MGMI
News Journal
A Quarterly Publication
Vol.47, No. 2, July - September, 2021



How Realistic is the Net - Zero Emission Target for India ?



ISSN No. : 0254-8003
Established 1906

THE MINING, GEOLOGICAL AND METALLURGICAL INSTITUTE OF INDIA

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MGMI NEWS JOURNAL

Vol. 47, No. 2 • July - September • 2021

ISSN 0254-8003

The Mining, Geological and Metallurgical Institute of India

ISSN 0254-8003

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Editorial Board

President's Message

HOW REALISTIC IS THE NET-ZERO EMISSION TARGET FOR INDIA?

In 2015, 196 countries - including India - adopted the historic Paris Agreement to reduce their carbon output "as soon as possible" and to do their best to keep global warming "to well below 2 degrees Celsius". Its overall goal was to limit warming to not more than 1.5 degrees Celsius compared to pre-industrial levels. Recently the Intergovernmental Panel on Climate Change (IPCC) released part of its Sixth Assessment Report which warns that we will not be able to limit global warming to even 2°C unless there are immediate, rapid and large-scale reductions in green house gas emissions. Human activity is the cause of climate change. Global temperatures have already risen by 1.1 degrees Celsius since the 19^{th} century. They have reached their highest in over 100,000 years, and only a fraction of that increase has come from natural forces. CO_2 levels were greater in 2019 than they had been in "at least two million years." Methane and nitrous oxide levels, the second and third major contributors of warming respectively, were higher in 2019 than at any point in "at least 800,000 years". While the extent of temperature rise may vary, it is almost certain that temperatures will rise across the world, causing heatwaves, floods and cyclones in many parts.

Collectively, the top 10 emitters, which include India, account for over two-thirds of global GHG emissions, while the bottom 100 countries account for only 3.6%. In terms of absolute carbon emissions, India is now number three in the world after China and USA. The world cannot successfully fight climate change without significant action from the top 10 emitters. China is the biggest emitter at 31% of global greenhouse gas emissions, followed by the United States at 14%, the European Union at 8% and India at 7%. Most of the top 10 emitters have higher emissions per person than the world average (around 6.45 tCO_2e per person). Among the top 10 total greenhouse gas emitters, Canada and the United States have the highest per capita greenhouse gas emissions at 20.6 tCO_2e per person and 17.74 tCO_2e per person, respectively, while India has the lowest at 2.47 tCO_2e per person. China's per capita emissions (8.4 tCO_2e) continue to rise, surpassing those of the European Union (7.46 tCO_2e). Countries such as Qatar and Australia, while not among the top 10 emitters, have higher per capita emissions than most top emitters at 35.89 tCO_2e per person and 24.79 tCO_2e per person, respectively. Carbon dioxide (CO_2) comprises 74% of greenhouse gas emissions. Most CO_2 emissions (93%) are from the use of fossil fuels, especially for generation of electricity and heat, transportation and manufacturing and consumption. Methane (CH_4) and nitrous oxide (N_2O) make up 17.2% and 6.3% of total greenhouse gas emissions, respectively, mostly from agriculture, waste treatment and gas flaring. Net-zero, also referred to as carbon-neutrality, is a state in which a country's emissions are compensated by absorption and removal of greenhouse gases from the atmosphere. Absorption of the emissions can be increased by creating more carbon sinks such as forests, while removal of gases from the atmosphere requires advanced technologies such as carbon capture and storage. Net-zero does not mean that a country would bring down its emissions to zero. Through carbon absorption it is possible for nations to have negative emissions, if such absorption and removal of greenhouse gases exceed the actual emissions. Bhutan is a 'carbon-negative' nation as it absorbs more than it emits.

Net zero emission by 2050 is emerging as the latest war cry on the climate front. And the drum beat is getting louder as the Glasgow climate conference draws nearer. India's challenge has increased because, in at least 12 of the G20 economies, the net zero goal has either been adopted or is under discussion, with China being one among the latest entrants to the club. A net zero goal by 2050 is not a demand of the Paris Agreement, which only asks the signatories to furnish their commitments in a time-frame of five or 10 years. There is, of course, an expectation that each country will develop a long-term low-emission strategy for growth.

India is opposed to the net-zero emissions target as it is likely to be the most impacted by it. Over the next two to three decades, India's emissions are likely to grow at the fastest pace in the world, as it aggressively pushes for growth and development on all fronts. No amount of afforestation or reforestation would be able to compensate for the increased emissions at the scale is looking at. Moreover, most of the carbon removal technologies right now are either unreliable or expensive. It is important that developed nations having per capita GHG emissions above the world average reduce the levels to the world average by 2030. The shifting of goalposts and setting new benchmarks for climate ambition is unacceptable. The Paris climate accord envisaged financial and technological help from the developed world to the developing world for action on climate change. However finance from developed world has been disappointing.

India's position as the third largest greenhouse gas emitter but also with among the lowest per capita emissions means that it has always resisted a hard deadline — some countries have set their target years as 2050 or 2060 — to commit to a net-zero future. It is expected that the forthcoming COP 26 talks in Glasgow will see a commitment by the United States. In India, the need for coal is likely to continue till 2050. We will have to continue coal production as well as oil and gas to have energy for growth and development of the country.

India, as per its nationally determined contributions (NDC) target, 40% of India's generation capacity was to be non-fossil fuel based by 2030. India's share of non-fossil fuel-based energy resources in installed capacity of electricity generation has already reached 39%. The country plans to achieve 175 GW of renewable energy capacity by 2022 and 450 GW by 2030. If India were to achieve this, the share of installed capacity of non-fossils in India's electricity mix would reach 65%.

Coal India Limited the largest coal producing company in the world has taken a number of steps for reducing its carbon footprint:

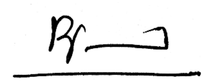
1. **Solar Power Plants:** A total of 3000 MW capacity solar power plants are to be set up. This will make CIL a net zero energy company.
2. **Tree plantation:** Since inception CIL has planted about 100 million trees in an area of 39,842 Ha. 2 million saplings were planted in FY20 and there was 11% increase in green cover in FY20 as compared to the previous year. The plantation target this year is 60% more than last year.
3. **Coal gasification:** Coal to methanol is a proven technology in the World, India being the 5th largest country with coal reserves, must tap its potential and produce methanol/ DME. 100 MT coal will be gasified by 2030. Setting up of Coal to Methanol plants will be a game changer as methanol is not only a cleaner fuel but will also enhance energy security of the country.
4. **CBM:** CBM was earlier released to atmosphere is now being tapped. 1 CBM block has been awarded in producing coal mine (first time in CIL), 2 CBM Blocks are under re-tendering. (FY22)
5. **Solar manufacturing:** CIL Board has approved bid for PLI for wafer manufacturing.
6. **FMC Projects:** 35 projects, each with more than 4 MTY capacity have been identified where coal will be transported by belt conveyors, CHP and silos from loading point to dispatch points.
7. **Pit Head Power Plants:** The carbon footprint of pit head power plants is less than power plants set up close to the demand centres, far away from mines. It is suggested to transfer coal by "wire" than by rakes.

Other options for reducing CO_2 emissions:

1. **Deployment on a large scale of High Efficiency Low Emission (HELE) power plants:** HELE power plants together with carbon capture, use and storage (CCUS) can be a pathway to nearly zero emission from coal fired power plants. HELE technologies are commercially available now and if deployed, can reduce greenhouse gas emissions from the entire power sector by around 20%.
2. **Adoption of Carbon dioxide (CO_2) capture and sequestration (CCS) technology:** CCS is a three-step process that includes:
   - Capture of CO_2 from power plants or industrial processes.
   - Transport of the captured and compressed CO_2 (usually in pipe lines).
   - Underground injection and geologic sequestration (also referred to as storage) of the CO_2 into deep underground rock formations. These formations are often a mile or more beneath the surface and consist of porous rock that holds the CO_2. Overlying these formations are impermeable, non-porous layers of rock that trap the CO_2 and prevent it from migrating upward.
3. **Adoption of hydrogen based economy:** On India's 75th Independence Day, the Prime Minster announced a Hydrogen Mission. Coal is one of the important sources of hydrogen making (Brown Hydrogen) apart from Natural Gas (Grey hydrogen) and renewable energy (Green Hydrogen) through electrolysis. In case of renewable energy (Green Hydrogen) surplus solar power is used to electrolyze water into hydrogen and oxygen. The global emphasis is on substituting liquid fuels with hydrogen (as fuel in vehicles), storage of surplus renewable power as hydrogen (as power cannot be stored at a cost effective price), and cutting down emission. Coal is one of the important sources of hydrogen making (Brown Hydrogen). Almost 100% of Hydrogen produced in India is through Natural Gas. Cost of Hydrogen produced from coal can be cheaper and less sensitive to imports when compared with hydrogen production through electrolysis and Natural Gas respectively. Production

of hydrogen from coal will have challenges in terms of high emissions and CCUS will play an important role. However, when the carbon monoxide and carbon dioxide formed during coal to hydrogen process are trapped and stored in an environmentally sustainable manner (CCS and CCUS), then, Indian coal reserves could become a great source of hydrogen. In steel making, lots of work has been done on production of steel by use of Hydrogen. However, iron reduction through hydrogen is an endothermic reaction and will require lot of heat. MoC has recently constituted committees to prepare a road map for coal based Hydrogen production and usage including economic viability, environmental sustainability and policy enablers required. This is aimed for contributing to the government agenda of a hydrogen-based economy in a clean manner.

To fix a year for net zero India will have to know its emissions peak year. We need to factor in the growth of energy needs and technologies to be able to do so. China announced it more than five years ago and decided on 2035; it may achieve it sooner than later. China has announced a net zero goal for 2060. That will give them 25 years or more for turning net zero, with nearly five times bigger an economy. How much time will it take for India to reach there? Second, India should work towards carbon neutrality at a sectoral level. The power sector is ready to make the transition. This needs to grow massively to around 5,000 GW of solar alone to be able to support full decarbonisation in 2050. The transition to solar energy means that coal use will shrink, though not vanish. We have to ensure a just transition – a transition without tears from coal. There should be no net loss of employment and income to the people. The country has to move fast towards a hydrogen economy. The developed world has to support this transition financially and by sharing of advanced technology.



P.M. Prasad
President, MGMI

From The Desk of Editor-in-Chief

The scientists and governments of different parts of the world have been talking about the energy crisis and deterioration of environment along with numerous theories and statistics. Nations have quite a significant amount of engaged time, resources and wisdom during the last five decades. However, the results of the attempts to balance the exploitation of nature and remediation is far from expectation. The present global climate change catastrophes are declaring aloud that time is running out, fast.

Global warming due to anthropogenic release of greenhouse gases is now not a contemplation but a proven reality that is affecting every sphere of our life.

The modern lifestyle and human needs have moulded the scientific development of the 20^{th} century. This has led to the growth of an energy hungry industrial world providing the commodities indispensable for today's advanced society. Unquestionably, the indiscriminate destruction of forests and exploitation of minerals by the developed nations initiated the process of global warming.

We cannot imagine India without coal at least for the next 3 to 4 decades. The transition to harvesting renewal energy will induce new demands of minerals and hence mining must continue. Indisputably, energy system today is a complex supply chain architecture with numerous nodes leaving their carbon footprint. Transition from fossil fuel to renewable sources for electricity generation is a process that shall take more than a few years. In this view, the national energy economics, environmental economics, safety economics and global geo-political diplomacy have become a crucial player in decision making. Consequently, international agreements for net-zero, emission reduction targets and goals for green transition require careful analysis.

The net zero, as we know refers to the balance between the amount of greenhouse gas produced and the amount removed from the atmosphere. We reach net zero when the amount we add is no more than the amount taken away. To reduce the greenhouse gas production emphasis is on elimination of coal based thermal power station and use of renewable energy. However, it is important here to highlight the fact that the transition costs may jeopardize the developmental paths of developing and underdeveloped Nations.

Net zero carbon commitments always involve emission reductions. This requires an initial carbon footprint measurement. This is followed by strategic greenhouse gas emission reduction initiatives, the implementation of renewable energy solutions and then carbon offsetting. As stated by Torill Bigg, the chief carbon reduction engineer with Tunley Engineering, the offsetting is used to counteract the essential emissions that remain after all available reduction initiatives have been implemented. To be carbon neutral we need to implement a policy of not increasing carbon emissions and of achieving carbon reduction through carbon offsetting. While net zero carbon means making changes to reduce carbon emissions to the lowest amount – and offsetting is thus the last resort. The offsetting is used to counteract the essential emissions that remain after all available reduction initiatives have been implemented.

At this juncture, India must streamline its approach with the world. However, constant vigilance must be practiced at all levels in order to avoid exploitation by the developed world. We must not let history to repeat and leave the opportunities and resources of the planet for a selected few.

Innovations and pro-result management have no alternatives in the growth and wealth creation. NMDC's new combo plant of beneficiation and palletization is an Indian industrial success story of waste to wealth conversion using tailings. However, we are afraid of the lack of coordination of MoEFCC and Ministry of Industry that may lead to operational difficulty in operations of the plant. Management of leases for mining operations and post mining restoration should be on techo-economic premises so that it accrues overall benefits to the Nation.

The reduction of carbon foot print and mitigation of global warming needs to come as a people's movement. Coal based thermal power will have to continue in India, however, through a Net-zero policy within the country as well as adoption of judicious Carbon Capture and Sequestration (CCS) projects, India can set new records in the world in the near future. The effectiveness of inter-company and interstate carbon trading and strict implementation of polluting licence in India needs critical analysis. An amicable solution could be achieved only through dedicated R&D based policy development. Till then individual attempts to carbon capture from sources, reduction of GHG emissions and transition to renewable energy sources are must as to embrace a Go-Green movement in all sectors.

The MGMI is dedicated to mineral development and nation building. It is expected that the forthcoming the 9th Asian Mining Congress being organized in 2022 will address number of issues including the global warming and climate change and role of mining and mineral sector including fossil fuel's supply chain. With the new drives of induction of young members by the different chapters of MGMI, we are hopeful that soon a new dynamism will emerge in this sector through the innovations of enthusiast start-ups

Khanindra Pathak
Editor-in-Chief

THEME

The Next Issue Vol. 47, No. 3, October - December 2021

"Computerization and Digitalization in the Indian Mining Industry"

Associate Editor's Column

The challenges with measuring and managing decarbonization in India's energy sector

An important task that the Editorial Board was assigned by the MGMI council was to keep our publications in tune with the global state-of-the-art. Indeed, this issue's theme builds up on that commitment. On September 29 2021, a comment was published in the world's leading scientific periodical *Nature* on the lessons we could learn for the net-zero target (Joppa et al, 2021, *Nature*, **597**, 629-632). Thus, the global relevance of this issue is clear and MGMI's objective is to perform a strong industrial footing to these scientific deliberations. This August, MGMI organized a webinar on the possibilities of coal co-existing with robust climate constraints. We are glad to present the current issue of *MGMI News* that seeks to augment those discussions by compiling a set of articles and an interview with Shri D.N. Prasad.

Several important points could be raised when we discuss the climate constraints for India. The first question is within the theme of the issue itself, "how realistic is the net-zero target for India?". In fact, the Government of India's commitment during the Paris Agreement framework talked about substantial reductions in the greenhouse gas (GHG) intensity and also a sizeable increase in the renewable energy capacity. It is important to note that India is the only economy of its size to not only meet, but also exceed these commitments. The Climate Action Tracker's website shows that India's emissions are already coherent with a 2°C carbon budget. That said, several expert op-eds, media pieces and increasingly peer-reviewed publications have been talking about the net-zero emissions targets for India. It is therefore of interest to understand the impact this would have on the energy sector and the economy at large. Beyond this, a more stringent climate target would near-certainly involve significantly larger investments and changes in employment paradigms. During our last special issue, we already provided a strong coverage on these need for these transitions to be just and sustainable.

Another key point worth discussing is the measurement strategies that must be in place for understanding India's GHG emissions. We have made significant advances in the inventory practices for several sectors, including coal mining and handling – where I had the privilege of leading the fugitive methane emissions measurement exercises at CSIR-CIMFR. The key lesson that our group learnt during these measurements was to focus on the regional patterns of emissions and using a combination of field and statistical methods to enhance the robustness of the measurements. These practices have led to the emission factors from this sector to have been included in the IPCC's Emission Factor Database. Similarly, methodology improvement has taken place for estimating CO_2 emissions from coal combustion and utilization as well. We have to think about raising the inventory best practices in other sectors as well. As we move forward with corporate environmental standards, it would be meaningful to strengthen other reporting mechanisms also. For instance, Coal India Limited has had a strong record on afforestation and understanding these emission and sequestration fluxes could be critical in how sustainability performance is reported.

Technologies will be key in ensuring that we are able to move away from an inertia of high carbon emissions in the long run. These technological domains cover a whole range of mechanisms involving reduction in use of energy (i.e., energy efficiency), changing fuel mixes, diversifying the way fossil fuels are used, using novel energy carriers and ultimately, trying to capture CO_2 from the atmosphere. The President's message from this issue gives an excellent exposition of the several technologies that exist in this domain. Three expert articles by Adams et al (on high efficiency, low emission plants), Singh and Singh (on carbon dioxide removal) and Verma and Vishal (on geological carbon sequestration) describe three important ways in which energy sector decarbonization could take place. An important issue for our economy is to understand the technologies which could be of particular relevance to India. Deployment of coalbed methane extraction technology has already shown that there are several regional challenges which require indigenous learning. Thus, institutions like our must focus on training a strong workforce who are well poised to take up these challenges.

Finally, understanding policy dimensions that could be must optimal in the Indian context is also critical. Integrated assessment modeling shows that a steady increase in carbon prices upto \$200/t-CO_2 in 2050 will be instrumental in achieving the carbon reductions necessary. This could be implemented in the form of multiple market-based mechanisms. Voluntary mechanisms such as the Clean Development Mechanism have also been used in India and other developing countries. The article by Mehra and Pandey in this issue provides an excellent review of these topics. It also remains to be seen how regulatory mechanisms could fit in together with these market and voluntary market mechanisms.

In summary, the breadth of the R&D domains for achieving reliable decarbonization over the next eight decades is wide. We would very much appreciate the contributions from the MGMI community on which themes could be addressed by our membership, along with their insights on the key challenges they are encountering in measuring and managing these considerations, in addition to our publications, the 9th Asian Mining Congress is also planned during February 15-18, 2022, and I would request our members to participate in this conference and also encourage their colleagues to share their work.

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

Headquarters' Activities

Minutes of 888th Council Meeting

(Held through Zoom - VIRTUAL PLATFORM)

https://us02web.zoom.us/j/4997468863?pwd=TXBtUUs3bStXQ1psdk5qTENUS3ljZz09

Date & Time: 04th June, 2021 at 06.00 PM
The report of the 888th Council Meeting 'of' MGMI Bldg., GN-38/4, Sector – V, Salt Lake, Kolkata – 700091 on 04th June 2021 at 06.00 p.m. (Duly approved in the 889th Council Meeting held on 7th August 2021).

PRESENT : Shri P M Prasad, President in the Chair. The meeting was attended by Prof Banerjee Sakti Pada, Prof. Dhar B B, Dr Nanda N K, S/Shri Jha Anil Kr, Jha N C , Ritolia R P , Saha R K, Goenka J P, Mandal P R, Roy Prasanta, Talapatra Ranajit, Karmakar Anil Kumar, Prof Pathak Khanindra, Dr. Singh Ajoy Kumar, Arora V K, Barnwal J P, Prof Bhattacharya Ashish, Biswas Anup, Bose L K, Chakrabarti Smarajit, Prof Dasgupta Sajal, Prof Dey N C, Prof Karmakar G P, Nag T K, Prof Sarkar Bhabesh Chandra, Dr Sen Kalyan, Singh Anil Kr, Dr Sinha Amalendu, Moitra Ajoy Kumar, Bhati G S, Wadhwa I P and Lochan Rajiw

ITEM No. 0 Opening of the Meeting

1.1 The President welcomed the Past Presidents, Vice Presidents, all Council Members present in the meeting along with invitees. He wished all will be healthy and safe in current pandemic situation, COVID 19. The meeting called to order by the President and he requested the Hony. Secretary to take up the Agenda for deliberations.

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

888.1.0 To confirm the Minutes of the 887th meeting of the Council held at MGMI (H.Q.), Kolkata on 16th December, 2020

The draft Minute were circulated to all the Council Members. Since, no comments were received, the Council resolved that:

Resolution: The Minutes of the 887th (3rd meeting of the 114th Session) Meeting of the Council held on 16th December, 2020 at 12.00 Noon on Hybrid Mode (Physical & Virtual Platform) be confirmed.

888.1.1 To consider matters arising out of the Minutes.
The Council considered the Action Taken Report in respect of the Minutes of 887th Council Meeting held on 16th December 2020 (on hybrid mode).

Item 887.3.0 To discuss on 114th Annual General Meeting of the Institute.
The 114th AGM of MGMI held on 27th December, 2020 at 11.30 AM at MGMI (H.Q.) Office, Salt Lake, Kolkata in hybrid mode in association with Central Depository Services (India) Limited, (CDSL). Report of AGM has been uploaded at MGMI Site, circulated among members and proceedings submitted to ROC for compliance as well uploaded on GoI Ministry of Corporate Affairs website to comply all provisions as per Government advisories and guidelines.

