2019). These studies help strike a balance between meeting human needs for sand and preserving the ecological integrity of river ecosystems.

In essence, the importance of sand mining lies in its contribution to human development, but it must be managed responsibly to avoid ecological degradation (Sonak et al., 2006). Replenishment studies provide the scientific foundation for implementing sustainable sand extraction practices, ensuring that the resource is used judiciously and that the environmental impact is minimized (*Shah et al., 2021).*

The Government of India (GoI) has indeed implemented various statutory measures to regulate sand mining across the country. These measures are designed to address the environmental, social, and economic challenges associated with uncontrolled sand extraction.

2. Statutory Requirement

Sustainable Sand Mining Management Guidelines (MoEFCC, 2016) and experience suggest that the source of sand in India are through

a) River (riverbed and flood plain),
b) Lakes and reservoirs,
c) Agricultural fields,
d) Coastal / marine sand,
e) Palaeo-channels and
f) Manufactured Sand (M-Sand).

The Sustainable Sand Mining Management Guidelines (SSMMG) – 2016 highlights the identification of the sand mining sources, replenishment of the River Bed Material (Sand, Boulder,

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Gravel, Cobble etc.), preparation of Districts Survey Report, and Standard Environmental, Conditions suitable for sand mining projects.

The necessary requirements to facilitate effective monitoring and enforcement of regulatory provision for sand mining in the country are as follows:

i. Identification of sand mining sources, its quantification and feasibility for mining considering various environmental (proximity of protected area, wetlands, creeks, forest etc.) and other factors such as important structures, places of archaeological importance, habitation, prohibited area etc.

ii. The mining lease auctioned by State government as per their Minor Mineral Concession Rules are granted Letter of Intent (LoI), but it has been observed that many of the sites are not suitable w.r.t environmental aspects. In most of the cases, the unplanned grant of mining lease leads to formation of cluster and/or contiguous cluster of small mining leases, which sometimes is difficult to regulate and monitor. In order to address such issues, more emphasis is required on the preparation of District Survey Report and its format for reporting.

iii. Mining Plan is an important document to assist the mine owner to operate the mine in a scientific manner. States have their own format for preparation of mining plan and it is observed that recording of the initial level of mining lease at shorter interval say 25m X 25m grid interval is not present.

iv. There is no practice for regular replenishment study to ascertain the rate of depositing, plan and section needs to be prepared based on the restrictions provided in letter of intent and provisions of Sustainable Sand Mining Management Guidelines 2016.

v. Environmental Clearance is a process wherein the regulatory authorities after considering the potential environment impact of mining clearance is granted with a set of specific & standard conditions to carry out mining operations, but often it is observed that letter of intent is granted for a location which has less potential for mining and not feasible for environment-friendly mining. This leads to an unnecessary financial burden on the mine owners and litigations. Thus, LoI should be preferably granted for those locations, which have the least possibility of an impact on the environment and nearby habitation.

vi. It is the responsibility of the mine owner to obtain all the statutory clearance and comply with the conditions stipulated in the clearance letter. Mining should be carried out within the mining lease area as per approved mining plan or mining plan concurred by other regulatory authorities.

vii. Mining operation also involves transportation of mineral from the mining area to end-user and it is necessary that movement of the mineral needs to be monitored. The State Government already have power under section 23c of MMDR, Act 1957 (IBM, 2012) to make rules for preventing illegal mining, transportation and storage of minerals. However, there are instances of illegal mining, which shows that there is a need for strengthening the system of mineral dispatch and its monitoring. This document provides good practices already under implementation by various states for regulating the mineral sale, dispatch, storage, transportation and use.

viii. The river reaches with sand provide the resource and thus it is necessary to ascertain the rate of replenishment of the mineral. Regular replenishment study needs to be carried out to keep a balance between deposition and extraction. This document provides the procedure to be followed for conducting replenishment study.

The Scientific Sand replenishment study is to be done every year as per the statutory Enforcement and Monitoring guidelines of Sand Mining, 2020.

3. Methodology

The study incudes physical survey through Drone/ DGPS and an analytical study is carried out by

using bed load transport model in Pre-monsoon & post-monsoon.

A three-stage sand replenishment study, described hereunder, was undertaken.

