7th Roundtable Conference on Coal

Coal to Oil

Theme :

Indian Coal : Potential and Diversification

Tuesday, 24th September, 2019

Sovereign 1, Hotel Le Meridien, New Delhi

Shri Anil Kumar Jha, Chairman, CIL exchanged MoU with Mr. Leonid Gennadievich Petukhov of "The Far East Agency for Attracting Investment & Supporting Export" & "Far Eastern Mining Company" to Explore Coal Mining in Russia.

Souvenir

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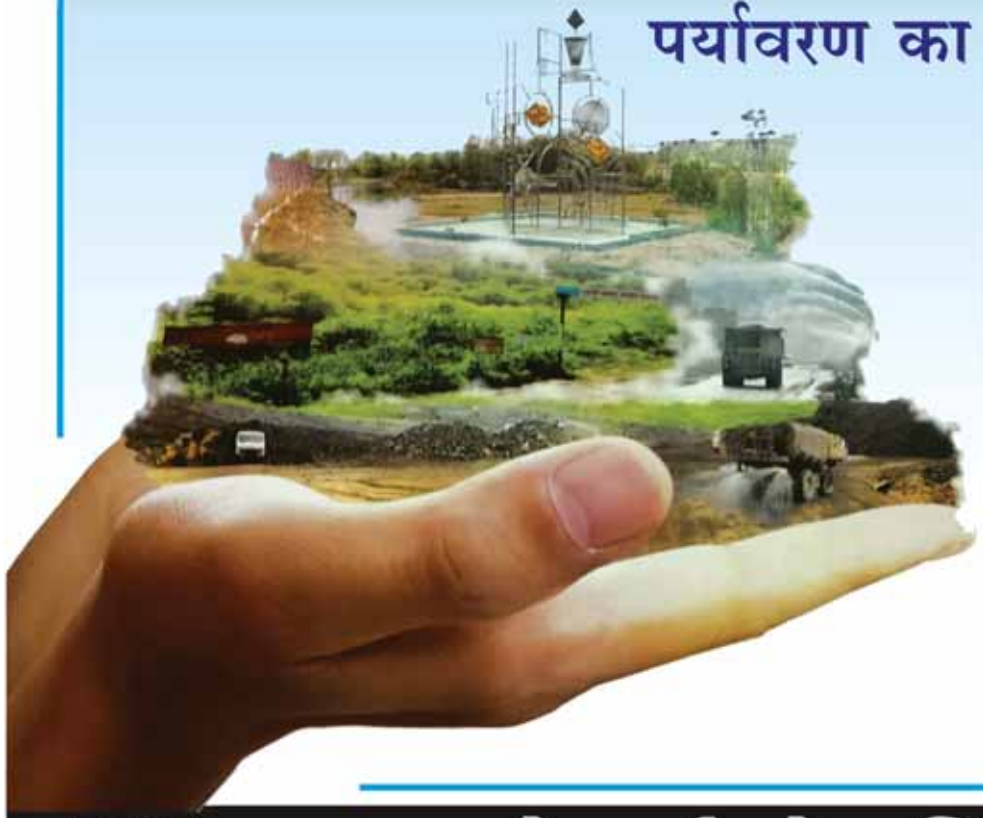

वेस्टर्न कोलफील्ड्स लिमिटेड

(एक मिनी रत्न कंपनी – कोल इंडिया लिमिटेड का एक उपक्रम)

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Source: Actual photographs of Dipka Washery and Korba Power Plant

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7th Roundtable Conference on Coal

"Indian Coal : Potential and Diversification"

Tuesday, 24th September, 2019

Sovereign 1, Hotel Le Meridien, New Delhi

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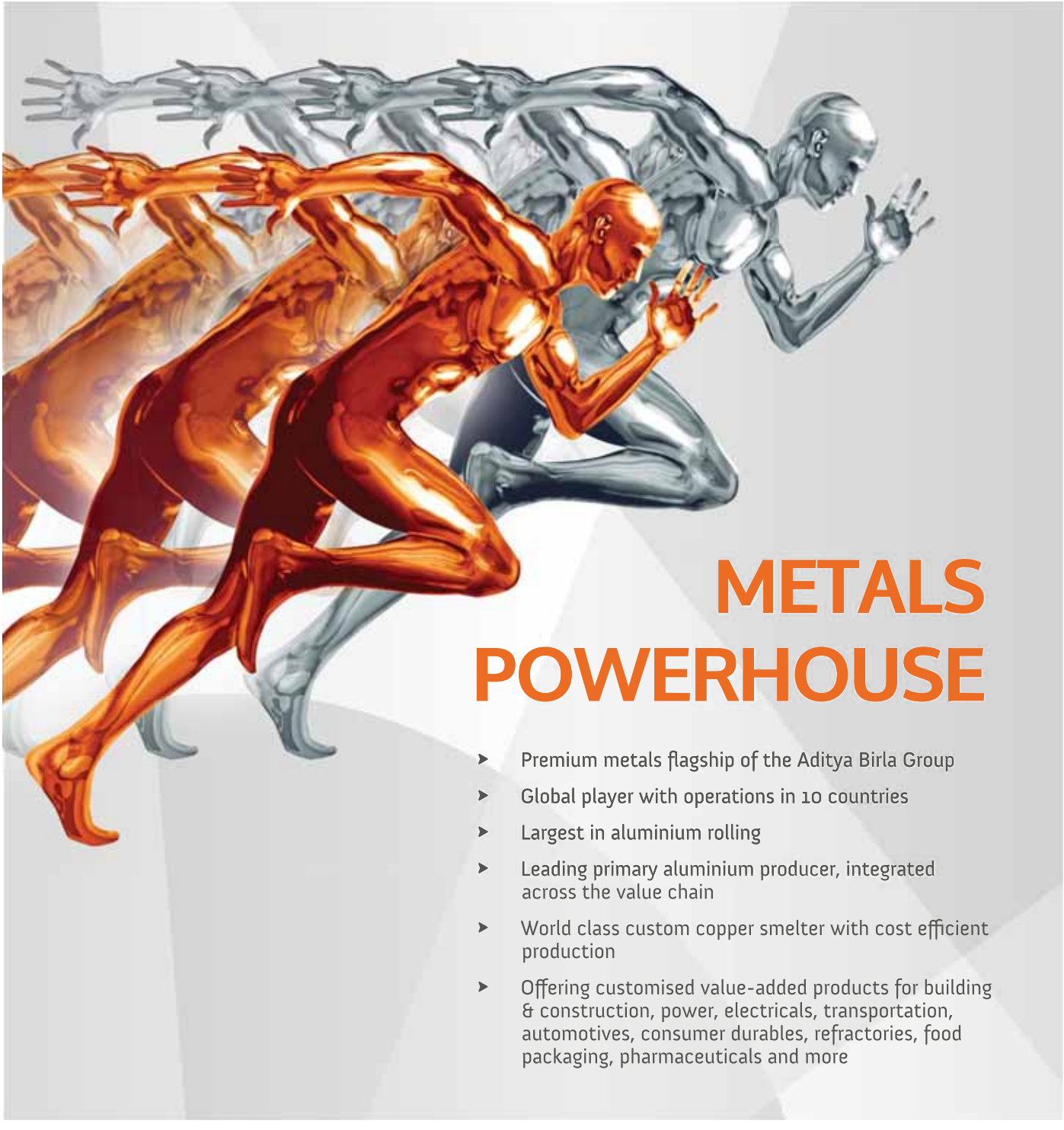

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Section-1

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Shri Venkaiah Naidu

Vice-President of India

Message

The Hon'ble Vice President of India is happy to know that the Mining Geological and Metallurgical Institute (MGMI), Delhi Chapter, in association with Indian School of Mines Alumni Association (ISMAA) and India Energy Forum (IEF) are organizing the '7th Roundtable Conference on Coal' on September 24, 2019 at Hotel Le Meridien, New Delhi.

The Hon'ble Vice President extends his greetings and congratulations to the organizers and the participants and wishes the event all success.

16/9/19

(D. Prasanth Kumar Reddy)

New Delhi
16th September, 2019.

Distinguished Chief Guest

Shri Pralhad Joshi

Member of Parliament from DHARWAD (State – Karnataka)
Minister for Parliamentary Affairs, Coal & Mines, Govt of India

Brief Profile

Pralhad Venkatesh Joshi (born 27 November 1962) is an Indian politician who is the current Minister of the Parliamentary Affairs in the Central Cabinet under PM Modi since May 2019, with additional portfolios of Mines and Coal. He has been a member of Lok Sabha since 2004 and was elected to 17th Lok Sabha in 2019 from the Dharwad Lok Sabha constituency. He was Karnataka State President of the Bharatiya Janata Party (BJP) from 2014 to 2016. He served in the panel of chairpersons of Lok sabha (2014-2018)

Pralhad Joshi (sometimes spelled Prahlad Joshi) first came to public notice with Rastradwaja Horata Samiti Sanchalak when they organised a movement to hoist the Tri-colour flag at Idagah Maidan (also known as Rani Kittur Chennamma Maidan) Hubli Karnataka during 1992-1994. Recently the Supreme court has upheld the Karnataka High Court order restoring the ownership of the said maidan to The Hubli-Dharwad Municipal corporation. He has been elected to Lok Sabha in the general elections of 2004, 2009, 2014, and 2019.

Joshi has identified himself as a man-in-service-of-mankind. A member of the R.S.S., since his young age, Shri. Joshi got himself trained in various training camps of R.S.S. He has been concerned with solving the problems of the poor and earned the name "Man of the masses". His area of interest is vast to include socio-cultural and educational. On 30 May 2019, Pralhad Joshi was sworn in as a cabinet minister in Prime Minister Narendra Modi's second term government. He is in charge of the Ministry of Parliamentary Affairs, Ministry of Coal, and Ministry of Mining.

Union Minister

He took oath as Cabinet minister on 30 May 2019 and became the Minister of Parliamentary Affairs, Coal and Mines.

सुमन्त चौधरी
सचिव
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सत्यमेव जयते

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MINISTRY OF COAL
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www. coal.gov.in

Message

I am pleased to learn that Mining, Geological and Metallurgical Institute of India (MGMI-DC) jointly with Indian School of Mines Alumni Association, Delhi Chapter (ISMAADC) and India Energy Forum (IEF) are organising 7th Round Table Conference on Coal on 24th September 2019 at Hotel Le Meridien, New Delhi with the theme **"Indian Coal – Potential and Diversification".**

Coal will continue to remain the mainstay of energy source in India for next 2/3 decades. With the Government of India committed to provide 24x7 electricity to each and every household, it becomes more imperative to augment coal production in the country to meet the demand of the Power Sector.

Govt of India has already announced policy to allow large scale mining for attracting efficient foreign players into the coal sector. The new policy regime governing the coal mining industry is of considerable significance due to several reasons like effective utilization of large resource base, to reduce coal imports, to promote alternative usage of coal, to open-up the industry for competition and to push forward the implementation of related policies such as those for auction and allocation of coal blocks, expeditious environment and forest clearances, to effectively address land acquisition & R&R issues, and so on.

The present theme of the Conference is timely to address all such issues of utmost importance including promotion of alternative usages of coal and encourage R&D in Clean Coal Technology.

I congratulate the organisers of the conference to have accepted the challenge and picked up befitting theme. I look forward for the appropriate recommendation arising out of the deliberations and wish conference a grand success.

(Sumanta Chaudhuri)

Place : New Delhi
Dated : 19th September, 2019

सुभाष चन्द्र गर्ग, भा.प्र.से.
सचिव
भारत सरकार
Subhash Chandra Garg, I.A.S.
Secretary
Government of India

सत्यमेव जयते

Ministry of Power
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September 17, 2019

Message

I am glad to learn that Mining Geological and Metallurgical Institute of India (MGMI-DC) jointly with Indian School of Mines Alumini Association, Delhi Chapter (ISMAADC) and India Energy Forum (IEF) are organising the 7th Roundtable Conference on Coal on 24th September 2018 at Hotel Le Meridien, New Delhi on the theme **"Indian Coal : Potential and Diversification"**.

In spite of a lot of thrust for stepping up power generation by renewable sources like solar, wind etc, coal will continue to play a dominant role as the major base load source of energy in the foreseeable future in India's energy basket to fulfil the desired goal of **"24x7 Power for All"** by 2019-20. Our long-term projections for domestic coal production of 1 billion tonne places enormous responsibilities on the Coal Sector. It is high time to address all aspects of coal production, including beneficiation of coal, affordability and pricing together with environmental concerns and clean coal technology. The country is passing through very important phase, the challenge of coal demand and availability need to be addressed thereby minimising dependence on import of thermal coal. In fact, we should, by implementing all needed reforms, including awarding large coal blocks on concessional sale basis, create a situation in the country that domestic coal availability is larger than demand. This will not only allow all sectors to use as much coal as they want but would eliminate import of thermal coal.

We are extremely gratified and highly enthused to see the turn-around that our coal industry has demonstrated over a period of last 15 months. The way things have moved and the speed at which trail-blazing steps and new initiatives have been taken coal industry would emerge in a totally new vibrant and capable of meeting challenges.

I am confident that all the participants will have the occasion to discuss such critical issues. I wish the Conference a great success.

(Subhash Chandra Garg)

RIGHT TO INFORMATION

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Amitabh Kant
मुख्य कार्यकारी अधिकारी
Chief Executive Officer

सत्यमेव जयते

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Message

I am happy to note that India Energy Forum, Mining Geological Metallurgical Institute of India (MGMI-DC) & Indian School of Mines Alumni Association (ISMAA-DC) have taken a joint initiative to organise 7th Roundtable Conference on Coal on 24th September 2019 at Hotel Le Meridien, New Delhi with the befitting theme **"Indian Coal – Potential and Diversification".**

We are fortunate to have large reserves of coal in India which can support the industry for next 2-3 decades. Despite huge reserves of coal available in the country, it is highly disturbing that we are still dependent upon imports thus draining our precious foreign exchange. This necessitates urgent & emergent need to augment coal production in the country to reduce the demand-supply gap.

I am confident that India with structural reforms in the offing shall easily achieve the target of becoming a 5 trillion dollar economy. Coal will certainly have to play a major role in achieving this ambitious target & pave the way for double digit growth. Coal Industry has also been visualized as one of the major employment generator in next couple of years.

I appreciate with relevant theme it will help various stakeholders to deliberate on major issues like augmenting coal production, diversification of coal usages & sustainable practices. The organizers' effort is laudable and I am sure that this conference will be beneficial to bring out useful recommendations and pave way for successful implementation of the current policies.

(Amitabh Kant)

अनिल कुमार झा
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Anil Kumar Jha
Chairman-cum-Managing Director

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Kolkata-700 156

Message

MGMI – Delhi Chapter, ISMAA – Delhi Chapter & IEF have had the right mix of dedication and enthusiasm for over two decades and have been successfully organising Coal Summits and Round Table Conferences on Coal which have deliberated challenges faced by the Coal Industry.

It is heartening that they are organising the "7th Round Table Conference on Coal" with the theme, "Indian Coal – Potential and Diversification".

Coal is the largest source of electricity in the world. Coal-fired power plants generate 72% of India's electricity. This, combined with the growth of coal-consuming industrial sectors like steel, is why coal, the basic source of energy, will continue to be an integral part of India's economy in the next couple of decades. Till battery technologies to store solar power improve and become cost-effective, the country's peak electricity demand will have to be met by thermal power, especially as the outlook for hydel and nuclear power is not so rosy.

It is encouraging to see that an entire session in the Conference will be devoted to issues pertaining to production, augmentation and alternative usage of Coal.

I am confident that the exchange of ideas among technocrats and coal professionals at this conference will help the Indian Coal Industry in the future.

I wish the Conference great success and congratulate the organisers for their well-planned endeavour.

Anil Kumar Jha
Chairman, CIL

Ph. : Off. : (033) 2324 6611/2324 6622, Fax : (033) 2324 4023 ▪ Email : chairman.cil@coalindia.in ▪ Website : www.coalindia.in

राकेश कुमार
RAKESH KUMAR
अध्यक्ष सह प्रबंध निदेशक
Chairman cum Managing Director
NLC India Limited
(formerly Neyveli Lignite Corporation Limited)
Navratna - Govt. of India Enterprise
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Dated 16-09-2019

Message

The challenges of meeting the coal and lignite demand have come to occupy centre stage in energy sector as huge installed capacity has been created for power generation. However with the increased emphasises on Renewable Energy, Fossil Fuels like Coal and Lignite have to start focusing on alternative use of rich resources of the country. The theme of 7th Roundtable Conference on Coal **"Indian Coal: Potential and Diversifications"** is a step in the right direction. With adoption of technology of reducing moisture in Lignite, this source can be ideal feedstock for Lignite to Gas, Lignite to Liquid, Lignite to Chemicals and thereby minimise import of such chemical.

7th Roundtable Conference on Coal will provide a very important platform to all the stake holders to deliberate in an open manner to suggest changes in policy and find ways & means to meet growth in production in a sustained manner for alternate use of coal and lignite.

I am confident the experts of India Energy Forum (IEF), Indian School of Mines Alumni Association, Delhi Chapter (ISMAADC), along with Mining, Geological and Metallurgical Institute, Delhi Chapter (MGMIDC) being organised on 24th September, 2019 at Hotel Le Meridien, New Delhi will surely come up with recommendations to meet the demand of coal in the country.

I wish the conference a success!

Rakesh Kumar

(Rakesh Kumar)

पंजीकृत कार्यालय : प्रथम तल, नं. 8, मेयर सत्यमूर्ति रोड, एफएस.डी, एग्मोर कांप्लेक्स, भारतीय खाद्य निगम, चेतपेट, चेन्नै - 600 031.
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Rajiv R. Mishra
Chairman-cum-Managing Director

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website : http//westerncoal.gov.in

Message

It gives me immense pleasure to note that the Mining Geological and Metallurgical Institute (MGMI), Delhi Chapter and Indian School of Mines Alumni Association (ISMAA) Delhi Chapter jointly with India Energy Forum (IEF) are organizing **7th Roundtable Conference on Coal** with theme of **"Indian Coal : Potential and Diversifications"** on 24th September, 2019 at Hotel Le Meridien, New Delhi.

Coal is the dominant source for generation of power of India as it accounts for 55% of the country's energy need. The present reserve of coal substantiates its role to continue to occupy the centre-stage of India's energy scenario in the foreseeable future. The accelerated rate of growth in demand of coal throws an enormous challenge to Coal India Limited and its subsidiaries. Now a stage is also set for coal sector to accept challenges from renewable energy sector and so coal sector need to focus on Diversified uses of coal.

The topic of the conference, therefore, is of great importance in the present situation. I am sure, the deliberations at the conference will come up with concrete steps to be taken to attain the objectives.

I wish the 7th Roundtable Conference on Coal a grand Success.

(Rajiv R. Mishra)

शेखर सरन
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Message

It gives me immense pleasure to note that Mining, Geological, and Metallurgical Institute (MGMI) jointly with Indian School of Mines Alumni Association (ISMAA) and India Energy Forum, are organizing 7th Roundtable Conference on Coal on 24th September, 2019 at New Delhi with theme "Indian Coal : Potential and Diversifications".

Coal provides 56% of India's energy needs & about 73% of the entire power generation in the country is coal based. It holds the most dominant source of energy in the energy basket of India. The present reserve of coal of about 319 Billion tonnes endorses its role to continue to occupy the centre-stage of India's energy scenario in the foreseeable future also. However, concerns of environmental, grade quality related, logistical etc., must be addressed for its sustainable future. Additionally, emphasis on diversification of use of coal through gasification of coal is as vital. The advancement in recovery and utilization techniques viz. Coal bed Methane (CBM)/Coal Mine Methane (CMM), Surface Gasification of coal, etc., as a source of clean energy, have multi-faceted advantages for the country's energy needs and economy. I am sure that deliberations in the Round Table Conference will come out with relevant recommendations for the sustainable growth in energy sector and alternate use of Indian coals.

I wish the Conference a grand success.

(Shekhar Saran)
Chairman-cum-Managing Director

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Message

One of the important parameter of assessing growth of economy is per capita consumption of Electricity. Thus availability of Power is one of the most important parameters which requires capacity building in generation and availability of raw materials like Coal. Thrust has been on non-conventional Energy these days, however for sustained supply of Power specially as base load dependence on coal as fuel is being envisaged for 3 to 4 decades till a cost effective large capacity storage system gets established. So coal as source of Electricity shall remain as main stay for growth of our economy. However, to utilise large resources of coal, it is time to work out alternate use of coal.

I congratulate the organisers in selecting the topic **"Indian Coal : Potential and Diversifications"** organised by Mining, Geological, Metallurgical Institute of India (MGMI -DC), ISM Alumini Association (ISMAA – DC) and India Energy Forum (IEF), for an appropriate theme of **7th Roundtable Conference on Coal** being held on 24th September, 2019 at Hotel Le Meridien, New Delhi.

I wish the conference a great Success.

(N.SRIDHAR)
Chairman& Managing Director

SATISH PAI
MANAGING DIRECTOR

Message

I am happy to note that Mining, Geological and Metallurgical Institute of India (MGMI-DC) jointly with Indian School of Mines Alumni Association, Delhi Chapter (ISMAADC) and India Energy Forum (IEF) are organising the 7th Round Table Conference on Coal in New Delhi on 24th September 2019 on the very relevant topic "Indian Coal – Potential and Diversification".

Coal is an essential component of India's growth. With manufacturing at the heart of India's growth model, a large rise in energy is needed to fuel India's development. Coal-fired plants today account for 72% of the country's electricity. This fuel will continue to remain an important part of India's energy mix for the next few decades, along with renewables. The coal sector must, however, vigorously pursue new technologies for more efficient combustion of coal, which will improve its environmental performance significantly.

India is home to the fifth largest coal reserves in the world. In spite of being endowed with 319 billion tonnes of high-quality coal resources, India is one of the largest importers in the world. Coal imports have swelled in recent years – from 191 million tonnes in 2016-17, to more than 235 million tonnes of coal today, valued at a staggering Rs. 1.7 lakh crore.

Industrial production and power generation are bearing the brunt on many fronts. Importing high-grade coal to generate power is a costly endeavour, particularly for industries such as aluminium – a key metal for infrastructure, power, defence and other strategic sectors. The immediate challenge for the Indian coal industry, therefore, is to make the country self-sufficient in power grade coal.

For the coal sector to survive and support India's growth vision, this critical resource could also be made available in a new form – as a feedstock for industries like fertilizers, chemicals and pharmaceuticals. The two parts of the round table's theme – Growth and Diversification – therefore, cover the present and the future challenges for Indian coal.

I am confident that the deliberations at the Conference will lead to the formulation of strategies, which will help domestic coal to continue contributing to the competitiveness of Indian businesses. I wish the 7th Round Table Conference on Coal great success!

Satish Pai

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SECTOR HEAD
MINERAL RESOURCE DEVELOPMENT - ADITYA BIRLA GROUP
MANAGING DIRECTOR
ESSEL MINING & INDUSTRIES LTD.

ADITYA BIRLA GROUP

Message

I am very happy to learn that Mining, Geological and Metallurgical Institute of India, Delhi Chapter (MGMI-DC) jointly with Indian School of Mines Alumni Association, Delhi Chapter (ISMAADC) and India Energy Forum (IEF) are organising the 7th Roundtable Conference on Coal on 24th September 2019 at Hotel Le Meridien, New Delhi.

Indian economy has the distinction of being the fastest- growing major economy in the world and one of the prime requisites for maintaining and for improving on the present growth rate is sustained availability of assured and affordable energy. India being richly endowed with huge Coal resources and not being as fortunate in other fossil energy sources, it is Coal that will ensure this availability at least till the technology for storage of Renewables-based electricity gets developed to economically viable status.

Unfortunately, Coal-shortage in India appears to have assumed endemic proportions and it is impacting Industrial production. It is therefore in the fitness of things that this conference will dwell on this aspect of Indian Coal industry.