Item 887.5.0 To appoint the Institute's Auditor for the financial year 2020 – 21 with their remuneration.
The Council approved the appointment of M/s. Jha & Jha Chartered Accountants Company as Auditors of MGMI for the FY 2020-21 at a remuneration of Rs. 12,000/- (excluding applicable taxes) for execution of all assignments of Audit, ROC, Annual Filling, IT Returns etc. An appointment letter has been issued for the same as confirmed in the AGM also.

887.7.0 Any other matter with the permission of the Chair.

Dues of 8th AMC and Exhibition: Several letters and reminder were sent to M/s. Tafcon to clear the outstanding dues against 8th IME concurrently held with 8th AMC which is long overdue. Also follow-up was made with M/s. Tafcon, Managing Partner, Shri I.P Wadhwa. Recently received Rs.7 lakhs in two instalments and still due Rs. 18.70 Lakhs. Shri I.P. Wadhwa was present in the meeting and clarified the issue and assured the Council that within a Quarter i.e; September 2021, he will clear all outstanding dues. Once again Council expressed their displeasure on M/s Tafcon for habitual delay in paying outstanding dues.

888.2.0 To elect Office Bearers (Vice Presidents, Hony Joint Secretary, Hony Treasurer and Hony Editor for new term i.e; 2020-21)

The Council deliberated on recent surge of covid which put us in the extra ordinary condition due to prevailing pandemic situation and unanimously agreed to take all precaution for the safety of each member as prime priority to be safe and healthy first.

Council elected the following Office bearers unanimously for the new terms 2020-2021, after discussion and clarification, elected the officer bearers as under:

Vice Presidents: (1) Shri Binay Dayal, (2) Shri P K Sinha, (3) Shri P R Mandal and (4) Shri J P Goenka are Proposed by Dr Amalendu Sinha and Seconded by Shri Anil Kr Karmakar.

Treasurer: Shri Anil Kr Karmakar, Proposed by Shri Ranajit Talpatra and Seconded by Shri V K Arora, Joint Secretary: Shri Ranajit Talapatra, Proposed by Shri Prasanta Roy and Seconded by Shri Anil Kr Singh, and Hony Editor: Prof (Dr) Khanindra Pathak, Proposed by Shri Rajiw Lochan and Seconded by Dr J P Barnwal.

888.3.0 To consider and constitute a Board of Scrutinizers to conduct Election of Council Members for the years 2021-2024

The Council after detailed discussion considering AGM approval also, the "Board of Scrutinizers" has been constituted and approved to conduct election for the Council Members of MGMI for the Years 2021-2024 and advised the Committee to place the report in the 115th AGM of the MGMI. The constituted Committee Members are as hereunder and unanimously approved by the Council.

1. Shri Ranjan Kr Saha - Convenor
2. Shri Samarajit Chakrabarti,
3. Shri Prasanta Roy,
4. Shri Ranajit Talaptra,
5. Shri Rajiw Lochan, Hony Secretary - Ex -Officio

888.3.1 The resultant vacancies are nine for electing new council members for 2021-24 against the following retiring council members:

1) Prof (Dr) Khanindra Pathak
2) Dr Kalyan Sen
3) Prof (Dr) Sajal Dasgupta
4) Shri Virendra Kr Arora
5) Shri Anup Biswas
6) Shri Akhilesh Choudhury
7) Prof (Dr) Bhabesh Chandra Sarkar
8) Prof (Dr) Netai Chandra Dey
9) Shri Anil Kr Karmakar

888.4.0 Future Programmes:

1. 9th Asian Mining Congress

The Council discussed in detail on continuing pandemic condition which led to extra ordinary situation due to surge of corona virus and uncertainty due to natural calamity. It was opined that we should think only, when situation improves and safe to organize physical event after obtaining permissions from the government. Accordingly, it was agreed that this year MGMI will not organize their Bi-annual event in October, 2021. It was noted that any International Event can only be planned or organized, once Government permits and intention received from potential foreign participants for International Mining Exhibition (IME) and Asian Mining Congress (AMC).

M/s Tafcon representatives briefed the council about future events by other organizations, and also suggested that initially we may think to organize the 9th IME & AMC during 17th – 20th January' 2022.

The Council was in opinion that it is too early to consider it, as Government is making all emergency arrangement for third wave and we should not consider any thing at the cost of life and safety. Council also raised the issue on long outstanding dues in which Rs. 18.70 Lakhs is still not paid by M/s Tafcon. Shri I.P. Wadhwa, Managing Partner of Tafcon confirmed the Council that it will be cleared within July quarter.

It was further agreed by the Council that a separate meeting will be convened to evaluate the situation and possibility when the 9th AMC should be organised. In the meantime, M/s Tafcon will also explore about availability of suitable venue, Government permissions and response from foreign participants.

2. Short Term Courses

The Council suggested to, organize Short Term Course(s) on Virtual Platform for the following courses as per exercise made. The Coordination Committee with the following members were constituted as hereunder:

Exploration Techniques:

Dr Amalendu Sinha, Co-ordinator
Prof Bhabesh Chandra Sarkar, Member
Shri Prasanta Roy, Member
Shri Ranjit Dutta, Member

Sustainability Development in Mining considering Environmental Issues:

Dr. Amalendu Sinha, Co-ordinator
Shri Samarjit Chakrabarti, Member
Dr Ajay Kr Singh, Member
Dr A K Samantray, Member

New Legislations – CMR 2017, Occupational Safety Health & Working Condition Code 2020 and Draft Central Rules:

Shri N C Jha, Co-ordinator
Shri Anup Biswas, Member
Prof Sajal Dasgupta, Member
Prof. Khanindra Pathak, Member

Further, it was agreed that Model prepared for the course on "Exploration Techniques" by Prof. Bhabesh Chandra Sarkar should also be considered for other two courses and accordingly it should be finalized.

President requested coordinators to finalize the brochure on priority so that MGMI can approach respective organization to sponsor and nominate participants for these courses.

It was brought to the notice of the Council that there is long term MoU with MGMI and CIMFR to organize various training courses jointly and two courses have been organized successfully. This MoU require further extension of additional term. The Council approved the further extension of two years and directed to proceed further to complete the formality with CIMFR and MGMI on priority to keep continuity.

3. Technical Paper Sessions

Prof (Dr) Khanindra Pathak and Dr Ajay Kr Singh appraised the Council that Virtual Paper Meet was organized by MGMI on 8th May 2021, wherein the following papers were presented:

i. Application of data analytics for performance analysis of dump trucks by Pragjyoti Das, IIT Kharagpur, Chandan Gautam, SECL and Khanindra Pathak, IIT Kharagpur.
ii. Variation in Rake Loading of Coal and its Consequence by S.K. Sadangi, CVO, CIL.
iii. Experiment and Demonstration of Rapid Forest Regeneration over Steel Slag, authored by Anjani Kumar, S V Brahmandam, Khanindra Pathak, IIT Kharagpur, Saroj Kumar Banerjee, TSBSL and Padmanav Mahakud, TSBSL.
iv. Flammable and Toxic Gases in Opencast Coal Mines by Munir Ahmed, MCL.

Modified/Edited above technical papers will be published in the MGMI Transactions, Vol. 117, April 2020 - March 2021.

Prof Pathak requested Council Members to motivate people to send their technical papers to MGMI for presentation and publication, as they are not successful in getting good technical papers. Prof S P Banerjee suggested to organize technical paper session, more frequently which will automatically improve paper flow and its quality.

Hony. Secretary again requested MGMI Editorial Board to initiate all necessary steps to obtain the accreditation for MGMI's Publication which is long due and it will be added one more feather to MGMI. Authors will happily submit their paper to MGMI for consideration and publication as it will automatically enhance reader's viewing and credibility. Dr Ajay Kr Singh has assured the Council that he will take-up this job on priority basis.

4. President's Golf Tournament

Shri J P Goenka, Convenor of the tournament informed the Council that it can only be organized, after withdrawal of Government restrictions which is in force due to COVID 19 protocol. President suggested that it can also be organized at Sambalpur. Convenor, submitted that last time it was organized by MCL, so for change we may organize it at Kolkata, if situation permits.

888.5.0 To consider applications for membership and the membership position of the Institute:

a) The Council approved 5 Life membership applications. All of them have been intimated their membership number by individual letters.

b) The Council noted the present position of membership which is as follows:

Membership Position
(As on 30.05.2021)

	16.12.2020	**Add**	**Trans**	**Loss**	**30.05.2021**
Member	265	-	-	-	265
Life Member **Associate**	2566 41	08 1	- -	- -	2574 42
Student Associate	07	01	-	-	07
Life Subscriber	32	-	-	-	32
Subscriber	01	-	-	-	01
Donor	03	-	-	-	03
Patron **Corporate** **Life Corporate**	04 08 02	- - -	- - -	- - -	04 08 02
	2929	**08**			**2937**

888.6.0 Any other matter with the permission of the Chair

888.6.1 The Council appreciated the efforts of the Editorial Board and publication of MGMI's News Journals and Transaction even in current pandemic and restrictions imposed to prevent corona virus. It was informed that following MGMI's News Journals and Transactions were published and uploaded at MGMI website:

1. MGMI News Journal, Vol. 46, No.3, October – December 2020,

   Theme of the Issue: "Commercial Coal

Mining in India and Asset Management in the Mining Industry".

2. MGMI News Journal, Vol. 46, No.4, January – March 2021
   Theme of the Issue: "Metal Extraction vis-à-vis Mineral Resources: Indian Perspective"
3. MGMI Transactions, Vol. 116, April 2019 - March 2020

Under finalization:

4. MGMI News Journal, Vol. 47, No.1, April – June 2021
   Theme of the Issue: "Sustainable Pathways for India's Coal Sector"

Hony. Secretary informed the council to keep Members Data Bank updated one and effort has also been made by providing online up-dation tab facility at MGMI Website where members can update their contact details very easily on-line at the site itself. Members were requested to promote this facility so that MGMI can maintain recent updates on members to keep more frequent communication and response.

888.6.2 Webinar on "Coal Mining"

Chief Consular Officer, Honorary Consulate of the Republic of Poland in Kolkata has approached MGMI to organise an Online Webinar on Coal Mining. The Council agreed to organize it on mutually agreed date and time.

888.6.3 Indian National Committee (INC) of World Mining Congress (WMC)

Hony. Secretary appraised the Council that INC/WMC is registered body under Society Registration Act, 1860 wherein MGMI is one of the Members under "Representative of Professional Body" which is notified by MoC-GoI vide approval letter no. 34011/02/2011-CRC-I dated 23rd Sept, 2014. Secretary (Coal) is the Chairman of the Organization and Member Secretary is the Chairman, CIL with other representatives. The Chairman of the Executive Committee is Additional Secretary (Coal) and Member Secretary is the Chairman, CIL with other members. Coal India Limited is extending all support and secretarial help to this body as Patron is the Minister of Coal.

AGM of this apex body was convened through VC on 4th March, 2021 under Chairmanship of Secretary (Coal). Members of INC/WMC have attended this meeting where MGMI was represented by Hony. Secretary Shri Rajiw Lochan. It was agreed in the meeting that now onwards Director (Technical), CIL will replace Chairman, CIL for all purpose, however, CIL will extend all support as directed by MoC.

Secretary (Coal) appreciated the role of MGMI and requested to actively participate as and when requested, in their activities also, which was agreed by MGMI representative. It was agreed that initially Webinar will be organized in October, 2021 on Coal.

888.6.4 Appointment of Mr Suman Sinha on Contract in MGMI

Hony. Secretary informed the Council that MGMI day to day workings also suffered as most of the working staffs were unable to join their duties on regular basis due to corona, mainly aged employees serving on contract. They are still not fully recovered however our activities could have been managed with the cooperation of Office Bearers and staffs. Based on requirement contract of respective staffs have been extended and everyone was paid their salaries on time as per prevailing practice which has also led to financial burden.

Hony. Secretary further informed the Council that Mr Joy Chakraborti, who was serving MGMI on yearly contract basis had requested MGMI to release him to join other job where he is getting better opportunity to grow further, accordingly, considering his better future he was allowed to resign from MGMI. His service to MGMI was good and on his resignation need to appoint young experienced person was very much required. It was agreed that there will not be any regular appointment on roll and now onwards aged people will not be considered for appointment.

An application of Mr Suman Sinha was received to MGMI office who is having multifaceted professional experience of more than 23 years' experience with Graduation degree in B Com. He was associated with Peerless Group with experience of Secretarial and Office Administration. A committee consisting of Hony Joint Secretary and Hony Treasurer took his interview and found suitable and recommended for contractual appointment with remuneration for Rs. 22,000/- PM, inclusive of all. The Council after discussion and clarification approved the contractual appointment of Shri Suman Sinha initially for one year for a remuneration @Rs. 22,000/- per month.

888.6.5 Seeking authorization for financial operation

The matter regarding statutory expenses incurred after AGM till further formation of the new Executive Committee and intimation to the Banks, regarding change of Signatory, if needed was deliberated. It was requested to the Council to authorize outgoing Executive Committee till election of New Executive Committee to operate the Bank accounts for statutory expenses, payments for the smooth functioning of MGMI administrative activities. The Council considered the operational problems faced every year and authorised outgoing office bearers to operate Bank accounts till formation of the new Executive Committee and approved the modalities accordingly.

President Shri P M Prasad thanked the Past Presidents, Council Members and Branch Representatives for their valued time and participation in the virtual meeting and hope very soon we will meet in person till than be healthy and safe.

The meeting ended at 7.45 PM with Vote of Thanks to the Chair and others by Hony Joint Secretary Shri Ranajit Talapatra.

REPORT ON PROCEEDING OF
THE 115th ANNUAL GENERAL MEETING FOR THE YEAR 2020-21

CS. Mohammad Menazuddin
ACS, B. Com (H)

Address: 233, Tiljala Road, Kolkata – 700 046
Phone No: +91 9874582083

SCRUTINIZER'S REPORT

[Pursuant to Section 108 of the Companies Act, 2013 and Rule 20 of the Companies (Management and Administration) Rules, 2014 (as amended)]

September 28, 2021

To,
Mr. Ranajit Talapatra,
Director/Honorary Secretary,
The Mining Geological & Metallurgical Institute of India,
CIN: U10200WB1909GAP001938.
GN 38/4 Sector V Salt Lake,
P S East Bidhan Nagar, Kolkata 700091

Dear Sir(s),

Sub: Scrutinizer's Report on voting through Remote E-voting and E-voting at the Annual General Meeting (AGM) conducted pursuant to the provisions of Sections 108 of the Companies Act, 2013 read with Rule 20 of the Companies (Management and Administration) Rules, 2014, and the General Circular No. 20/2020 dated 5th May, 2020 read with Circular dated 8th April, 2020 and 13th April, 2020 and 13th January, 2021 issued by the Ministry of Corporate Affairs ("MCA Circulars") for the 115th Annual General Meeting of The Mining Geological & Metallurgical Institute of India held through Video-Conferencing ("VC") or other Audio-Visual Means ("OAVM") in accordance with the applicable provisions of the Companies Act, 2013 ("the Act'") on Saturday, 25th September, 2021 at 10:30 A.M.

I, Mohammad Menazuddin, Practicing Company Secretary, appointed by the Board of Directors of **The Mining Geological & Metallurgical Institute of India ("the Company")** to act as the Scrutinizer for the purpose of scrutinizing the voting process through Voting by electronic mean pursuant to the provisions of Sections 108 of the Companies Act, 2013 **("the Act")** read with **Companies (Management and Administration) Rules, 2014** and MCA circulars in respect of the Resolutions mentioned in the Annual General Meeting **("AGM")** Notice dated **24th August, 2021.**

Mohammad Menazuddin ★ Practicing Company Secretary ★ C.P. No.- 20629

Email: md.menaz@gmail.com; csmd.menaz@gmail.com

CS. Mohammad Menazuddin
ACS, B. Com (H)

Address: 233, Tiljala Road, Kolkata – 700 046
Phone No: +91 9874582083

The Management of the Company is responsible to ensure the compliance with the requirements of the Sections 108 of the Act read with Companies (Management and Administration) Rules, 2014 and MCA Circulars. My responsibility as a Scrutinizer is to ensure that the voting process is conducted in a fair and transparent manner and is restricted to making Scrutinizer Report for ascertaining the votes cast in "favor" or "against" for respective resolutions of the Annual General Meeting Notice.

A person who was a member as on the cut-off date i.e., 18th September, 2021 was entitled to vote on the resolutions of the Annual General Meeting Notice.

The Company had engaged the services of Central Depository Services (India) Ltd. for providing remote e-voting facility and the service provider had set up the remote e-voting facility on its website www.evotingindia.com. The Service Provider has provided a system for recording the electronic votes of the members on all the items of the business sought to be transacted at the Annual General Meeting.

I hereby submit my Report as under:

1 The period for remote e-voting had commenced at 10:00 a.m. on Wednesday, 22nd September, 2021 and closed at 5.00 p.m. on Friday,24th September, 2021. At the end of the remote e-voting period, the facility was blocked by the Service Provider.

2 The results of remote e-voting and e voting done at the AGM are based on the reports generated from Service Provider website www.evotingindia.com .

3 I have collated the votes downloaded from the remote e-voting and e-voting at the AGM to declare the final results for each of the resolution(s) forming part of the Annual General Meeting Notice and to ascertain the number of votes in "Favor" or "Against". The members who have abstained from the voting during the aforesaid voting process have not been considered in preparation of this Scrutinizer's Report.

Email: md.menaz@gmail.com; csmd.menaz@gmail.com

Mohammad Menazuddin ★ Practicing Company Secretary ★ C.P. No.- 20629

CS. Mohammad Menazuddin
ACS, B. Com (H)

Address: 233, Tiljala Road, Kolkata – 700 046
Phone No: +91 9874582083

As per the report generated from the e-voting website of CDSL, 53 Members have casted their votes through remote e-voting. None of the Members have cast their votes e voting at the AGM.

I hereby submit Scrutinizer Report as per the provisions of Section 108 of the Act read with Rule 20 of the Companies (Management and Administration) Rules, 2014 and MCA Circulars, containing the results of each of the resolutions of the Annual General Meeting as detailed in **Annexure A.**

I hereby confirm that the Registers and Records generated from the e-voting platform of the Service Provider are being maintained in the electronic form.

The Registers and all other records/ papers relating to Voting by electronic mean shall remain in my custody till the Chairman considers, approves and signs the Annual General Meeting Minutes and thereafter the same shall be returned.

You may accordingly declare the Result of Voting for each Resolution of the Annual General Meeting Notice as detailed in the attachment and marked as **Annexure-A.**

Thanking you,

Place: Kolkata
Dated: 28.09.2021

Mohammad Menazuddin ★ C.P. No.- 20629 ★ Practicing Company Secretary

(Mohammad Menazuddin)
Practicing Company Secretary
C.P. No. 20629
UDIN: A047770C001029621

Email: md.menaz@gmail.com; csmd.menaz@gmail.com

CS. Mohammad Menazuddin
ACS, B. Com (H)

Address: 233, Tiljala Road, Kolkata – 700 046
Phone No: +91 9874582083

We, the undersigned witnesses that the votes in respect of e-voting of members of The Mining Geological & Metallurgical Institute of India were unblocked from e-voting website of Central Depository Services (India) Limited (CDSL) in our presence at 12:40 P.M. on 26th September, 2021.

Mrs. Ridhima Arora
1051 Civil Lines, Jhansi,
UP - 284001

Mr. Manohar Mishra
83, Sashi Bhusan Mukherjee Lane,
Howrah - 711106

Countersigned by
For The Mining Geological & Metallurgical Institute of India

Ranajit Talapatra,
Director/Honorary Secretary
DIN: 09038653
Address: FD 401, Salt Lake City
Sector 3, Bidhannagar (M), IB Market, North 24 PAR
Kolkata – 700106.

Email: md.menaz@gmail.com; csmd.menaz@gmail.com

Mohammad Menazuddin ★ Practicing Company Secretary ★ C.P. No.- 20629

ANNEXURE A

Particulars	Number of Members voted through Remote E-voting	Number of Remote E-votes casted	Number of Members voted through E - Voting at the AGM	Number of votes casted through E - Voting at the AGM	Total No. of votes cast through Remote-voting and E - Voting at the AGM	% of total number of valid votes cast
	1	2	3	4	5=(2) + (4)	6
Item No.1 : To receive and adopt the Council's Report, Audited Balance Sheet and Statement of Accounts for the year ended on 31st March, 2021.						
Voted in favour of the resolution	53	53	0	0	53	100.00
Voted against the resolution	0	0	0	0	0	0.00
Total	**53**	**53**	**0**	**0**	**53**	**100.00**
Invalid /Abstain votes	0	0	0	0	0	-
Item No. 2 : To appoint the Institute's Auditor for the year 2021-22 and fix their remuneration.						
Voted in favour of the resolution	53	53	0	0	53	100.00
Voted against the resolution	0	0	0	0	0	0.00
Total	**53**	**53**	**0**	**0**	**53**	**100.00**
Invalid /Abstain votes	0	0	0	0	0	-

Place: Kolkata
Dated: 28.09.2021

Mohammad Menazuddin ★ Practicing Company Secretary ★
C.P. No.- 20629

Mohammad Menazuddin
Practicing Company Secretary
C.P. No. 20629

REPORT ON PROCEEDING OF
THE 115th ANNUAL GENERAL MEETING FOR THE YEAR 2020-21

The 115th Annual General Meeting of MGMI was held on 25th September 2021 at 10.30 hrs at MGMI Office, Salt Lake, Kolkata through video conferencing with host site being MGMI Office at Kolkata. The web logistics for the event was organised by Central Depository Services (India) Limited (CDSL).