I. **Stage one :** Preliminary study with field data collection was done (Figure 1). The grain size analysis i.e. d10, d30, d50 and d60, uniformity coefficient and coefficient of curvature was also determined as an input for estimation of bajri/sand replenishment of rivers under study. Monsoon Water Sample data collection was carried for TSS analysis, water flow, depth of water channel etc.

Figure 1 : Reconnaissance survey of Sand Ghats in UP Yamuna River.

II. **Stage second :** Includes, use of RL survey method through DGPS was adapted for benchmarking the annual replenishment of sand/bajri. The RL survey at the selected mine sites at Pre-monsoon and Post-monsoon was undertaken.

III. **Final stage :** Comprises of use of analytical model study of bed load transport from the rivers flowing through the mining lease area. The data for this study was taken from field survey, and approved mine plan of lease. Field data was used in the Meyer Peter's equation for calculation of bed load transport.

3.1 Methodology of DGPS Survey :

DGPS Survey was carried out by CMPDI survey team during the mining phase in running mines/ closed mines/new mines at the selected mine leases in the Son river. The DGPS survey was carried out in the month of May-June, 2022 in pre-monsoon, followed by post-monsoon survey in December, 2022. A total of 14 mine leases were selected for RL survey in the Sone river across five districts. A base station was set up by survey team for about 15 km radius and RL readings of the mine lease were recorded by the CMPDI survey team. The step wise methodology adopted for estimation of volume through DGPS survey is provided hereunder :

- Pre-Monsoon Field Work & Office Work
- Establishment of Benchmark near the Sand Patch using DGPS
- Survey of sand patch using DGPS (Figure 2)
- Downloading and processing the data
- Preparation of Digital Terrain Model (DTM)/ contour preparation
- Post-Monsoon Field Work & Office Work

- Survey using DGPS using pre-established Benchmark station or otherwise Benchmark will have to be re-established
- Downloading and processing the data
- Preparation of DTM/ contour preparation
- Volume computation between Post-Monsoon & Pre-Monsoon through DTM to DTM

Figure 2 : DGPS survey

4. A Case Study of Banda District Sand Mining in the state of Uttar Pradesh

The case of Banda, a district in the Indian state of Uttar Pradesh, exemplifies the intricate relationship between sand mining and its environmental impacts (Figure 3). The case study focuses on Banda district in Uttar Pradesh, where illegal sand mining has been rampant for several years. This illegal activity has caused a number of environmental problems, including river bed erosion, loss of aquatic life, and increased turbidity in the water. It has also had a negative impact on the livelihoods of local communities, who depend on the river for fishing and agriculture.

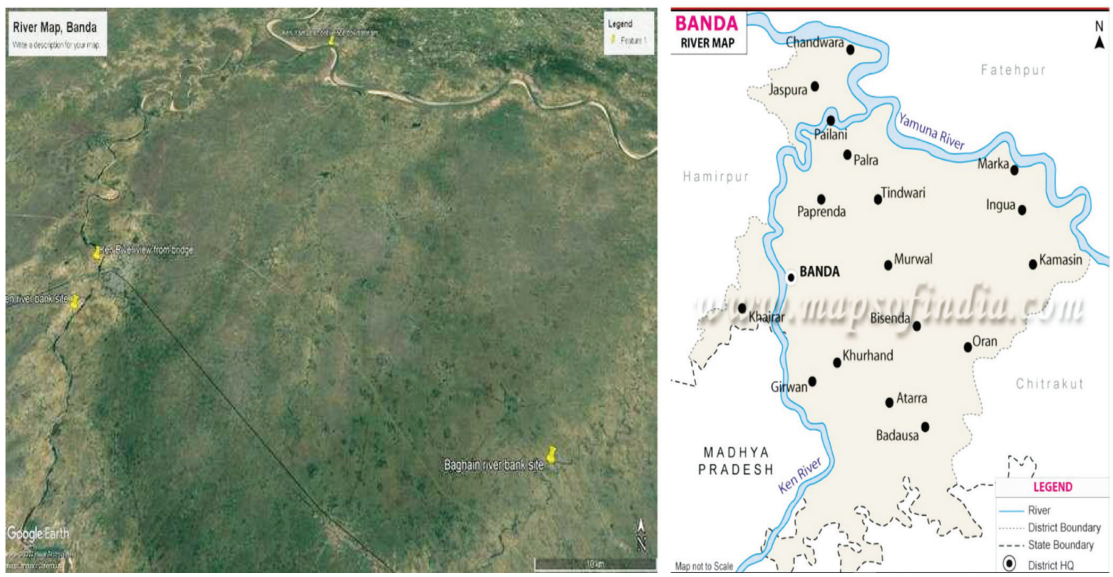

Figure 3 : River Map of Banda District showing Ken River, Yamuna River and Baghein River