Simultaneously this Industry will also have to be ready for another challenge which is gradually building up globally in the sense that world-wide there is an appreciation that the Globe will not be able to absorb the massive addition of Greenhouse gases that is taking place today. If coal has to remain relevant in future also it has to change its color as well as role to become Greener and to take the garb of Feed-stock than Fuel.

It is obvious from the list of subjects to be discussed and Authors who will present papers that the Conference will be in a position to present the way ahead for the Industry to meet the current as well as the future challenges.

I wish the conference a grand success.

Tuhin Mukherjee

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Ganesh Chandra Mrig
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Former CMD: Bharat Coking Coal Limited (BCCL) & South Eastern Coalfields Limited (SECL) (GOI U/T)
Former Promoter-MD: ACB (India) Limited
President: ISMAA Delhi Chapter
Vice President: India Energy Forum

Message

It is indeed a great pleasure that India Energy Forum, MGMI & ISMAA Delhi Chapter are jointly organising the 7th Round table conference on Coal on 24th September 2019 at New Delhi.

The Theme selected "Indian Coal – Potential and Diversification" is the need of the hour.

Inspite of Green Energy, Coal is going to stay for some more time. Today country needs more coal and we will have to produce.

I am sure together we can contribute a lot for the development of the Coal Sector which will in-turn boost the pace of nation building.

I wish the conference a grand success!

Ganesh Chandra Mrig

Place: Gurgaon
Date: 01/09/2019

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Message

I am happy to note that Mining Geological and Metallurgical Institute of India (MGMI-DC) jointly with Indian School of Mines Alumini Association, Delhi Chapter (ISMAADC) and India Energy Forum (IEF) are organising 7th Roundtable Conference on Coal on 24th September, 2019 at Hotel Le Meridien, New Delhi.

Coal is one of the important raw-material for development of energy and thereby economy. For fulfilling the challenging task of "24x7 power for all by 2019-20" coal sector has to play pivotal role by stepping up of coal production. Country is targeted to produce over 1 billion tonnes of coal by within the current financial year. The constraints and bottlenecks in this area need to be addressed from time to time. I am sure deliberation during the conference would focus on such area also. The theme of Summit **the "Indian Coal – Potential & Dimensions"** is very pertinent in the present scenario.

I congratulate the Organisers of the Conference for choosing the relevant topic and wish this conference great success. I am sure the conference will come out with the recommendations which will be useful in energising Coal Sector.

Capt R.S. Sindhu

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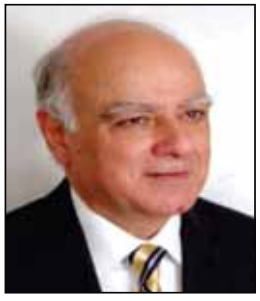
Anil Razdan
President, India Energy Forum
Former Secretary, Ministry of Power
Government of India



Message

The 7th Roundtable Conference on Coal is one of the flagship events of the India Energy Forum. It has evoked keen interest from energy experts, domain specialists and commercial establishments connected with the coal sector. The Roundtable Conference will deliberate on issues related to Coal Production, Meeting the Demand, Coal Diversification and Cleaner use of Coal like Coal to Oil, Coal to Gas, and Coal to Chemicals.

Coal continues to be India's dominant energy fuel and will continue to do so for some years. The production of Coal and coal based power generation are largely indigenous and besides providing energy security, are also a major employment avenue in India.

Globally, concerns related to Climate Change and atmospheric pollution have increased in recent years and the use of fossil fuels is being discouraged. India has made a commitment at CoP 21 in Paris to reduce by 2030 the emissions per unit of GDP to a level 33% lower than in 2005. However, with larger universal electrification programmes like Saubhagya, and increased industrial, activity particularly in the metal industry, the domestic requirement of coal has been increasing over the years. India continues to import metallurgical and steam coal. The Indian coal industry is facing the paradox of increasing coal demand in the immediate future and the prospect of reduction in the demand for steam coal, a decade or two later, when renewable fuels will dominate electricity production.

However, coal is a very versatile element of nature. Combustion is only one of possible uses. Coal can eminently be used as feedstock for conversion to oil, chemicals, fertilisers and methanol. Coal to Liquids, Coal to Gas, Coal to Chemicals are the prospects for the future. However, this paradigm shift can only take place if there is accelerated investment in Research and Development as well as in the new identified sectors of diversification. The theme and the sessions of the Round Table Conference have been selected with this in view.

The India Energy Forum is thankful to the Mining, Geological and Metallurgical Institute of India (MGMI), Delhi Chapter and the Indian School of Mines Alumni Association (ISMAA), Delhi Chapter for their collaboration in this event.

I wish the 7th Roundtable Conference great success!

Anil Razdan

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Section-2

About 7th Roundtable Conference on Coal

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7th Roundtable Conference on Coal

"Indian Coal: Potential and Diversification"

29th September, 2019 • New Delhi

Roundtable Conference on Coal

This Roundtable is organised on a Biennial basis jointly by India Energy Forum, a premier think tank in the country on Energy issues, Delhi Chapter of Mining, Geological and Metallurgical Institute of India (MGMI) which is the oldest professional body in India looking after Mining, Geology and Metallurgy Sciences and Indian School of Mines Alumni Association which has been making meaningful contribution in the field of disseminating knowledge about advancement of Mining Science and Technology.

The idea of having this Roundtable Conference arose out the fact that Coal has been and will continue to be the prime commercial energy source in India and a suitable platform should be available for dissemination of knowledge about developments in coal Sector and exchange of ideas among Policy Makers and Coal Professionals for guiding the destiny of the Indian Coal Sector.

The subject Conference will be 7th in the series and has been conceptualised and designed taking into account the Coal scenario in India as it exists today and is going to unfold in immediate as well as long term future & the challenges that Coal Sector in India will have to tackle arising out of global campaign for cutting down on Coal consumption.

Preamble

Indian Coal Sector is facing an unprecedented dilemma arising out of :

1. Country's commitment at Paris to cutting down on Green House Gas Emissions by 30% compared to the level in 2005.
2. The coal requirement in the country going up and projected to grow atleast for next two decades which will surely add to Green House Gas emissions.
3. Despite being endowed with huge coal resources of the order of 320 billion tons, the country not producing enough coal to meet its requirement and dependence on Import going up and
4. Ultimately when the country's dependence on Coal as a prime energy source is over, diversification in its usage so that the Nature's bounty in the form of coal resources can continue to be utilised for making effective contribution. Despite all the advances made in the country towards improving the living standard of the large population by providing more energy/ power per capita, India is still at 1/3rd of the world average. This indicates clearly that there is a massive leeway to be made. This means not only providing more affordable but also more reliable power on 24/7 basis to the consumers particularly to the poor and rural segment of the population. In this context, Coal is the only energy source since country is deficient in other Fossil energy sources like Oil and gas, Hydel power involves submergence of huge land mass and Nuclear energy still has safety related issues .

A very ambitious programme for creating 175 GW generation capacity based on Renewables has been launched but this, in the present state of technological development will not contribute to base load requirement for which dependence on Coal will continue.

As per projections available going forward the share of Coal in the over all energy basket in the country will go down but total coalrequirement in absolute terms will continue to grow. Normally, with the huge resource base, the country should have no problem in meeting its requirement but unfortunately, the coal shortage has become endemic and the import dependence has continued to grow.

The immediate demand on Indian Coal Industry is therefore, to produce enough for meeting the country's needsand yet the production and consumption systems have to be made so environment - friendly that these don't make unacceptable addition to Green House Gas emissions.

Simultaneously, it has got to be accepted that going forward, a day will certainly come and it is not very far off that Coal will lose its dominant position in the country's energy scenario and yet country will not be able to lose the huge contribution that Coal is making to the national economy.

Coal, fortunately is a very versatile commodity- it can be used as an energy source as well as the feed - stock for producing chemicals and other products which are more valuable than the power for generating which coal is primarily used today.

Development of technologies for other gainful usage of coal will take time, resources and dedication and it is time that we get down to this task so that there is no time-gap between the loss of dominant position of Coal as energy source and effective utilisation of Coal for producing chemicals, fertilisers, oil etc.

This requires well-planned and well -coordinated efforts on the part of policy makers, mine planners, coal producers and coal consumers .

On the one hand effective steps need to be taken for achieving immediate increase in coal production to cut down on Imports and evolving technologies for use of non-coking coal for steel production development of appropriate India -centric technologies for reducing the impact of coal combustion on environment and on carbon capture and sequestration and on the other we have concentrate on deploying established technologies & engage in serious R&D efforts to develop new technologies for utilisation of our coal resources for valuable products like Chemicals Fertilisers , Oil etc.

It is in consideration of this task ahead that the theme for the Round Table has been selected as “Indian coal- Potential and Diversification”.

The focus of the Round Table Conference will cover the entire Coal value-chain starting from exploration, production, utilisation and Research and Development so that the task before the Indian Coal Sector – meeting the current and future requirement of Coal, making Coal utilisation environment - friendly and enabling coal continue to make its contribution to the National wealth even when it becomes a secondary player in matters of power generation is achieved.

Relevant issues to be dwelt upon have been identified as under :

1. Augmenting Coal production –
    a. Expediting Approvals
    b. Land Acquisition and R&R
    c. Creating Evacuation Infrastructure
    d. Making coal value -chain environment friendly and diversification in coal usage.
2. Coal Beneficiation
3. CBM
4. Alternative Usage of Coal
    a. Coal Gasification-U/G & Surface
    b. Coal to Liquid/Chemicals/Methanol/ Fertilisers

Successful organisation of an Event of this nature and magnitude will require the active support of all the stakeholders in Coal Sector like Coal Producers, Coal Consumers, Regulatory Authorities in general and that of Ministry of Coal, Ministry of Power, Ministry of Environment and Forests, Ministry of Steel, Ministry of Chemicals and Fertilizers, Indian Railways, concerned State Governments in particular. This support has already been sought and assured.

About Organisers

India Energy Forum

The Forum is a unique NGO, which promotes energy sector as a whole. Most major players in Power, Oil & Gas, Coal and Renewable are our members. These include NTPC, NHPC, Power Grid Corpn., Power Finance Corpn., PTC, Tata Power, ALSTOM, ONGC, IOCL, CIL, Neyveli Lignite Corporation, Vestas RRB, JP Group, Bhilwara Group and about 110 eminent energy experts. In addition, it has MOUs with leading regional chambers and specialized organizations including Bombay Chamber, Bengal Chamber, Bangalore Chamber, Madras Chamber, PHD Chamber, Observer Research Foundation, IRADE, INWEA, MGMI-DC, ISMAA-DC & FIPI and work closely with them.

MGMI - Delhi Chapter

MGMI is one of the oldest professional Institutes of its kind in Asia having being founded in 1906. It has been organizing conferences and seminars on issues impacting the mineral sciences. MGMI is a unique, independent, non-profit organization and represents professionals of the mineral sector as a whole. It is manned by highly qualified and experienced mining engineers, geologists and metallurgists and energy experts.

Indian School of Mines Alumni Association (ISMAA)-Delhi Chapter

The ISM Alumni Association continues to provide yeoman service to the mineral industry in India as well as abroad with complete dedication and commitment to the mineral industry. In appreciation of the fact that the prime pre-requisite for industrialisation in India will be a sound Mineral Sector, Govt of India way back in 1926 set-up a world class Mining Institution at Dhanbad which was named Indian School of Mines and Applied Geology. This was formally inaugurated by his Excellency Lord Erwin the then Viceroy on 9th December 1926. Now named as Indian School of Mines, it has become a full -fledged University and the Captains of Indian mineral Industry take pride in calling themselves the Alumni of this world class Institution. ISM Alumni Association works as a think tank for Mineral Industry in India and coordinates with ISM Alumni abroad for updating and upgrading mineral science in the country.

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Glimpses of Previous Conferences

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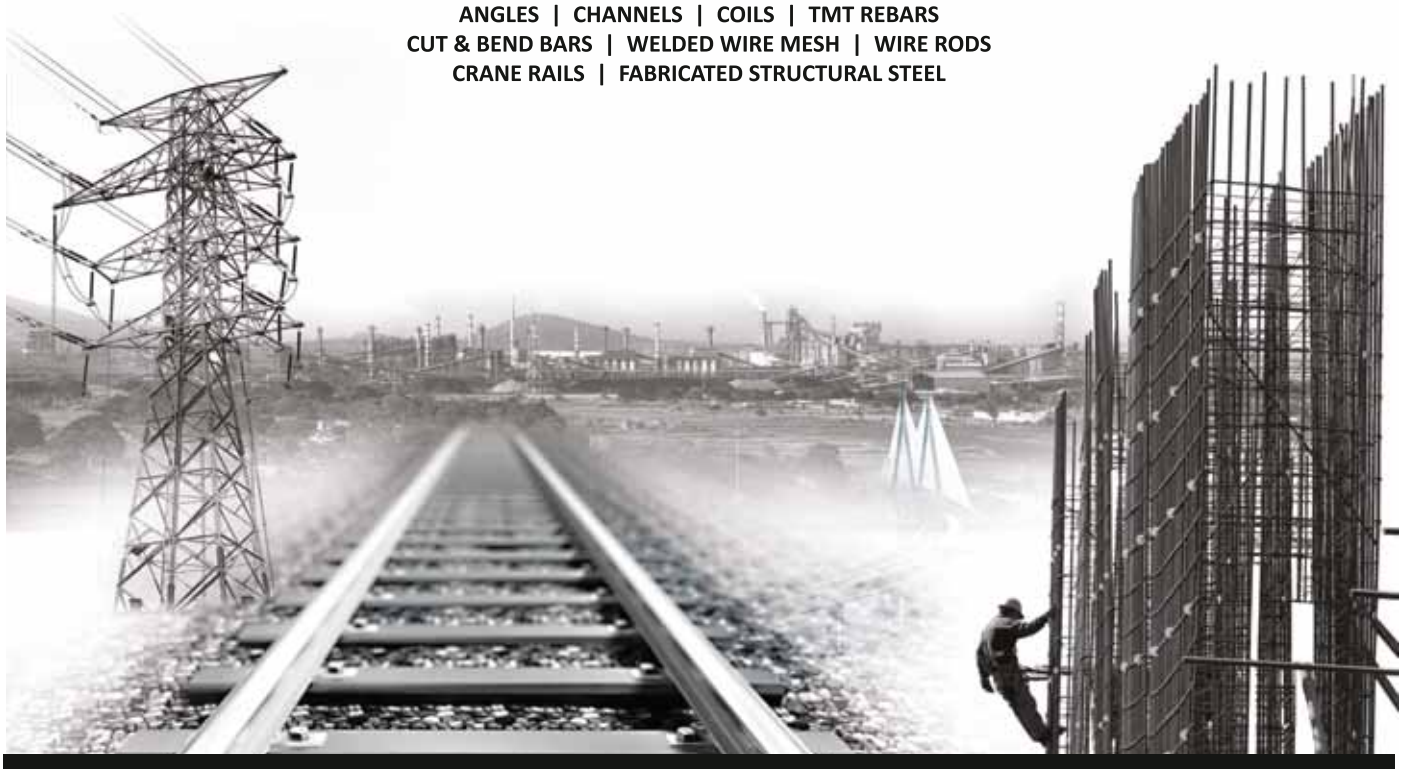

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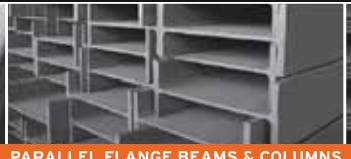

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Section-3

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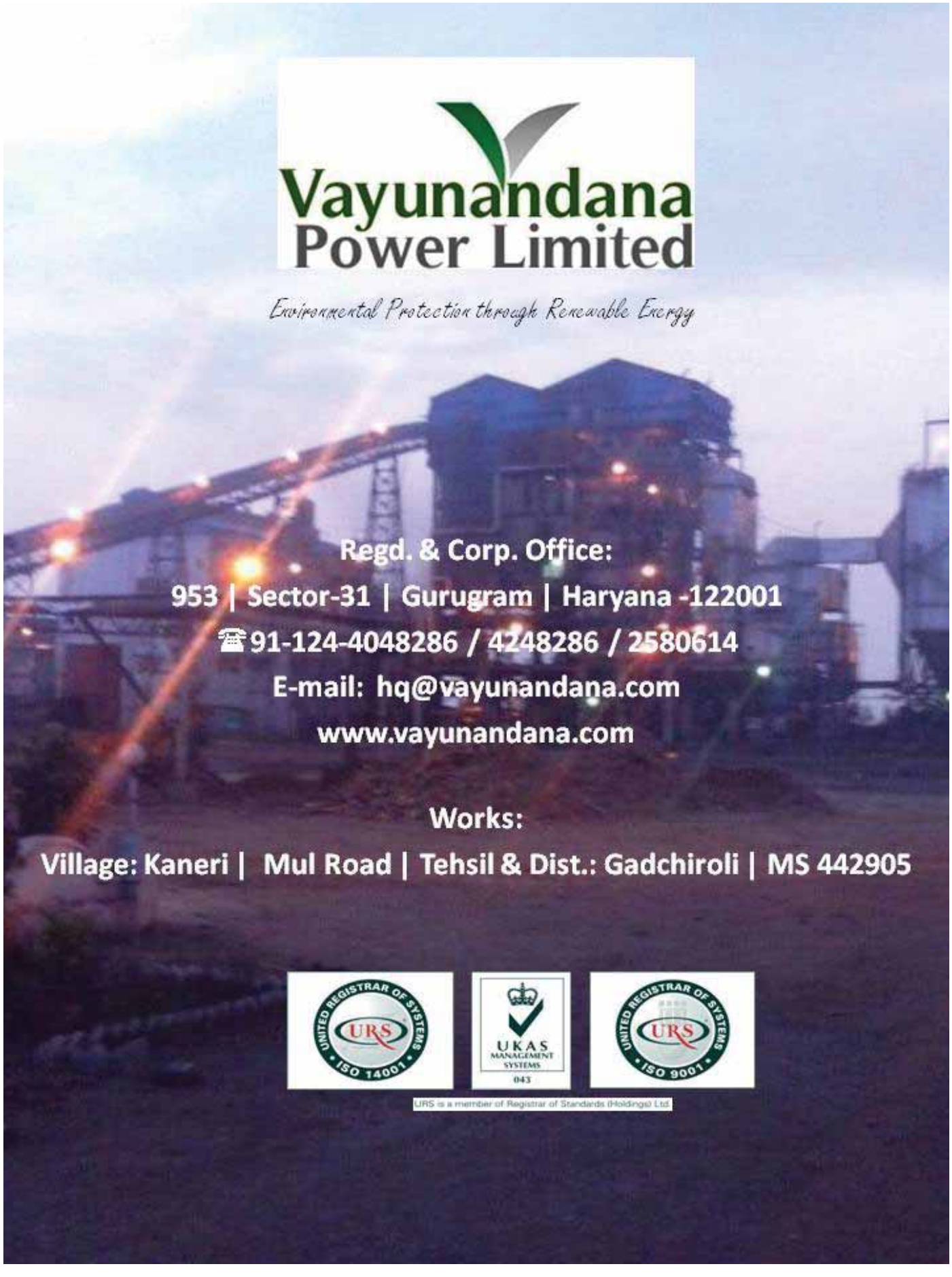
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7th Coal Summit 2018

Theme : "Can India Grow Sustainably without Green Coal?"

5th & 6th September, 2018
Hotel The Ashok, New Delhi

RECOMMENDATIONS

1. ***Coal Demand and Supply***

India is blessed with huge coal resources. As per latest estimates it is of the order of 320 billion tons-most of it of non-coking variety. Even the Proven Reserves are of the order of 140 billion tons .

Further coal production in the country has always maintained a growing trend though slow some times but generally of the order of 4-5%. Despite this . the country is facing almost an endemic coal shortage and its dependence on import even for power grade coal has also become a permanent feature.

This is the situation when almost 1/3rd of country's population is going without electricity connection and even the remaining 2/3 rds are facing problems on account of poor quality of power supply . The current PLF is only of the order of 63% and if the PLF goes to a normal 80-85% the coal shortage will increase by another 200 million tons per annum.

The coal demand/ supply scenario has got to be looked at from this angle and the industry has to intensify its efforts towards increasing the rate of growth in coal production so that the need for coal import is eliminated at least for power grade coal. The coal production target of 1500 million tons by 2022 has therefore, to be pursued vigorously and for achieving this various measures have to be taken like adoption of modern coal mining technologies and simplification of systems for grant of statutory clearances particularly forestry and environment clearances and land acquisition and rehabilitation and resettlement of Project Affected People.

2. ***Structure of Indian Coal Industry***

Till about 1993, the entire Coal Industry in India was in Public Sector barring a few Captive Mines of TISCO, IISCO & DVC.

For the sake of keeping inflationary pressure in the economy under control, coal prices were regulated by Govt. and Public Sector Coal Companies were -being subsidised through the budget. Once the economy was liberalised in 1993, Budgetary support to Coal India was withdrawn and it was felt that Coal India would not be able to generate adequate investible funds for opening new Coalfields/new Coal Projects for increasing production to meet the country's ever increasing coal requirement.

The solution was found in the form of Captive Mining. Close to 220 coal blocks of various sizes were allotted to Private Sector as well as Public Sector companies in Power, Iron and Steel

including Sponge Iron and Cement Sectors. These were to be worked only for meeting the Captive requirement of the Block allocatees. Various problems however stood in the way of Captive Mining delivering as per expectations. The result was ever-increasing coal shortage and dependence on coal imports.

The route that Coal industry should take for achieving the required growth in production so that the Nation's coal requirement could be met from domestic Coal has been under consideration for a long long time. One of the alternatives that has been considered at various times is splitting of Coal India subsidiaries into smaller companies. This has however, its own minus points and it has not been implemented.

Globally, major part of the Coal Industry has always been and is even now in Private hands and the path for adopting a similar model in India was cleared through The Coal Mines (Special Provisions) Act 2015. A decision has been taken to open Coal Sector for Commercial Mining Public consultations have also been held and the detailed methodology for conducting Auction for allocation of Blocks for Commercial Mining is under consideration.

It is hoped that this major reform in Coal Mining would pave the way for introduction of improved mining technologies as well as Modern Mine Management practices in Indian Coal Industry which should go a long way in increasing the rate of growth in Coal production and minimising the need for Coal Import.

PS : Regrettably an announcement has come that the very idea of opening the Coal Sector to Commercial Mining has been dropped .

3. ***Coal Beneficiation***

Indian Coal is of Drift origin, it is inherently dirty having very high Ash content and is very difficult to wash. Almost 95% of Indian Coal comes from Open Cast Mines where the operations are carried out by mechanised means and as the depth of these mines increases and the Stripping Ratio becomes more adverse, bigger equipment are being deployed. These big equipment also mean high levels of production and it is not possible to pick out stones from such high production mines manually.

The Planning process for Opencast Mines has been re-designed with quality as the focus but this can make only marginal difference in Coal quality. The ultimate solution is Coal Beneficiation so that the Ash content in the Coal can be brought down to the desired level.

Though the benefits from Coal washing were established way back in 1986, the power sector was rather reluctant to accept washed coal on account of increase in price.

MOEF has however, forced the pace in this regard by issuing a mandate in 1997 making it obligatory on the part of Power Stations located at more than 1000 kms from the Pitheads and those located in environmentally sensitive and critically polluted areas to use coal having less than 34% ash. This did give an impetus to coal washing but the reluctance in power sector persisted.

This cut -off distance has been brought down by MOEF to 750 kms and now to 500 kms. While the

prescribed date for implementation of this mandate is long over both Power and Coal Sector have failed to honour it so far. This resistance primarily comes from those power stations which are located just marginally above 500 kms from the concerned coal source. Their argument is that the additional expenditure inherent in use of washed coal makes their power unattractive in "Merit Order" through which the Discoms decide to select their power source.