The meeting was chaired by Shri PM Prasad, President, MGMI. The office bearers and members, who joined the meeting on-line are S/Shri PM Prasad, Anil Kr Jha, Dr NK Nanda, Nirmal Ch. Jha, Prof. S.P. Banerjee, Prof B.B. Dhar, R.P. Ritolia, R.K. Saha, Rajiw Lochan, Prasanta Roy, Ranajit Talapatra, P S Mishra, Dr. Amalendu Sinha, Dr. P.K. Singh, T.K. Nag, J.P. Goenka, V.K. Arora, P.R. Mondal. N.N. Gautam, B.R. Reddy, Ashis Bhattacharya, Dr. Khanindra Pathak, Dr. Ajay Kumar Singh, Anil Kumar Karmakar, Ranjit Datta, Smarajit Chakraborty, Prof. Netai Ch. Dey, Anup Biswas, Anil Singh, Prof. G.P. Karmakar, K. Ramakrishna, C.S. Singh, Dr. Bhabesh Ch. Sarkar, Alok Kumar Singh, Dr. J.P. Barnwal, Sayan Ghosh, K.K. Mishra, Dr Anal Sinha and Shri G.S. Khuntia.

At the onset, one-minute silence was observed in memory of the members who left us during the last one year, after their names were read out by the Secretary.

Sri P M Prasad, President, MGMI called the meeting to Order on confirmation of establishment of Quoram at 10.40Hrs. The President welcomed all members present by thanking the Past Presidents, Office bearers, Council members and Members attending the meeting on virtual platform through video conferencing organized in association with CDSL.

Hony Secretary, MGMI Shri Rajiw Lochan initiated the meeting proceedings. The notice convening the 115th Annual General Meeting containing the agenda and the 115th Annual Report of MGMI was sent to all members through email in advance by the office and same was read out by Shri Rajiw Lochan, Hony. Secretary for convenience of members attending the meeting. The minutes of the 114th Annual General Meeting was circulated to the members through email by MGMI office. In addition, CSDL also sent the (i) 115th AGM Notice and (ii) Annual Report 2020-21 to members through email for compliance. It was also placed on MGMI Official website https://www.mgmiindia.in/.

The Actions Taken report on the minutes were presented by the Hony Secretary. The minutes were confirmed by the house, which was proposed by Prof B B Dhar and seconded by Shri N N Gautam.

The members were requested vide e-mail with details of link and process to e-vote for accepting or rejecting the audited balance sheet (up to March 2021) and the proposal of appointing the auditor. The e-voting was open from 22nd September and quite a few members (53) availed the facility. Report on the last audited balance sheet was also sent through email, post hard copy and put up in the website by MGMI office. For convenience of attending members the salient points of the audit report were read out. The audited report was confirmed and accepted by the house, which was proposed by Shri P R Mondal and seconded by Dr Amalendu Sinha. House unanimously adopted that M/s Jha & Jha Co will be the auditors for the financial year 2021-22 with the remuneration of Rs. 12,000/- for all the necessary services as approved in the 889th Council Meeting.

Then Shri P M Prasad, President, MGMI was invited to deliver the Presidential address. The written address had been posted in MGMI website and also sent to members through WhatsApp.

Welcoming the participants, Shri Prasad discussed the challenges mining industry is facing along with the solutions that could be developed using the experience and knowledge of the members of this great century-old Institute. He briefly spoke of India's economic progress since independence mentioning that there has been a 10-fold increase in the GDP (at constant prices) since the reform process began in 1991. Economy is recovering faster than expected after the second Covid-19 wave.

In the development model of India, natural resources have played a crucial role in promotion of Make in India initiative. According to him, for "Make in India" to succeed, we must "Mine in India" first. Development of the mining sector will be important if India has to achieve 7%-plus GDP growth. Mineral production needs to keep pace with the growing demand of infrastructure development to minimize the import bill of minerals. Shri P.M.Prasad, President, discussed the energy consumption of India, vis-à-vis other developed countries as also energy options of our country. Our dependence on oil imports is over 85 percent and our oil production has been declining at a CAGR of 0.5 % in the last 10 years. The trend is similar for natural gas production, which has declined at a CAGR of 0.4% in the last ten years. The import dependence for natural gas is about 45 percent. In this bleak fossil fuel production scenario, coal production has been an exception. In FY21, the country produced 716 MT of coal. The CAGR of coal production in the last 10 years is about 3%. According to him, Coal will continue to be the backbone of India's energy sector for the next two decades.

Coal India Limited is the largest coal producing company in the world. It also operates the largest number of coal mines in the world. He further discussed some of the steps taken for sustainability in Coal India, which are -- 1) First Mile Connectivity Projects, 2) Planning of large capacity mines, 3) Increased deployment of Surface Miners and continuous miners, 4) Tree plantation, 5) Rehabilitation of Jharia fire sites, 6) Diversification – a) Coal to Chemicals Plants, b) CBM, CMM, Coal Gasification (Surface & Underground), c) Pit Head Power Plants, d) Solar Power Plants, e) Solar manufacturing, f) Monetization of waste -- Reuse of Reclaimed Land, Overburden Waste Processing Plants, Mine water utilization. Then he mentioned move towards sustainability seen in the private sector.

Shri Prasad spoke about Net zero emission, Hydrogen as an important source of energy, sustainability of metalliferous mining and future of production of minor minerals like graphite, lithium and cobalt. India has not been able to utilize its rich natural resource endowment (of iron, coal, mineral oil, manganese, bauxite, chromite, copper, tungsten, gypsum, limestone, and mica) to full potential to maximize growth and strengthen the economy.

In conclusion, he hailed MGMI's activities, especially during the pandemic period, like regularly organizing knowledge sharing events, improving quality of MGMI News Journal, etc.

He shared that the 9th Asian Mining Congress is scheduled to be held early next year and shown his confidence that the congress and the associated mining equipment exhibition will be a great success. He thanked Shri Rajiw Lochan, Hony Secretary, for organizing the smooth functioning of MGMI even in pandemic and kept all regular activities as scheduled.

After the Presidential address, Secretary announced that Consul General, Poland met MGMI officials and Poland is likely to be the partner country for the 9th AMC. He also announced the names of important office-bearers of the 9th AMC i.e; Chairman, Shri P S Mishra, Convenor Shri Rajiw Lochan. In this context, Prof B B Dhar suggested that younger members should be included in the AMC committees. Similarly for the 9th IME Shri Bhola Singh will be Chairman and Shri Prasanta Roy will be the Convenor to organize this event in befitted manner. Committee members will be further adopted for making global event a grand success.

The report of the Board of Scrutineers for Election of the Council Members for the years 2021-24 was presented. The essence of the report is -- Total Ballot papers dispatched – 1881; Ballots received 430; No response of voters – 1202; Number of council members elected -9; No of candidate contested – 12. The newly elected council members are:

1. Dr. Ajay Kr Singh, 2. Sri Chandra Sekhar Singh, 3. Sri Anup Biswas, 4. Sri Pravat Ranjan Mandal, 5. Dr Bhabesh Chandra Sarkar, 6. Dr Netai Chandra Dey, 7. Sri Nitya Nand Gautam, 8. Dr Kalyan Sen, & 9. Sri Bhaskar Chakraborti.

The President, Secretary, Joint Secretary, Council Members and members present congratulated and welcomed the new council members.

In response to the suggestion of Shri J P Goenka of electronic voting in future, Shri Rajiw Lochan, Hony. Secretary informed that as per MGMI constitution, 60 days' notice is to be given for voting and window for voting is too large. Agency conducting e-voting have not developed such long period of voting. Dr Asis Bhattacharya, Dr Khanindra Pathak, Prof B B Dhar interacted to advise that MGMI constitution may please be considered to modify suitably to meet the need of the time and adopt advancement. It was agreed that the matter will be further deliberated in Council Meeting of MGMI to draw way forward.

Hony Secretary informed the house that in the 889th Council Meeting it was unanimously decided that Shri P M Prasad will continue as the President of the MGMI for another tenure i.e; 2021-22. In the 889th Council Meeting itself the Hony Joint Secretary Shri Ranajit Talapatra elected as Hony Secretary for the period 2021-23 as current Hony Secretary Sri Rajiw Lochan is completing his tenure as Hony Secretary as per provision of MGMI constitution.

In the open session, Shri J P Goenka wished that more sincere efforts are made towards inducting more members, especially young members. He pointed out that number of MGMI members are decreasing. Shri R P Ritolia suggested there should be young council members and reservation for this may be considered. Shri V K Arora spoke for reservation for ladies. Dr. Khanindra Pathak suggested that important persons from other organizations may be co-opted as ex-officio council members.

Past President Shri N C Jha said that he is not in favour of any reservation. Shri N N Gautam supported Shri Jha views, pointing out that there is no bar for young people to apply for election. They need to be made interested in MGMI activities.

Shri J P Goenka raised the point of returning award money to Mrs. Bhatnagar, as the awards are not being given out. In this connection, Secretary informed that a new proposal was sent to Mrs. Bhatnagar, but so far no response has been received. However, it was decided that these issues will be discussed in the next Council meeting.

Prof S P Banerjee desired MGMI to make an updated directory. Hony Secretary informed the house that latest directory, updated as on 31 August 2021 has been prepared by Shri Ranjit Datta, a senior member of MGMI and it has been posted in MGMI website, however it need further refinement. It was informed that further discussions on this could take place in Council Meeting.

House put on record the word of appreciation for the Outgoing Hony Secretary Shri Rajiw Lochan for his exemplary services to make MGMI more visible at global level and maintained all rich tradition of century old organization to a new height through his best efforts.

The meeting concluded at 11:45Hrs with Vote of Thanks by Hony Secretary (elect) Shri Ranajit Talapatra, who will be the Hony Secretary of MGMI for the tenure 2021-23.

- Though miles may lie between us, we are never apart; for friendship does not count miles, it's measured by the heart.
- It's your road and yours alone. Others may walk it with you, but no one can walk for you!
- Read, Think, Write and Send your thoughts to the Editor MGMI for sharing it with the member- readers through the News Journal.
- When people hurt you OVER AND OVER, think of them as SAND PAPER, they scratch and hurt you, but at the end you are POLISHED, and they are all used up.
- Dream is not what we see in sleep; it is the thing which does not let you sleep."

–APJ Abdul Kalam

News About Members

As on 01.07.2021

Shri S N Rana (10735-LM) MMGI is now at Narbheram Power and Steel Pvt Ltd, P O- Barbil, Dist- Keonjhar, Odisha Pin- 758035. M: 94375769 86/9777032663/9098861104.
email : 1969snrana@gmail.com

Shri Ashok Podder (LM 6374) MMGI is now GM(Excv), ECL, C2/S4, Durgapur Residency (Phase-III), J. K. Paul Lane, Benachity, Durgapur - 713 213, Dist. Pashchim Bardhaman, W.B.
Contact no. : 9434008530

Shri Anil Kumar Bharali (9323-LM) MMGI is now at BeltolaTinali, Lakhimipath, Seiji Path Bye lane, House number 09, Guwahati 781028 (Assam), Contact number 9433006095

Shri Briendra Kumar Sinha (8968-LM) MMGI is now at Block – K, H No -10, Kalikaji, New Delhi- 110019, email : bk.kiran53@rediffmail.com

Shri Sunil Kumar Sinha (9668-LM) MMGI is now at Flat No. E-7 / 8-D, Sail City, New Pundag, Ranchi - 834007
Contact no- +918329310329

Shri Sukhanjan Bose (10758-LM) MMGI is now at SRK Mining Services (India) Pvt. Ltd, DD – 30, 5th Floor, Andromeda Building, Sector 1, Salt Lake City, Kolkata – 700064, Tel: +91-82740 88317; / +91-33-4062-1003, Mobile:+91-98743-53537
email: sbose@srk.co.in

Shri Vikrant P Kawade, (10722-LM) MMGI is now at Quarter No. B-95, Bhalar Township, Bhalar, Taluka- Wani, Dist- Yavatmal, Maharashtra – 445304 (Bhalar)

Shri H.R. Kalihari, (5182-LM) MMGI is now at Bhoomi 237 Friends Colony Katol Road, Nagpur Contact No. 7620593865
email : kalihari56@gmail.com

Shri Ram Prakash Singh (10386-LM) MMGI is now at L/08/01, Celebrity Garden Sector-B, Sushant Gold City Lucknow-226 022
email-bharat2ram@yahoo.co.in

Dr. Subir Majumder (9474-LM) MMGI is now at 47/4, Shyamnagar Road PO – Dum Dum Park, Kolkata – 700055 Mobile : 9831718410/9433270270
email : dr.subir.majumder@gmail.com

Shri Shivaji Gupta (8655-LM) MMGI is now at Flat NO 10 EF, Manikarn, 3B, Ram Mohan Mullick Garden Lane, Kolkata 700010.

Prof Subrata Ghosh (8667-LM) MMGI is now at HB-216, 2nd Floor, Salt Lake, Sector – III, Kolkata – 700106. M: 9433271418,
email : sg1961@gmail.com

Shri Bhaskar Mandal (10621-LM**)** MMGI is now Chief Manager(Mining), Coal India Limited, Flat No D-6A, Rohini Housing Complex, P 225 CIT Scheme No VIIM, Block R, Ultadanga, Kolkata 700054, M: 9433031198,
email : bmandal.cil@coalindia.in

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As on 31.07.2021

Interview

Coal and Sustainability : Outlook for India

D. N. Prasad

For this issue of MGMI News, we discussed the challenges and opportunities for the Indian coal sector with Shri D.N. Prasad, Former Advisor (Projects), Ministry of Coal, who currently serves as Advisor (Mining) at SCCL. The interview was conducted by a team led by Associate Editor, Dr. Ajay Kumar Singh, and delved into policy, technical and societal issues pertaining to coal mining in India. He is a Graduate Mining Engineer from the University College of Engineering, Osmania University with University First rank, holder of First Class Mine Manager's Certificate of Competency to manage coal mines and MBA from UK and has put in about 32 years of overall experience in the Coal and Energy sectors of India. His experience includes eleven years of operation and management of coal mines in the Public Sector Coal Companies, Coal India Ltd. and Singareni Collieries Co. Ltd. and about 21 years in Development Policy Planning for Energy fuels Coal & Lignite in the Energy Division of the Planning Commission and Ministry of Coal, Government of India. He represented Planning Commission & Ministry of Coal on various Committees related to coal development and visited a number of countries including Australia, Japan, Germany, UK, USA, Belgium, France, China, Turkey etc. in relation to professional work. He has a distinguished leadership record, having served on the Board of Directors of CCL, CMPDI, ECL, NCL and SCCL.

Previous policy statements by the Ministry of Coal and Coal India Limited mention demand of 1.5-2.0 billion tonnes of coal by 2030-40. Do you think that has changed in recent years?

Obviously, yes. The basic reason is that, as per the commitment made by the Government of India under the Nationally Determined Contributions (NDCs), our target is to achieve 40% of the total installed capacity from renewable energy by 2030. However, today we have more than doubled our renewable energy capacity target from 175 GW to 450 GW by 2030. So, it is clear that the use of fossil fuels will be further reduced. Hence, the 1 billion tonne (coal production) target, which we were talking about in 2014-15, is becoming a question. However, India is a coal-based energy economy and coal being the fuel for baseload option, we cannot discount the role of coal for at least next three to four decades to come, say up to 2050 or so in view of the rapidly increasing demand for power. Rather, in my opinion, it is important to peak the production and use of coal before reaching the cap. Whatever renewable energy sources we are pumping into the system, it will only be supplementary to coal but cannot replace coal for the time-being.

The complete transition to renewables is not possible for some time to come and demand for coal would more or less hover around the current levels with slight increase, and around 35,000 to 40,000 MW coal-based capacity is still in the pipeline and our power stations are operating at below 50% PLF, sometimes 55%, sometimes 45% PLF. So, considering all these factors and looking at the system as a whole, we need to look at the way by which we can peak up the consumption and the supply of coal and meet the demand. Coal still has good relevance for near future and beyond and there is no doubt about it. Even with the improved efficiency factors, the supplementary role of renewables, nuclear etc., in the overall energy mix, would be significantly lower than coal.

In your opinion, what have the limitations been for India for effective coal exploration?

The basic thing has been policy issue. Coal was nationalized way back in the early 1970s and everything was kept under the public sector, but a few leases were continued in the private sector to companies like the Tatas. When the demand was rapidly increasing, the Government realized that the efforts of the public sector (Coal India and SCCL) need to be supplemented and in the early 1990s, they partially opened the sector limited to captive mining, which was a flaw at that time. I still remember, I entered the then Planning Commission in the early 1990s, where Late Shri Pranab Mukherjee was our Deputy Chairman. When the Ministry of Coal's proposal came for captive mining, he himself and Mr. V. Krishnamurthy, Member, Energy, both of them clearly pointed out why we should not open the sector for commercial mining when the demand was not being met through the public sector. They said that we must not go with a half-hearted approach.

The Government, which was in minority, were all along negotiating with the trade unions for introducing commercial mining, but for huge resistance from the unions, they were unable to go ahead with the commercial mining policy. Ultimately, it come through in 2018 or so. Therefore, the exploration of whatever coal was required for the production programme of Coal India or for SCCL, was being aimed at besides some Regional Exploration by GSI and Promotional Exploration by all government agencies including state agencies and coordinated by the nodal agency like CMPDIL. Had the sector been opened and exploration cum mining licences were allowed way back in 1990s, the situation would have been different by now.

Why is India's coal production largely coming from opencast mining and is it impeding the billion-tonne coal production target of India?

I have a personal opinion here. Coal mining, like any other business is associated with techno-economic feasibility and financial viability. Therefore earlier, the concept of share of underground vs opencast used to matter particularly at the time of Nationalisation when taken over mines comprised of huge number of underground mines in the eastern part of the country. But when the demand started growing up, the means to increase the production with the kind of deposits we have, was feasible only through opening large scale open cast mines. NTPC and Coal India, both were formed in 1975. The way the power demand was growing and big power stations were coming up at pit heads, to match their requirement, companies like Northern Coalfields Limited (Singrauli) and many other projects came up in different subsidiary companies of CIL & SCCL. To achieve rapid increase in production of coal and to meet ever increasing thermal coal demand, it was only feasible through taking up large scale open cast projects with economies of scale.

Secondly, the underground mines, from the time they were taken over, were becoming a big liability because of the huge manpower, low productivity, high cost of production and due to the very limited deposits with very few "economies of scale" operations. As a result, the public sector was really unable to address these issues or whatever social and political problems were there. And though they tried within their limits, they were not successful in mechanizing the mines to the extent required as those mines were not planned basically keeping mechanisation in view. They planned some longwall projects with inadequate studies and many mis-matches leading to many failures and ultimate foreclosure of the projects. Thus the coal production from underground mines suffered and never reached planned levels. Added to this the contribution from UG was miniscule compared to OC production discouraging efforts.

Do you see climate change constraints as becoming a limitation to Coal India Ltd. revenue at some point?

As I said earlier, though we have around three to four decades time to continue with use of coal, at the same time we should address the issues of climate change simultaneously for both coal mining and use of coal in different sectors, keeping global commitments in view. We have to continue doing our business addressing climate change issues locally.

The basic thing is that, because we changed the land profile, therefore, the land reclamation is most important as a responsible miner. And at the same time, we need to enhance afforestation of the areas which we degrade, we need to do conserve water, conservation of minerals, whatever is possible. Address issues being faced by the surrounding communities due to taking up of mining. The sustainable development goals (SDG's) have already been defined. SDG's matter a lot and going ahead, the business would not be as usual. They (companies) have to be very responsible and this is possible only from the top driven approach for which government directives are also there, but as a commercial operator, Coal India has to take some advance actions addressing these issues. Sensitizing/awareness about these issues and understanding the importance of the responsibility of how to mine is required right from top management to the worker level. Otherwise, we will not be in a position to meet the expectations of the society.

A number of actions have already been initiated voluntarily by the industry be it afforestation, land reclamation, water conservation, soil conservation, maintaining water bodies, reducing blasting operations and switching over to coal cutting, extraction of CMM/CBM, entering into coal gasification, etc., switching over to supercritical power stations for coal use for power, retiring old stations with sub critical technology etc. Therefore, I will not say that the climate change constraints are really going to adversely affect the coal production or Coal India's operation for the time being.

What could be the alternative revenue sources for coal mining companies?

One source of revenue may be the unconventional gas source, i.e., coalbed methane, but we have very limited deposits of coalbed methane. Second source of revenue may be the coal-based chemicals, i.e., ethanol, methanol etc. But what is their operation capacity? Each plant is hardly 1 million or 1.5 million tonnes, something like that and they consume hardly 4 to 5 million tonnes of coal per annum. How many such plants can we afford to build? These plants require huge capital investment of more than Rs. 7,000 to 8,000 crore per million tonne of production. Coal India definitely does not have such resources to entertain these types of plants. However, in the power generation sector, coal demand is usually in hundreds of million tonnes and there is huge scope for revenue generation. So, there is no comparison when you look at the hard fuel trading versus alternative ways of generating the revenue. Also, recently, as we are strip opening the seams in the opencast mines, there is another concept of converting over burden material into sand to conserve the environment and riverbeds and to use it (sand) as building material. There are some experiments which are going on in some small-scale units and operations have started at a few places.