In 2016, the National Green Tribunal (NGT) of India took notice of the situation in Banda and issued a series of orders to address the problem. The NGT ordered the state government to take immediate action to stop illegal sand mining and to conduct a replenishment study to assess the environmental impact of sand mining in the district. The NGT also directed the state government to develop a sustainable sand mining policy.

Banda is home to several rivers, including the Ken, Baghein, and Yamuna, which serve as the primary sources of sand. The demand for sand in the district has surged due to rapid urbanization and infrastructure projects. However, unregulated and rampant sand mining has led to a range of environmental concerns.

4.1. Environmental Impacts of Sand Mining in Banda

1. **Riverbed Degradation :** Indiscriminate sand extraction from riverbeds has caused significant alterations in river morphology, including deepening of river channels, erosion of riverbanks, and loss of riparian vegetation. This degradation has disrupted the natural flow of rivers, affecting aquatic ecosystems and increasing the risk of floods.
2. **Water Quality Degradation :** Sand mining activities release large amounts of sediment into the rivers, increasing turbidity and reducing dissolved oxygen levels.
3. **Loss of Biodiversity :** Sand mining destroys the natural habitats of various aquatic and terrestrial species, leading to a decline in biodiversity of Phytoplankton and Zooplanktons. The loss of riparian vegetation, in particular, affects the nesting and foraging grounds of numerous bird species.

4.2. A three-stage sand replenishment study, described hereunder, was undertaken to estimate the replenishment rate of sand Ghats.

4.2.1. During stage one, preliminary study with field data collection was done. The grain size analysis i.e. D10, D30, D50 and D60, uniformity coefficient and coefficient of curvature was also determined as an input for estimation of bajri/sand replenishment of rivers under study. Use of Universal Soil Erosion Equation was also done to have an idea of the soil erosion from the river catchment area.

4.2.2. During second stage, RL survey method through DGPS was adopted for the annual replenishment of sand/bajri computation. The RL survey at the selected mine sites was carried out during three time periods. First survey was carried out in February, 2022 to assess the level of sand ghats, followed by survey at the closure of Mines during Pre-Monsoon season from 8th June to 14th June 2022. The third survey was done during Post-monsoon season from 4th Nov to 10th Nov, 2022. The difference in average RL readings of 3rd survey of post monsoon in November, 2022 and 2nd survey i.e. June 2022 give the physical volume estimation of sand replenishment.

4.2.3. The final stage of this study comprises of use of analytical model study of bed load transport from the rivers flowing through the mining lease area. The data for this study was taken from field survey and approved mine plan of lease. Field data was used in the Meyer Peter's equation for calculation of bed load transport. The bed load transport rate was determined at surveyed mine sites.

The amount of replenishment is calculated based on the average representative RLs determined through DGPS survey in Pre-monsoon and post-monsoon seasons over the area of consideration. Sand replenishment calculated by CMPDI was found comparatively less than the planned production capacity of Sand. Highest sand replenished in river Yamuna in Benda Khadar mine with 844456.921 cum. In river Ken, highest sand replenished in Marauli with 465442.966 cum while lowest is in Lahureta with 8288.451 cum. In river Baghein, 18271.881 cum. sand replenished.

4.3. Grain size analysis -Ken River

The typical testing procedure consists of the following steps :

- Weigh a dry soil sample which should be at least 500gr.
- Record the weight of the sieves and the pan that will be utilized during the analysis. Each sieve should be thoroughly cleaned up before the test.
- Assemble the sieves in ascending order, placing those with the larger openings on top. Therefore, the No. 4 sieve should be on top and the No. 200 sieve on the bottom of the stack.
- Place the soil sample into the top sieve and place a cap/lid over it.
- Place the stack in a mechanical shaker and shake for 10 minutes
- Remove the sieve stack from the shaker and measure the weight of each sieve and that of the pan placed at the bottom of the stack.