It is therefore recommended that use of washed coal should be made mandatory for all power stations. On the one hand, this will help reduce the emission of Green House gases and on the other it would reduce the cost of power since it has been established very conclusively that use of washed coal is economically beneficial even for pithead- based power stations.

An other problem that stands in the way of large- scale washing of power grade coal is the MOEF mandate that all washery rejects irrespective of their quality should be used for power generation through Fluidised Bed boilers. It has to be understood that utilisation of Rejects for Power generation will be beneficial only if the quantum of power that can be generated from the Rejects is more than the power that would be consumed in pulverisation of the Rejects for making it fit for FBC Boilers

It is therefore recommended that this mandate of MOEF should be suitably amended so that only such Rejects are to be used for Power generation where the power that can be generated is more than the power that will be consumed in pulverisation of the Rejects & other associated activities.

It is also recommended that the stress should be on improvement in washing technology so that Heat value in the Rejects is reduced to the minimum.

Simultaneously intensive R&D efforts should be undertaken for evolving better washing technologies including Dry Beneficiation and Chemical Cleaning of Coal or combination of various such technologies.

4. ***Statutory Clearances***

Coal Industry in India is highly regulated and is subject to control by a large number of Statutory provisions. For opening a new Coal Mine series of clearances has to be obtained and the most time consuming ones among them are the Forestry and Environmental clearance.

The industry recognises that O/C mining which is the default mining system in the country damages the valuable forest cover but then it has developed the expertise for regenerating better quality forest after the mined out land is reclaimed. Similarly , so for Environment is concerned the industry recognises its responsibilities and commendable work is being done on this front too.

It is therefore, recommended that grant of these clearances should be made streamlined and it should be ensured that opening and construction of coal mines does not get delayed on account of delay in grant of these clearances.

An other major problem that the industry is facing is the difficulty in Land Acquisition and Rehabilitation and Resettlement of Project Affected People. Industry has made a commendable

beginning in respect of land reclamation by making the reclaimed land fit for agriculture . The Coal Companies as well as Project Affected People should be encouraged to go for leasing of land instead of acquisition or purchase thereof . In the Leasing system, the land could be reclaimed after mining operations are over to its original status as far as possible or to cultivable status and could be returned to the land owners with adequate compensation for that portion of their holdings which has not been reclaimed . During the Lease period the land owners could be paid handsome lease rent which could be more attractive than the value of the crop that they would have got from the land.

5. ***Coal Transportation***

The actively mined coalfields in India have more or less reached the saturation level in so far as Coal production capacity is concerned. Naturally the additional coal that the country requires will have to come from un-developed coalfields or under developed ones . These Coalfields are almost totally devoid of infrastructural facilities particularly Rail-connectivity.

In India, construction of Railway Lines is the monopoly of Indian Railways and construction of new Lines is a very capital intensive , long drawn and time consuming process. This is partly on account of Railways' time consuming process & their shortage of Funds.

While Coal companies are coming forward to help Railways with funds the construction part has to be handled by Railways alone . Because of this delay in construction of Rail Lines, the mines get developed earlier and pressure for coal supply being as intense as it is , the Coal company has no choice but to resort to Road transport for Coal evacuation.

Road transport is inherently anti-environment since it involves large scale burning of Diesel and it also generates dust all along the route which the trucks take.

Even otherwise, this involves burning of high quality fuel like diesel for transporting low quality fuel like Coal and is therefore, not only unscientific but also wrong from economic angle.

It is therefore recommended that Coal evacuation facilities should be constructed to synchronise with the mine development and road transport of coal should be avoided.

6. ***Coal Combustion***

On account of financial constraints, in India we continue to run the power plants even after their rated life is over. As a result, a major part of Coal -based power generation in the country is still based on sub-critical technology. Globally, however, tremendous advances have been made in Boiler Technology and most of the coal-based power generation is now based on super-critical and even ultra super-critical technologies.

Improvement on other fronts have also been achieved as a part of Global efforts towards High Efficiency Low Emission (HELE) Power Generation.

It is recommended that all new Power Plants should be based on HELE technologies and all old power plants based on sub–critical technology should be gradually phased out.

7. ***Coal Bed-Methane***

Coal Bed-Methane (CBM) is a clean source of energy of which plenty is available in the country as has been proved by the limited amount of work that has been done in Raniganj Coalfield.

Apart from CBM, Methane is also available in the form of Coal Mine Methane (CMM), Ventilation Air Methane (VAM) and Abandoned Mine Methane (AMM).

Theoretically speaking Methane from these sources can also be harnessed though it requires sustained R&D efforts to establish their technical & commercial viability. Fortunately, lot of work has been done abroad on these fronts.

Currently, all this Methane is getting released into the atmosphere & Methane being a more potent green house gas than CO2 is making very substantial contribution to global warming. At the same time, Methane is a Clean Energy Source. It is therefore imperative that ways & means are evolved for gainful utilisation of all forms of Methane.

It therefore recommended that a comprehensive programme for establishing and exploiting Coal Bed Methane should be launched and collaboration agreements should be entered into with companies abroad which have developed expertise on harnessing CMM, VAM & AMM.

8. ***Mine Safety***

Despite all the progress that has been made by the Industry on safety front , the number of mine accidents that the industry faces even now is unacceptable. Globally, new concepts have been developed for making the mines safer. The industry should take help from abroad for introducing safe Mining technologies and Safety Systems which have made their mines safe.

It is also recommended that mine specific Safety Management Plans should be prepared and sustained programme for making the entire work force part of this plan should be launched at each mine.

9. ***Alternative Usage of Coal***

While it is accepted that Coal will continue to be the dominant source of commercial energy in India for quite some time to come , it has also to be admitted that its share in the Energy -mix will gradually go down with Renewables occupying more space . Coal however, is a very versatile energy source and it can be the feed-stock for production of very valuable products like Ethanol, Methanol, Petroleum products and fertilisers etc.

It is gratifying to see that Projects for producing, Methanol and Fertilisers have already been launched in our country.

It is recommended that intensive R&D efforts should be undertaken for selecting Coals which can produce the best results in this respect .

It is also recommended that the steps initiated earlier for conversion of Coal into Liquid should be revived. Established technologies in this regard are available abroad and these technologies should be imported through Collaboration Agreements particularly when the entire economy of

the country is getting de-railed on account of sustained increase in prices of Petroleum products.

10. ***Emerging Technologies***

A very learned presentation was also made on the emerging technologies for reduction of Moisture in High Moisture Coal and Lignite. These technologies can bring down even Inherent Moisture in Coal.

Normally, Indian Coal has Low Moisture but going forward , these technologies may prove to be useful in case of Lignite in India and also in case of import of Low Ash High Moisture Coal from Indonesia for Coastal Power Stations which are designed for burning Low Ash Coal. Reduction of Moisture in such Coal would improve its Heat Value and Combustion quality and also reduce the cost consequent upon reduction in freight which would take place because of reduction in weight of coal arising out of reduction in Moisture.

Scientists in Wyoming University , USA have evolved a technology for reducing Ash in Coal which could convert Thermal Coal into Coal suitable for Metallurgical purposes. This could enable High Ash Washery grade Coal in India being converted into Metallurgical Coal . Similar success has been achieved on reducing moisture in Coal to improve its Heat Value.

Indian Coal Industry should take a serious look at these technologies particularly De-ashing of Coal in the context of ever increasing Import of Metallurgical Coal against heavy out-go of precious foreign exchange.

An other technology that received close attention pertain to Carbon Capture and Sequestration . It was however, noted that this technology is yet to reach Commercial scale application. Going forward however, it may have relevance to Indian conditions .

6th Roundtable Conference on Coal

Theme : Indian Coal – Today and Tomorrow

20th September, 2017
Hotel Le Meridien, New Delhi

RECOMMENDATIONS

The entire gamut pertaining to Coal Mining Industry in India was discussed at 3 Technical and 1 Valedictory session and the following recommendations have emerged:

1. **Coal Demand and Supply :** The healthy Coal Production trend in 2014-15 and 2015-16 created a situation of Coal surplus in the country which continued till the first half of 2017-18 when all of a sudden a shortage situation developed again. Analysis has revealed that low off-take of Coal in first half of 2017-18 was on account of adequate stocks at Power Stations and this prompted Coal India Ltd to peg down production at certain mines with the result that when the coal demand picked up in the 2nd half of the year the shortage situation re-appeared. It is therefore, recommended that a protocol should be worked out so that the Power Stations lift their pre-determined coal quotas month after month and if they fail to do so, Coal India should be compensated monetarily for keeping the Coal in their stock on behalf of the defaulting power stations.

2. **Transport Logistics :** Bulk of the increase in coal production is to come from new or else under-developed Coalfields. As it is, rail connectivity in major coalfields like Korba, North Karanpura, Talcher and IB Valley is in-adequate, the same in developing/to be developed Coalfields like Mand-Raigarh and Hasdeo Arand is practically non-existent. It is therefore, recommended that expansion of rail connectively in these 6 coalfields should be taken up on mission mode.

   Simultaneously eco-friendly transportation systems like Coal Slurry Pipelines, Riverine transport of Coal and Coastal Shipment should also be encouraged.

3. **Coal Quality :** Considering the fact that Indian Coal is inherently of poor quality steps should be taken for incentivising coal washing . As a major step in this direction MOEF's mandate that the washery rejects must be utilised for power generation should be given a fresh look. Instead Stress should be on improving the quality of washing so that the Heat Value in the Rejects is reduced to the minimum and only those Rejects should be mandatorily used for power generation wherein the Heat Value is more than 2200 K/Cal/Kg.

4. **Land Acquisition and Reclamation :** There was unanimity on the fact that going forward land acquisition would become more and more difficult. It was therefore recommended that instead of outright acquisition of land, the fact that the mines have limited life should be taken advantage of and land should be taken on lease with handsome lease rent being paid to the land owners and non -forest land being reclaimed to Agricultural quality as far as possible. Since this will entail additional expenditure which the industry in its present financial position is not able

to afford, the funds collected by way of clean environment cess should be made available for subsidising this activity.

Further, an agency in the Govt should be created for taking up reclamation of all old mining sites to make them fit for agriculture/ afforestation and the expenses should be met out of Clean Environment Cess.

5. **Coal Exploration :** About 4000 sq kms of Coal bearing area has not been even regionally explored so far. Further, out of about 310 billion tons of Coal Resources only about 130 billion tons are in "Reserves" category. Exploration activities should be intensified to cover the un-explored 4000 sq kms and to convert all the Inferred/Indicated Coal Resource into "Reserve" category.

   It is also recommended that there should be no restriction on no of bore holes to be drilled as part of Coal Exploration provided no trees are cut. In other cases a minimum of 10 bore holes per sq km should be permitted.

6. **Coal Mine Development Plan :** Time frame specified for achieving different mile stones for Mine development should be made more realistic.

7. **Underground Mining :** It was noted that atleast 40% of the Coal Resources in the country are located in depth range of +300 mtrs and are therefore amenable only to U/G Mining. On the other hand the industry's performance on U/G mining front has not been very encouraging. It is recommended that a broad -based committee consisting of U/G Mining experts from both Govt and non-Govt sectors should be constituted for ascertaining the reasons for this poor performance and recommending appropriate measures.

8. **Up-gradation of Mining Equipment :** It was noted that with the introduction of MDO concept the progress made towards up-gradation of O/C Mining equipment has taken a U Turn and construction equipment are now being used as Mining equipment. This militates against safety as well as environment and should be discouraged.

9. **U/G Mining Equipment :** It was noted that one of the factors which has stood in the way of U/G production has been lack of Indigenous capacity for manufacturing U/G equipment appropriate for Indian conditions. It was recommended that a task force should be constituted for studying the U/G Mining conditions in India and suggesting appropriate designs for U/G equipment which should be manufactured by BEML and MAMC which is being revived.

10. **Tax Burden on Coal :** It was noted that Tax burden on Coal is very high – much higher that anywhere in the world and this together with high rail freight makes Indian coal costly at distant destinations despite the fact that Pithead cost of Indian Coal is by far the lowest in the world. The comparative chart showing the taxation structure on Coal in India and in certain major coal producing countries abroad is enclosed as Annexure I.

    It is therefore recommended that tax burden on Indian coal should be rationalised.

11. **Coking Coal :** It was noted that the country was dependent for its coking coal supply almost to the extent of 80% on Imports. With an ambitious target of 300 mill tons of steel production to be

achieved by 2030 the import volume of Coking Coal will shoot up. On the other hand washery Grade III and IV Coking Coals were being used in the country for power generation. It was recommended that these Coals should be subjected to deep-washing for getting as much metallurgical coal as possible and only the Midlings should be used for power generation.

Further, the existing practice of charging an additional Rs 630/- per ton as Recovery Charges from Power Plants being forced to use Washery Grade III and IV should be stopped.

12. **CBM/CMM :** It is recommended that CBM Blocks allotted more than 5 years but not made operational so far should be deallocated and reallocated to serious players.

13. **Commercial Mining :** The Round table welcomes Govt decision for opening Coal Sector to Commercial Mining. It recommends that the Blocks allotted for Commercial Mining should be capable of supporting large production volumes so that the investment required to be made on transport logistics can get justified.

14. **Alternative Usage of Coal:** It was noted that Coal is a very versatile commodity and can be used for producing items having higher value addition than power generation. It is therefore recommended that while Coal should continue to fuel the power generation, its alternative usage for coal gasification, coal liquefaction and production of Methanol, DME and Ammonia etc should be examined and encouraged.

15. **Skill Development :** Going forward level of mechanisation in both O/C and U/G Mining will increase. The mechanisation will however, yield the desired results only if machines are operated and maintained by competent persons. It is therefore recommended that manpower requirement for future growth in Coal Industry should be assessed and a comprehensive skilling programme should be designed with creation of required infrastructure.

16. **R&D :** Following R&D activities pertaining to Coal should be given priority attention:

    i. Coal Gassification

    ii. ***Coal Bed Methane:*** CBM Cells should be created in CMPDI and in subsidiaries of CIL and CBM activities in the area should be treated as independent projects.

    iii. Coal to Liquid

    iv. Coal utilisation by switching to Super Critical and Ultra Super Critical Technologies for Power Generation

    v. Gainful utilisation of Fly Ash and Washery Rejects

    vi. Wider application of FBC Technology for utilisation of Inferior Grade Coal/ Washery Rejects

    vii. Carbon Sequestration Technology

    viii. Slurry Transportation

    ix. Use of Non-Coking Coal for Steel Making Chemical Industry.

6th Coal Summit 2016

Theme : Indian Coal –Sustaining the Momentum

6-7 September, 2016

Hotel Le-Meridian, New Delhi

RECOMMENDATIONS

1. **Coal Supply:** It is recommended that in view of increase in Coal Production by Coal India Ltd & drop in Coal demand from Power Sector the Coal Distribution/ Marketing philosophy of CIL should be reoriented so as to meet the entire Coal requirement of all sectors in full.

   For this purpose, the FSAs should be modified to provide for the full requirement of the consumers being met on administered price.

   Justification: It was brought out at the conference that Demand for Coal in India had gone down drastically particularly because the financial condition of the Discoms is not healthy and they don't have money to pay for the Coal.

   On the other hand, Cement and Sponge Iron Plants are facing difficulties in meeting their Coal requirement. Further there are quite a few power plants which are ready for commissioning but are not able to do so for non-availability of assured coal supply.

   In this situation it should be possible for Coal India Ltd to meet the unsatisfied demand of all sectors without the necessity for different types of restrictions & curbs.

2. **Coal Transportation:** It is recommended that a comprehensive programme should be prepared and implemented for extending Railway Sidings to the Pitheads and wherever possible Road Transportation should be replaced by Belt-Conveyors.

   In case road transportation is totally unavoidable, a crash programme should be launched for improving the road surface and ensuring that coal is transported only in covered trucks.

   Justification : It was noted that very large quantity of coal is being transported in different Coalfields by Road for reaching the coal to the Railway Sidings or to the Consumers' Plants.

   Road transportation of Coal is the prime reason for Dust pollution in the Coalfields as well as in the areas in which coal transportation roads are located . Such transportation has become necessary since proper Coal evacuation infrastructure has not been developed.

   It was also brought out that road transportation of Coal involves transportation of Low energy Fuel like Coal by burning high energy fuel like Diesel which is against the Law of Economics and in effect, very inefficient and illogical.

   Incidentally, this switch from road transportation to Rail/ Conveyor will also bring down the Oil Import Bill.

   As an alternative CIL should encourage execution of Mine specific FSA with the rider that Coal off taken will set-up infrastructure for evacuation through belt conveyors for such other eco-

friendly systems. Till date the policy provides for such contracts being executed only if the off taken agrees to pay a premium over the notified Coal Price. The scheme does not appear to have taken of possibly because of premium acting as a dis-incentive.

For encouraging eco-friendly Coal evacuation the premium should be done away with.

Utilisation of funds generated from Clean Environment Cess:

(i) It is recommended that an Empowered body should be created for undertaking the reclamation of old unreclaimed opencast mines and this operation should be funded from out of the funds generated through Clean Environment Cess.

Justification: It was brought out that the annual receipt from this cess would be of the order of Rs 25000 to Rs 30000 crores. Though this entire money would be coming from Coal, Coal Sector was getting no benefit out of this fund.

On the other hand, Coal Industry is facing severe adverse criticism arising out of a large number of old Opencast Mines having been abandoned without proper reclamation.

Quite a few of these Mines date back to pre-nationalisation days and the concerned subsidiaries of Coal India Ltd. in whose command area they are located do not have the legal obligation for their reclamation.

Some of these subsidiaries may not also be well placed financially to meet the expenses on such reclamation.

3. **Coal Distribution Policy**

It is recommended that for ensuring that Indian Coal price remains competitive despite the drop in International Coal price, the current Dual Pricing Policy as per which different prices for Coal are charged from Regulated and Non-regulated sectors should be given a fresh look.

Justification: For several years now, Dual Coal Pricing Policy has been followed in our country. As per this policy, the Non-regulated sector which covers major Coal consumers like Steel and Cement Industries have to pay much higher price than what the Regulated sector like power industry has to pay. This is based on the perception that Non-regulated sector has the freedom to fix the product prices and they would therefore be able to recover the extra cost paid for coal from the consumers.

This policy however, requires a fresh look in consideration of the fact that International Coal prices have gone down, Railway freight in India has increased and on this account competitiveness of in India Coal has been hurt. It has also to be kept in mind that the Non-regulated Sector also has to face International Competition & the perception about their freedom to fix their product prices is therefore not totally correct. In this situation, Coal consuming industry in non-regulated sector may opt for imported Coal resulting in loss of market for domestic Coal and all the attendant consequences.

4. Underground Mining

It is recommended that for the sake of improving Underground production, a High Powered Committee consisting of both Govt and non-Govt Experts should be constituted for ascertaining reasons for country's failure on Underground Mining front, examining the success stories and identifying Deposits to be taken up for Underground Mining through appropriate Mass Production Technology.

It is also recommended that an Incentive Scheme should be evolved for making Underground Mining Cost Competitive and this Incentive money should come from the proceeds from Clean environment Cess. In this connection Cross subsidy for Underground Mining from Opencast Mining could also be examined.

Justification : It was noted with concern that despite the noble intentions and ambitious programmes in the various Five -year Plans, Underground production has continued to decline. Underground Mining needs a boost on account of the following:

a. Large Valuable Coking Coal Reserves in Jharia Coalfield are blocked in developed pillars which are not amenable to Opencast Mining and must be worked by Underground Mining Method

b. On account of Land Acquisition problems and environmental concerns, time is fast coming when it will not be possible to extend, the depth of Opencast Mines beyond a certain point. The balance Coal Reserves will therefore have to be worked by Underground Mining Methods.

c. Underground Mining Methods, for being cost -competitive and capable of delivering the volumes will have to be oriented towards Mass Production Technologies mastering of which takes time & it may become too late if the country introduces these technologies after opencast mining has already reached the plateau.

Now is therefore the time to act, tomorrow may be too late.

5. Opencast Mining

It is recommended that in the Interest of both safety and environment, the progress made towards upgradation of Opencast Equipment should be maintained and should not be allowed to get diluted by deploying small –sized construction industry equipment in mines.

Justification: Opencast Mining Technology has made considerable progress in India and large Opencast Mines are now operational with large equipment like 42 Cub Mtr Bucket capacity Shovels and 240 Tonner Trucks.

Unfortunately, a retrograde trend consisting in use of very small construction- Industry equipment like 1.2 cub mtr Excavators and 10 Tonner Trucks is also getting more pronounced by the day.

These equipments are not appropriate for large- scale mining operations and their deployment leads to heavy congestion on the working faces as well as Haul Roads which poses a serious safety hazard.

Also, as it is, the coal Industry is facing acute shortage of trained manpower and deployment of small equipment results in huge requirement of such trained manpower which is not available in the market. As a result the Operators who are deployed to run these equipment are generally untrained or not fully trained which again becomes a safety hazard.

6. Coal Washing

It is recommended that MOEF should be approached to amend its notification in respect of use of Rejects to the extent that Power Generation from Rejects should be insisted upon only if the GCV in Rejects is higher than 2200 K/Cal/Kg. Simultaneously MOEF should also insist on introduction of modern coal washing technologies so as to ensure that GCV in Rejects is less than 2200 K/Cal/Kg.

It is, further recommended that Rejects -based power plants if required to be installed on account of the Rejects having + 2200 K.Cals/Kg GCV should be subsidised from out of the funds generated from Clean Environment Cess to make them economically viable.

Justification: It was noted with concern that on the one hand MOEF has been reducing the cut - off distance for use of washed coal by Power Sector and on the other even the existing washing capacities are not being fully utilised.

One of the reasons for this contradiction is the insistence of MoEF on utilisation of Washery Rejects for Power Generation through FBC Route.

It was brought out that such power generation can be an economically viable activity only if the GCV in Rejects would be higher than 2200 K/Cal/Per Kg.

It has got to be appreciated that utilisation of Rejects for Power Generation with FBC Technology can be economically viable only if the Rejects have Heat Value adequate for generating more power than is required for grinding of the Rejects.

Further, if Rejects have to be used for power generation, the total polluting effect remains the same as would have been the case if Raw Coal would have been utilised in the Power Plants. All that will be achieved is that the source of pollution instead of being limited to a single location which is the main power plant will get distributed over two locations namely the main power plant and the Rejects based Power Plant.

The objective of cutting down on Green House Gas Emission by improving the quality of Coal by washing therefore gets completely defeated.

7. Taxation on Coal

It is recommended that the taxation regime on Coal in India should be re-examined to align it with the rates obtaining in major Coal producing countries.

Justification : It was noted that Indian Coal is the most heavily taxed in the world. The taxation rates for Coal in different countries is given below:

- Effective Tax Rates (ETR) which is the combined effect of all taxes on Coal in different countries is as under:

Name of the Country	**Effective Tax Rate (%)**
Mongolia	31.3
Canada (Quebec)	34.0
Chile	37.6
Indonesia (Sulawesi)	38.1
Canada (NWT)	39.5
Australia	39.7
South Africa	39.7
Namibia	44.2
Indonesia (West Papua)	45.5
India (New Mines)	59.8
India (Existing Mines)	64.0

The manner in which the tax burden on Indian Coal has gone up on account of increase in Royalty, Imposition of District Mineral Fund (30% of Royalty), Imposition of NMET (2% of Royalty) and increase in Clean Energy Cess (now Clean Environment Cess) from Rs 50/- per ton in financial year 2013 to Rs 100/- in financial year 2014 , Rs 200/- in financial year 2015 and Rs 400/- in financial year 2017 will be evident from the following:

Year	**Tax burden as percentage of Coal Price**
2007	9
2012	14
2013	15.5
2014	17
2015	24.8
2016 and 2017	30.42 - which will go as high as 46.94 % if Auction Commitment is taken into account.