To what extent is solar or other renewable power competitive with coal-based generation in your opinion?

If you look at the recent tariffs which are being offered, i.e., around Rs 2/kWh or Rs. 2.2/kWh for solar, they seem to be very low, but only the energy charges are comparable with thermal based power generation, and not the fixed costs. Unless storage facilities are developed true costs of RE are not comparable on apple-to-apple basis. If you look at the things in a comprehensive manner, there are so many issues and hence it is not fair to say to just switch over to renewables going by the recently discovered tariffs. For the kind of demand which we are going to face, we need to analyze whether it is really sustainable, and we also need to look at the implied economics of switching over to renewables. There is the storage issue to be resolved and we need to look at what would be its economic implications of and how does it compare with the actual baseload stations. As per my interaction with Chairman, NTPC, some time back, he was also of the view that we cannot shut down our coal stations just like that. We will have to depend on coal for quite some time to come. Amidst all the hype associated with renewables, especially with solar, in the long run, it remains to be seen how much will the cost of storage be so that we get reliable and continuous power. If you look at the national economy, we have created so much of infrastructure, so much of grid capacity, so much of employment, hence we cannot do away with coal just like that. While desiring for transition we should also address social impacts of such transition from coal to renewables.

There was an interesting paper by our previous economic advisor to Government of India, Mr. Subramaniam in one of TERI's annual conference (Darbari Seth Memorial Lecture). He has very clearly said we should not discard thermal based power generation for the sake of bringing in solar energy, we must take a very cautious approach. But, one thing which I feel that the government has taken a retrograde step in the policy regarding discarding the mandatory use of washed coal at power plants located beyond 500 km from source of supply of coal, which is clearly not a good decision. From all the earlier studies, it is clear that the use of washed coal has lots of advantages for the consumer from both economic and environmental aspects but the policymakers suddenly changed the decision and removed the mandatory use of washed coal.

Coming to the point regarding FGD's, I must say that use of FGD is a fancy thing for Indian coals. It is a thrust (obligation) on the part of industry. There is no real use of FGD, unless you have significant content of sulphur in coals. Generally sulphur is present in our coals in the pyritic form which can be taken out through coal washing. In our circumstances, control of emissions of Suspended Particulate Matter (SPM) is the most important thing to be taken note of rather than going for FGDs leading to huge costs and thus burden on consumer of power.

But, the most surprising thing is that after committing to NDC's, we have stopped the coal washing. It is a very big drawback and I sincerely feel that coal washing must be restored. When the burning (combustion) of coal improves in the boiler with reduced amount of ash content in coal feed, it would be the best solution to reduce emissions.

Recently, the Government of India opened up commercial coal mining to the private sector. Do you see a major impact on coal productivity and/ or sustainability – either positive or negative?

When you talk about productivity, I will say that it will have a positive impact. The private investors do not have luxury the way our public sector units are operating. For each rupee which they invest, they would definitely expect certain basic benchmarks in operational parameters. So therefore, they will be very cautious in producing coal with better efficiency and cost control than what we are seeing in the public sector. That will put pressure on the public sector to tighten their belts, in order to improve their productivity and reduce their cost of production and compete in the market. It is definitely a welcoming step.

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

I will first talk about some of the previous things which we have done. The most important thing where I will take full credit is when I was there in the ministry, is the policy regarding switching over from UHV to GCV based grading and trading of the thermal coals on par with best practices of the world coal markets. It took almost five to six years for me to run that file and convince my authorities to bring that and, ultimately, we were successful during Mr. Jaiswal's time. From 01-01-

2012, it was totally converted to GCV though, there was a hue and cry and total resistance from our power stations. The point is, consumer should know what he is paying for and producer should know what he is supplying. So, with this intention, the system of GCV was introduced, so that it is a measurable scale physically and it is not the empirical formula-based approach.

So, today, almost eight years since it was introduced, a lot of actions have been taken. Still, the industry needs to meet the expectations of the coal consumers, for which the government has to put a regulator in place. We must have an independent regulator to look into the aspects of coal quality, coal pricing etc., because today, pricing is not rational. So, as I understand, they are simply updating whatever indices are there as per old Bureau of Industrial Costs and Prices (BICP) formula and they are just trying to put whatever basic returns are required for the investment. I understand that Coal India has its own issues, it has a basket of mines, more than 410 of them, still there is a good scope to take care of the needs of the quality aspect and pricing rationalization and improving productivity. Hence, it requires a proper regulation from the government side on these aspects in the mutual interest of both producer and consumer.

Another aspect to consider is the distribution of coal. Still, they are following the guidelines proposed by the linkage committees. When a sector is opened, we must leave it to the concerned companies. Let them decide whom they want to supply and whom they don't want to supply. But the Government has a fear that if full autonomy is given, there may be a crisis, because companies would not look into the larger interests of the public and they may just concentrate on some pockets in the interests of their own revenue generation. The major player in this entire gamut is the railways. Nobody raises any questions about them. So, in between a producer and a consumer, there is a transport network, a triangular linkage is there, which must be properly addressed with complete responsibility on the part of railways. i.e., they (railways) must be answerable and held responsible for any mistake or error on their part. Unfortunately, today, the situation is not like that. For example, if I load a wagon, which is meant to be delivered to an 'X' consumer, it must reach the same consumer and not a different consumer. If I load a particular quality of coal, the same quality coal must be available at the consumer end. Today, there is a big fight between the consumer and the producer. Producer says, when I dispatch the coal, my responsibility gets over (as per the Free on board (Supply of Goods Act)). Railways, on the other hand do not take any onus of the proper movement or theft and other things. However, consumer(s) expect particular quality of coal to be delivered at their end.

Another aspect is about the labour laws. When you talk about labour laws, we are still following the same old labour laws. Today, when we are talking about bringing in commercial mining, it is not only the social overheads, there must be some responsibility on the part of trade unions as well. So, for that you must have the right of "Hire and Fire" system. You can take whatever perks and incentives are there, but it must be related to the productivity of the operations. It should not be the case that the outsource operation contractor would produce and I would enjoy the benefits as a permanent employee. This is a big drawback of the total system of operations of the public sector. On technology front along with the focus laid on surface coal gasification and CBM/CMM, they should also focus on underground coal gasification which is a more promising area from energy supply.

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

The quality of the coal is the most important aspect to be looked into. That is why I was stressing on the fact that washing of coal is the most important, whether it is for the consumer or the producer. Everyone must become quality conscious and we must conserve the precious resource of coal. Just because the resource is cheaply available (as it is not properly priced), doesn't mean that it must be misused/wasted.

If NTPC's consumption is 0.68 kg/kWh, why can't it be reduced further in the larger interest of the environment. In today's world, in addition to economics, environmental considerations are dominating everywhere. We have to care for the society, the nation and the world. So, every business unit must understand that if they are drawing a natural resource from somewhere, they must be responsible in using it properly.

Today, the government is not permitting any thermal units which have anything lesser than the supercritical technology. Similarly, if there are old units, already policies are there to do away with those old units. You can replace it only with the supercritical or ultra-supercritical units. Similarly, if some cement consumers are there, they should look for better technology for conversion of coal energy into their FGC's (functionally graded concrete). So is the case with sponge iron. So, wherever the utilization part is there, they must look into the best possible technology of conversion of the energy available in the coal, which is consumed by them. That is how you can address the issue of emissions.

The Government of Gujarat has said that they will not build any new coal plants. The state of Chhattisgarh has also said so. Do you think that at an all-India level, a stay should be encouraged, maybe beyond a certain level? Of course, replacement, which you are saying is absolutely justified because we need power also for the people. But, can we cap it, how much new, as a technology level, what type of technology and how much in capacity at a national level. Do you think it is feasible?

The nodal agency Central Electricity Authority (CEA) is responsible for assessing the demand at the national level and looking at the regional centres. CEA determines where to transfer the excess demand, where to meet the excess demand from, how better the grid connection can be improved etc. All these things are already studied and there are umpteen number of reports. So, if one particular region is, let us say in need of more power, as was the case with the eastern region earlier (it was a big sufferer). Today they are very much surplus in this. So is the case with the northern region. So, for the southern people if it needs to be brought, the network is yet to be completed, something like that, the Power Grid people will help in doing that.

So, at the national level, CEA has to tell the country, whether this station is required or not required. If it is not required, then how you are going to meet it. What is the source of supply? If that is not possible, then what is Plan B. If that is not there, what is the next plan and so on. These things are a very big exercise on its own and I feel there are solutions. Suppose if a 'X' state says that I don't want any coal station, then what is the alternative. In the next 10 to 15 years to come and in the horizon of 20 years, what is the demand going to be like from that state, and what are the sources available to them. If a particular source is not available, then where will they bring it from. There are so many exercises being performed and today's world has become very competitive for electricity markets and so many reforms are being contemplated. As a national agency, CEA is the best agency, under the aegis of Ministry of Power, to tell us what is relevant and what is not relevant.

What are some steps that could be followed for ensuring equitable lives for coal workers and their families?

The coal mine worker is the highest paid worker when compared to other industries. Economically if you look at the income levels per head, a regular worker draws not less than INR 50,000 to 60,000 per month as compared to a daily wage worker who on an average, gets around INR 15,000 to 20,000 per month. So, this type of economic disparity is there in the wage structure for the coal mine workers. This needs correction. When compared to the earlier days of nationalization, today, people are more educated, and awareness is also more due to influence of media. They are able to plan and take good decisions about their wards education, career etc. An extending hand from the organisations they are serving would bring more focus on the matters and would help their families to improve their standard of living and lead a better life. Due to increasing awareness it is also paving way in understanding gender issues and creating equal opportunities to girls in families. Added to this a number of social development programmes by the individual states is also helping people in availing opportunities in various spectrums of society.

When you talk about the labour laws, there are very strong trade unions, for example: the Coal Union in India is kind of strong. So, when you are talking about this "hire and fire", would it be a very complex issue, to put forward as such?

When you start thinking about something which is going to be a strict law, there will definitely be resistance from the people concerned. For eg: look at the disinvestment policy of the Government of India. It was subject to so much resentment from the people working in different sectors. But every sector is now subject to disinvestment. In many companies you can see that decisions are being made just overnight. Therefore, only time will tell us what is appropriate for a particular sector or for a particular industry. This type of trade unionism is no more a valid factor. As long as you are addressing the rights of the workers, nobody will question you. Unless I perform, how can I expect the employer to keep quiet, without taking any action against me? Things are changing and they have to understand that it is not going to be the same as what it used to be at the time of nationalization of the industry.

On the other hand, you have already opened the sector to commercial mining and within no time there will be huge competition. Once the private sector starts production as part of the commercial mining and if it reaches upto say 100-200 million tonnes, then the total market will be shaken up for the public sector. So therefore, it goes without saying that they have to tighten their belts from now onwards to look at where they're going to be from where they are now. So, this threat of survival will make them understand and these laws have to be there to make them perform better and to make them understand, otherwise business, as a commercial unit, cannot survive in these changing times.

You had authored one of the articles with Mr. Sutirtha Bhattacharya on coalbed methane. So, what do you think will be the trajectory of the coalbed methane industry in India?

When we started way back in 1997, there was a big expectation because the petroleum ministry was taking a lead through DGH (Directorate General of Hydrocarbons). Four to Five rounds of bidding were carried out and some 33-34 blocks were offered both through auction and also through nomination to public and private companies. As it was a technical subject, highly skilled people were required for understanding the gas behaviour in coal, where it all starts from the exploration, assessment of the availability of the gas in place, then the flow of the gas and how to capture it. Though these things appear to be common, they are highly technology oriented. As a result, some of the areas which these people have taken, they surveyed. But they did not follow the proper protocols and they did not follow the standard international lab tests. Even the lab set up and infrastructure were not up to the mark. And then they declared that there is no potential in those areas, which is a typical situation to really compromise upon. They then went to well-known places like Raniganj and Jharia and they had good success there. Reliance and Essar, these companies got some good deposits in Madhya Pradesh.

So, what made them to be successful and what made others to be not successful is a question of technology and understanding of the behaviour of the geology of the seams, geology of the strata and also their way of approach for exploration and assessment of gas. These things matter a lot and it is difficult for the common man to understand the potential gaps. Just because the gas is oozing out from the seams in these underground mines in the Raniganj area and the Jharia area, we say that there is more potential in these areas but technically speaking, gas is available with all coals. Only thing is how efficiently you can tap that gas is the question to be addressed.

Our article highlights the policy support of the government and shortcomings in the approach by the block allocates and how to improve the situation to harness the CBM resource in the country as we have already lost precious time since it was initiated.

As you said very correctly that for 30 years from now, India will remain with coal in some form and it is not possible to replace coal very quickly. But suppose we have to move away from coal earlier because of global pressure or something, how do you think we can have a practical just transition for India? We call it just transition, because the transition should be justified and it should be a soft landing for everyone including the companies, including the users of coal, including the transporters of coal, including the workers of course.

Complete Transition to RE is a long drawn process for the reasons we have already discussed earlier. However RE cannot replace base load stations of coal. Cost of solar coupled with battery storage is not clear to consider it to be competitive.

Take the example of a plant with a 1000 MW installed capacity, which produces around 8 million units per annum at 80% PLF. How much area will be required to replicate a similar generation facility using a solar panel or using a wind farm. I understand some four acres of land is required per MW of solar plant as against some 0.3-0.5 acres per MW in case of coal thermal plant leading to a big issue of land unless you move to desert areas on the western region. Once battery storage starts it also requires huge chunks of land adding to already constrained resource. Further there are issues once the panel life is over, after 15-20 years, how to dispose of the panels and what will be the negative impacts on the environment and the public.

Overall demand as well as peak demand for power is growing. Last year we generated 6 billion units of electricity from solar energy out of a total of 13 billion units from renewable energy sources, whereas generation from non-renewable energy sources was 1234 billion units. Where is the comparison? One has to understand where an energy source needs to be replaced and where it is not to be considered for replacement. An immediate transition across the board may not be feasible unless power grid is developed connecting all corners of the country.

Perspective Piece

A Pathway to Reducing Emissions from Coal Power in India

Debo Adams[1], Toby Lockwood[1], Paul Baruya[1], Malgorzata Wiatros-Motyka[1], Qian Zhu[1]

This study, commissioned by the International Energy Agency's Coal Industry Advisory Board, offers a pathway to reduce emissions from India's coal fired power generation industry. It will help India deliver on its climate change commitments, improve air quality and enhance electricity reliability and access. In completing the study, the International Centre for Sustainable Carbon, ICSC (formerly the IEA Clean Coal Centre) worked with key Indian stakeholders both in government and in the power sector.

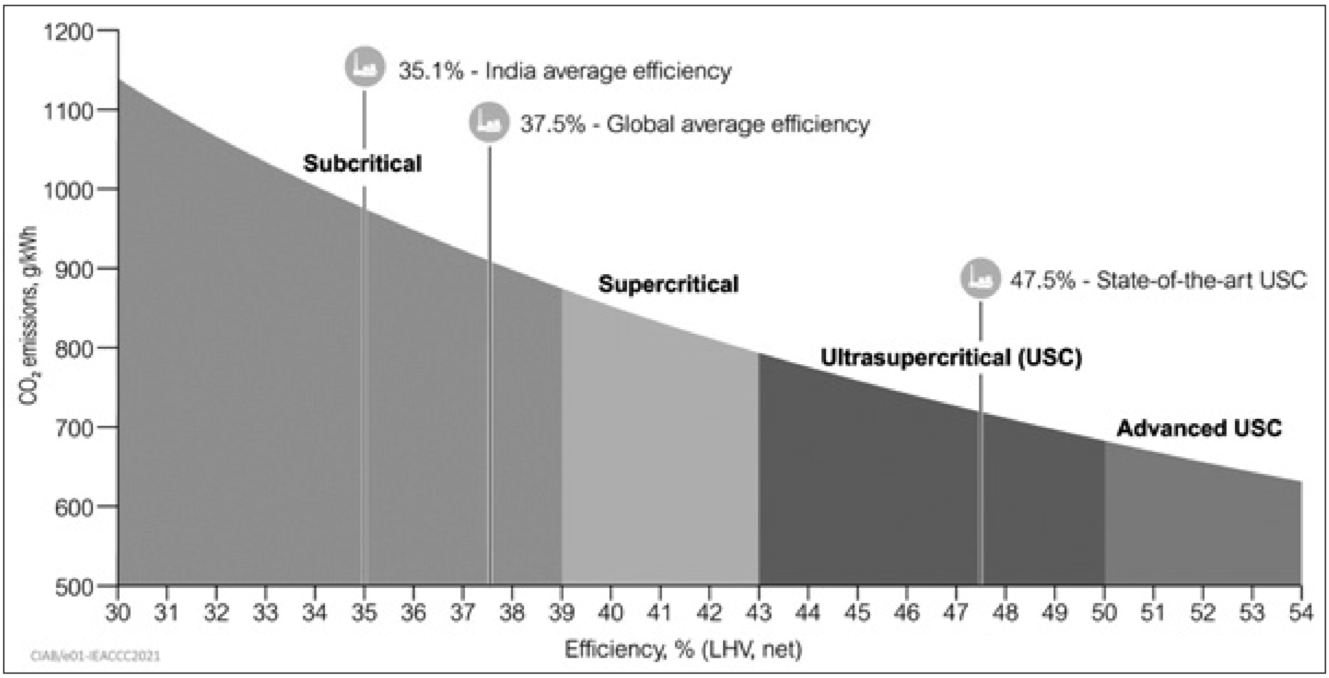


Figure 1. CO_2 reductions achievable with increasing coal plant efficiency (ICSC, 2020)

Indian economy relies on coal

India is a vast country of 1.37 billion people which has undergone rapid economic growth over the last 20 years to become the world's fifth largest economy. This growth has been inextricably linked with a successful drive to increase the availability of electricity, with total power generation increasing by 40% over the last decade. Owing to the country's enormous coal reserves and limited oil and gas, coal fired power has remained dominant over this period, even slightly increasing its share of total generation to 72% (1135 TWh) in 2019.

India is a success story in many respects. Rapid power plant deployment in recent years has meant that there is abundant generating capacity. Electricity access for all is mostly successful. Despite this remarkable rise, Indians still experience a per capita energy consumption of

1 International Centre for Sustainable Carbon (ICSC), 27 Old Gloucester Street, London, WC1N 3AX, UK This article is based on the report *A pathway to reducing emissions from coal power in India*. It was published in January 2021 and is available from www.sustainable-carbon.org.

only around 10% that of highincome countries, and further growth in standards of living and associated energy demand is therefore urgently needed. While the Government of India has ambitious plans to meet much of the expected growth with wind and solar power capacity – up to 400 GW in 2030 – coal will continue to play a fundamental role in providing India with dispatchable power and energy security for the next 20 years and beyond.

Reducing carbon emissions with a flexible, efficient fleet

However, the Indian coal fleet emitted 1.1 $GtCO_2$ in 2019 and contributes to poor air quality in some regions, due to emissions of SO_2, nitrogen oxides (NOx) and particulate matter, with associated impacts on health, ecology and economy. Coal quality varies substantially across India. A key challenge is the impact of burning high ash content (25–50%), indigenous coal on plant performance and emissions management.

Increasing coal-fired power plant efficiency reduces emissions of CO_2 per MWh generated. In India the average unit efficiency is 35% compared to state-of-the-art efficiency of 47.5%. There is therefore significant potential to reduce CO_2 emissions from India's coal fleet through a combination of retiring or upgrading older units and building new efficient ones. There are various incentive schemes to promote upgrading of subcritical plants covering improved operation and maintenance (O&M) practices, instrumentation and control upgrades as well as more substantial turbine and boiler upgrades/retrofits. For example, the upgrading of some small units (<200 MWe) has resulted in savings of over 100 kt/y coal and 165–190 kt/y of CO_2 emissions at each unit with a return on investment of less than 2 years.