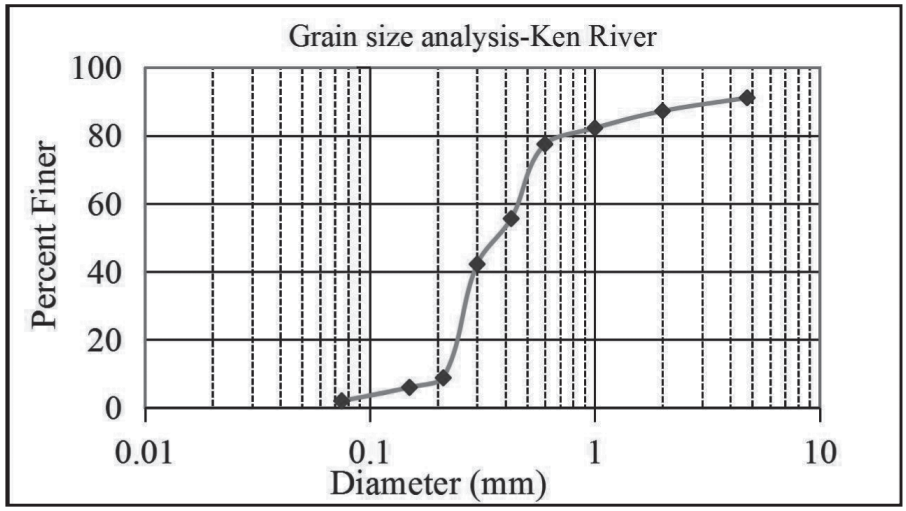

Figure 4 : Grain size analysis-Ken River, UP

4.3.1. The Uniformity Coefficient (Cu)

The uniformity coefficient (C_u) expresses the variety in particle sizes of soil and is defined as the ratio of D_{60} to D_{10} (Table 1). The value D_{60} is the grain diameter at which 60% of soil particles are finer and 40% of soil particles are coarser, while D_{10} is the grain diameter at which 10% of particles are finer and 90% of the particles are coarser. Therefore, C_u is estimated as (geoengineer.org) :

$$C_u = \frac{D_{60}}{D_{10}}$$

When C_u is greater than 4, the soil is classified as well graded, whereas when C_u is less than 4 the soil is classified as poorly graded/uniformly graded.

Table 1: Composition of Sand in Ken River

Gravel (%)	-
Sand (%)	98.00
Silt+Clay (%)	1.60
D60	0.45
D50	0.36
D30	0.27
D10	0.21
Cu	2.14
Cc	0.77
Class	SP
Remark	Poorly Graded Sand

4.4. Key Takeaways from Banda Sand Mining Study :

- Sand mining is an essential industry but requires careful management to minimize environmental impacts.
- Unregulated sand mining can lead to severe degradation of river ecosystems and loss of biodiversity.
- Effective enforcement of environmental regulations is crucial to curb illegal sand mining and protect the environment.
- Sand Replenishment studies need to be considered prior to approval of extraction of mineral resources

The Banda sand mining case study highlights the need for a balanced approach that addresses the demand for sand for development while ensuring sustainable practices and protecting the environment through adaptation of scientific method of extraction of this renewable mineral resource. As, replenishment of sand is not guaranteed every year and depends on various physical, environmental and human activities, the resource accounting of sand replenishment and its allotment for extraction needs to be regulated based on scientific studies.

5. Outcome of the study

The process of obtaining approvals for sustainable sand mining extraction, based on replenishment study reports submitted by the Central Mine Planning and Design Institute (CMPDI), is a systematic and crucial endeavour. The client, typically an entity engaged in sand mining operations, relies on the findings and recommendations of this study to secure the necessary approvals from competent authorities. The competent authority reviews the study reports to assess the environmental impact and the proposed limits for sand extraction. This process involves a thorough evaluation of the scientific data and recommendations provided by CMPDI. Upon satisfactory review, the competent authority grants approvals to the client for the sustainable quantity of sand mining extraction from the studied areas. These approvals come with specific conditions and guidelines to ensure adherence to environmentally responsible mining practices.