On the other hand, International Coal Prices have gone down and a situation has now come when Indian Coal is gradually becoming uncompetitive. In fact Coal India Ltd. has already been compelled to cut down the price of Superior Grade coal on this account.

For maintaining the cost competitiveness of Indian Coal and ensuring the survival of Indian Coal Industry, it is necessary that the tax rates are brought in line with those obtaining in major Coal producing countries.

8. Augmenting Coking Coal Supply

It is recommended that all Washery Grade III and Grade IV Coals should be washed for generating Metallurgical Coal, and the implementation of plans prepared earlier for rehabilitating abandoned Coking Coal Mines and starting new Coking Coal Projects should be fast tracked.

Justification: It was noted with concern that on the one hand, the volume of import of Coking Coal was going up and the other hand Inferior Grade Coking coal of Washery Grade III and Grade IV is being utilised for Power Generation. It was noted with satisfaction that CIL has planned about 6 mill tons new Washing capacity for Inferior Grade Coking Coal for generating Metallurgical Coal. This would however, still leave more than 20 mill tons of such Coal which will continue to be used for Power Generation. It was hoped that in due course Coal India would set up new Washeries to ensure that these 20 mill tons of Washery Grade III and Washery Grade IV Coals would also be washed for generating Metallurgical Coal.

It was however, felt that pending the construction and commissioning of these washeries , these coals could be supplied to the washeries belonging to integrated steel plants which have surplus washing capacity. The Metallurgical Coal obtained from such washing could be utilised by these Integrated steel plants and the Middlings obtained could be used as substitute for power grade coal for which they have the linkage. In case the quantity of Middlings goes in excess of the Power Grade Coal linkage, this excess could be supplied by these Integrated Steel plants to the Power Stations having linkage with proportionate reduction in the said linkage.

About 8 years back, Coal India had prepared plans for rehabilitating some abandoned Coking coal Mines which had workable reserves left therein but where operations had been stopped on account of Geological / Safety problems. For various reasons, however, no progress was made in this direction.

Some of these Mines could be reopened and it would be desirable to get the possibility examined by appointing a multi-disciplinary Committee for the purpose.

One of the Coking Coal projects which has been hanging fire for close to 50 years is Damodar River Diversion Project in East Bokaro Coalfield where large Coking Coal Reserves are available. This project could not progress on account of Land Acquisition problem. It is felt that it can be made operational by enlisting the co-operation of Jharkhand Govt.

9. Recovery Charges

It is recommended that the existing practice of imposing additional burden of Rs. 630/- per ton as Recovery Charges on Power Plants being forced to use Washery Grade III and Grade IV Coal should be stopped and instead these Coals should be washed for generating Metallurgical Coal.

Justification: It was noted that Coal India was charging Rs. 630/- per ton as Recovery Charges on supply of washery Grade III and Grade IV Coal to Power Sector.

It was felt that this is not logical since such Coal is being supplied to the Power Plants not because Power Plants are asking for it but it is being done for Coal India's convenience.

It was also felt that the loss of revenue by stopping this Recovery charge could be made up to very large extent by washing these coals for generating Metallurgical Coal which sells at a very high price.

10. Dry Beneficiation of Coal

It is recommended that one or 2 mines producing Power Grade Coal should be identified for trial of Dry Beneficiation Technology.

Justification: One of the negatives associated with washing of Power Grade Coal is the additional Moisture that Clean Coal acquires in the process of washing.

It was also noted that China had made good progress with Dry Coal beneficiation.

12. CBM/CMM

It is recommended that CBM Blocks allotted more than 5 years back but not made operational so far should be taken away from the Allocatees and should be given to those who have firm plans for down -stream End -Use Plants.

It is recommended that the current status in respect of CBM Blocks should be reviewed in totality. There are cases where the development of Coal resource is held up since no progress is being made towards exploitation of CBM resource.

In such case unless it is clearly established that the exploitation CBM reserves is economically viable development of coal extraction should be permitted to proceed.

Further in several foray projections made about CBM potential in India has been questioned of scientific basis.

As a policy matter therefore, development of a Core Blocks should not be made hostage to development of CBM.

Justification : It was noted with concern that though India had substantial CBM/ CMM potential, not much had been achieved on harnessing them - the reason being absence of firm programme for setting up of End Use Plants by the Block Allottees.

First CBM block was allotted in the year 1993-94. Since then till 2011 total 32 Coal Blocks have been allotted through auctioning. Out of all these blocks possibly only 2 are operating commercially that too in a much lower scale than was earlier planned. Nine blocks have been surrendered. The basic reason for such dismal performance in CBM sector is very low Methane availability in the rank of coal in India (barring possibly 3-4 areas. Even in these areas no major commercial contract could be signed as the promoters are not sure about the quantity and quality of gas to be produced). In most cases it is not economically viable both in quantity and qualitative terms to extract the gas and that is why even after 22 years of initiating the CBM operations, it is not gaining any momentum. In all the allotted blocks the planned development programme have gone haywire and its not achievable.

13. Commercial Mining

It is recommended that while identifying Blocks for Commercial Mining care should be taken to ensure that it would be possible to connect them to the Coal Evacuation infrastructure in an economically viable manner.

Justification: It was noted with satisfaction that Govt had taken a decision for permitting Commercial Mining. It was hoped that advent of Commercial Mining would create conditions for deployment of Modern Mining technologies and practices and would go a long way in improving the productivity of Indian Coal Industry. It was however, noted with concern that the demarcation of captive coal Blocks in particularly Talcher Coalfield in Odisha, had earlier been done in such a manner that some of the Blocks could not even be approached without intruding on the adjacent Blocks.

Also in a large number of cases, the Block- sizes were such that it was not financially feasible to connect them with facilities like Rail and Road links.

For making Blocks identified for Commercial Mining attractive to the investors, smaller Blocks should be merged together to form larger Blocks and this would be so demarcated that they are naturally bounded by non-coal bearing areas to create economy of scale for Commercial Mining.

The Blocks should be allotted through a transparent QCBS model that gives due weightage to competence in mining.

14. Efficiency Parameters

It is recommended that the time frame specified for different Efficiency Parameters should be closely examined and made realistic

Justification : A table consisting of "Efficiency Parameters" forms a part of the Coal Mines Development and Production Agreement executed between the Nominated Authority under the Coal Mines (Special Provisions) Act 2015 and the successful bidder of the auction process. For various mile stones listed as Efficiency Parameters specific time frames have been given and any failure in achieving these mile stones results in Invocation of Performance Guarantee to the relevant extent. These time frames are rather unrealistic against some of the parameters like the one related to obtaining Prospecting License. Time allowed for this activity has been specified as 4 months. As things stand the minimum time required for obtaining this license is 18 months and in case Forest Land is evolved, it may take several years.

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Email: Info@globalcoal.net

Locations : Talcher, IB Valley, Ramagundam, Manuguru, Pargi, Suthari

Section-4

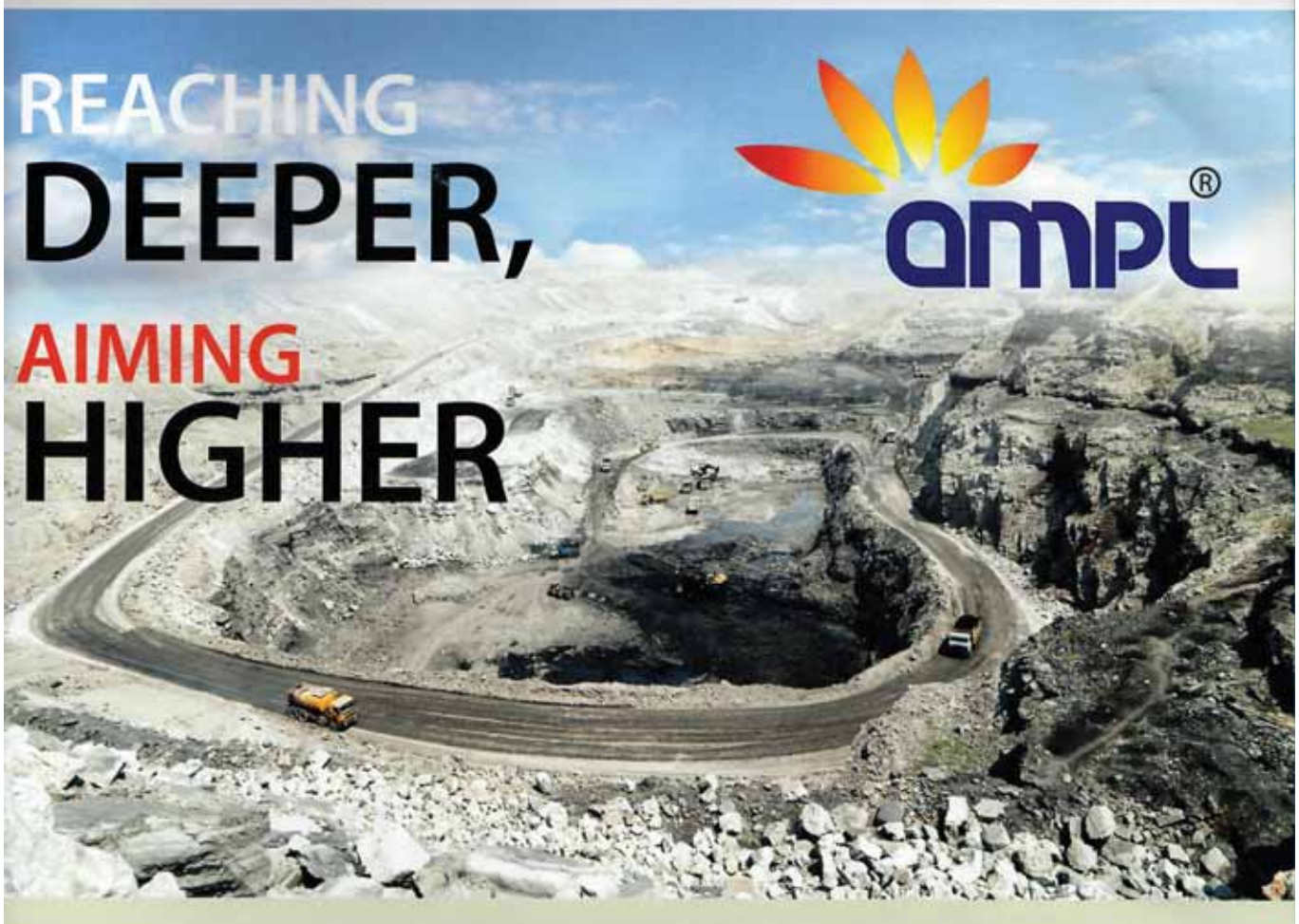
Coal – Not a Forgotten Story

Future Potentials - its Diversification

INDIA ENERGY FORUM

MINING GEOLOGICAL & METALLURGICAL INSTITUTE OF INDIA 1906
DELHI CHAPTER

INDIAN SCHOOL OF MINES ISMAA DELHI



AMPL is an end to end service provider to the coal industry.

OUR SERVICES

- Mine Development and Operation
- Mine Identification & Planning
- Assistance in R & R, Land Acquisition and obtaining other approvals
- Coal and Ash Logistics (Rail & Road)
- Crushing and Allied Services

OUR STRENGTH

- 30 Years of Operation in Private Mines and CIL.
- Mining Capability of 35 Million Cum.
- 12 Operating Coal Projects.
- Operation in 7 States.
- Pioneer in Surface Miner Operation.
- Crushing Capacity of 3 Million Tonnes per month.

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Coal – Not a Forgotten Story

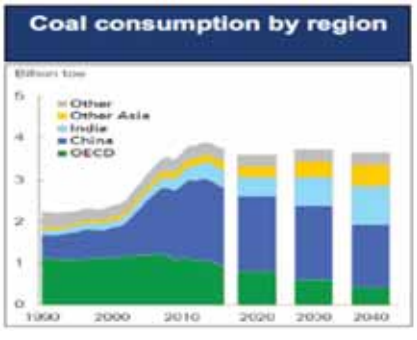
Future Potentials - its Diversification

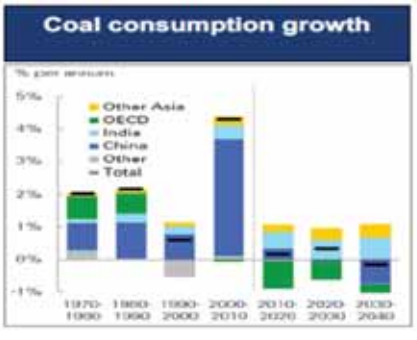
– S K Grover* & Kapil Dhagat**

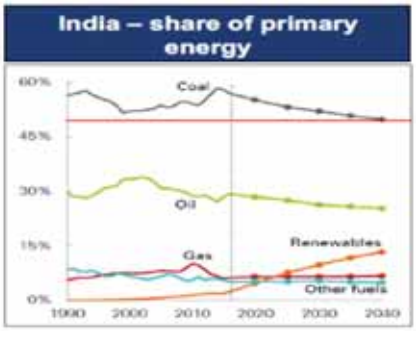
Coal has played a vital role to revolutionize the Industry World-over since 17th Century. It became an important energy source during the Industrial Revolution between 1760 to 1840 when it was primarily used to power steam engines, steam locomotives for Railways heat buildings and generate electricity. Coal mining picked up in 19th Century and shined with an accelerated growth especially for power generation until recently when a debate has started over its further use as main feedstock for power generation due to environmental issues. As the World is trying hard to find viable alternative energy sources, coal continues to maintain its sheen in Asia Pacific region and shall continue to dominate the energy scene for at least next two-three decades.

Coal, a carbon-intensive energy source, is at the centre of debate on energy and climate policy. In a growing number of countries, the elimination of coal-fired generation is a key climate policy goal after the signing of Paris Agreement under COP21. In others, especially in Asia Pacific Region, coal remains the preferred source of electricity and is seen as abundant and affordable. Despite significant media attention being given to divestments and move away from coal, market trends are proving resistant to change.

Global coal demand in the next five years will be stable, with declines in Europe and United States offset by growth in India and other Asian countries. China, the main player in the global coal market, will see a gradual decline in demand. Coal's contribution to the global energy mix will decline from 27% to 25%, mainly due to growth of renewables and natural gas.







Due to policy framework, European Union has already started 3-pronged action i.e. Action on Climate change; Action on air pollution and Action to specifically phase out coal-fired power generation. Along with the expansion of renewables, spurred by the growing competitiveness of wind and solar, these policy efforts will result in substantially reduction of coal consumption.

One out of every four tonnes of coal used in the world is burnt to produce electricity in China. Hence, coal's fate largely rests on the Chinese power sector. In our forecast, global coal demand is very

*Former GM (Fuels), NTPC.

**Executive Vice President - BU Coal, JSPL.

sensitive to trends of electricity use in China. Considering environmental pressures and to have clearer skies, it is assumed that its electricity intensity will decline over time, stopping further growth in coal for power generation by 2020. Whereas cleaner use of coal is another pillar of the strategy, the only sector in which we see significant growth is coal conversion, i.e. coal-to-liquids, coal-to-gas and coal-to-chemicals.

Potential of Coal in India, an Emerging Coal Consuming Destination

The unmatched period of coal power generation growth in India is set to continue. Coal power generation in India has grown continuously since 1974.

Coal Supply and Demand

(In million tonnes)

Source	2016-17 Target/ Estimate	2016-17	2017-18 Target/ Estimate	2017-18	2018-19 Target	2018-19
CIL	598.61	542.98	600.00	579.57	610.00	608.20
SCCL	58.00	60.79	62.00	62.89	67.00	67.68
Others	68.10	42.21	68.10	45.37	55.00	58.44
Total indigenous supply	724.71	645.98	730.10	687.83	732.00	734.32
Demand projected / Actual supply (Domestic+ Import)	884.87	836.93	908.40	896.10	991.35	928.92*
Import– Estimated / Actual	160.16	190.95	178.30	208.27	259.35	194.60*

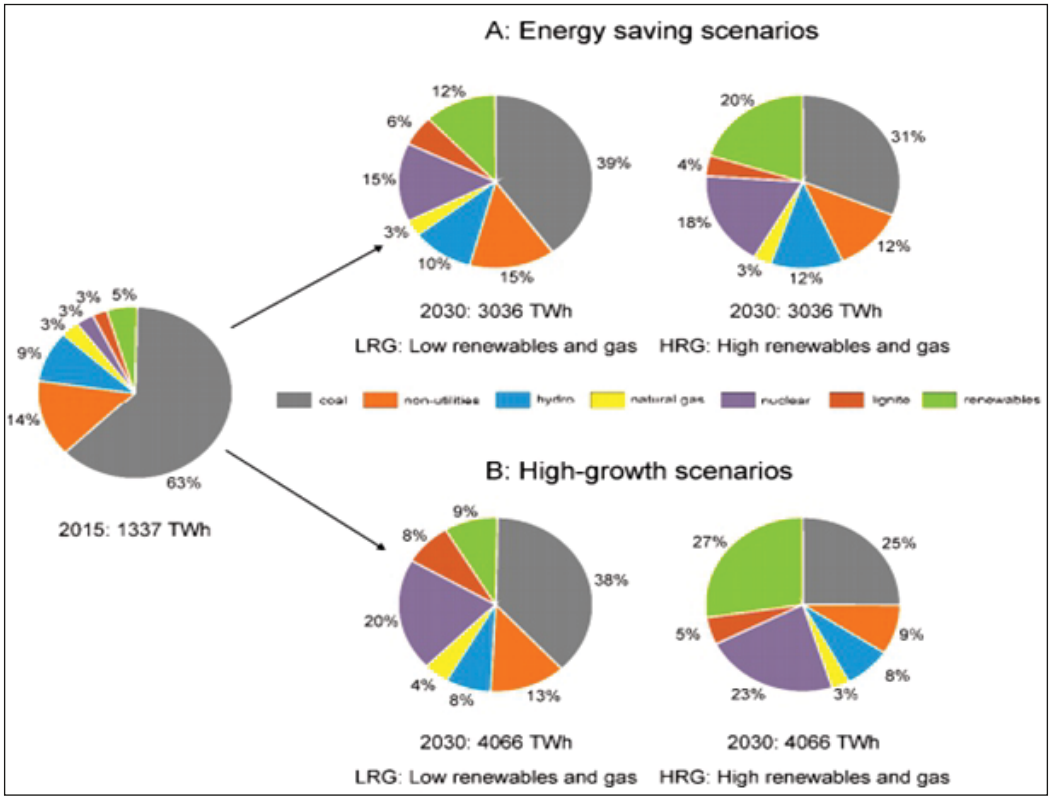
Note: Demand is assessed by the Planning Commission at the beginning of each Annual Plan whereas th e supply figures are based on actual as realized by the end of the reporting period.

P – Provisional *Up to January, 2019

With the Indian economy expected to grow over 8% per year to 2023 and the electrification process continuing, power demand is forecast to rise by more than 5% per year over the period. The large-scale ongoing renewable expansion and the use of supercritical technology in new coal power plants will not affect the coal demand growth in view of massive infrastructure development programme. Also, ambitious steel & cement capacity augmentation would support coal uses over the next few decades.

As per projection available going forward the share of coal in overall energy basket in the country will go down from 63% in 2015 to 30% in 2036 but total coal requirement in absolute terms will continue to grow atleast over a few decades as from the Table A.

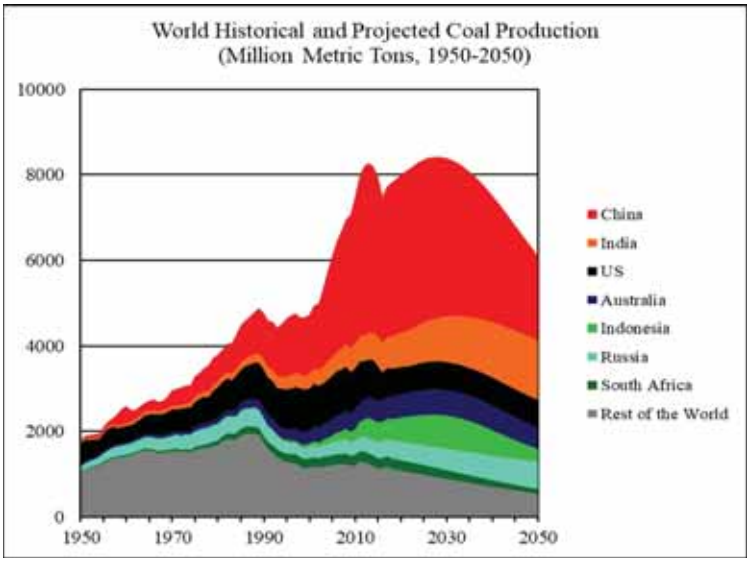
There are two scenarios which will decide the share of coal use while meeting India's energy needs. The success of renewables and also the spurt in demand will eventually trigger the increased coal use. It has been estimated that coal will have its dominant position under all scenarios but its share will reduce with addition of renewables and nuclear capacities. While the share of hydro (10%) and natural gas (3%) will remain sub-dued, there will be smart gains by renewables and nuclear to acquire more share in India's energy scene.



Electricity Generation in India under Two Scenarios

Impact on Coal Mining

Risks associated with climate policies, potentially stranded assets, local opposition, and the memories of the last downturn have cooled investors' appetite to invest in new production. Banks, insurance companies, hedge funds, utilities and other operators in advanced economies are exiting the coal business. In many parts of the world, growing opposition to coal projects has provided strong disincentives for investors. It may be seen from the graph that a gradual



decline in world coal production will be observed beyond 2025 but India will maintain its emphatic dependence on coal until 2050.

While there is a clear intent to increase coal production in India, Coal India Limited has taken the following steps to increase production of coal:

- High capacity mines are being planned, approved & executed with State-of-the Art mechanization wherever feasible.
- Mines are being modernized for increasing man productivity both in underground & opencast mines depending upon geo-mining conditions.
- Improving capacity utilization through efficiency improvement.
- Ensuring implementation of on-going projects in time bound manner to achieve targeted production as per schedule.
- Capacity augmentation of running projects through special dispensation under the EP act 2006
- In order to maintain the planned growth in production and evacuation in future, CIL has undertaken three major Railway Infrastructure Projects to be executed by Indian Railways in coalfields of SECL, MCL & CCL having potential of growth.

The country as a whole contributed 730 Million tonne with the contribution of SCCL & Captive Mines. While the demand was around 965 Million tonne, the gap of 235 Million tonne was met by coal imports which have seriously impacted the State Exchequer. While the import of coal would continue due to obvious reasons for coastal based power stations and for Steel Industry requiring high quality coking coal, Govt of India is committed to reduce at least 125 Million tonne of thermal coal currently moving towards hinterlands as CIL is unable to meet the demand. It has been realized that country needs more player to add capacities and bring more competitiveness. Considering this, Govt of India has recently announced to open-up the coal sector in India and has allowed 100% Foreign Direct Investment in commercial mining under the automatic route in mining for the sale of coal and for coal mining activities, including associated processing infrastructure subject to provisions of the Coal Mines (Special Provisions) Act, 2015 and the Mines and Minerals (Development and Regulation) Act, 1957, amended over time. The changed policy regime, thus, allows foreign companies to extract coal for commercial purposes for sale in the open market and in "associated infrastructure" that include washeries, crushing, coal handling and separation.

The share of Underground coal mining has been declining steadily since nationalization. Currently opencast mines which are contributing about 93% of coal production from CIL mines are working up to a maximum depth of 300 m. There are about 95 Billion tonne of untapped reserves from 300 to 600m depth which can be projectised with advanced UG technologies specific to the particular deposit type. This will also help in increasing higher grade production as in most cases better coal grade are available at greater depths. There is a strong need of private participation in underground mining specially in coking coal regions. Some of the unviable underground mines under CIL can be brought into profits by auctioning it to efficient miners. This will help in mining better grades of coal lying at depth and also put much lesser impact on environment. The current policy of the Govt to explore such possibility and offer such opportunities to the private sector will go in a long way.