Coal-fired power plant capacity has more than quadrupled to over 205 GW (utility) in 20 years with a further 33 GW under construction. The first supercritical (SC) unit came online in 2010 and since then a further 52 GW of SC capacity has been added. The first ultrasupercritical (USC) plant was commissioned in 2019. By 2023 India is expected to have 250 GW of utility coal-fired generating capacity in operation, almost a third of which will be SC or USC. The hope is that this impressive performance of improving efficiency will be continued. However, new capacity additions have outpaced demand for electricity, so utilisation factors have fallen from approximately 70% in 2010 to 56% in 2019. Utilisation is likely

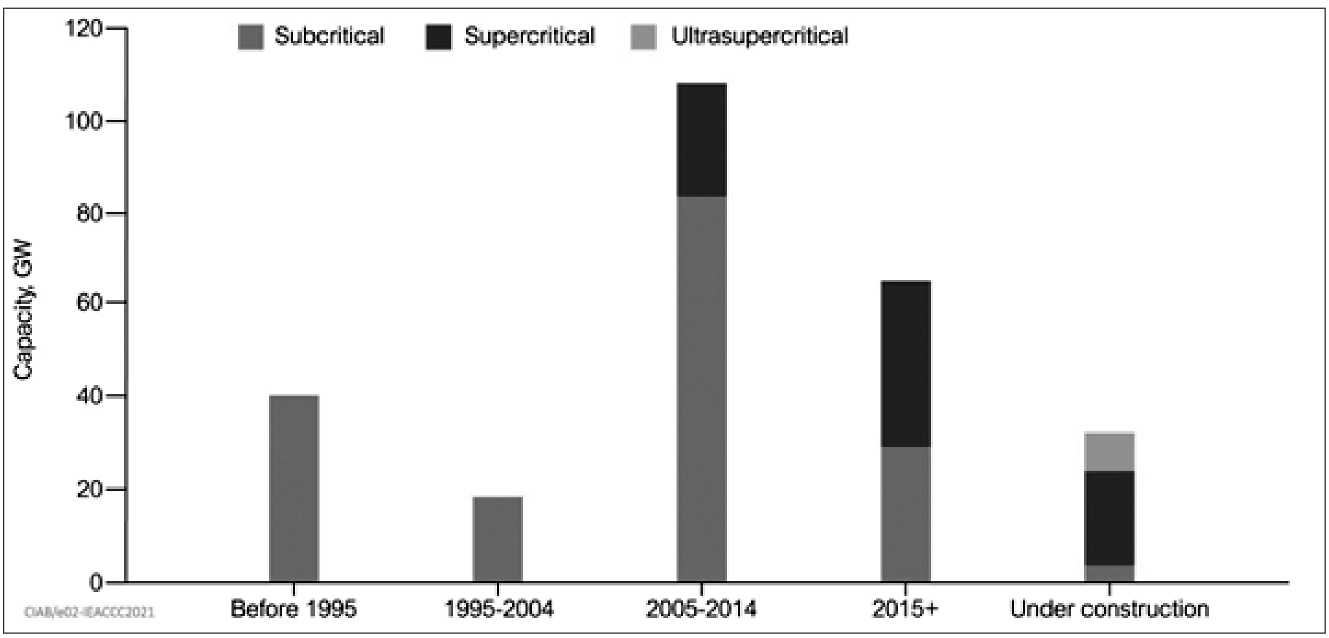


Figure 2. Composition of India's coal fleet by age and technology type (S&P Global, 2020)

to recover in the next few years.

The transition to higher efficiency technologies has already made good progress. However, further reductions in emissions could be achieved through changes to dispatch mechanisms and implementation of supporting policies such as:

- Continuing the transition towards economic-based merit-order dispatch to provide market incentives for more efficient, flexible units;
- Introducing efficiency standards to ensure all new units are supercritical as a minimum and ultrasupercritical from 2025;
- Easing the regulatory process for retirement of inefficient units and replacement with new ones;
- Encouraging greater use of digital tools to facilitate optimal operation, efficiency and flexibility; and
- Supporting technical capacity building and international knowledge sharing in the manufacture and operation of high-efficiency, flexible units.

Based on experience in Europe and other regions, the ability to operate in a flexible manner will be key if coal power plants are to remain competitive in a market with a greater proportion of renewables. More emphasis will need to be placed on planning and readiness for likely changes in the market and operational environment.

Emissions controls and air quality

The introduction of more stringent emission standards 'norms' for coal power in 2015 was a significant step in mitigating air pollutants including SO_2, NOx, and particulates. However, progress in meeting these standards through the widespread deployment of flue gas desulphurisation and NOx control technologies has been slow, with the deadline extended to 2022 and some NOx limits relaxed. Significant NOx reductions are achievable

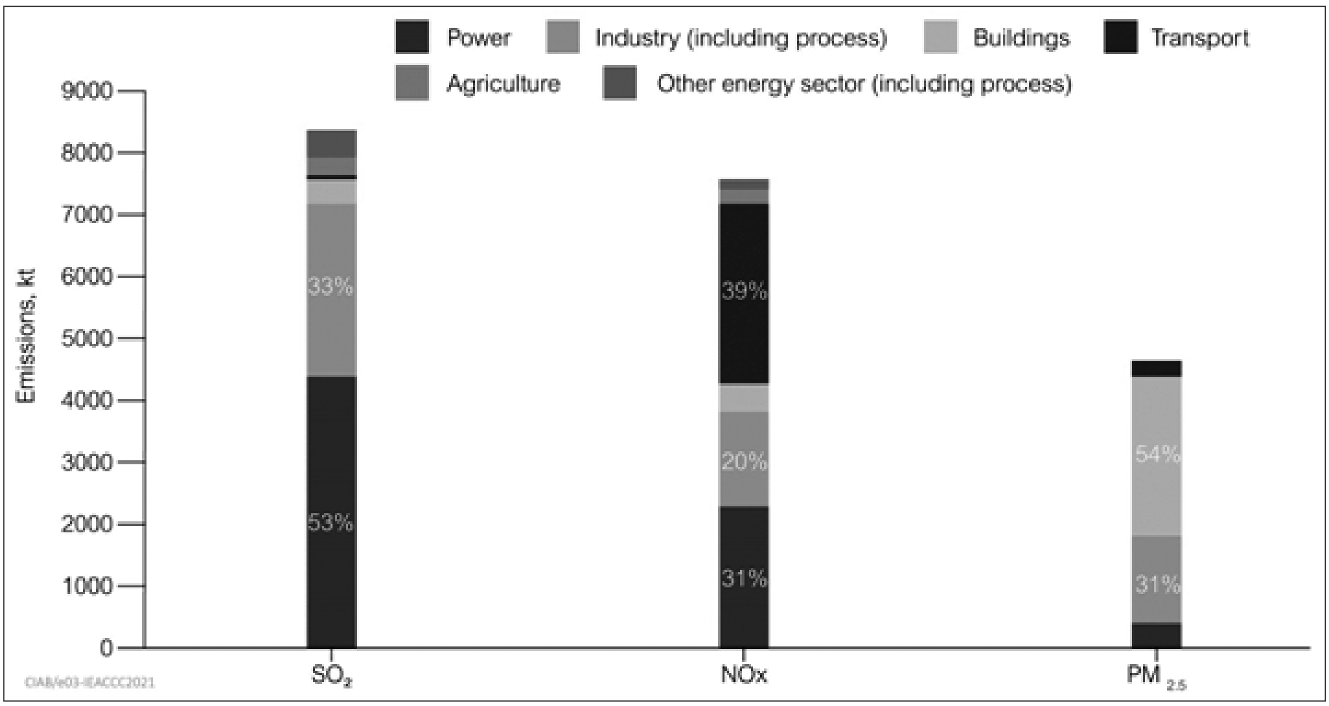


Figure 3. India's SOx, NOx, and PM2.5 emissions by source, 2018 (IEA, 2019a)

in most Indian coal plants simply through the effective combination of combustion optimisation and appropriate primary control measures. More costly secondary measures will be needed to achieve the stricter NOx limits for newer plants, but these technologies can be successfully applied even to the relatively high-ash environments associated with firing Indian coals. Rather than seeking to delay implementation of the existing norms, the sector should work to anticipate the globally observed trend of progressively tightening standards. The recommendations include:

- Significant NOx reduction (around 10%) and efficiency gains (up to 2 percentage points) can be achieved through optimisation and accurate monitoring of combustion parameters; In combination with optimised combustion, primary NOx controls such as separated overfire air and low NOx burners can be used effectively to reach 300 mg/m^3;
- Selective catalytic reduction (SCR) can be adapted to the high-ash conditions associated with firing Indian coal, and should be further explored through full-scale trials, including 'cold-side' operation;
- Strong incentives to meet the emission standards, such as placing compliant plants higher in the merit order or imposing stronger penalties on those which do not take action;
- Emission standards should be met on a rolling average basis, helping to make lower emission standards (such as 300 mg/m^3 for NOx) practically achievable with primary measures alone;
- Reconsider the relaxation of the NOx standard to 450 mg/m^3 for plants built 2004 to 2017;
- Consider tightening the standard for plants commissioned before 2004 to 450 mg/m^3, which should be easily achieved through primary controls; and
- The limit of 100 mg/m^3 for plants built after January 2017 should be upheld, and achieved with a combination of advanced primary measures, appropriate operating and maintenance practice, and secondary controls.

CO_2 capture utilisation and storage (CCUS)

As the only means of imposing deep cuts on fossil fuel CO_2 emissions, CCUS is experiencing a resurgence in global interest and should represent the ultimate goal for India's coal fleet. Although India continues to actively support research in CO_2 capture and utilisation, energy shortages and perceptions of high costs and unpromising geological storage capacity have deterred political backing for large-scale deployment. However, recent rapid growth in coal power capacity and more ambitious climate targets present a more favourable environment for CCUS.

Recent studies estimate that the country has the potential to store at least 100 $GtCO_2$ (90 years of current coal emissions), even without considering emerging opportunities in basalt and deep coal seams. However, the true potential will only be clear once more targeted characterisation has been carried out. This study has mapped India's coal plants against geological resources as a means of highlighting the most suitable storage locations and plant clusters for near-term development.

India can take a number of preliminary steps to drive early demonstration of CCUS and attain a state of readiness for greater deployment from 2030 onwards:

- A more detailed assessment of geological storage potential is urgently needed, including characterisation of promising saline aquifers in coal-producing regions;
- Priority dispatch for CCUS-equipped coal plant, together with tariff pass-through of additional coal costs, could act as an incentive for early projects;
- Enhanced oil recovery and CO_2 conversion technologies can also play a role in kickstarting firstmover projects, supported by incentives for domestic, low-carbon products;
- New coal plants in India should be 'capture-ready', including a storage assessment;
- The Methanol Economy is an opportunity to develop CCUS clusters associated with gasification clusters, incorporating production of high-value products and power;
- Government should coordinate an integrated,

cross-sectoral technology demonstration strategy among relevant public sector undertakings; and

- CCUS should be explicitly included in India's international climate commitments.

Initial financing of CCUS deployment will likely require international investment, international support, including through multi-lateral development banks, and policy incentives. Other incentives such as tax credits may be needed to further support CCUS deployment and wide-spread power system decarbonisation.

Coal power to 2040

The future of coal-fired power generation is fundamentally determined by the overall rise in electricity demand and the penetration of non-coal power sources into the market. Thus, the share of the market taken by coal is likely to diminish but remain significant. In this study, analysis of coal power to 2040 in India is based on two pathways – one higher growth based on the NITI Aayog Draft Energy Policy (2017) and the other based on the lower rate of growth of the Stated Energy Policies (STEPS) scenario of the IEA (2020). Both scenarios show the CO_2 emissions that can be avoided if coal-fired units are retired after 25 years and replaced with HELE technologies. They also include the addition of CCS to 26 GW of coalfired capacity.

Higher growth

In the higher growth scenario, the replacement of 25 year old subcritical units with a range of HELE technologies decouples the rate of CO_2 emissions growth from that of coal-fired capacity. The addition of CCS from 2030 onwards to around 10% of the fleet reduces emissions further. The results indicate that HELE plants with the addition of CCS on 26 GW of coal-fired capacity could avoid up to 4300 $MtCO_2$ between 2021 and 2040, equivalent to roughly 215 $MtCO_2$/y.

Lower growth

In the lower growth scenario, based on IEA 2020 STEPS power plants still retire after 25 years, and

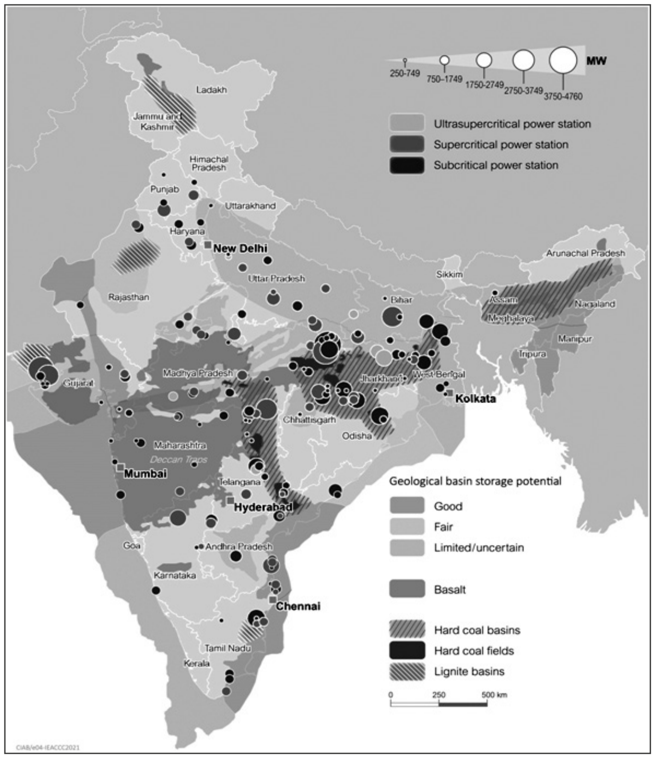


Figure 4. Locations of India's major coal plants with respect to CO_2 storage options

there is a greater decline in the need for coal-fired power. The subcritical fleet decreases to 23 GW by 2040, and the need for additional coal capacity is lower. The aggressive replacement of older plants with HELE ones, as recommended in the study, leads to a total decrease in CO_2 emissions from approximately 1104 $MtCO_2$/y in 2019 to 1023 Mt/y in 2040 with HELE plant only and 905 Mt/y in 2040 with CCS on 26 GW. More rapid deployment of HELE technologies in this scenario leads to a

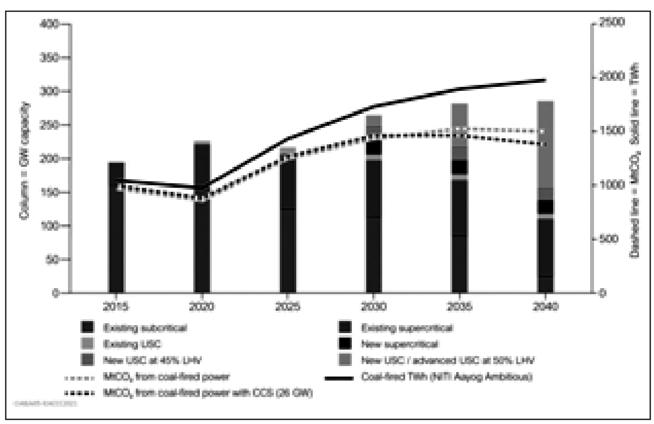
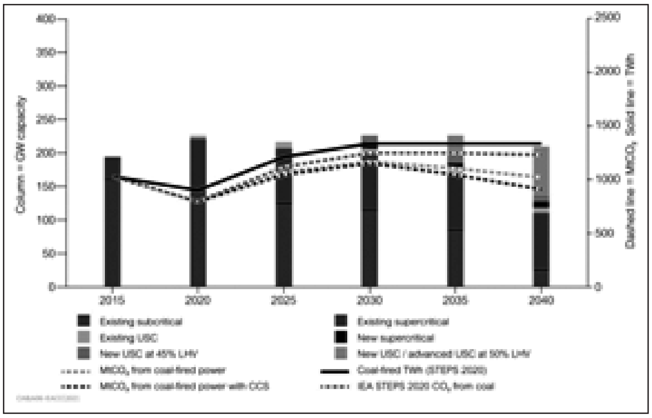


Figure 5. ICSC projections based on NITI Aayog Ambitious Scenario

27% lower emissions intensity for the sector in 2040, compared with the STEPS 2020.

Figure 6. The ICSC HELE projections applied to the



IEA 2020 STEPS outlook for power generation

KEY MESSAGES

This study offers a pathway to reduced emissions and improved air quality, while still using affordable and reliable coal power in a growing economy. Plant efficiency can be improved with some measures being inexpensive. Emissions standards can be met in many instances without costly measures and payback of only a few years. The resulting improvements will have health, environmental and economic benefits. Market reforms to finance to incentivise adoption of new, proven technologies will be required to achieve the desired improvements. Deploying HELE coal can help support government objectives, from improving air quality to operational flexibility in a market with increasing renewables penetration. Specific recommendations include:

- Increased emphasis on ultrasupercritical technology or better by 2040, with remaining subcritical units confined to minimal operating hours;
- Further focus on compliance with 2015 emissions standards using available technologies;
- CCUS – the groundwork such as storage assessment and regulatory development must be laid now if it is to remain an option;
- The power market should aim to value all aspects of energy provision, including availability, flexibility, and grid reliability and resilience;
- International support in the form of both investment and expertise should be further encouraged; and
- Nurture India’s capacity as a global centre of engineering excellence in HELE and CCUS technologies.

There is a real risk that prevailing perceptions of coal as an outmoded energy source, combined with financial challenges, will stifle efforts to transition to cleaner forms of coal power and slow the promising progress made in transforming India’s coal fleet. Recognising that coal power will remain fundamental to the country’s pursuit of UN Sustainable Development Goals, including affordable and clean energy (SDG7), decent work and economic growth (SDG8), and industry, innovation, and infrastructure (SDG9), maximising the use of HELE coal technologies and CCUS must be seen as key to India’s actions on both public health (SDG3) and climate change (SDG13).

Technical Note

Role of Geological Carbon-Dioxide Sequestration in India's Efforts Towards Net Zero Emissions

Yashvardhan Verma[1,2], Vikram Vishal[2]

Introduction

Anthropogenic carbon dioxide levels in the atmosphere have been rising continuously at an alarming rate for the last few decades. We have already seen a more than 1°C increase in the global average temperature since the industrial age started more than a century back. The severity of climate change was recognized on the global level when the 2015 Paris climate agreement was signed by 191+ state parties (United Nations Climate Change, 2015), wherein they mutually decided on an aim to keep the global temperature rise to 2°C above pre-industrial levels, and endeavor to keep it below 1.5°C (Rogelj et al., 2016). These goals are a result of deliberations of international committees over several decades, and signify an agreement that ensuring the temperature rise remains below 2°C would avoid a climate disaster while allowing sustainable development (Randalls, 2010). In order to track the performance of involved parties and quantify the intended goals of Paris Climate Agreement, Intergovernmental Panel on Climate Change (Metz et al., 2005) introduced a carbon budget of 2.9 trillion metric tons that puts an upper bound on the total amount of carbon dioxide emissions (Stocker et al., 2013).

India is at the cusp of major leapfrog of its economy. 7% economic growth has become a norm now and it only needs to grow further. The economy is poised to grow from the current size of 2.8 trillion to 5 trillion in the next 5 years and 10 trillion in 8 years after that. India is also a responsible global citizen and has vowed to ensure that India's per capita CO_2 emission will not be more than that of the developed world. At the same time, India has also signed the Paris agreement and committed itself to reducing the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level. While these are admirable goals, one must understand that the economic growth will have to be supported by use of more natural resources. This will require deep decarbonization and it cannot be obtained without the extensive implementation of Carbon Capture and Storage (CCS) (Vishal et al., 2021a). According to the International Energy Agency, CCS is the most effective and important negative emissions technology for CO_2 savings. The Intergovernmental Panel on Climate Change (IPCC) estimates that the costs of halting global warming would double without involving CCS (Metz et al., 2005). According to the Fifth Assessment Report (AR5) that was published by Working Group III of the IPCC (Jewell et al., 2016), India needs to drastically cut down its CO_2 emissions from all sectors through CCS to even approach the restricting of CO_2 concentration in the atmosphere to less than 450 ppm (Figure 1). Immediate opportunities lie in enhanced oil recovery (EOR), enhanced gas recovery (EGR) and enhanced coalbed methane recovery (ECBM). However, none of these is exploited fully.