With the obtained approvals, the client can proceed with sand mining operations within the defined sustainable limits. This approach aims to strike a balance between meeting the demand for sand and preserving the health of the riverine ecosystem and its geo-morphology.

In summary, the collaboration between CMPDI, the client, and the competent authority facilitates a regulated and environmentally conscious approach to sand mining, safeguarding the integrity of river ecosystems while meeting the essential needs for construction and development.

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LIST OF MGMI SPECIAL PUBLICATIONS

Name of the Publications	Year	US$	Rs
Progress of the Mineral Industry * (Golden Jubilee Vol.1906-1956)	1956	12	60
Dr. D.N. Wadia Commemorative Volume*	1965	15	100
Small Scale Mining in India and abroad *	1991	45	450
New Finds of Coal In India – Resource potential and Mining Possibilities	1993	30	300
Computer Applications in Mineral Industry	1993	40	400
Indian Mining Directory (4th Edition)*	1993	40	400
Asian Mining 1993	1993	85	850
Mine Productivity & Technology	1994	75	500
Maintenance Management for Mining Machinery*	1995	60	600
High Production Technology for underground Mines*	1996	50	500
Mineral Industry Development in India – Issues, Perspective & Policy	1996	20	200
Disaster Prevention Management for Coal Mines, Vol I	1996	50	500
Disaster Prevention Management for Coal Mines, Vol II	1996	50	500
Business and Investment opportunities in Mining Industries (BIMI '96) *	1996	40	400
Indian Mining Directory (5th Edition)	1996	50	500
Information Technology in Mineral Industry(MGMIT'97)*	1997	50	500
Technological Advances in Opencast Mining(Opencast'98)*	1998	80	800
Management of Mining Machinery (MMM 1999)	1999	80	800
Mining & Marketing of Minerals (MMM 2000)	2000	80	800
Mechanisation and Automation in Mineral Industry(MAMI 2001)	2001	80	800
Mineral Industry : Issues on Economics, Environment and Technology (MEET 2002)	2002	80	800
Development of Indian Mineral Industry Looking Ahead(DIMI 2003)	2003	20	200
Emerging Challenges in Mining Industry (ECMI 2003)	2003	50	500
Future of Indian Mineral Industry (FIMI 2004)	2004	80	800
Bridging the Demand Supply Gap in Indian Coal Industry*	2005	30	300
Asian Mining Towards A New Resurgence (Vol. I & II)	2006	175	2400
Indian Mining Directory (6th Edition)	2006	60	600
Turnaround Stories of Coal Companies and Future Strategies	2006	20	200
Reprints of Holland Memorial Lecture	2006	40	400
Glimpses from Transactions	2006	30	300
Coal Beneficiation & Development of Coal Derivatives*	2007	40	400
2nd Asian Mining Congress*	2008	200	2000
Glimpses of Hundred years of MGMI of India (1906 – 2006)	2008	50	500
3rd Asian Mining Congress	2010	160	2000
4th Asian Mining Congress	2012	100	1000
5th Asian Mining Congress	2014 (CD)	100	1000
National Seminar on Indian Mining Industry-Challenges Ahead (IMICA)	2015	15	150
6th Asian Mining Congress (Pen Drive)	2016	100	1000
6th Asian Mining Congress (Proceeding Vol)	2016	500	5000
7th Asian Mining Congress (Pen Drive)	2017	100	1000
8th Asian Mining Congress (Green Mining: The Way Forward)	2019	250	2500
9th Asian Mining Congress (Technological Advancements in Mining Industy : Status and Challenges)	2022	25	2500
10th Asian Mining Congress (Roadmap for Best Mining Practices vis-a-vis Global Transformation)	2023	35	3500
Regular Publications	a) News Letter (published quarterly) b) Transactions (published Annually)		

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Rules & Regulations

1.

Accommodation	Room Rent	Accommodation	Room Rent
Single Occupancy	Rs. 1,500/-	Triple Occupancy	Rs. 2,500/-
Double Occupancy	Rs. 2,000/-	Extra Bed	Rs. 600/-

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 :@12% Extra

LIFT Facility Available

Complementary Breakfast

For Booking Please Contact MGMI Office at the Numbers and Email Addresses given above

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