Coal Sector - Diversification

India has 319 billion tonnes of Coal Reserves of which measured resources are as under

GEOLOGICAL RESOURCES OF COAL IN INDIA
AS ON 01.04.2018

STATE	Category-wise Coal Resources (in MT)				
	Measured (Proved)	Indicated	Inferred (Exploration)	Inferred (Mapping)	Total
GRAND TOTAL	148787	139164	30319	750	319020

Source: Geological Survey of India's Inventory of Geological Resources of Indian Coal as on 1.4.18. The inventory did not take into account the mined out reserves.

So India needs to utilize its natural resources in the most useful way and so its Diversification.

Globally coal is expected to experience sluggish growth through 2022. While coal will continue to be used as a fuel resource to generate energy in many countries such as China, India, Japan, South Korea and USA in substantial quantities for years to come, use as a feedstock for making petrochemicals and other non- energy products offers new opportunities too. Increasingly, in the US this feature is attracting significant R&D dollars, notably through Federal funding. The Government of India has conclusively recognized the importance of coal beneficiation as part of its push to recover the latent value in its naturally occurring coal resources too.

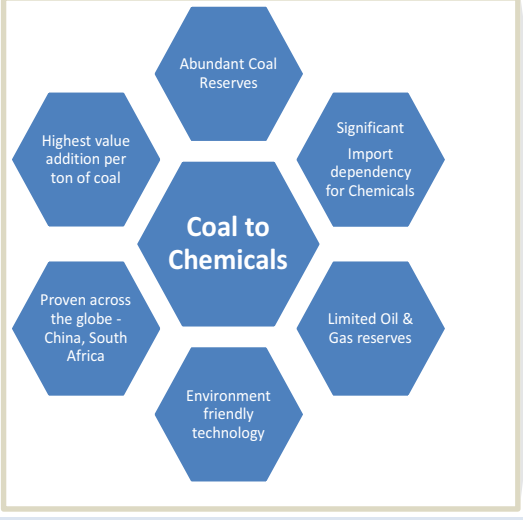
Demand for metallurgical coke is rising. Metallurgical coke is made by destructive distillation of coal - (generally bitumous types) in special high temperature ovens in the absence of oxygen until a greater part of the volatile matter is driven off, resulting in a high carbon content solid - Coke. There are a range of process approaches to make coke. High coke prices and increasing demand, have stimulated increasing interest in converting sub-bitumus coal into coke too. Until recently, The State of Wyoming was transforming its sub-bitumous coal resources from its Kemmerer mine into salable metallurgical coal. A promising emerging coal beneficiation approaches for upgrading low-quality coal - deashing it, is the Kobe steel Hyper-coal technology which uses solvent extraction to de-ash the run-of-mine (ROM) coal, offering a process route to upgrade high-ash content coal into metallurgical coke as well as producing other valuable co-products.

De-ashing Wyoming Powder River Basin (PRB) sub-bitumous coal with simple but effective solvent systems has shown to be feasible and possible in the laboratory using a proprietary thermo-chemical process rout developed at the University of Wyoming. Early indications from laboratory studies reveal that demineralizing and dewatering sub-bitumous coal can generate respectable yields of high quality extract and residual materials that could be converted into metallurgical coke, and as a co-product, high performance polymeric materials and coal chars, for such duties as agricultural soil amendments

or as a feed to further process into activated carbons and other porous carbons. Most recent experimental pathways have included demineralization of coal deploying the properties of hydrophobicity and hydrophilic behavior. Results will be presented from the ongoing program. The understanding and comprehension of molecular structure, physics and chemistry of coal, built upon systems engineering principles, is required to appreciate and identify the potential to beneficiate and upgrade low rank coals.

The proven colossal coal reserves and the aromatic macro-molecular components present in coal, makes it ideal feed stocks for industrial chemicals and carbon-based materials such as basic chemicals, plastics and fibers. These chemicals and carbon based materials are derived mostly from petroleum and natural gas. Coal is now being recognized as an important potential source for producing carbon materials and chemicals and therefore is an area for future coal research and development. However, the traditional source of coal chemicals, tars or liquids obtained as by-products of coke ovens, has steadily decreased in the last few decades. The main hurdles towards the use of coal for producing chemicals and carbon materials include its structural complexity, processing difficulties, heterogeneity of organic matrix, inorganic impurities and processing costs. The number of chemicals that may be produced from coal is boundless. Major chemicals currently being produced from coal include mono-ethylene glycol, di-methyl either, olefins, acetic acid, formaldehyde, urea, ammonia, acetylenes, vinyl chloride monomer, poly vinyl chloride, butane diol, vinyl acetate monomer, acrylic acid, acrylonitrile, naphthalene derivates as well as humates agrichemicals from lignite. High value - low volume products which include activated carbon, carbon electrodes, carbon fiber and composite materials like carbon nano tubes and graphene may be sourced from coal feed stocks.

Why Coal to Chemicals in India?



- Coal to Chemicals will boost the coal consumption while also reducing import dependency of key chemicals, fertilizers and fuels
- Coal to chemicals offers the cheapest and best indigenized solution compared to other feedstock like Natural Gas & Naphtha
- The chemicals produced through coal gasification result in the higher value addition to coal as compared to many of its other current use.
- The technology of the coal gasification is a technically & commercially proven across the globe. China has been using this technology to produce large quantities of chemicals, fertilizers, etc.
- Mega coal to chemicals plant complexes at coal pit-heads can bring in regional economic prosperity as well as help meeting the gaps in interior states of the country.

Coal to Chemicals is an ideal solution for developing the country as chemical manufacturing hub while also boosting coal consumption

Meeting the needs of Chemicals, Fertilizers and Fuels through Coal Gasification

Coal to Chemicals could be frontrunner in utilisation of untapped coal reserves

Key Chemicals	Demand gap by 2025 (MMTPA)	Coal required for chemical production (MMTPA)
Acetic acid	1.1	7
Methanol*	6.6	32
MEG	1.4	8
Poly-Olefins	7.0	87
Urea	5.2	12
DME*	2.3	4.8
Total		**150**

Benefits of Coal to Chemicals

20 Bn $ of Foreign exchange saved annually by indigenous production

>160000 Employment Generation

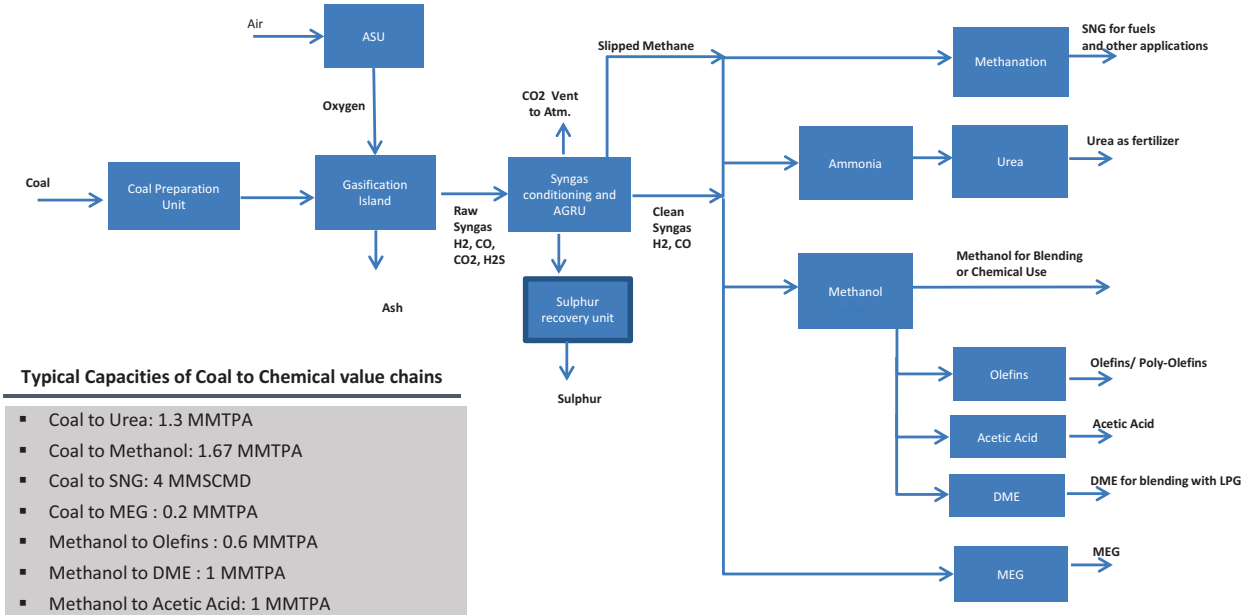
Supply security for Enhanced Energy , Fertilizer & Speciality Chemicals

Revenue to the Govt. over the project life as Taxes, Duties, Coal Royalty etc.

99% Recovery of Sulphur in coal as saleable Sulphur; CO2 in ready to capture form

Coal requirement calculation is based on Indian Coal of GCV 3300 Kcal/kg, 45% Ash and Lurgi FBDB Gasification Technology
Demand supply gap taken from ICIS database, in-house analysis
*Assumed 15% of Methanol blending will be by Govt. DME blending of 10% in LPG would also be allowed by Govt.
38 MMSCMD of SNG would be generated through slipped methane (FBDB) along with above products

Coal Gasification: Product Value Chains



Typical Capacities of Coal to Chemical value chains

- Coal to Urea: 1.3 MMTPA
- Coal to Methanol: 1.67 MMTPA
- Coal to SNG: 4 MMSCMD
- Coal to MEG : 0.2 MMTPA
- Methanol to Olefins : 0.6 MMTPA
- Methanol to DME : 1 MMTPA
- Methanol to Acetic Acid: 1 MMTPA

Conclusion

- With huge coal resources in order of 319 billion tonnes, the country has the **Potentials** to grow and should have no problems in meeting its requirement for thermal power generation, cement industry etc. which may remain as a stable, more reliable and affordable source as of now.
- Further lot of research work is going on across the world to convert thermal coal for its better use like metallurgical coke for steel sector. This research work is of immense importance for the country and need to be addressed of its top priority as it may substantially reduce the high value import of coking coal and save import bill of over $ 30 billion per annum.
- It can be seen that in not very far off future Coal will lose its dominant and to utilise our huge coal resource country needs to addressed Diversification of coal, as fortunately Coal is very versatile commodity. It can be a good feedstock for producing **Chemicals, Coal to Liquid, Coal to Gas, Active Carbon** etc. All these products will add more value for coal than the power generation from Coal. Country had been importing lot of Chemicals. It should be feasible to utilise about 150 million tonnes of Coal to Chemicals by 2024-25 and also shall save the import bill for the country to the tune of about US$ 21 Billion per annum.
- So any amount spent on research for processing coal for Alternate use is worth.
- It is also time to utilise Lignite to its alternative use by reducing moisture from lignite to produce a stable low ash, low moisture product ideally suitable for Diversification for its much better use.

Section-5

Technical Papers & Abstracts

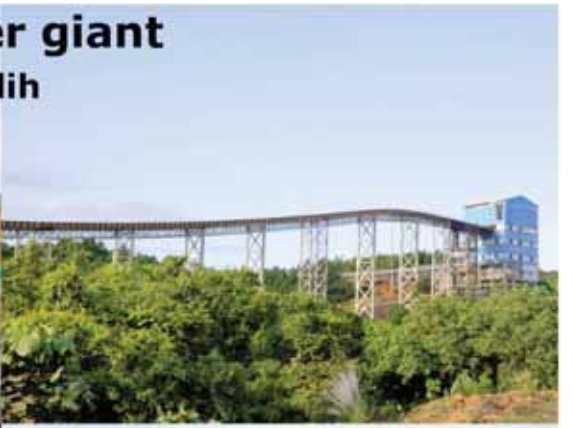
INDIA ENERGY FORUM

MINING GEOLOGICAL & METALLURGICAL INSTITUTE OF INDIA 1906 DELHI CHAPTER

INDIAN SCHOOL OF MINES ISMAA DELHI

Energizing NTPC - India's power giant

Thriveni Sainik JV - Pakri Barwadih



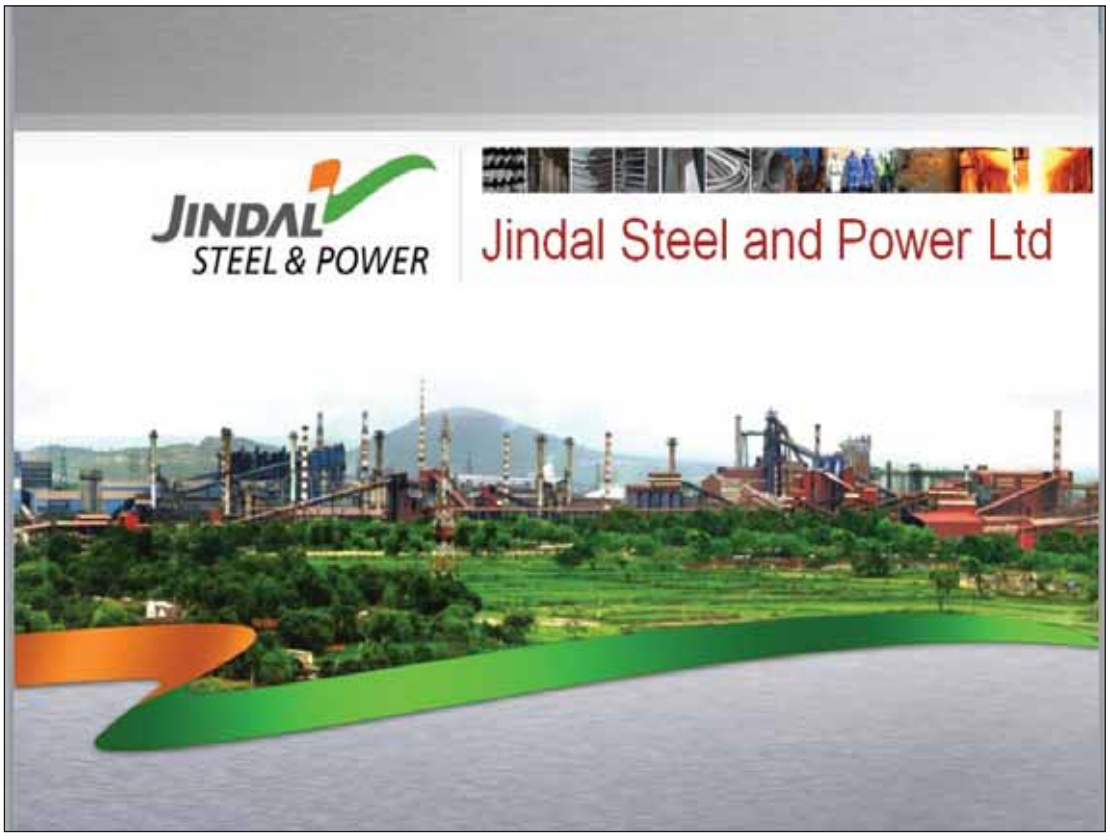
AUG - 2019

831,494 t – dispatch

760,370 t – production

NTPC's Pakri Barwadih project achieved its highest ever monthly dispatch and production
The Thriveni Sainik Joint Venture is proud to build on our robust & growing partnership with NTPC

THRIVENI SAINIK MINING PRIVATE LIMITED
Project Office: C/o: NTPC Ltd., Langatu,
PO: Barkagaon, Dist.: Hazaribag-825311, Jharkhand, India
Phone: 06546-223115, **Email**: info@thrivenisainik.com,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STEEL & POWER
Jindal Steel and Power Ltd


JINDAL
Seminar on "Indian Coal- Potential & Diversification"
Dated-24th September' 2019
COAL GASIFICATION
Presented to:7th Roundtable Conference on Coal Secretariat
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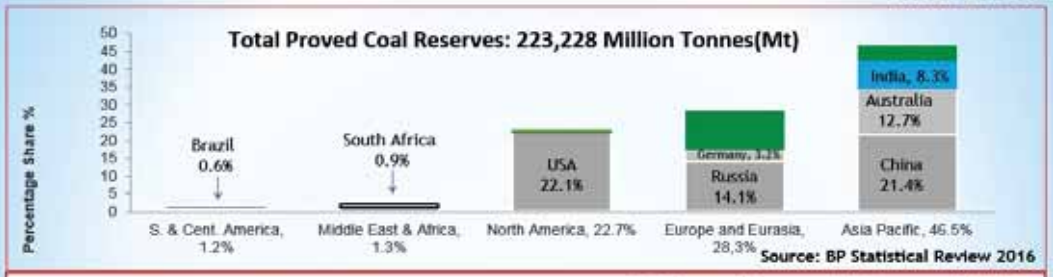
Global & Domestic Coal Reserve

JINDAL STEEL & POWER



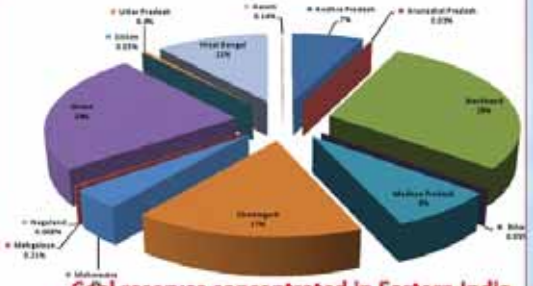
Source: BP Statistical Review 2016

- India has 4th largest coal reserve in World: **315,148.81 Million tonnes(Mt)** on 1st April 2017

Category Wise Coal reserve	Non Coking 279,027 Mt	Coal Extracted from Coalfields
Measured 45.4%	Superior 13.4%	2016-17: 644.31 Mt
Indicated 44.2%	Inferior 75.8%	Since 1950 up to 2016-17: 14438.22 Mt
Inferred 10.4%	Ungraded 10.8%	

Source: GSI, NERM 2017

- **Proven/Measured Coal reserves (India):** Coal for more than 236 years



Of the total coal reserves 77% is either Inferior Grade or Ungraded coal Non-Coking Coal

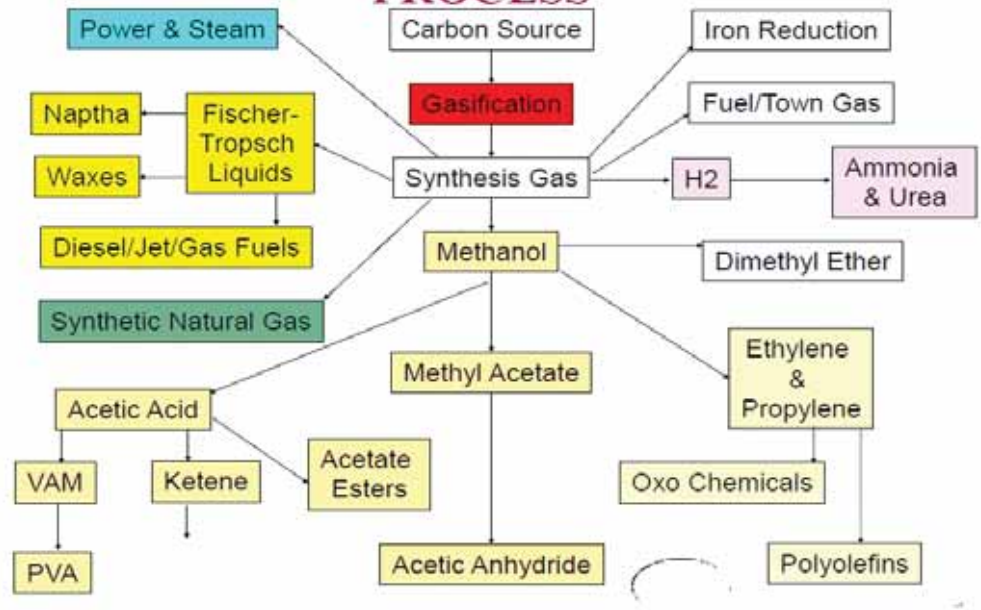
Coal reserves concentrated in Eastern India, Hence CG project based in Angul, Orissa

4

Coal Gasification Theory Contd..

JINDAL STEEL & POWER

APPLICATIONS OF GASIFICATION PROCESS



Coal Gasification Theory

JINDAL STEEL & POWER

WHAT IS GASIFICATION?

- Conversion of any carbonaceous fuel to a gaseous product with a useable heating value.
- The feed for Gasification can be
  - Gas (e.g., Natural gas)
  - Liquid (e.g., Light or Heavy oils)
  - Solid (e.g., Coal, Petroleum Coke, Lignite or Biomass)

Coal Gasification Theory Contd..

JINDAL STEEL & POWER

GASIFICATION Vs. COMBUSTION

- Partial oxidation
- Higher temperature, often high pressure
- Purpose - Get Fuel-rich gas & not High temperature gas
- Product gases (CO, H_2, CH_4, CO_2, H_2O) have fuel value
- Oxygen as feed instead of air
- Intermediate scrubbing of gas
- Char reaction rate is slower

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Coal Gasification Theory Contd..

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GENERAL REACTIONS

$CH + O_2 + H_2O \rightarrow CO + H_2 + CO_2 + H_2O + CH_4$

$H_2 + S = H_2S$

$C + \frac{1}{2} H_2 + \frac{1}{2} N_2 = HCN$

$\frac{1}{2} N_2 + \frac{3}{2} H_2 = NH_3$

$C + S + \frac{1}{2} O_2 = COS$

$\frac{1}{2} H_2 + \frac{1}{2} Cl_2 = HCl$

$ASH \rightarrow SLAG + FLY\ ASH$

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Coal Gasification Theory Contd..

JINDAL STEEL & POWER

GENERAL REACTIONS

		ΔH (+ Endothermic / - Exothermic)
Combustion reactions		
$C + ½ O_2$	$= CO$	- 111 MJ/kmol
$CO + ½ O_2$	$= CO_2$	- 283 MJ/kmol
$C + O_2$	$= CO_2$	- 394 MJ/kmol
$H_2 + ½ O_2$	$= H_2O$	- 242 MJ/kmol
Boudouard reaction		
$C + CO_2$	$\leftrightarrows 2\ CO$	+ 172 MJ/kmol
Water gas reaction		
$C + H_2O$	$\leftrightarrows CO + H_2$	+ 131 MJ/kmol

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Coal Gasification Theory Contd..

JINDAL STEEL & POWER

GENERAL REACTIONS

		ΔH (+ Endothermic / - Exothermic)
Methanation reaction		
$C + 2\ H_2$	$\leftrightarrows CH_4$	- 75 MJ/kmol
$CO + 3\ H_2$	$\leftrightarrows CH_4 + H_2O$	- 206 MJ/kmol
$CO_2 + 4\ H_2$	$\leftrightarrows CH_4 + 2\ H_2O$	- 165 MJ/kmol

The reverse Steam-reforming reactions are endothermic

CO shift reaction		
$CO + H_2O$	$\leftrightarrows CO_2 + H_2$	- 41 MJ/kmol

Gasification Reaction – Summary

$CH + O_2 + H_2O \rightarrow CO + H_2 + CO_2 + H_2O + CH_4$

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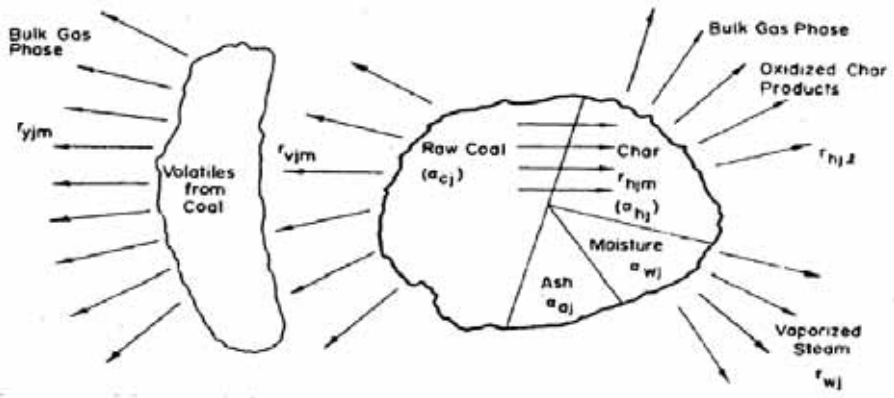
Coal Gasification Theory Contd..