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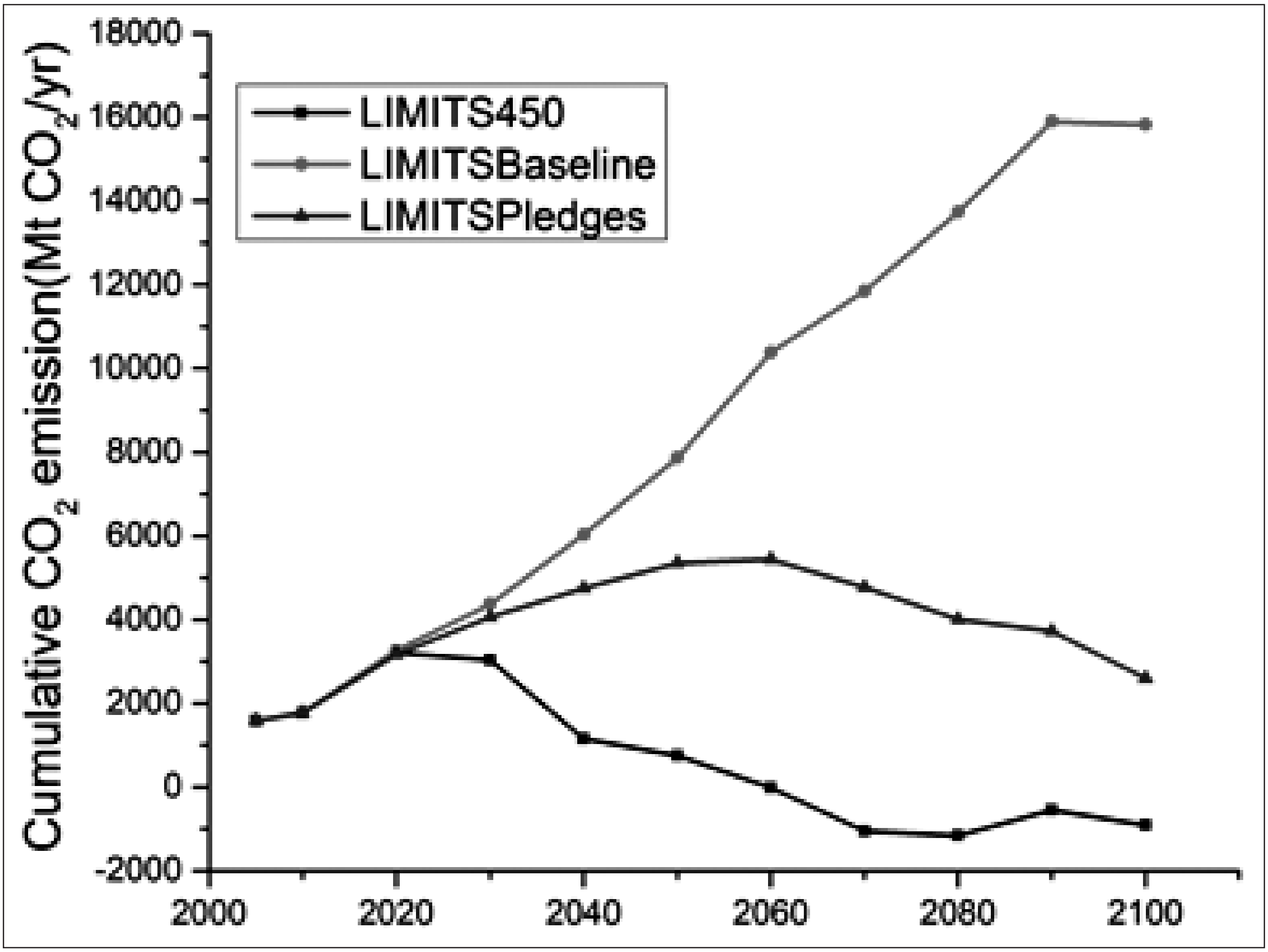

Figure 1 : Cumulative CO_2 emission from various sources in India. Real data till 2020, followed by tentative emission metrics to achieve different milestones. LIMITS 450 shows the most ambitious emission goals to restrict the global CO_2 concentration towithin 450 ppm. The baseline shows the BAU scenario, whereas Pledges indicates the implementation of moderate climate policies (Vishal et al., 2021b).

Geological CO_2 storage

Carbon dioxide storage essentially involves injecting CO_2 at high pressures inside the Earth where suitable geological conditions exist for it to remain there for possibly hundreds or thousands of years. The CO_2 is compressed before injecting such that it forms a supercritical fluid. CO_2 is a gas at atmospheric conditions, but when it encounters pressure above 7.38 MPa, and temperature beyond 31.1°C, also known as its critical point, it becomes a supercritical fluid (Doughty and Pruess, 2004). It then displays characteristics of both liquids and gases and becomes conducive for storage in the subsurface. Its density becomes comparable to that of liquids allowing more CO_2 to be stored in the limited pore spaces of the rocks, while its viscosity remains similar to that of gases, permitting it to flow easily through liquids (Metz et al., 2005).

Typical reservoirs usually lie at depths greater than one km, are ten to five hundred meters in thickness, and can stretch several hundred kilometers laterally (Szulczewski, 2013). These reservoir depths allow the injected CO_2 to remain in a supercritical state. In this state, it is lighter (~700 kg/m3) than brine, oil, or other fluids that might be present in situ, which push it to the top of the reservoir because of buoyancy forces. Most reservoirs consist of cemented sediments overlain by a low-permeability layer known as seal or caprock. The CO_2 stops rising until it encounters the caprock, which helps in trapping it underground. This mechanism of storage is known as structural or stratigraphic trapping, and is the dominant storage mechanism in the initial stage of injection (IEAGHG, 2009). Another form of trapping is residual gas trapping, where CO_2 gets trapped in the pores of the rocks through surface tension. The injected CO_2 also dissolves in the already present fluids which increases their density and helps keep the CO_2 down, also called hydrodynamic trapping or dissolution trapping. In mineral trapping, CO_2 reacts with minerals present in the rocks to form carbonates. The conversion of CO_2 into solid carbonates ensures almost its permanent storage in the rocks (De Silva and Ranjith, 2012). These processes do not occur in isolation, and usually more than a couple are acting in unison to strengthen the storage security for long periods of time. Retention rates of greater than 99% over 100 years have been kept as goals for CO_2 storage projects (Bruno et al., 2014).

Storage in saline aquifers

Deep saline aquifers represent large storage potential for carbon dioxide. Kearns et al. (2017) estimate the global capacity at approximately between 8000 Gt and 55000 Gt. Saline formations usually run quite deep, are unused, and contain non-potable water reserves; therefore, they are perfect for storing CO_2 safely without affecting near-surface groundwater. The biggest limitation in the utilization of such saline formations is the lack of in-depth geological understanding about them because they hold no economic value for exploitation and are largely unexplored territories. Fortunately, due to their similarity with oil and gas fields, the technology used for exploring and exploiting hydrocarbon resources can be easily adapted for such formations (Shukla et al., 2010). However, a lot of resources still need to be devoted to the accurate mapping of the storage capacities that are present in these reservoirs.

CO_2 enhanced oil recovery

Conventional oil and gas reservoirs are only able to recover generally not more than about 40% of their estimated capacity (Bachu et al., 2004; Godec et al., 2011a). Due to continued production, these fields eventually reach their life's end when the pore pressure decreases to the extent that the primary drive is no longer able to exert enough force to push the oil to the surface. Fluids, usually water, are introduced through injection wells to increase the pore pressures and revitalize the field to drive the oil to the surface through the production wells, also known as secondary recovery. To further enhance production, tertiary recovery through injection of CO_2 is used (Figure 2). At supercritical conditions at which CO_2 is injected, it has high miscibility with oil and lowers the viscosity making it easier for the fluid to flow through the rocks (Hornafius and Hornafius, 2015). More than half of the CO_2 is sequestered in the process (Gozalpour et al., 2005; IEA, 2015), making it a highly lucrative way for petroleum companies to increase their production and offset their carbon footprint. Currently, carbon storage in depleted oil and gas fields provides the most cost-effective way to store CO_2 and is already implemented on a large scale in fields like the Weyburn in Canada (Cavanagh and Ringrose, 2014; Brown et al., 2017), SACROC and Cranfield in USA (Hannis et al., 2017).

Enhanced coal bed methane recovery

Coal contains dual porosity system which include the micropores where the gases are stored while the macropores which are the conduits for transport of methane. Coal gas methane stays adsorbed onto the surface of the coal. However, coal has a higher affinity for CO_2 than methane. As a result, injection of CO_2 into the deep unmineable coal beds replaces and releases the methane which can be exploited as a potential source of energy. The methane produced from the coal seams compensates the cost of adding CO_2 into the reservoir and simultaneously acts as a viable pathway for carbon storage. Challenges in CO_2 storage in coal includes the loss in injectivity due to swelling in the matrix due to coal-CO_2 interaction, changes in fluid phases, strength weakening in coal, etc. (Vishal, 2017a, 2017b). Prospectivity of CO_2 storage in coalfields of Raniganj and Jharia have been estimated in earlier studies and they are promising for consideration in India (Vishal et al., 2013, 2018).

Storage in basalts

Currently, most of the carbon sequestration projects worldwide involve the injection of CO_2 into large sedimentary basins. The primary trapping mechanism for CO_2 in such formations is structural and residual gas trapping. However, mineral trapping, which involves the conversion of carbon dioxide into carbonate minerals, ensures a much more permanent form of storage. However, it happens at a slow rate, and the kinetics of mineralization are debated (Zhang and DePaolo, 2017; Kelemen et al., 2019). To use the mineral trapping mechanism more effectively, CO_2 injection has been experimented with in basalt formations, and recent research in basalt sequestration shows some promise (Matter et al., 2016). The primary advantage of basalts over sedimentary rocks is that they are much more reactive and reduce the time that is required for injected CO_2 to convert into carbonates (Snæbjörnsdóttir et al., 2020).

CO_2 hydrates

Density of liquid CO_2 is higher than sea water. As such CO_2 can be injected into deep oceans where they form a pool and stay low. Under the conditions existing at such large depths, CO_2 gets converted into gas/clathrate hydrates which are even heavier and sink into the sea bottom. Clathrates are basically composed of cage-like structures formed by water molecules enclosing a foreign molecular species like CO_2. They are relatively stable at typical seabed depth pressures and temperatures (Tohidi et al., 2010). Although due to low concentrations of CO_2 away from the injection site, the stability of the hydrate reduces when CO_2 spreads farther. Thus, it is not considered as a long-term storage option (IEAGHG, 2004).

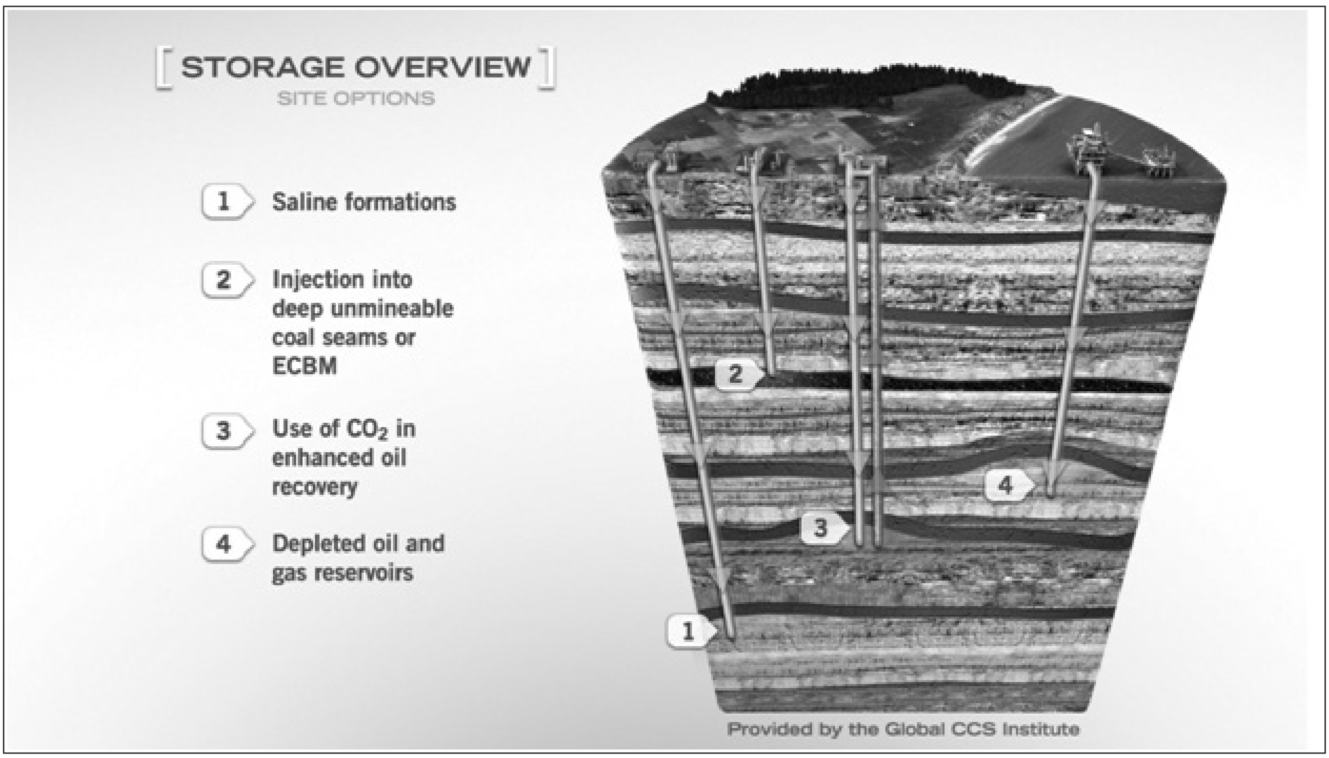

Figure 2 Schematic showing miscible CO_2-EOR process (Source: Global CCS Institute)

CO_2 storage capacity

Estimating CO_2 storage capacity has always been a complicated process. There have been many attempts throughout the years at quantifying the global CO_2 storage potential but all entail a large amount of uncertainty (Zhou et al., 2008; Godec et al., 2011b; Dooley, 2013; Consoli and Wildgust, 2017). The capacity estimations vary from 100s to 100,000s of Gigatons of CO_2 worldwide (Bradshaw et al., 2007). The theoretical capacity is then trimmed by applying technical limitations and accurate site data to obtain realistic capacities. The realistic capacities are still toned down by subjecting them to economic and practical restrictions to acquire the viable capacity (De Silva and Ranjith, 2012). The underlying approach to capacity storage estimation involves knowledge of the storage mechanisms, the type of sedimentary formation, the depths at which it occurs, and the temperature and pressure associated with the depth to calculate the theoretical pore space available for fluids. The tricky part is to apply the knowledge to a specific region because of the variety of unknown factors involved, like different trapping mechanisms and their periods of operation, assumptions made and lack of accurate subsurface data. This leads to decreased confidence and often result in conflicting capacity estimates.

With fast-changing statistics in the energy sector due to continuous resource exploration and discoveries, a current and comprehensive assessment of the cumulative storage capacity of CO_2 in India is of utmost importance. It is also corroborated by the India Energy Outlook 2021 (IEA, 2021), which highlights that "India's CO_2 storage potential has not yet been properly mapped. Given the important role likely to be played by CCUS in a variety of sectors in India, if CO_2 can be securely stored, there is a strong case for defining the potential and understanding how its geographic distribution might influence future investments in industry and power."

Recently, Vishal et al. (2021b) have provided the most comprehensive assessment of CO_2 storage capacity in India yet. The storage potential is divided into storage in saline aquifers (291 Gt), basalts (97–316 Gt), through enhanced oil recovery (3.4 Gt) and enhanced coal bed methane recovery (3.7 Gt). The authors have also classified the 19 major sedimentary basins in India based on their storage prospectivity to assist stakeholders in screening potential sites for future CCS projects (Table 1).

Table 1 List of Indian sedimentary basins classified on the basis of their Storage Prospectivity (Vishal et al., 2021b)

Classification	Storage Prospectivity	Basins
Class I	Very high potential	Assam–Arakan Fold belt
		Cambay
		Cauvery
		Assam shelf
		Krishna–Godavari
Class II	High potential	Mumbai Offshore
		Rajasthan

Class III	Moderate potential	Bengal–Purnea
		Saurashtra
		Kerala–Konkan
		Kutch
		Andaman Nicobar
		Vindhyan
		Cuddapah
Class IV	Low potential	Mahanadi
		Pranhita–Godavari
		Satpura–South Rewa–Damodar
		Chhattisgarh
		Rewa Damodar

Geomechanical risks in CO_2 storage

Geomechanics has recently gained popularity in the hydrocarbon industry with the rising interest in unconventional resources like tight oil, shale gas, coalbed methane, etc. and methods like horizontal drilling and hydraulic fracturing becoming further mainstream. The enhanced understanding of the subsurface geomechanical properties can help in solving the problems associated with CO_2 storage. Coupling of fluid flow with geomechanical deformations has come into the fore with increasing complexities in the subsurface (Minkoff et al., 2004; Rutqvist, 2011; Rutqvist et al., 2015). With the increasing amounts of CO_2 injection in underground rocks for storage or exploitation of energy sources, geomechanics starts playing a vital role in planning the operations and monitoring the progress of the projects (Verma et al., 2021).

Introduction of fluids in the subsurface results in increased pore pressure in the reservoir rocks. The enhanced pore pressure reduces the effective normal stress acting on the rocks and leads to expansion of the reservoir seen as uplift on the surface. The reduced normal stress increases the risk of rocks slipping and deforming in the presence of shear stresses which are unaffected by pore pressure changes. The amount of deformation depends on the rock strength, porosity and permeability, the pressure buildup, and the original stress state. Significant deformation can cause issues in storage integrity through induced micro-seismicity. Large pore pressure increase can also activate dormant faults or even generate newer fractures which can act as pathways for CO_2 migration. Seismicity can fracture the caprock restraining the CO_2 in the ground and may lead to its leakage to the surface. Deformation due to injection should be managed to contain the CO_2 in the subsurface and prevent any damage that sufficiently large earthquakes can cause to the environment and the local community. Adequate safety measures should also be taken to avoid CO_2 migration into potable water supply or seepage to the surface (Verdon, 2014).

Leakage of injected CO_2 from the deep reservoir may be governed by different mechanisms and their combinations. The factors driving such mechanisms may include geological, hydrogeological, geomechanical and geochemical ones, as well engineering factors such as well construction, and injection practices. The major geomechanical risks associated include:

- Fault activation due to increase in pore pressure through direct hydrological contact,
- Seismicity due to changes in loading conditions on fault induced by pressure changes in the reservoir,
- Seismicity induced in the overburden due to reservoir compaction or expansion,
- Caprock failure due to induced shear stresses,
- Fracturing due to high-pressure injection,
- Borehole instability during well drilling, completion, and production,
- Casing deformation and failure.

With significant advances in computer modeling techniques, coupled study of geomechanics and reservoir flow effects has become standard in CO_2 storage projects. Over the years many models have been developed to account for the behavior of underground rocks with changes in the stress state due to fluid intrusion.

The largest induced seismic events reported in the literature are associated with projects that did not balance the large volumes of fluids injected into, or extracted from, the Earth within the reservoir. The net volume of fluid that is injected and/or extracted causes significant changes in subsurface stress regimes and is affected by pore pressure, injection and extraction rates, and other factors. Projects involving large net volumes of injected or extracted fluids over long periods such as enhanced oil recovery and CCS would lead to higher risks for maximum magnitude events. The actual magnitude and intensity of possible induced events would be largely dependent upon the conditions in the subsurface—the state of stress in the rocks, presence of existing faults, fault properties, and pore pressure. The relationship between induced seismicity and projects with large-volume, long-term injection, such as in large-scale CO_2 EOR projects, needs to be studied in depth in order to scale the projects from pilot to commercial levels.

Conclusion

According to IEA, India holds the future to CCUS with a predicted share of almost 20% of global industrial CCS by 2060 (IEAGHG, 2019). Consequently, major steps are being taken by the Government of India to advance CCUS in India. The CCUS Roadmap for India by TIFAC (Technology Information Forecasting and Assessment Council) has identified CO_2 EOR and ECBMR as the first two immediate pathways for CCUS in India. Industrial CCUS has also made considerable advances in India. CO_2 capture from Koyali refinery is being planned by ONGC–IOCL partnership for CO_2-EOR in Gandhar field, Gujarat. A similar collaboration between OIL and IOCL is in the works for EOR in Nahorkatiya and Dikom oil fields in Assam through CO_2 capture from the flue-gas stacks of hydrogen generation unit and gas turbine power plant at Digboi refinery. CCSL and TAC operated plant in Tuticorin has developed facility for 60 ktpa CO_2 capture and conversion to baking soda. Essar O&G E&PL is conducting feasibility assessment of pilot scale CO_2 enhanced coalbed methane recovery. Moreover, Ministry of Petroleum & Natural Gas has developed a framework for incentivizing EOR and IOR (Improved oil recovery) which includes CO_2 enhanced oil and gas recovery. India is also a key member of Mission Innovation initiative and ACT (Accelerating CCS Technologies) consortium. As shown by Vishal et al. (2021b), significant potential for storage of captured CO_2 in sinks is present in India. With a fair share of India in global CO_2 emissions, CCUS could lead the country toward a sustainable future, and aid economic growth and social development. However, there is a need for effective source-sink match, suitable site-selection, and comprehensive risk assessment through adoption of global best practices, which can lead to significant cost reduction in CCS undertakings. Furthermore, favourable policy frameworks and financial incentives can accelerate deployment of CCUS in India leading to a successful pilot storage project.

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Technical Note

The Role of Carbon Dioxide Removal in Climate Change

Udayan Singh[1,2], Jayant Singh[3]

Background

The Paris Agreement signed in 2015 lays the groundwork for multinational alignment on climate action by targeting an end-of-century temperature rise by 2/1.5°C. This was an important milestone in two ways. First, it was the first agreement signed by 190+ countries and looking at common but differentiated set of goals. But from a scientific viewpoint, it marked a transition to looking at temperature rise as the constraining criteria instead of annual CO_2 emissions or atmospheric CO_2 levels (McLaren and Marcusson, 2020).

Ensemble modeling of energy and climate systems has shown that meeting the aforementioned criteria would require major shifts in energy infrastructure – from phasing out fossil fuels, to deployment of large scale solar and wind power and also demand-side changes such as energy efficiency (van Soest et al, 2017; Fawcett et al, 2015). However, due to the target of end-of-century temperature rise instead of actual CO_2 emissions, an additional portfolio of technologies called carbon dioxide removal technologies (CDRs) has come to the forefront. These technologies involve removal of CO_2 from the atmosphere through biological, physical or chemical means and have been deemed near-essential by consensus reports such as the recent IPCC Special Report on 1.5°C (Rogelj et al, 2018).

What are CDRS?

Broadly, CDRs are classified into six major types depending on the method of capture and storage of CO_2. Converting CO_2 into biomass using photosynthesis, is of one the primary methods of removing carbon from the atmosphere. Biomass carbon sequestration as a method to capture carbon is further classified based on the habitat of the autotroph used for sequestration, namely open ocean, coastal or terrestrial. Costal biomass carbon sequestration, also called the Coastal Blue carbon, includes autotrophs that grow and store carbon in the soft-sediment soil like wetlands, marshlands or seagrass beds. Whereas, the oceanic carbon sequestration includes biomass in the form of planktons and Microalgae that are majorly found in open sea. Similarly, the terrestrial carbon sequestration is the accumulation of carbon in the form of land-based plants. The oceanic carbon sequestration the largest sink out of the three, taking up almost 70% of the total CO_2 sequestrated. The carbon trapped in the form of biomass in all the cases, however, is likely to return to the carbon cycle and again become a carbon neutral cycle. This would be more prominent in case of species like the Microalgae (coastal and oceanic), which are prone to herbivory and therefore only have a possibility of carbon removal, upon burial or export of the biomass to deep sea or continent shelf. Therefore, the carbon burial in soil becomes a more effective way of long-term carbon sequestration. The terrestrial biomass contributes the most to soil carbon stock, in addition to providing woody biomass which is ideal for long term storage and removal of carbon.

Bioenergy (electricity/biochar/biofuels) with Carbon Capture and Sequestration (BECCS), uses biomass (carbon fixed from the atmosphere) to

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generate power followed by the capture and sequestration of CO_2 emitted during power generation. Though it has the potential to be a negative emission power generation technology, at the current state of the technology it struggles with the numerous challenges like the regular supply of biomass, low plant efficiencies and the high cost of electricity produced. The thermochemical conversion of biomass to biochar has been proven to be economically and environmentally promising, however the biological conversion of biomass to biofuel (liquid) faces challenge in the form of lignin decomposition (40% content of all biomass by energy).

Direct Air Capture is the active separation of CO_2 from a mixture of gases using sorbent/solvent and then storing the sequestered CO_2. Though it incurs the higher cost, it provides an ease in terms of flexibility of operation (controlling the purity and throughput).

Carbon mineralization is a method to capture and store CO_2 in the form of carbonate minerals. It is also called the process of accelerated weathering, where the CO_2 from the air is made to react with selectively reactive minerals like olivine, wollastonite, perdonite and other such minerals rich in Ca and Mg. The storage/reaction can be in-situ where concentrated CO_2 is stored in subsurface ultramafic and basaltic rocks, or ex-situ is where the reaction of the CO_2 from the ambient air is made to react with rock at the surface of the earth. Out of the two, in-situ method of mineralization is found to be economically more competent and also a larger potential for storage but requires further efforts to establish technological feasibility.

Role of CDRS in Decarbonization

The role of CDRs has become important because mitigation measures noted above are essential in reducing or avoiding future CO_2 emissions. However, they do not reduce the harmful impacts of the CO_2 emissions that have already been released into the atmosphere. We have noted through widespread climate change induced disasters such as Hurricane Maria (2017) that the extent of climate change that has already occurred could be catastrophic. CDRs can aid in this task in the following ways:

- **Allowing for temporal flexibility in mitigation efforts**: Large-scale mitigation efforts, while necessary, are limited by multiple aspects. Finding socio-political consensus to the approaches for optimal mitigation has proven to be vastly difficult even with the presence of suitable technologies (Jewell and Cherp, 2020). Further, disruptions such as natural disasters or more recently COVID-19 may shift investments to more immediately apparent concerns such as rehabilitation or public health. A strong portfolio of CDRs would ensure that even with somewhat delayed mitigation efforts or temporary disruptions, the end-of-century temperature rise could be limited to the desired levels.
- **Decoupling energy and emissions**: For most countries, a critical decision-making feature for climate action is assessing the "peak year" i.e. a period where CO_2 emissions have reached an all-time maximum (Rogelj et al, 2020). Around this period, we note that CO_2 emissions decrease even as energy consumption increases, in what is called as decoupling (Deutch, 2017). Particular CDRs could ensure that energy and emissions could get physically decoupled. As an example, the California Low Carbon Fuel Standard (LCFS) incentivized some forms of carbon dioxide removal that could be treated as theoretically offset from their crude oil system (Beuttler et al, 2019). Accordingly, CDRs could aid in a degree of modularity in decoupling energy and emissions.
- **Offsetting residual emissions:** From a life-cycle perspective, even low-carbon technologies might result in considerable CO_2 emissions. For instance, coal and gas power plants deployed with end-of-pipe

mitigation through CO_2 capture still emit 50-150 g/kWh, that is higher than some countries' pledged emission factor targets for electricity systems. Similarly, solar and wind infrastructure do release some amount of "non-zero" emissions due to upstream manufacturing requirements (Dolan et al, 2012). To reach a net-zero energy system, therefore, requires countering of these residual emissions and that can be achieved through CDRs.

The Rationale for CDRS in the United States

Once we have established the CDRs are an essential part of future infrastructure additions and that they do offer considerable advantages, we need to look at the scale of deployment targeted. Modeling results suggest that a deployment to the tune of 8-15 Gt-CO_2 globally will be required globally (Gasser et al, 2015). Most literature shows that a rapid upscale of CDR infrastructure would be observed in 2/1.5°C scenarios post-2030. The rate of growth in such infrastructure would be nearly 6% (Anderson and Peters, 2016) and broad concentrations would be seen in the United States and European Union, due to stringent emission constraints and historically high emissions (Pozo et al, 2020). Here, in addition to such literature, we make the bottom-up case for why particular CDRs would make considerable sense in the United States based on a confluence of factors.

First, it is well-established that CDRs have large geophysical requirements. Thus, land-based CDRs such as BECCS or afforestation have large land and water (and possibly nutrient) requirements. More engineered CDRs rely on large-scale energy provision for CO_2 removal. A wide variety of CDRs also rely upon availability of ubiquitous geologic storage formations for CO_2 disposal (Minx et al, 2018). As we shall show in the individual chapters, regions within the US exhibit a confluence of such resource availability (agricultural productivity or surplus energy availability interspersed with good-quality sinks). This is not the case in several developing countries where the current priorities are revolve around basic human needs such as 100% electrification (Calvin et al, 2018).

Second, CDRs are still a work in progress from a technological viewpoint. The costs for CO_2 abatement through the two most most-discussed CDRs are in the range of $ 100-600/t-CO_2 (Fuss et al, 2018). At these cost levels, such technologies could be extremely cost-prohibitive and require detailed technological learning. North America has already seen investments and pilot-studies towards individual CDRs that facilitate easier assimilation into the US energy systems (Meng et al, 2020).

Third, regulatory regimes have begun to favor and incentivize CDRs at the state and federal levels. We have already discussed California's LCFS system. In 2018, the federal 45Q tax credits also create sufficient incentives through a wide variety of carbon mitigation platforms aimed at aiding infrastructure addition of CDRs. Having suitable regulatory practices are essential during operational lifetimes of CDRs as well. From the governance perspective, land-based CDRs are the most difficult to monitor and review because the carbon uptake at the soil level are expensive to estimate. In developing countries such as US, such facilities exist that could enable in accurate estimation of such CO_2 removal (Mace et al, 2018).

Fourth, in addition to the direct financial benefits discussed earlier, the US has additional financial conditions that create helpful conditions for investors. This includes a virtually zero percent interest rate that is beneficial considering the high capital intensiveness of CDRs.

Literature Review

There has been a considerable amount of research on the feasibility of carbon dioxide removal over the last five years. These pertain to the scope of carbon dioxide removal required for meeting climate constraints (Gasser et al, 2015), there potential in different regional contexts (Geden et al, 2019), technological innovation and upscaling (Keith et al, 2018), and legal challenges (Fuss et al, 2014). Multi-author consortia have also developed synthesis of such analyses to present overarching research questions across CDRs (Smith et al, 2017). Here, we review the pertinent literature on environmental and economic burdens of BECCS and DAC, the two prominent technologies being studied in the dissertation.

Environmental implications

Environmental issues arising due to carbon dioxide removal strongly depend on the technological pathway. The platforms in question here are quite different. BECCS is a technology characterized by a combination of somewhat developed sub-technologies, and accordingly the environmental burdens are apportioned over the large supply chain. It is also the only CDR capable of providing energy, at least ideally, while also aiding CO_2 removal. On the other hand, DAC is considerably more modular and the environmental burdens largely arise due to the vast energy consumption for operating the DAC unit itself.

Due to its compatibility with existing energy frameworks, initial published literature on carbon dioxide removal largely pertained to BECCS (Fuhrman et al, 2019). As such, BECCS has been seen with some skepticism for the large land and water use, characteristic of nearly all bioenergy pathways (Smith et al, 2015). Kato and Yamagata (2014) estimated that first generation bioenergy crops would be incapable of meeting the 2°C targets. Even with advancements in bioenergy cropping patterns and technologies, they project that land-use changes would undercut around half of the intended CO_2 sequestration. Similar concerns are echoed by Heck et al (2018) who found that large irrigation demands are required such that BECCS is not deployed in regions with high biodiversity risks. To counter the above, suggestions have been made over the past couple of years that relate to using marginal croplands or oceanic areas to cultivate bioenergy crops (Fajardy et al, 2018; Beal et al, 2018).

Off late, research has also looked at the risk of poor life-cycle performance in large-scale BECCS projects. Tanzer and Ramirez (2019) have pointed out that due to the logistically-complex supply chain and differences in bioenergy platforms, some consistency in needed in demarcating "carbon dioxide removal". This pertains to the permanency of geologic storage, and incorporating the upstream and downstream emissions to ensure actual sequestration versus avoiding end-of-pipe emissions. Generally, the permanency of geologic storage has been established by subject experts and leakage is not expected to substantially counter the CO_2 removal from BECCS (Lyngfelt et al, 2019). However, upstream emissions from processing may considerably affect the net greenhouse gas balance of BECCS. For terrestrial BECCS, it is found that carbon and energy objectives are often at odds with each other. Thus, inefficient power plants with low energy return on investment may lead to improved life-cycle GHG performance while prioritizing efficiency might lead to positive emissions (Mac Dowell and Fajardy, 2017). Because of the logistical complexity accompanying BECCS, solutions to these problems may be found in optimal use of fertilizers (Fajardy and Mac Dowell, 2017) and improvements in thermochemical conversion technologies (Cheng et al, 2020).

LCA methodologies for DAC are relatively straightforward due to the process modularity. The life-cycle emissions balance for DAC is largely affected by the energy source being used to power the DAC plant. For instance, powering DAC through coal-fired electricity could lead to countering of 90% of the captured emissions (de Jonge et al, 2019). Because of multiple technological players in DAC, variabilities in process data has led to considerably different conclusions about life-cycle energy use. Thus, van Der Giesen et al (2017) project that energy consumption would increase appreciably with DAC deployment but still be within a manageable range. Additional literature has found DAC to deliver suitable efficiency to bolster the case of CO_2 utilization via chemical synthesis (Daggash et al, 2018; Liu et al, 2020). On the other hand, Realmonte et al (2019) have concluded that using DAC solely for a majority of carbon dioxide removal need would create large energy surpluses in the society.

Finally, recent literature has identified a need for frameworks and metrics for consistent life-cycle evaluation across CDRs. Most initial studies focusing on BECCS used electricity system metrics and computed their outputs relative to a power-based functional unit i.e. 1 kWh. However, Goglio et al (2020) conclude that since the main function of CDRs is CO_2 removal, a functional unit should correspond to this value. This does lead to some complications. Notably, most CDRs are multifunctional systems, e.g. BECCS could both CO_2 removal and power production, DAC could be combined with chemical synthesis, and so on (Muller et al, 2020). Traditional LCA does not allow for usage of two simultaneous functional units and therefore, it is largely preferred that such studies use systems expansion to avoid allocation ambiguities (Pour et al, 2018a).

Economic implications

While CDRs have been prominently discussed in the literature, they are yet to be deployed on a large-scale. In fact, even the most optimistic models do not project their large-scale deployment before 2030. As such, the low readiness of these set of approaches with no commercial learning leads to high costs in the present day. Approaches with lower potential offer CO_2 removal opportunities at very low costs (e.g. afforestation or blue carbon management could be achieved at \$ 10-20/t-CO_2). The BECCS approach, as a hybrid of agriculture and engineered technology depicts abatement costs close to \$ 100/t-CO_2 (Pour et al, 2018b; Gough and Upham, 2011). More engineered approaches such as DAC or basalt mineralization have costs of the order of \$ 10^2-10^3/t-CO_2 (The National Academies of Sciences, Engineering and Medicine, 2018).

At the above cost ranges, it is clear that these technologies are unlikely to be successful without additional regulations, in the form of a price on carbon or added incentives to remove it. We have already discussed how the US Federal Government and California have incentivized particular CDRs. At scale, incentives for CDRs might be very high and could consume up to a third of government expenditure in developed countries (Bednar et al, 2019). In the presence of such frameworks, inclusion of carbon dioxide removal brings down overall abatement costs. Results from the TIAM model suggest that a carbon price of \$ 85/t-CO_2 by 2050 and \$ 690/t-CO_2 by 2100 will be adequate for meeting the 2°C targets (Selosse and Ficci, 2014). If, however, BECCS is not within the technology portfolio, these costs increase by about 45%. Muratori et al (2016) have furthered this argument by showing that inclusion of BECCS also reduces food prices by lessening the upward pressure on such crops. It is also anticipated that with technology innovation and learning, the costs of CDRs would fall post-2030. Currently, the CO_2 avoidance cost of BECCS is close to \$ 250/t-CO_2 (Muratori et al, 2017). This is strongly related to a very high capital cost (3-4 times higher than a gas plant with CCS) and very low plant efficiency of 18-20%. In the future, learning in such plants (conventional BECCS platforms with combustion) is itself projected to reduce the capital costs by 30-40% (Heuberger et al, 2017). Simultaneously, it is anticipated that technologies more suitable for bioenergy, such as gasification or chemical looping advance to higher readiness levels and they can offer cost reductions of around \$ 50/MWh (Bhave et al, 2017; Li and Wright, 2019).

Technological learning is anticipated to play an even higher role in DAC systems. Earlier estimates for ambient air capture put DAC costs at an unappealing range of \$ 600/t-CO_2. Large-scale private investments have brought these costs down considerably with Keith et al (2018) reported a levelized cost of \$ 90-120/t-CO_2 for their technology. Similarly, ClimeWorks is targeting an avoidance cost \$ 100-200/t-CO_2 (Fuss et al, 2018). With future technological learning as well as system reconfiguration through waste heat recovery, of around \$ 70/t-CO_2 are targeted by 2030 (Fasihi et al, 2019).

Additional system components are also expected to affect avoidance costs for CDRs to a considerable extent. For instance, some researchers have suggested the use of enhanced oil recovery (EOR) to supplement the energy deficits of such projects (Hammond, 2018). While this undercuts the CO_2

removal objective, a thorough analysis of storage formations and their respective environmental and economic burdens is essential in architecture of CDR systems. Prior work relating to fossil fuel CCS has focused on the CO_2 transport and storage cost implications in designing CCS "clusters" (Garg et al, 2017; Grant et al, 2018). Due to the added complexity of bioenergy crop locations, these analyses need revision to design optimal carbon dioxide removal clusters.

Acknowledgement

This work is extends on the doctoral research of the first author. He gratefully acknowledges funding from the David and Joy Peyton Fellowship, and research mentorship provided by Professor Lisa Colosi Peterson.

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Technical Note

Carbon Trading Mechanism

Swapan Mehra[1], Shweta Pandey[2]

Climate Change

Climate change is defined as the change in the state of the global or regional climate pattern due to natural internal processes or external forcing, or changes in the composition of the atmosphere or in land use due to anthropogenic activities.

According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

Climate Mitigation

Climate mitigation is an effort to reduce or prevent the emissions of greenhouse gases using new alternative emission reduction options (e.g. renewable energies), energy-efficient technologies, or changing management practices.

Kyoto Protocol

The Kyoto Protocol was adopted by consensus of more than 150 signatories in COP-3, held in 1997 in Kyoto, Japan. This Protocol recognised that the developed nations are responsible for the high greenhouse gas emissions in the atmosphere due to their involvement in the industrial activities for over a prolonged time in the past and at present. Under the Protocol, industrialised countries' actual emissions were to be monitored, and precise records had to be kept of the trades carried out. The Kyoto Protocol set a target for 36 industrialised countries and the European Union to reduce their emissions by an average 5% below 1990 levels, for the period of 2008 to 2012. Though Kyoto Protocol was adopted on 11 December 1997 and but detailed rules for implementation known as "Marrakesh Accords", was determined at the Conference of Parties, Marrakesh, Morocco in 2001. Then, finally, Kyoto came into the force in 2005. The first commitment period of the Accords started in 2008 and ended in 2012. India ratified the accords on 26th August 2002. Later, on 8th December 2012, Doha Amendment of Kyoto Protocol was adopted with the commitment period of 2013 to 2020, with a different set of emission targets. India ratified the second commitment period in the year 2017.

The three major mechanisms which are proposed under the Kyoto protocol to facilitate the reduction of the GHG emissions are:

- Clean Development Mechanism (CDM),
- Joint Implementation (JI) and
- International emissions trading.

Clean Development Mechanism (CDM)

The CDM is defined in article 12 of the Kyoto Protocol. It allows the country with an emission reduction or limitation commitment under the protocol to implement the emission-reduction projects in the developing countries to earn certified emission reduction (CER) credits. Each CERs is equivalent to one tonne of CO_2, and these CERs in the CDM can be traded by industrialised countries to meet their emission reduction targets under the Kyoto Protocol. Every country involved in the CDM has to designate a national authority

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This is modified version of the invited lecture delivered at Workshop on Global Environment and Greenhouse Gas Emissions from Energy Systems, organized jointly by MGMI and CSIR-CIMFR

to overlook the CDM Projects in the state; these authorities are generally known as the Designated National Authority (DNA). The CDM Executive Board supervises this mechanism and it is answerable to the countries that have ratified the Kyoto Protocol.

Joint Implementation (JI)

The JI mechanism is defined in Article 6 of the protocol. According to this mechanism, countries can earn emission reduction unit (ERUs) from emission-reduction or emission removal project in another Annex B party countries to meet their targets. JI is flexible and cost-efficient means to meet the emission reduction targets.

Emission Trading (ET)

ET is defined in the article 17 of the Kyoto Protocol, which allows countries that have emission units to spare - emissions permitted them but not "used" to sell excess capacity to countries that are over their targets. Thus, a new commodity was created for trading in the form of emission reductions or removals known as the "carbon market."

To address the problem of oversell of the units by the Parties and unable to meet their own commitments, each Party is required to maintain reserve known as "commitment period reserve" of emission reduction units (ERUs) generated by JI projects, certified emission reduction (CERs) generated from CDM projects, removal unit (RUs) based on the afforestation activities. These reserves should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol or 100 per cent of five times its most recently reviewed inventory, and whichever is lowest.

Paris Agreement

COP-21 resulted in the global climate agreement, known as the Paris Agreement in 2015. *The long-term goal of the Paris Agreement is to hold the increase in global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit warming to 1.5°C*. Overall, the current pledges would lead to lower global emissions compared to previous expectations. However, further action will be required to keep warming to below 2°C or 1.5°C. As of April 2018, 175 parties had ratified the Paris Agreement. The Paris Agreement is based on the convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so.

Under the Paris Agreement, parties are expected to develop implementation rules to enable accurate accounting of NDCs. The Paris Agreement allows for the cooperation of countries in meeting their NDCs and introduces the concept of "Internationally Transferred Mitigation Outcomes" (ITMOs), which Parties can use toward achieving their NDC targets (Art. 6.2). Though the Paris Agreement does not fully define ITMOs—which could potentially take some form of carbon units—it does establish that as a condition of their use, Parties musts "apply robust accounting to ensure, inter alia, the avoidance of double counting." The decision that accompanies the Paris Agreement notes that this should be done on the basis of a "corresponding adjustment" by Parties (Para. 35). India ratified the Paris Agreement in 2016.

Voluntary Markets

The Voluntary Markets offers the opportunity to offset the emissions voluntarily by purchasing the carbon credits. These can be created either under CDM or under standards operating in the voluntary market such as Gold Standard (GS) and Verified Carbon Standard (VCS).

Gold Standard (GS)

GS sets the standard that sets requirements to design the projects for the maximum positive impact of the project in climate and development, and that allows to measure and report the outcome most credibly and efficiently. GS carbon credits represent the reduction and removal of one tonne of CO_2-equivalent and Sustainable Development Goals (SDGs) associated with the project.

Verified Carbon Standard (VCS)

The VCS allows project developers to turn their greenhouse gas (GHG) emissions reductions into tradable carbon credits after assessing their projects per VCS rules and requirements. It allows certified projects to monetise climate benefits through global and regional carbon market mechanisms. The VCS registry system is a multi-registry system, which comprises of two registry service providers such as IHS Markit and APX and a central project database. Market players such as Project developers, project proponents can open their accounts and submit required documentation to their chosen registry administrator in order to apply for project registration and issuance of Verified Carbon Units (VCUs). The registry administrators are responsible for sending project information from their registry to the VCS project database and for issuing VCUs into their customers' accounts. VCS registry administrators must comply with the strict conflict of interest policies and guarantee uninterrupted access to accounts. The VCS Program project database is the storehouse for all information and documentation relating to VCS Program projects. The project database is also responsible for ensuring uniqueness of projects, issuing VCU serial numbers and tracking VCU retirement. The project database makes project and VCU related information public.