JINDAL STEEL & POWER

What Happens to a Coal Particle?



Coal reactions are generally divided into two distinct components

- **Devolatilization of the raw coal**
- **Oxidation of the residual char**

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Coal Gasification Theory Contd..

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Reactivity : The reactivity of coal and char depends on various factors in particular

- The porosity of coal, that is, its inner structure, surface and active sites
- The crystal structure of the fixed carbon
- Catalytic effects of ash component in the coal
- Young (Low rank) coal such as brown coal has high specific surface and thus a high reactivity
- Older coal have lower reactivity
- Reactivity is enhanced by alkalies , particularly potassium

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Coal Gasification Theory Contd..

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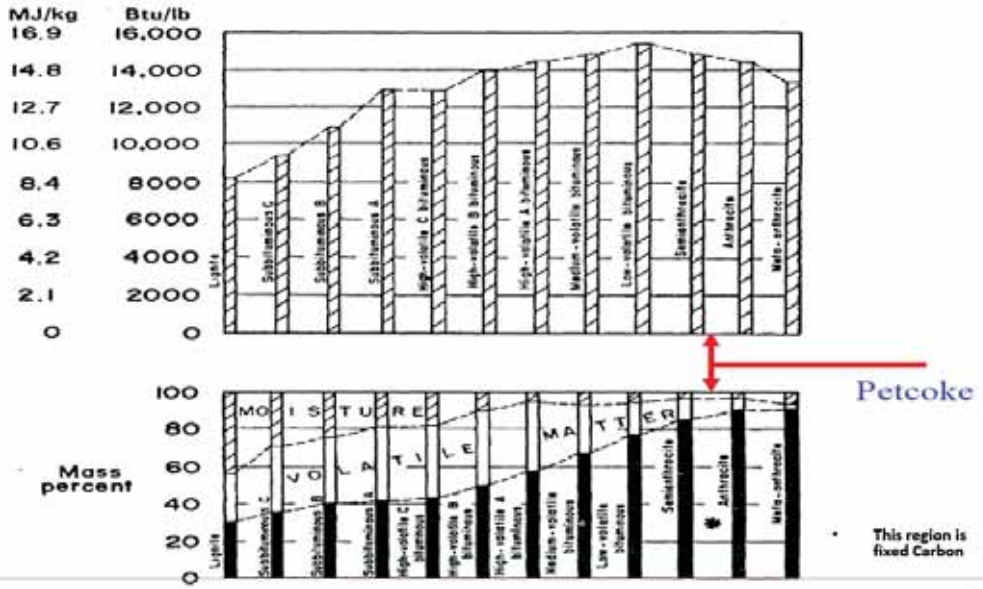
ENERGY CONTENT AND COMPOSITION OF COALS



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Coal Gasification Theory Contd..

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COAL ANALYSIS

- **PROXIMATE ANALYSIS**
  - Water
  - Volatile matter
  - Fixed carbon
  - Ash
  - Calorific value
- **ULTIMATE ANALYSIS**
  - Carbon
  - Hydrogen
  - Oxygen
  - Nitrogen
  - Sulphur
  - Chlorine
  - Metals
- **ASH ANALYSIS**
  - Metal oxides
- **ASH FUSION TEMPERATURE**
  - Ash melting point
  - Initial Deformation Temperature
  - Hemispherical Point
  - Flow Point

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Coal Gasification Theory Contd..

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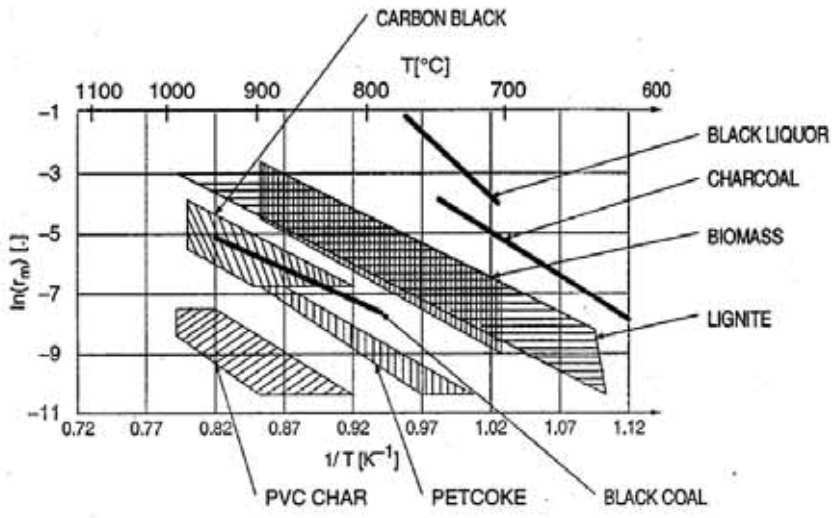
REACTIVITY OF FUELS AS FUNCTION OF TEMPERATURE



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Coal Gasification Theory Contd..

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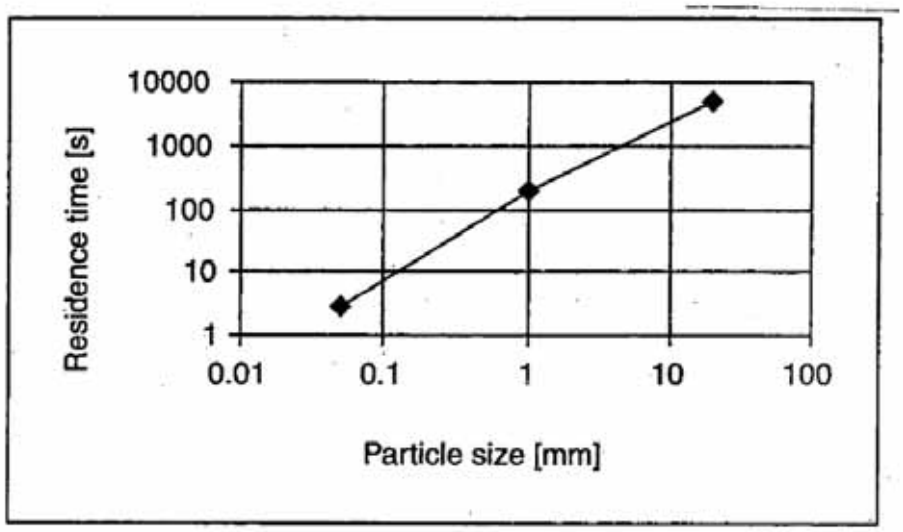
RESIDENCE TIME AS FUNCTION OF PARTICLE SIZE



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Coal Gasification Theory Contd..

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ASH BEHAVIOR

- The relationship between ash-melting characteristics and composition is a complicated one and is dependent largely on the quaternary SiO_2-Al_2O_3-CaO-FeO.

- In general, slags that are high in SiO_2 and/or Al_2O_3 will have high ash melting points, but this is reduced by the presence of both CaO and FeO.

- The SiO_2/Al_2O_3 ratio is also important – where the Calcium content is already high, SiO_2 addition can lower the ash melting point.

- Slag is very different from ash as it has been molten and is in fact a fusion-cast material similar to glass.

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Coal Gasification Theory Contd..

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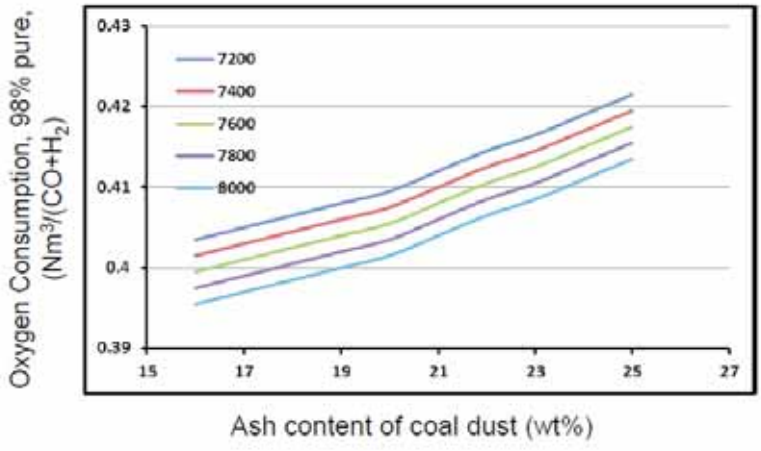
O2 consumption depending on Ash content and CV



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Coal Gasification Theory Contd..

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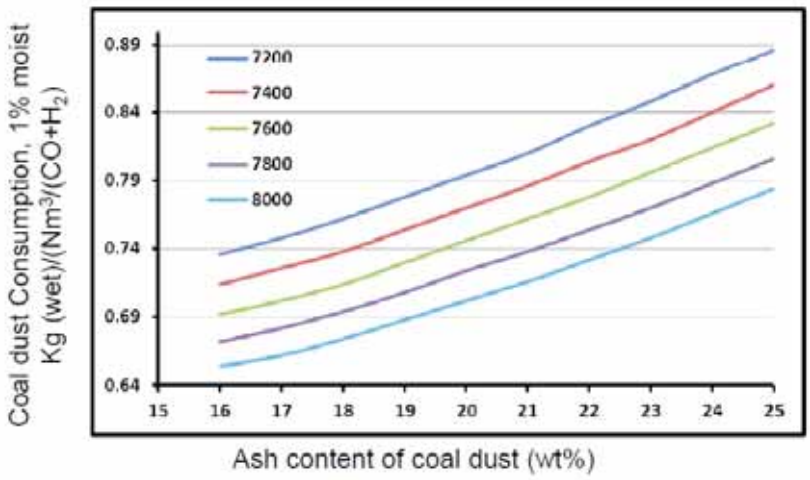
Coal dust consumption depending on Ash content and CV



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Coal Gasification Theory Contd..

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EFFECT OF PRESSURE

Synthesis gas composition changes with pressure

- Methane and CO2 content go up with increasing pressure
- H2 and CO content go down
- However, at high temperatures (1500°C) the change in gas composition with pressure is negligible.

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Coal Gasification Theory Contd..

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EFFECT OF TEMPERATURE

- Below the ash softening point for fluidized bed and dry ash moving bed Gasifiers
- Above the ash melting point for slagging (entrained bed) Gasifiers
- Flux may be required to be added for coal/coke having very high ash melting point
- CO content goes up while H_2 content goes down with increasing temperature
- CO + H_2 yield goes through a mild maximum between 1200 and 1300 deg C
- Methane content goes down with increasing temperature
- Oxygen demand is more at high temperatures

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Coal Gasification Theory Contd..

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TYPES OF GASIFIERS

1) **Moving/Fixed bed** — **Lurgi/BGL**

   Counter-current
   Co-current

2) **Fluidized bed** — **Winkler/KBR etc**

3) **Entrained flow** — **GE/Shell/Conoco/Siemens/Uhde**

   Dry pulverized solid fuel
   Fuel slurry
   Atomized liquid fuel

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Coal Gasification Theory Contd..

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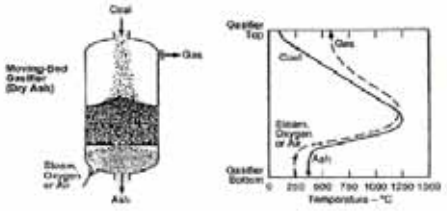
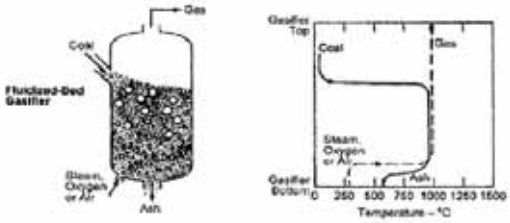
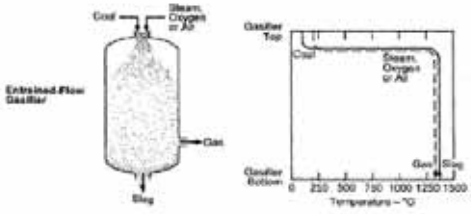
TYPES OF GASIFIERS



MOVING BED GASIFIER



FLUIDIZED BED GASIFIER



ENTRAINED FLOW GASIFIER

Coal Gasification Theory Contd..

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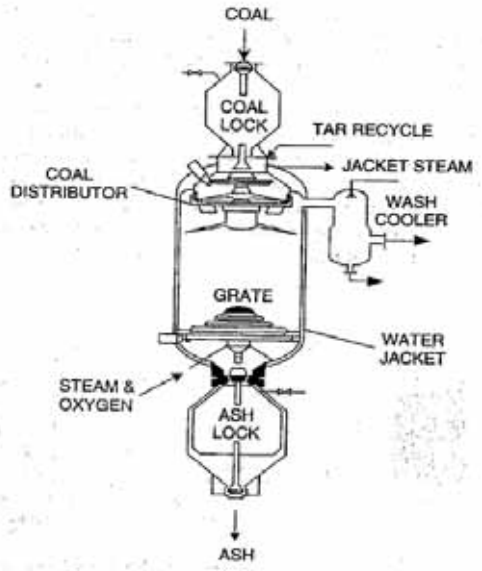
Category	Moving Bed		Fluidized Bed		Entrained flow
Ash Condition	Dry Ash	Slagging	Dry ash	agglomerating	slagging
Typical Processes	Lurgi	BGL	Winkler/HTW /CGB	KRW U-Gas	Shell, Texaco, E-Gas, Noell,KT
Feed Characteristics					
Size	6-50 mm	6-50 mm	6-10 mm	6-10 mm	< 100 µm
Acceptability of fines	Limited	Better than dry ash	Good	Better	Unlimited
Acceptability of caking coal	Yes (with stirrer)	Yes	Possibly	Yes	Yes
Preferred coal rank	any	high	Low	any	any
Operating Characteristics					
Outlet gas temp	Low (425-625°)	Low (425-625°C)	Moderate (950-1050°C)	Moderate (950-1050°C)	High (1250-1600°C)
Oxygen demand	Low	Low	Moderate	Moderate	High
Steam Demand	High	low	Moderate	Moderate	low
Other Characteristics	Hydrocarb on in gas	Hydrocarbon in gas	Lower carbon conversion	Lower carbon conversion	Pure gas high carbon conversion

Coal Gasification Theory Contd..

JINDAL STEEL & POWER

LURGI DRY ASH GASIFIER – MOVING BED



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Coal Gasification Theory Contd..

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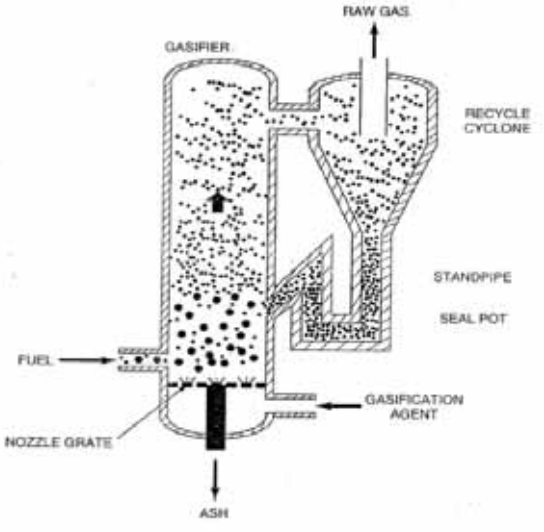
LURGI CIRCULATING GASIFIER – FLUIDIZED BED



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Coal Gasification Theory Contd..

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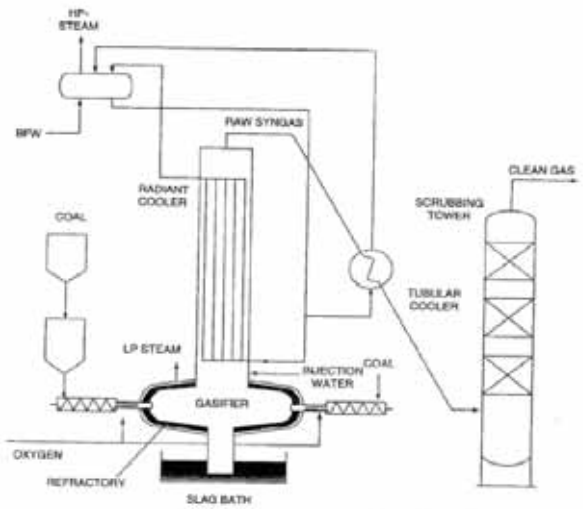
KOPPERS-TOTZEK GASIFIER – ENTRAINED BED



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HISTORY OF GASIFICATION

PERIOD	TECHNOLOGY
Before 1700	Major fuels were Wood and Charcoal
1700-1750	Industrial revolution – Coal as fuel
1800-1900	Coal Pyrolysis – Town gas supply Water gas, Producer Gas
1920	Cryogenic air separation – Oxygen replaces air
1926	Winkler Fluidized Bed Gasifier
1931	Lurgi Moving Bed Gasifier
1940	Koppers-Totzek Entrained Flow Gasifier

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HISTORY OF GASIFICATION (Cont....)

PERIOD	TECHNOLOGY
1950s	Texaco and Shell develop Oil Gasification
1970s	Oil crisis
1973	Texaco develops Slurry Process for Coal Gasification
1974	Shell and Koppers-Totzek Pressure Gasification JV
1981	High Temperature Winkler Gasification
1984	Lurgi Slagging Gasifier (together with British Gas)
1999	Shell/Krupp-Uhde develops Pressurised Entrained Flow (PRENFLO) Gasifier

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GASIFICATION – INDIAN CONTEXT

PERIOD	TECHNOLOGY	FEED	LOCATION
1940s	Wood Gasification	Wood	FACT - Cochin
1945-1950	Lurgi Fixed Bed	Coal	Sindri
1960s	Winkler Fluidized Bed	Lignite	Neyveli
1960s	Texaco	Naphtha	FACT - Cochin
1970s	Krupp-Koppers Entrained Bed Atm.	Coal	Ramagundam Talcher
1970s	Shell	Fuel oil	Sindri
1980s	Shell	Fuel oil	NFL - Bhatinda, Panipat, Nangal
1980s	Texaco	Fuel oil	GNFC - Bharuch

18th December 2017

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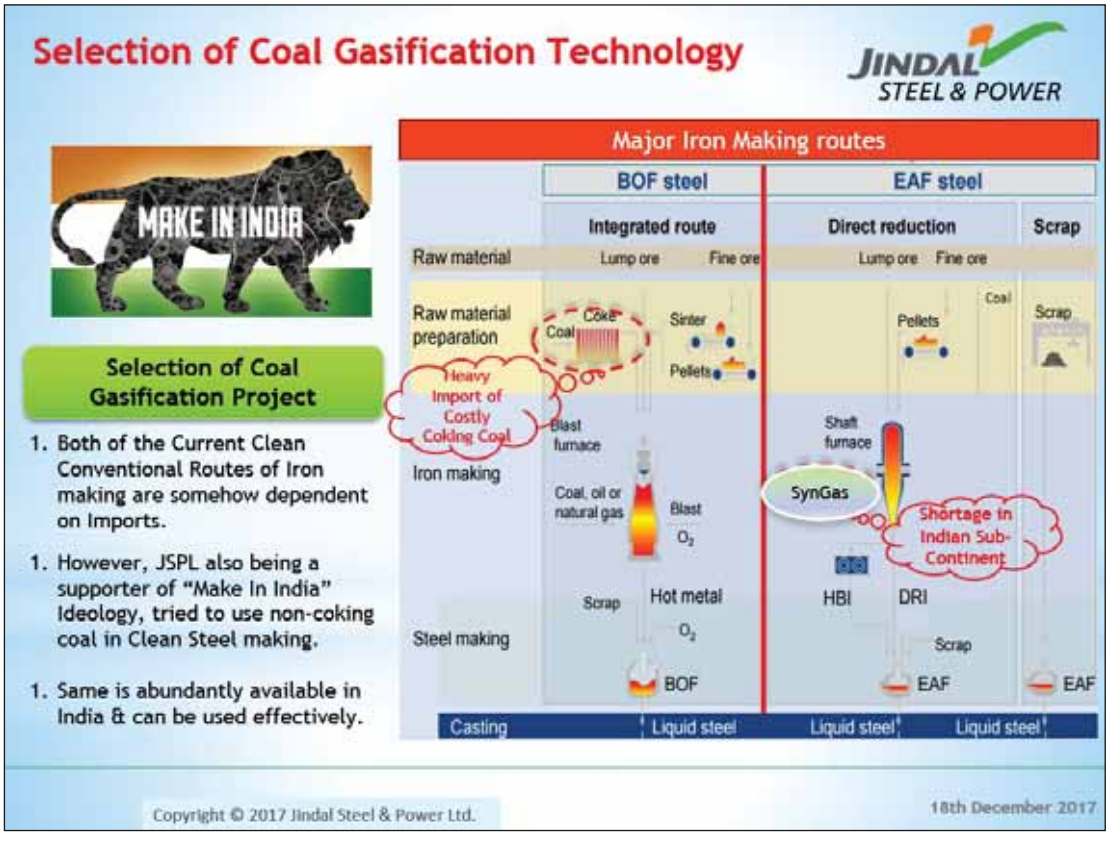
Selection of Coal Gasification Technology
JINDAL STEEL & POWER
MAKE IN INDIA
Selection of Coal Gasification Project
1. Both of the Current Clean Conventional Routes of Iron making are somehow dependent on Imports.
1. However, JSPL also being a supporter of "Make In India" Ideology, tried to use non-coking coal in Clean Steel making.
1. Same is abundantly available in India & can be used effectively.
Major Iron Making routes
BOF steel
EAF steel
Integrated route
Direct reduction
Scrap
Raw material
Lump ore
Fine ore
Lump ore
Fine ore
Raw material preparation
Coke
Coal
Sinter
Pellets
Coal
Pellets
Scrap
Heavy Import of Costly Coking Coal
Blast furnace
Iron making
Shaft furnace
SynGas
Coal, oil or natural gas
Blast
O_2
Shortage in Indian Sub-Continent
HBI
DRI
Scrap
Hot metal
O_2
Steel making
Scrap
BOF
EAF
EAF
Casting
Liquid steel
Liquid steel
Liquid steel
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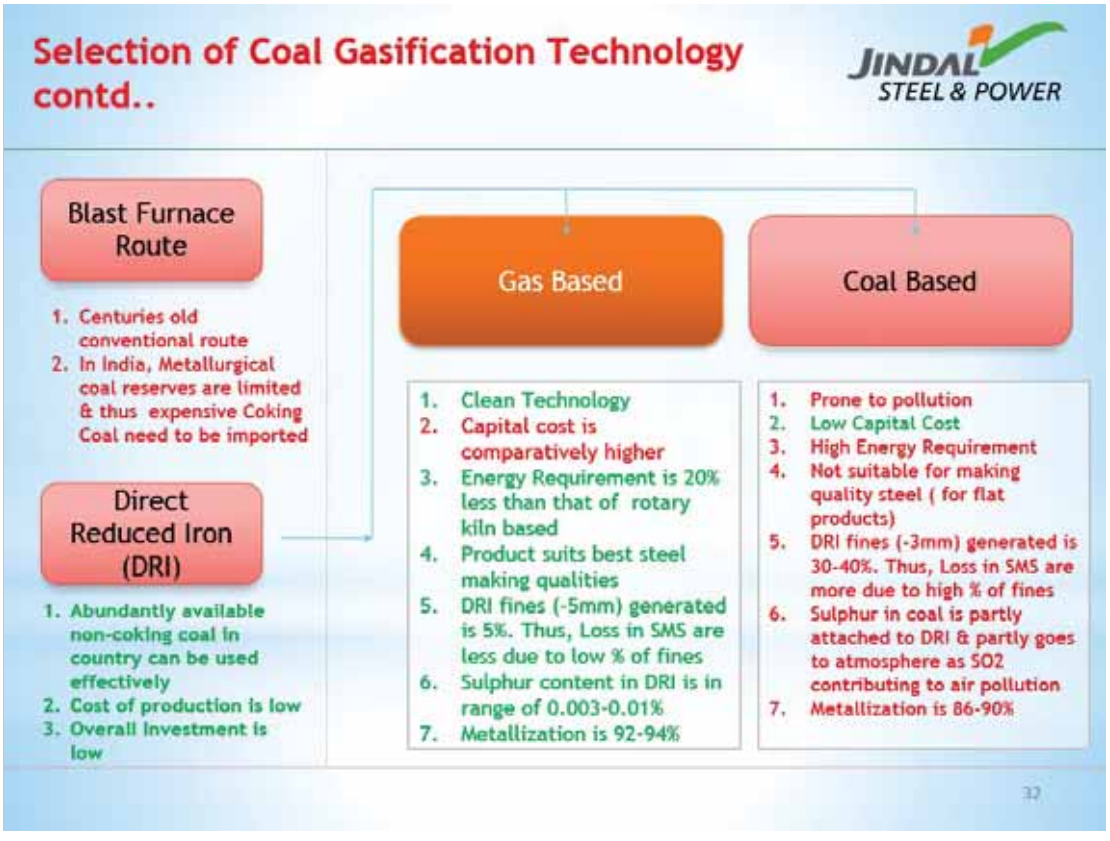
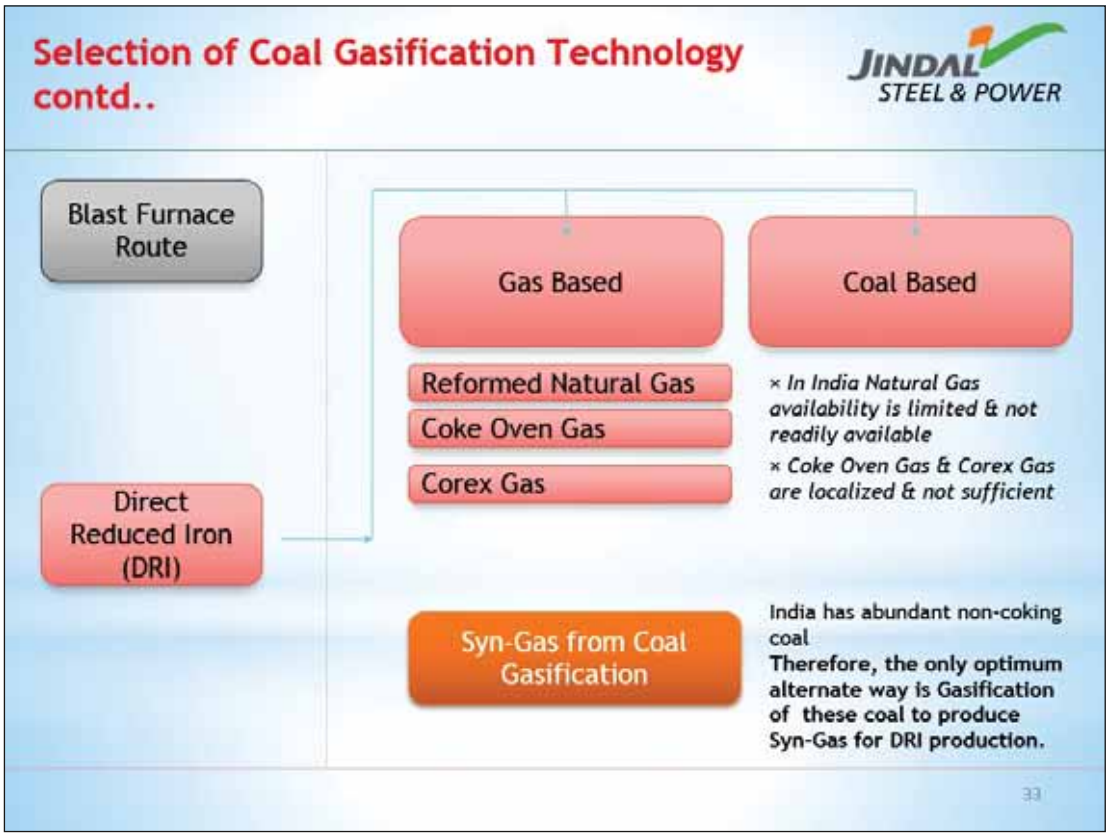

Selection of Coal Gasification Technology contd..
JINDAL STEEL & POWER
Blast Furnace Route
1. Centuries old conventional route
2. In India, Metallurgical coal reserves are limited & thus expensive Coking Coal need to be imported
Direct Reduced Iron (DRI)
1. Abundantly available non-coking coal in country can be used effectively
2. Cost of production is low
3. Overall investment is low
Gas Based
1. Clean Technology
2. Capital cost is comparatively higher
3. Energy Requirement is 20% less than that of rotary kiln based
4. Product suits best steel making qualities
5. DRI fines (-5mm) generated is 5%. Thus, Loss in SMS are less due to low % of fines
6. Sulphur content in DRI is in range of 0.003-0.01%
7. Metallization is 92-94%
Coal Based
1. Prone to pollution
2. Low Capital Cost
3. High Energy Requirement
4. Not suitable for making quality steel (for flat products)
5. DRI fines (-3mm) generated is 30-40%. Thus, Loss in SMS are more due to high % of fines
6. Sulphur in coal is partly attached to DRI & partly goes to atmosphere as SO2 contributing to air pollution
7. Metallization is 86-90%
32



Types of Gasification Technologies

JINDAL

Technology evaluation & Comparison

Various Gasification Technologies were considered and evaluated mainly on the basis of Commercial Scale Demonstration, Capital Cost & Operational Cost:

1. Moving/Fixed Bed (Counter- Current, Co-current)
1. Fluidized bed
1. Entrained Flow
   i) Dry Pulverized solid fuel
   ii) Fuel Slurry
   iii) Atomized Liquid Fuel

	FEATURES	Fixed Bed	Fluidized Bed	Entrain Bed
1. a)	Pressure , Kg/cm2	10-30	Atm	30-40
b)	Temperature deg C	1200	1100	1600
c)	Gas-outlet Temp, deg C	675	~850	1370
2	Type of Coal	All ranks	Low rank coal	All types
3	Feed coal size, mm	6 - 50	0 - 9.5	~200 mesh
4	Moisture in feed Coal, wt%	up to 18		<5
5	Maximum ash content, wt%	up to 40	up to 35	up to 25
6	Ash withdrawal	Dry Powder	Dry Powder	Molten Slag
7	Dry gas composition, vol%			
	CO	18-20	34-36	65-66
	H2	39-41	40-42	30-32
	CH4	10-12	3-4	0.4
	CO2	28-30	19-20	1-2
	S ' Compounds	~0.5	~0.5	0.4
	N2 and others	~0.5	1	1
8	H2/CO ratio in gas	2.1	1.25	0.48
9	Calorific value of gas, kcal / Nm3	2600-3400	2640	2980
10	Cold Gas efficiency, %	>85		80-83
11	Carbon Conversion, %	93-99		>93

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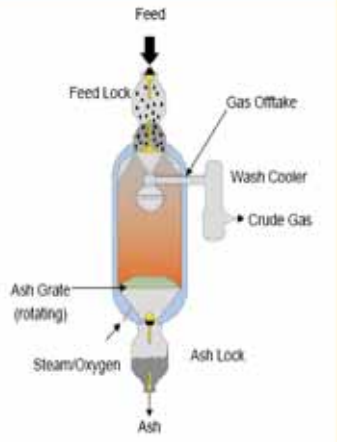
Selection of Fixed Bed Technology

- Well demonstrated, mature and Proven Technology with low risk. More than 100 Gasifiers in operation excl. China.
- Suitable for low Rank, high ash content Coal.
- High Carbon conversion efficiency (approx. 95%).
- High Cold Gas efficiency (85%) due to counter-current operation.
- Low Oxygen consumption.
- Gas Composition suitable for steel Industry.
- Ash fusion temperature of Indian Coal is high, therefore, dry bottom type is preferred.
- No Coal drying & grinding required, hence less energy consumption & not hazardous.
- Valuable By-Products like Tar, Oil, Phenol, Ammonia etc.



Fixed Bed Dry Bottom Gasifier

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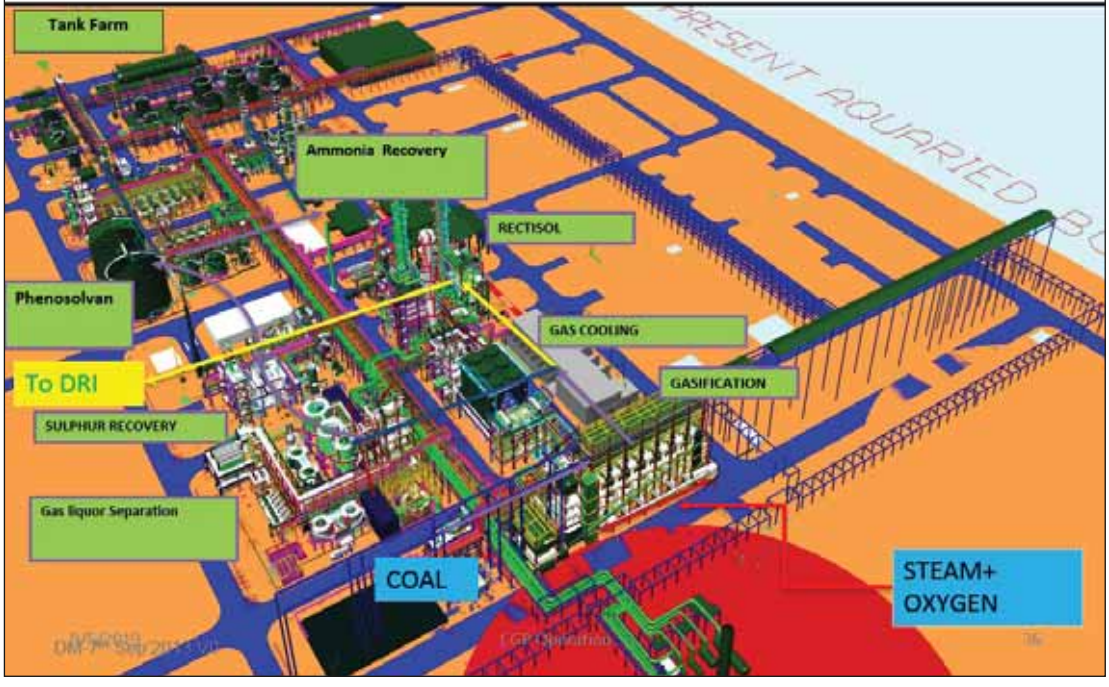
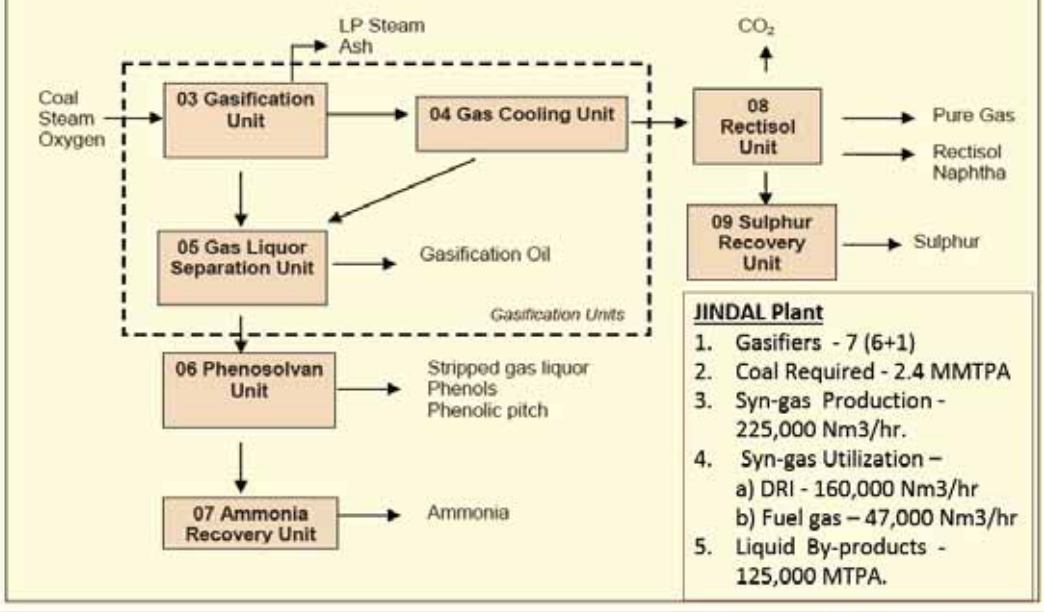
Coal Gasification Complex at a Glance



Syn-gas Production route & Units in CGP



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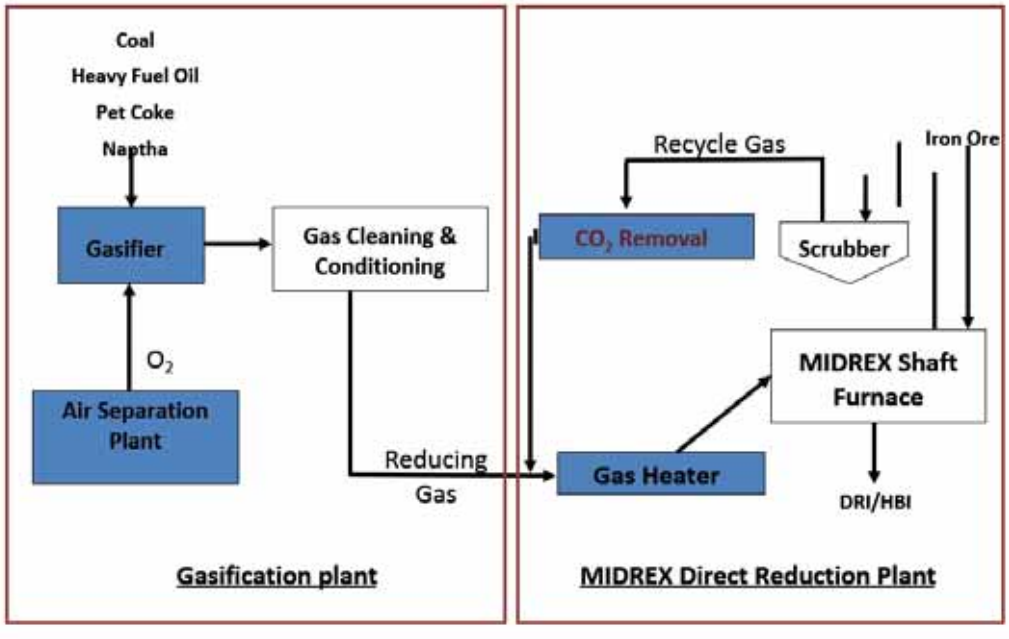
Syn Gas Integration Route to DRI



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CLEAN COAL SPECIFICATION

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Coal Analysis (air Dry basis)	Basis	Coal Gasification Plant Angul Unit - Clean Coal Specification (Non-Coking Coal)	Coal Analysis	Basis	Coal Gasification Plant Angul Unit - Clean Coal Specification (Non-Coking Coal)
Proximate Analysis	%		**Sizing mm**		
			- 70 to 50	%	>3
Moisture	ad	7.50	- 50 to 33	%	16
Ash	ad	34.3	- 33 to 22	%	29
Volatiles	ad	26.3	- 22 to 15	%	21
Fixed Carbon	ad	31.9	- 15 to 10	%	18
Ultimate Analysis	%		- 10 to 7		7
Carbon	daf	76.4	- 7 to 5		3
Hydrogen	daf	5.3	- 5 to 2		>3
Nitrogen	daf	1.9	**Coking Properties**		
Sulphur	daf	0.7	CO2 Reactivity	hr-1	5.9
Oxygen	daf	15.7			
Intial Deformation	°C	1530			
Hemispherical	°C	1590			
Flowing	°C	1600+			

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Gasification – Process overview

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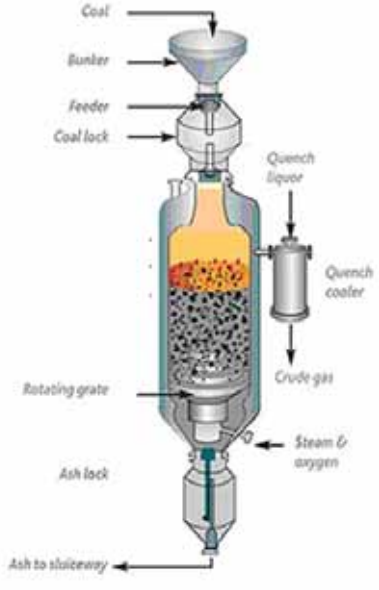
Gasification Unit

- Sasol-Lurgi gasification is a moderate temperature and pressure process.
- Coal is Gasified typically at a pressure of 29.0 Bar in presence of high pressure steam & pure oxygen to produce syngas for further purification & use.
- Raw Gas (400- 450ºc) immediately quenched with hot gas liquor to approximately 200ºc then it is cooled in Primary Waste Heat Boiler (PWHB) to 190ºC.

Note:- Gasification is the conversion by partial oxidation at elevated temperature of a carbonaceous material into a combustible gas termed as Synthesis gas

The Synthesis gas contains CO, CO2, H2, CH4 and traces of higher hydrocarbons etc.



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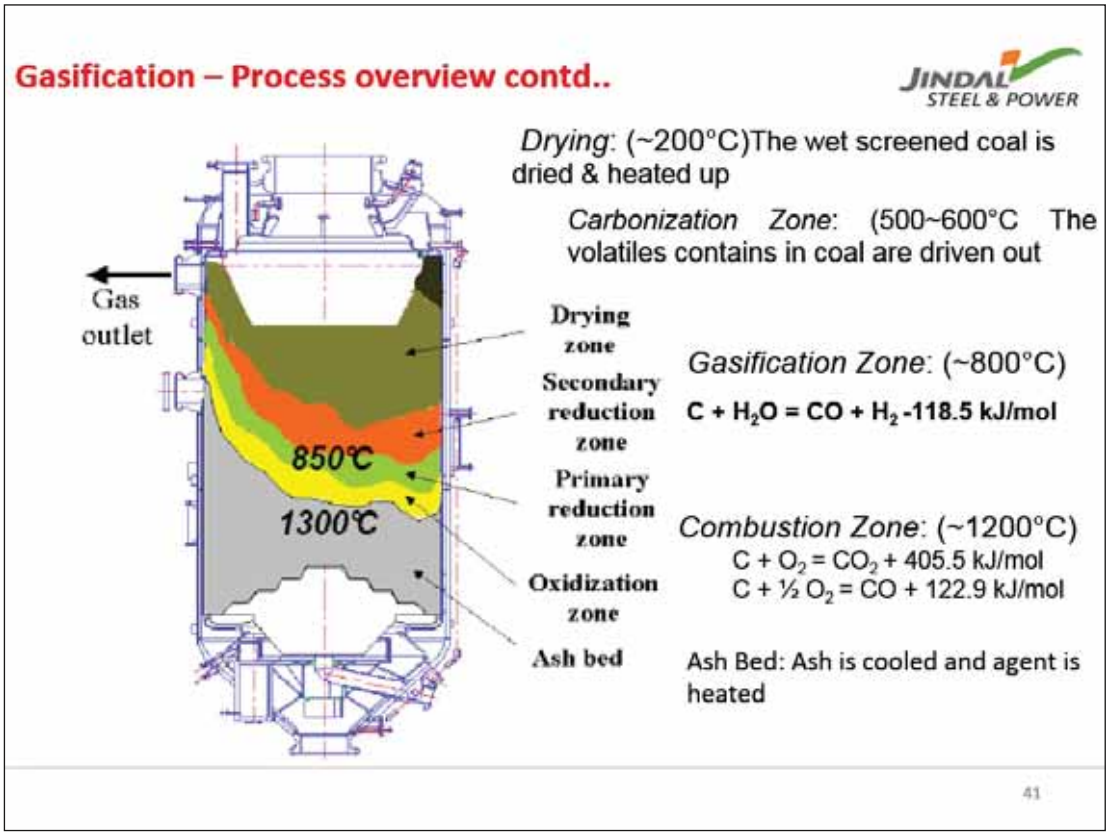
Gasification – Process overview contd..
JINDAL STEEL & POWER
Drying: (~200°C)The wet screened coal is dried & heated up
Carbonization Zone: (500~600°C The volatiles contains in coal are driven out
Gas outlet
850℃
1300℃
Drying zone
Secondary reduction zone
Primary reduction zone
Oxidization zone
Ash bed
Gasification Zone: (~800°C)
C + H2O = CO + H2 -118.5 kJ/mol
Combustion Zone: (~1200°C)
C + O2 = CO2 + 405.5 kJ/mol
C + ½ O2 = CO + 122.9 kJ/mol
Ash Bed: Ash is cooled and agent is heated
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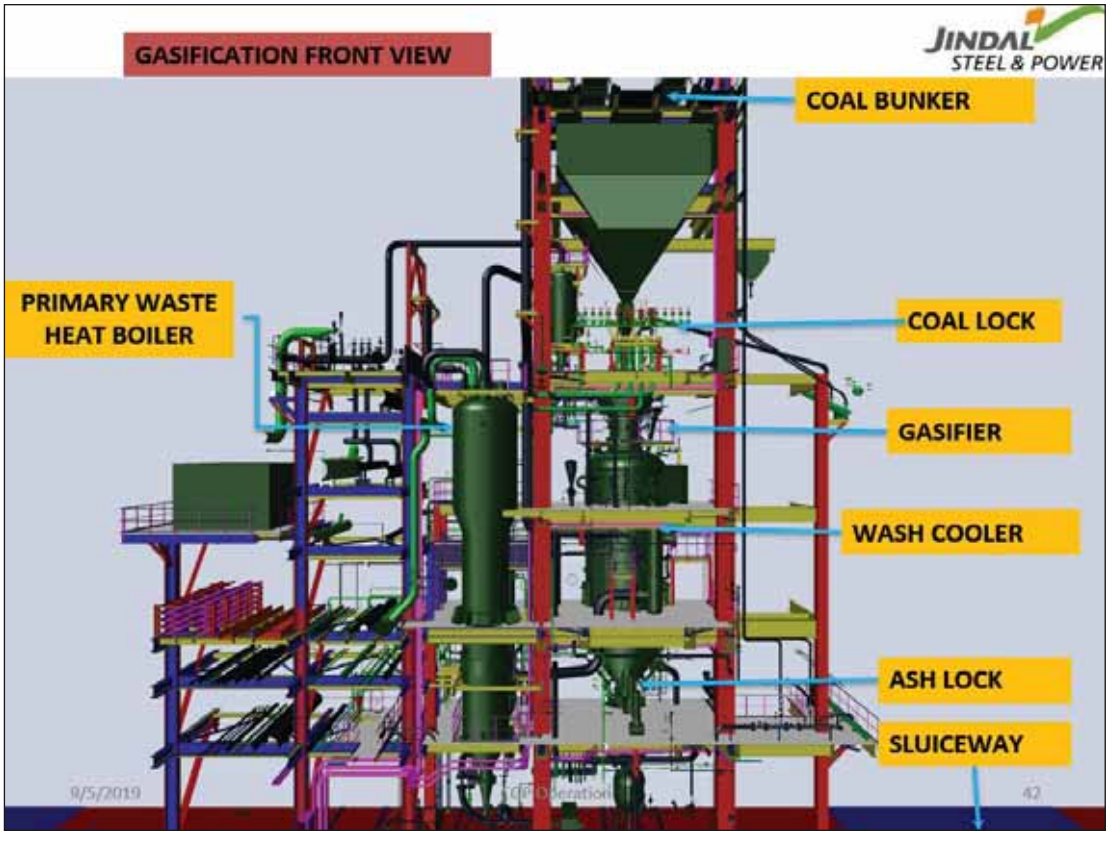
GASIFICATION FRONT VIEW
JINDAL STEEL & POWER
COAL BUNKER
PRIMARY WASTE HEAT BOILER
COAL LOCK
GASIFIER
WASH COOLER
ASH LOCK
SLUICEWAY
9/5/2019
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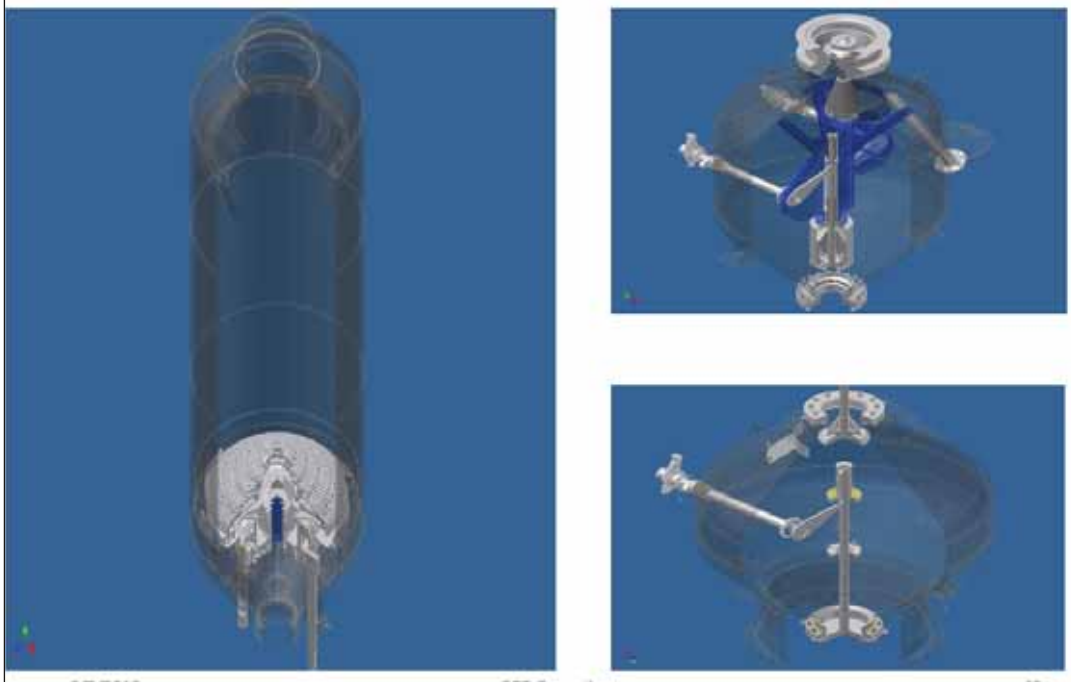
Gasification – Process overview contd..