Opening an account in the VCS registry is the first step towards the registration of the project. The VCS registry system currently has two independent registry operators (IHS Markit and APX) which interact directly with the central VCS Project Database to upload documents, register projects, and issue, track and ultimately retire Verified Carbon Units (VCUs). VCUs can be transferred between registry accounts at any time.

Green Climate Fund (GCF)

Parties established GCF at COP16 held in Cancun in 2010. It is as an operating entity of the financial mechanism of the convention under Article 11. The transitional committee designed it as per decision 1/CP.16, paragraph 109. The Fund is governed by GCF board. The board is accountable for this, and it functions under the guidance of the COP to support projects, programmes, policies and other activities in developing country Parties using thematic funding windows. At COP 17 held in Durban, Parties adopted the decision under 3/CP.17 (Launching the Green Climate Fund).

The Governing Instrument for the GCF stipulates that a trustee will administer the assets of the GCF only for the purpose of, and in accordance with, the relevant decisions of the GCF Board.

For the interim trustee of the GCF, the World Bank was invited by the COP, subject to review three years after operationalisation of the Fund. The World Bank to continue to serve as the Interim Trustee until a permanent Trustee is appointed (Board decision B.08/22).

Opportunities in Coal Mining Sector

ACM0008 V6 "Consolidated methodology for coal bed methane, coal mine methane and ventilation air methane capture and use for power (electrical or motive) and heat and/or destruction through flaring or flameless oxidation"

This provides the methodology for the following:[3]

- Coal bed methane (CBM): the methane originating in coal before any mining activities take place.
- Coal mine methane (CMM): Methane component of gases captured in a working mine by methane drainage techniques.
- Ventilation air methane (VAM): Methane mixed with the ventilation air in the mine that circulated sufficiently to dilute the methane to low concentrations for safety reasons.

Opportunities in the Energy Sector

The energy sector Sectoral scopes 1 to 3 include : [4]

- Electricity generation and supply;

3 https://cdm.unfccc.int/filestorage/F/R/L/FRLOKZ8HJ1PD62VAY3UW75BG49CQXE/EB55_repan12_ACM0008_ver07.pdf?t=ajB8cTQ4eWxzfDCmTx2QrXYZ2bg61EDE1CKS

4 https://cdm.unfccc.int/methodologies/documentation/meth_booklet.pdf#ACM0008

- Energy for industries;
- Energy (fuel) for transport;
- Energy for households and buildings.

Sectoral scopes 4 to 15 (other sectors) are categorized according to these mitigation activities:

- Displacement of a more-GHG-intensive output;
- Renewable energy;
- Energy efficiency;
- GHG destruction;
- GHG emission avoidance;
- Fuel switch;
- GHG removal by sinks.

Carbon Trading in India

India has consistently displayed leadership in global efforts to combat climate change and has put forth ambitious targets for its Nationally Determined Contribution (NDCs), including reducing its GHG emission intensity by 33-35% by 2030, relative to 2005 levels. In order to achieve its targets, India launched key initiatives, including both market-based and non-market-based mechanisms, to target emissions from a variety of sources. It is currently implementing two major domestic market-based mechanisms (MBMs): the Perform, Achieve and Trade mechanism (PAT) and the Renewable Energy Certificate mechanism (REC).

Since 2005, India has been an active participant in the CDM and represents a significant component of the global CDM market, registering the second-highest number of projects for any country. This represents 15.98% of CDM projects in Asia and 12.7% of global CDM projects. Across the 2938 CDM projects developed and registered by Indian participants, most projects are developed within the Energy sector (renewable/ non-renewable energy source) with 79% of all projects, followed by Manufacturing Industries at 8%, Energy Demand at 7.6%, Waste Handling and Disposal at 2.4% and rest all other sectors including Afforestation/Reforestation, Agriculture, fugitive emissions etc. (National CDM Authority, India). Within India, of the total CDM projects, only close to 24% projects were of large scale in nature while the bulk was of small scale CDM projects.

However, due to the shifting global market, the proponents of existing CDM projects that are eligible to earn CERs are unable to find suitable buyers. In an attempt to revive the market, the CDM EB introduced a voluntary cancellation feature in the registry in 2015. This allows individuals and small businesses to purchase and cancel CERs directly from project owners. To date 35651.906 k CERs generated from Indian projects have been reported to be voluntarily cancelled.

Current India Transaction Needs: India has about 1,664, i.e. 21.32% of the total 6,060-registered CDM projects to-date[5]. These projects have mainly been undertaken by industry and range from energy efficiency, replacement of conventional energy with renewables, waste management, HFC reduction and carbon sequestration in the forestry sector.

Domestic Markets

Perform Achieve and Trade (PAT) scheme flagship programme of BEE under the National Mission for Enhanced Energy Efficiency (NMEEE). It is an instrument to enhance energy efficiency and reduce the energy consumption among the specific energy-intensive industries in the country with an associated market-based mechanism to increase the cost- efficiency through certification of extra energy saving which can be traded. The target reduction for each Designated Consumer (DC) is based on their current levels of energy efficiency, the energy-efficient DCs will have a lower target of reduction, as compared to less energy efficient DCs which will have higher targets. Those industries which overachieve their targets are issued energy saving certificates (ESCerts), and those who underachieve are entitled to purchase energy-saving certificates which are tradeable.

The genesis of the scheme flows out of the

5 https://cdm.unfccc.int/Projects/index.html

provision of the Energy Conservation Act, 2001. Section 14(e) of the Act empowers the Central Government to notify energy intensive industries, as Designated Consumers (DCs). The Ministry of Power (MoP) notifies industrial units and other establishments consuming more energy than the threshold as DCs.

sources and the cost for environmental attributes. There are two categories of certificates, viz., solar certificates issued to eligible entities for the generation of electricity based on solar, and non-solar certificates issued to eligible entities for the generation of electricity based on renewable energy other than solar.

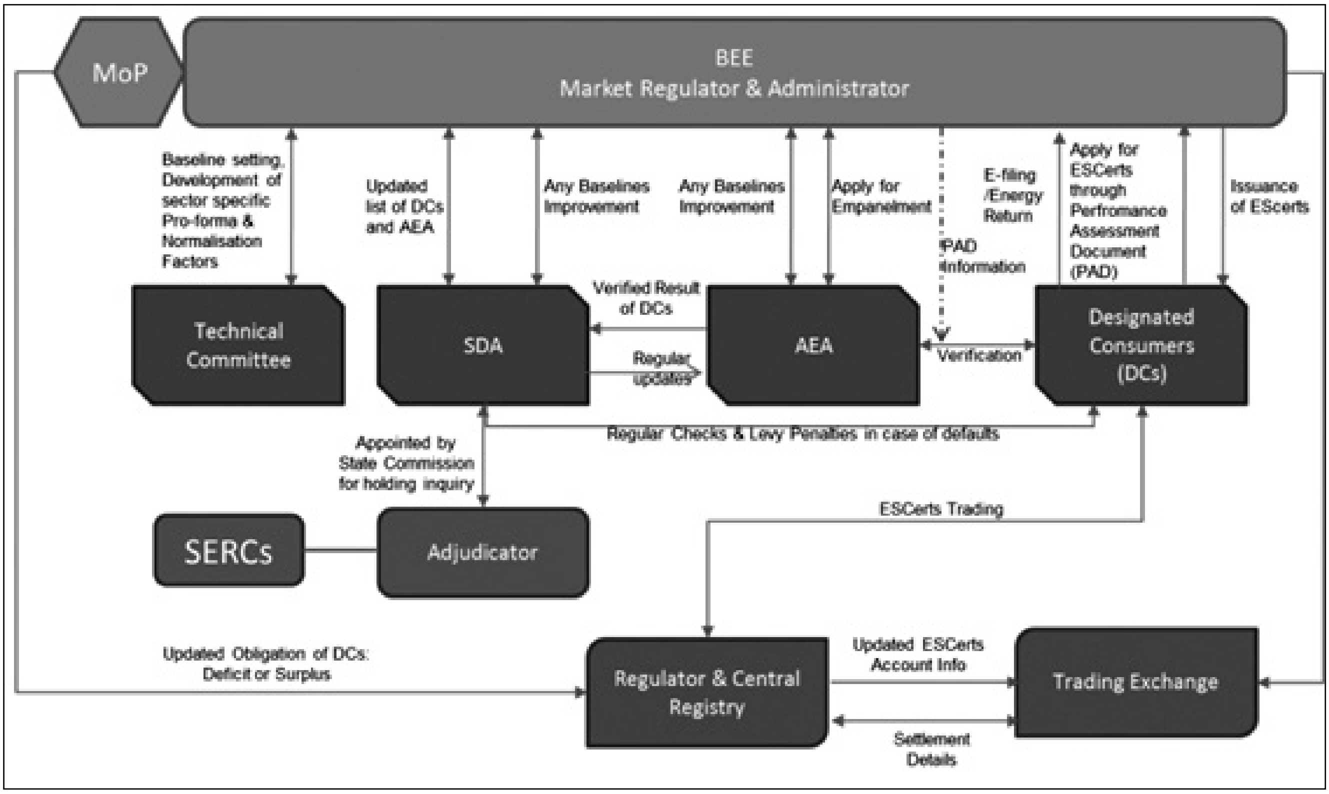

Figure 1 : Institutional Framework, PAT

Renewable Energy Certificate (REC)

REC is the market-based instrument that promotes renewable energy and facilitates the Renewable Purchase Obligation (RPO). The Renewable Purchase Obligation is the obligation mandated by the State Electricity Regulatory Commission (SERC) under the Electricity Act, 2003, to purchase a minimum level of renewable energy out of the total consumption in the area of a distribution licensee.

Cost of electricity generation from renewable energy sources is classified as the cost of electricity generation equivalent to conventional energy

The genesis of the REC mechanism flows out of the provision of the Electricity Act, 2003, the policies framed under the Act and the National Action Plan on Climate Change (NAPCC) further, providing for a roadmap to increase the share of renewable in the total generation capacity in the country. The Central Electricity Regulatory Commission (CERC) in 2010, notified Regulation on Renewable Energy Certificate (REC), in fulfilment of its mandate to promote renewable sources of energy and development of market in electricity.

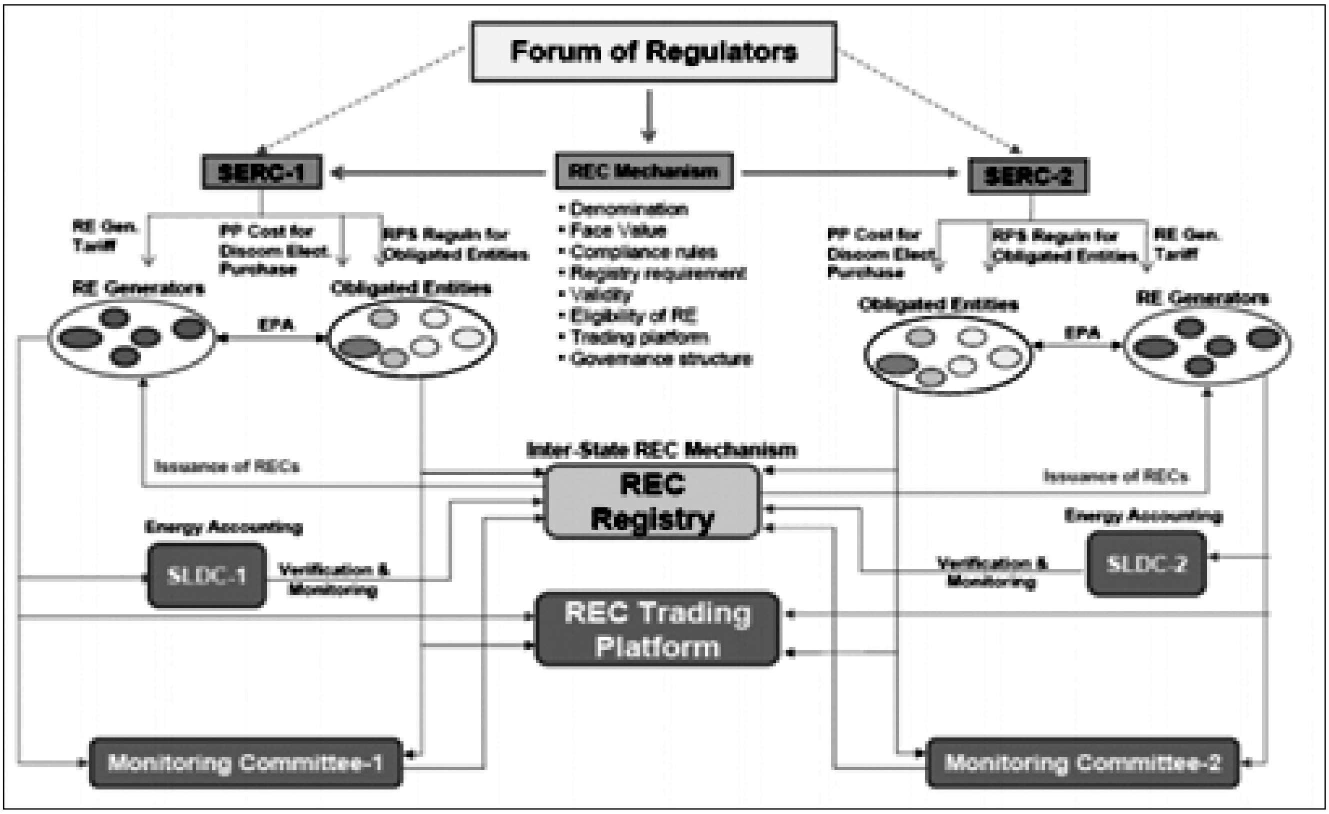

Figure 2 : Institutional Framework, REC

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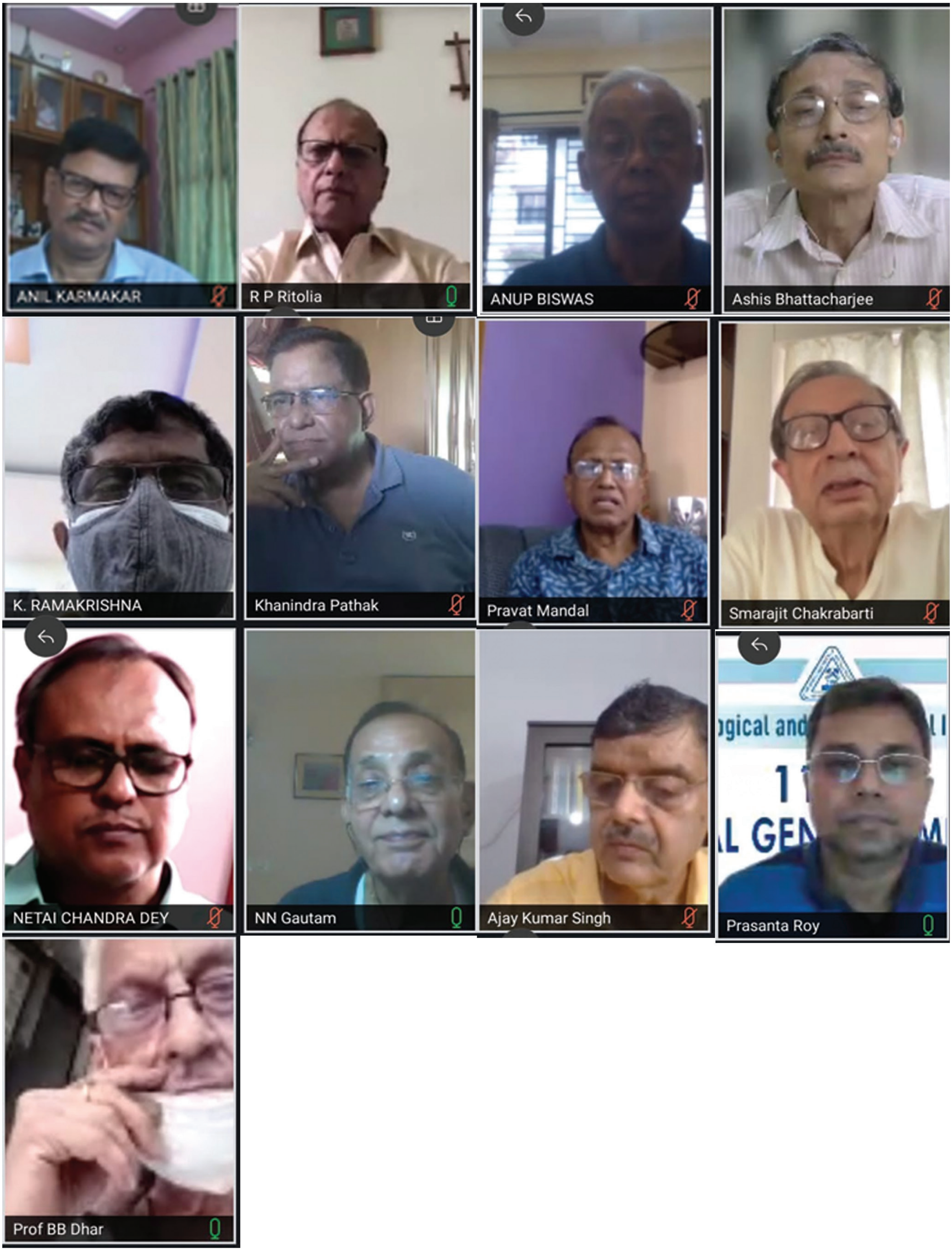
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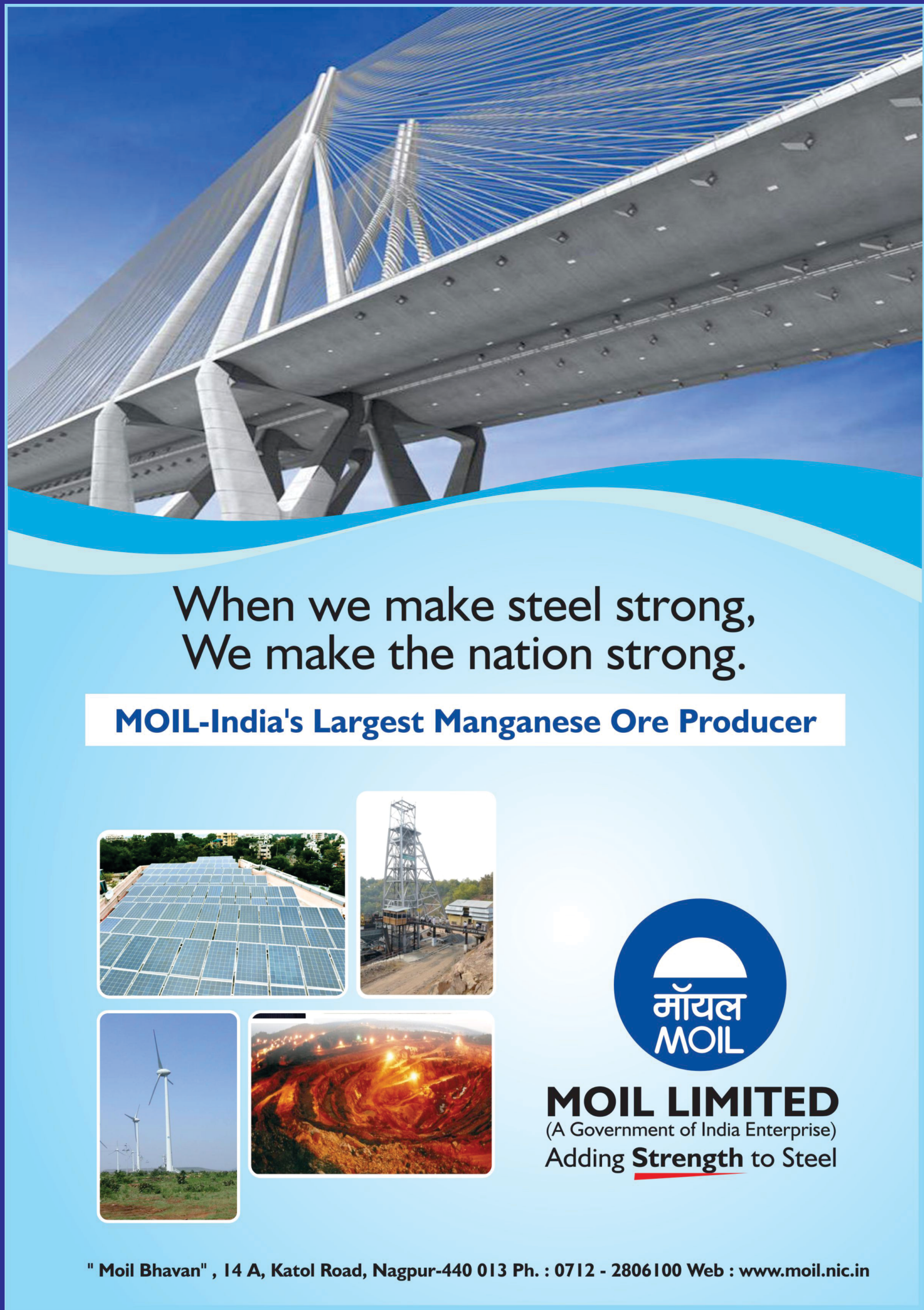

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