JINDAL STEEL & POWER



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Gasification By Products

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By Product	Description	Typical Uses	Potential Buyers
De-pitched Tar Acid (DTA)	• Tar acids are a mixture of phenols found in tars and tar distillates that is toxic combustible and soluble in alcohol and coal tar hydrocarbons	• Used as a wood preservative • As insecticide for farm animals • Disinfectants	• Chemical Industry (including insecticide and Detergent manufacturers) • Furniture manufacturers
Phenolic Pitch	• Residual oil left as a by product with potential to be used as illuminating fuel or be further refined into	• Sasol in South Africa is using it's Lurgi gasification to provide coal oil that is being refined to gasoline or diesel fuel	• Petroleum and petrochemical companies
Rectisol Naphtha	• These are hydrocarbons that are recovered as a by-product during the removal of acidic gases from raw syngas	• As diluent in bitumen mining • In the petrochemical industry for producing olefins and as feedstock for high octane gasoline	• Chemical industry • Petrochemical industry • Mining industry
Gasification Oil	• Oil is the hydrocarbon fraction with specific gravity<1 that is condensed when the raw syngas exiting the gasifier is cooled from 35-160 degrees C	• Can be used as the basis for further refining and processing to produce Fischer Tropsch liquids like diesel, furnace oil, gasoline etc.	• Petrochemical industry
Clear Tar	• Tar is a hydrocarbon fraction with specific gravity>1 that is condensed when raw syngas exiting the gasifier is cooled to +/-160 degree C	• Tar is a key component in road construction, and in manufacture of paints, synthetic dyes and photographic materials • It is also used in medicinal shampoos and ointments	• Construction industry • Paint and dye manufacturers • Pharmaceutical companies

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Gasification By Products contd..

JINDAL STEEL & POWER

Additionally, these by-products can be further processed to value added products; benefit-cost analyses required to establish value

PRELIMINARY

Selected By-Products	Typical Value-Added Products	Potential End Products	Customer Industries
De-Pitched Tar Acid (DTA)	Phenols	Disinfectants	Chemical
	Cresols	Solvents	Chemical
	Light Oils	Gasoline Additives (Benzene)	Petroleum
	Heavy Oils	Dye (Chrysene)	Dye/Paints
Phenolic Pitch	Acetophenone	Resins, Fragrances	
	Phenol	Bakelite, Nylon	Clothing/Baking Goods
	Cumene	Phenol, Acetone	Baking Materials
Rectisol Naphtha	Ethylene	Packaging and Carrier Bags	Plastics/Packaging Material
	Propylene	Films and Packaging	
	Butadiene	Synthetic Rubber	Tires/Hoses
	Benzene	Gasoline Additives, Solvents	Petroleum
	Xylene	Solvents	Chemical
	Toluene		
Gasification Oil	Diesel (FT)	Feedstock, Direct Use	Energy/Power
	Gasoline (FT)		
	Waxes	Polishes	Varnish/Furniture
Clear Tar	Creosote	Antiseptic/Astringent	Cosmetics/Pharmaceutical
	Cresolene	Disinfectants	Chemical

Gasification By Products contd..

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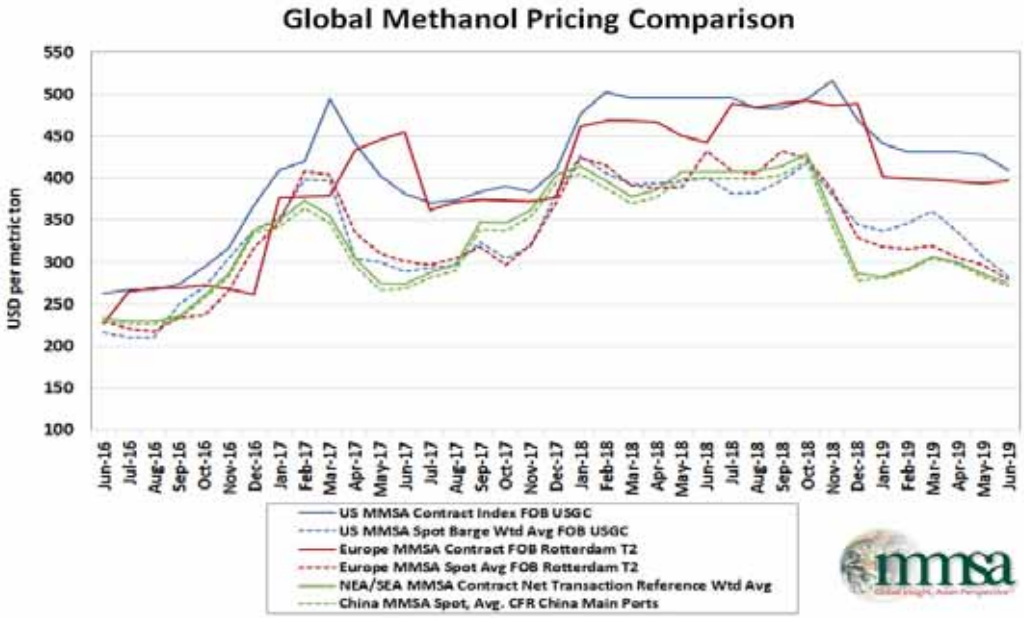
International Price of Ammonia 2019 ($/T)

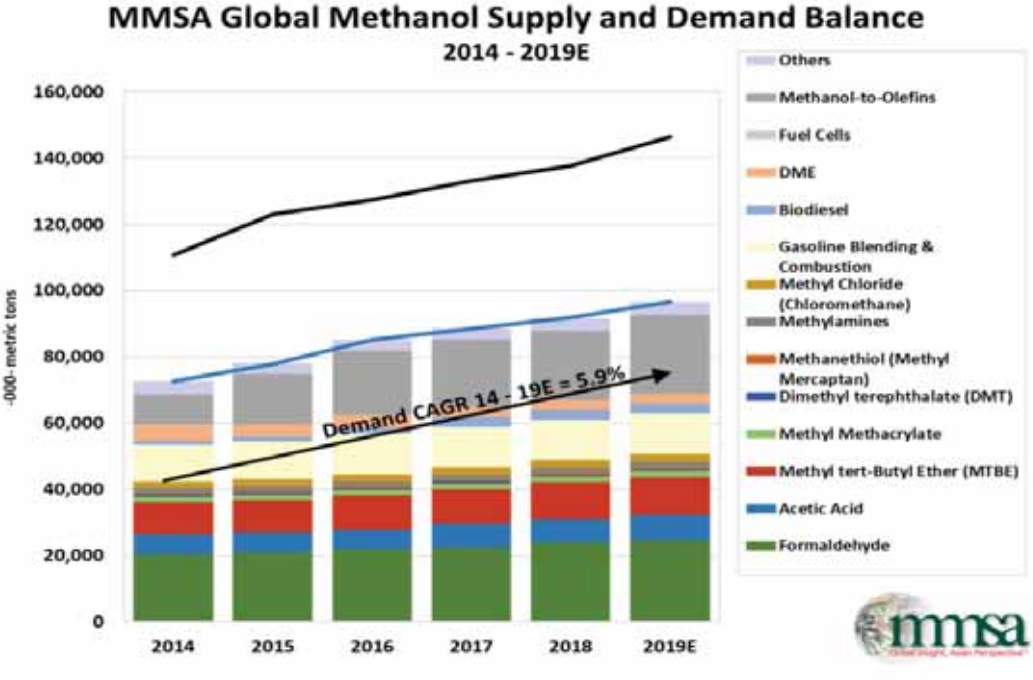
Month	Middle east FOB	India CFR	Tanpa CFR	USA Gulf CFR
Jan-2019	290	340	293	298
Feb-2019	269	306	285	290
Mar-2019	250	294	278	283
April-2019	243	282	267	265
May-2019	213	254	235	240
June-2019	199	240	220	225
July-2019	198	238	215	220

Gasification By Products contd..

Methanol Market Assessment of key global pricing and supply/demand figures by Methanol Market Services Asia (MMSA)



Gasification By Products contd..



JINDAL STEEL & POWER

Challenges for Clean Coal

- Complex projects
- High cost of new technology
- Need to strengthen research environment
- Expensive & high risk investment for any single industry player
- Need collaborations with emerging technology providers
- Needs strong support from Indian Government
- Need Public/ Private partnerships and partnership with technologically advanced players

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JINDAL STEEL & POWER

Progressive policy needed to accelerate improved coal utilization

- Accelerate opening up of Coal sector for private sector investments
- Develop clear policy on bidding and allotment of coal blocks
- Open new coal blocks for bidding
- Expedite clearances for new projects
- Strengthening of coal supply chain
- Promote consortia (private + public) for pre competitive technology development with financial support
- Policy concessions and economic incentives for development and deployment of new technologies in India
- Coal pricing to be market linked

Government's proactive role in building technical & operational capabilities is crucial

RU - 30 July 2013 V0

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Gasification Unit


Gas Cooling Unit


Gas Liquor
Separation Unit


Rectisol


Phenosolvan unit


Ammonia Recovery Unit

Sulphur Recovery Unit

Flare Stack

Author's brief Introduction

Awadhesh Narayan Tiwari

Executive Vice President
JSPL, Angul

A Chemical Engineer 1982 batch from university of Roorkee and MBA finance from Osmania University.

I have worked with The Fertilizer Corporation of India, Rama Petrochemicals Air Liquide, SIPCHEM and JSPL. 35 years of my carrier was associated with commissioning and operation of coal gasification, Ammonia, Methanol and Industral gases. Currently I am working with M/s Jindal Steel and power Limited.

My presentation mainly covers the application of coal gasification its theory. History of coal gasification challenges and few slides regarding imported price of Ammonia and Methan.

CBM in India

— Shri U Kumar*, N.N. Gautam**
P.N. Hajra***

The prime source of Commercial Energy world wide continues to be Fossil Fuels. One of these Fossil Fuels, which has lately assumed great importance is Natural Gas which has in-built advantage of Low Carbon Footprint and High Combustion efficiency. Its popularity as an Industrial as well as Domestic Fuel is increasing and even India is aspiring to increase its contribution to the Energy Basket from the current 6% to 15%.

Unfortunately, Indian Reserves of Natural Gas are rather poor- only 1340 Billion cub mtrs (120 .6 Billion Tons) against Global Reserves of 194 Trill . Cu. Mtrs. and its total Resource has been assessed as only 643 TCM. On the other hand, the country is endowed with huge coal resources - of the order of 325 billion tons . Coal Bed Methane is a Natural Gas which is "adsorbed" in Coal and it is expected that based on huge Coal resource in the country, CBM resource in the country should also be substantial. So far only 26000 sq. kms. of Coal bearing area in the country has been explored and 2600 billion cub mtrs CBM Resource has been estimated.

The total Coal Bearing area in the country being 1,80,000 sq. kms. , it is certain that if this entire area is explored, CBM Resource of a much higher order will be available.

History

CBM recovery from Coal Deposits started in USA in 80s and USA started production of substantial quantity of CBM by early 90s. This attracted global attention from the coal -rich nations including India in the last decade of last century and CBM policy was formulated in India in 1997.

The policy provided for sustained efforts for discovery and recovery of CBM for Industrial usage. Since Estimates for the CBM Resource were not available, Govt of India took up a "CBM Recovery and Utilisation Project" with "UNDP/Global Environmental Facility" in 2002. This was a Pilot -Scale Demonstration Project which consisted in 18 vertical Boreholes to be drilled in Moonidih project and I km long in-seam holes in Sudamdih Project of BCCL in Jharia Coalfield for tapping the CBM and utilising it for Power Generation. This project was successfully executed and that CBM could be tapped from vertical wells could be utilised for Power Generation by reciprocating electricity generating sets of I MW and economic viability was effectively established.

At this stage unfortunately things appear to have lost their way. CBM being a part of the Coal Deposit , CBM Recovery and Utilisation project was looked after by Ministry of Coal and it became the Administrative ministry for CBM Development. CBM however had not been defined as a Mineral in the statute and it could not therefore be called a part of coal.

Further, the statutory framework through which Coal Mining in the country was administered could

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not be related even distantly to CBM which is in gaseous form. On the other hand, CBM being a Gas had very similar characteristics as Natural Gas and thus being administratively logical, it was placed under the administrative charge of Ministry of Petroleum and Natural Gas. In the initial years therefore, CBM was being administered by two Ministries- while it is in the Coal Seam (CMM Recovery) it was under the purview of Ministry of Coal and once it would be recovered from virgin coal seams, it would come under Ministry of Petroleum and Natural Gas.

For better coordination however, a joint committee of Ministry of Coal and Ministry of Petroleum and Natural Gas was constituted to administer the development of CBM in the country.

There were other complexities as well:

1. Coal India Ltd, Singareni Collieries Co. Ltd, Tatas, Steel Authority of India Ltd ,DVC and Allocatees of Captive Coal Blocks and State Govt Mineral Development Corporations which had been given Coal Blocks through Nomination Route held the leases for Operating Coal Mines as well as the Coal Blocks allotted to them and awaiting development.
2. Coal Deposits which had not been allotted to any Coal production company.

   The question was who would have the ownership of CBM . After great deal of deliberations it was decided that:

   a. Title to the CBM would belong to the Lease holders where ever leases had been granted for Mining Coal or else Blocks had been allotted though Leases had not been granted and these companies would exploit the CBM resource who would be successful bidders through auction route.

   b. The title to the CBM in the Coal deposit which had not been allocated to anyone would vest in the Ministry of Petroleum and Natural Gas . It is this Ministry which would allocate the CBM in different areas for development through auction route.

While Coal production companies were deliberating on the manner & methodology to proceed, in the areas which were beyond the Leasehold referred to above , CBM Blocks were carved out by Directorate General of Hydro Carbons (DGH) in close interaction with Ministry of Coal and CMPDI.

These Blocks have been allocated by MoPG through Competitive Bidding Route and in 4 Rounds there of, 33 Blocks having a total area of 17327 sq kms have been awarded. Estimated Resource in these Blocks is 1.8 TCM and the total CBM production potential was estimated as 38 MMSCMD.

Progresstill date :

Over a period of last 15 years , the Reserves established are 400 BCM ie 22% of the Estimated Resources of 1800 BCM.

These Reserves have been established in 4 Blocks in Damodar Valley Coalfields namely Raniganj, Jharia, Bokaro and North Karanpura and 3 Blocks in Sone River Valley Coalfields namely Sohagpur East, Sohagpur West and Sohagpur North.

Currently 3 Blocks have gone under production and are producing 1.9 MMSCMD and the other 4 Blocks which have gone into initial production are expected to produce 2 MMSCMD.

An exercise on a hypothetical CBM project of 50 sq kms area with 7.5 BCM of reserves has revealed that in all about 150 Wells will be required and the rate of production would be around 5500 cub mtrs per day. The productive life of the Wells should be about 25 years and production rate would be 0.825 MMSCMD. The cost of production inclusive of Royalty Taxes etc is likely to be of the order of US$ 3.5 to 4.0 per MMBTU.

Even at the old Sale Price of US $ 8 per MMBTU, the Project would be viable. Now that the Price has been fixed at US$ 11 per Million BTU, the project would be highly profitable.

With this type of economics, we should have made substantial progress towards harnessing the CBM Resources which would have provided an environment friendly fuel as good as Natural Gas but the desired level of progress has not been achieved on account of the following which could be tackled by action shown against each of them.

1. Delay in grant of PEL by State Govts: The solution lies in the State Govts. becoming little more pro-active. They have to appreciate that maximisation of production of CBM would make cleaner fuel available to the people which will make their life easier. At the same time Royalty , Taxes etc. will add to the States' income. It will be worth its while that Central Govt , after deliberating with the concerned State Govts. lay down the time lines for the processing of applications leading to grant of PELs.

2. Problem about availability of Land: Fortunately the land requirement for individual CBM Project is not very large, it is only for a limited period and not much damage is done to the land in course of development and operation of the Project. Land can therefore be taken on lease with handsome lease rent being payable to the Land owners with a commitment that after the project is over, the land will be restored to productive status by the Developer and it will be handed over back to the land owners. With a lump sum grant for making necessary modifications on the land states.

3. Over lapping of Coal Mining Blocks with CBM Blocks : Now that lease holders for Coal have been authorised to produce CBM , this part of the problem in as much as it relates to the Blocks in already leased out area should be over. For the areas, which have not been leased out for Coal Mining, DGH together with CMPDI should chalk out the Action Plan for CBM Development and the developer who are awarded the Block should be given this Action Plan as a guideline.

4. Gas Price: An Independent Regulator for this sector should be appointed for fixing Sale Price and framing Rules and Regulations for the game.

5. Pipeline for transportation: Gas Marketing Companies in the country like GAIL , IOC, HPCL etc may be given different areas where the CBM Blocks have been allocated and they could lay the gas grid for which the investible fund could be made available by the Block Allocatees as per their gas producing plans. Alternatively, these Gas marketing companies could make their own investment and charge the CBM producers for utilisation of these pipelines.

6. Technology upgradation and absorption: Once the volume of activities picks up and this business establishes itself as a profit making venture venues for technology upgradation will open automatically.

7. Availability of Drilling and fracking equipment for CBM: Govt should consider tax incentives for import of these equipment

8. Non-availability of Expertise for logging and hydraulic fracturing etc. : Here again Govt should consider tax incentives for import of human expertise in this field.

9. Lack of Data regarding Gas content , Saturation level and Permeability of Indian Coal Deposit which is mostly of poor rank.: Govt should encourage expert foreign companies to come to India to make a study of the Coalfields and sell their knowledge to the prospective entrepreneurs who would be interested in getting the allocation of the CBM Blocks.

Going forward, it can be hoped that this indigenously available clean source of Energy would receive due attention in the country & it would contribute effectively. To India fulfilling its commitment on reducing the carbon foot-print in its GDP growth.

Actual progress and future programme of the CBM blocks under development

ONGC-CIL(90:10) : Jharia	**ONGC- IOC(80:20) : North Karanpura**
Total Area-85 Sq. Km. (85 BCM- DGH)	Total Area-340 Sq. Km. (62 BCM- DGH)
Established in-place vol. - 22.7 BCM	Established in-place vol. - 23 BCM
72 fresh development wells and 14 carried forward wells	68 fresh development/ 6 carried forward wells. ONGC roped in Prabha Energy (Deep Industries) by off- loading 25% of its PI for initiating development drilling .
Development drilling yet to start	Average well production 4000-5000Cu.m
Average well production 7000-8000 Cu.m	Expected Production from this area ~0.3 MMSCMD
Expected Production from this area ~0.6 MMSCMD	Regular production from the development wells yet to start
No information regarding initiation of Development drilling	Delayed progress due to difficulties in land acquisition.
Present Production- 15000m 3/day (i.e.0.015MMSCMD)	
Issue of overlapping of coal mining block and difficulties in land acquisition delayed the progress	

ONGC- IOC(80:20) : Bokaro	**GEECL: Raniganj South**
Total Area-95 Sq. Km. (45 BCM- DGH) Established in-place vol. - 28 BCM 146 fresh development wells and 9 carried forward wells Development drilling started Average well production 6000-8000 Cu.m Expected Production from this area ~0.8 MMSCMD Regular production from the development wells yet to start Delayed progress due to difficulties in land acquisition.	Total Area-210 Sq. Km. (30 BCM; DGH) Established in-place vol. - initially 38 BCM-revised to 69 BCM Currently in Development Phase ; planned to drill 300-400 wells Average well production 4000-6000 Cu.m Expected Production on full field deliverability ~2.5 MMSCMD Drilled about 150 wells ; Present Production- 0.5 MMSCMD 1st Operator to declare commercial production with 0.15 MMSCMD in 2008 Reason for gas production of only 0.5-0.6 MMSCMD in 10 years is difficult to explain
RIL: Sohagpur East & West	**ESSAR : Raniganj East**
Total Area-995 Sq. Km. (86BCM- DGH) Established in-place volume - >100 BCM Currently in Development Phase ; planned to drill 500-600 wells Average well production 5000-8000 Cu.m Expected Production on full field deliverability -2.5 - 4.5 MMSCMD Drilled about 230 wells Present Production-0.8 MMSCMD Problem of gas pricing and acquisition of land in tribal areas	Total Area-500 Sq. Km. (42 BCM- DGH) Established in-place volume - 120 BCM Currently in Development Phase ; Identified Fair Way area of around 200 sq. km. planned to drill 550 wells Average well production 3000-5000 Cu.m Expected Production on full field deliverability -2.5 - 3.0 MMSCMD Drilled about 348 wells ; ~150 wells on production Present Production-0.6 MMSCMD Problem of gas pricing and problems in supply end-reason for less production

Reliance Infra: Sohagpur North	**RIL: Sohagpur East & West**
Total Area-609Sq. Km. (19 BCM- DGH)	Total Area-995 Sq. Km. (86BCM- DGH)
Established in-place vol. - 54 BCM	Established in-place volume - >100 BCM
Exploration Phase completed	Currently in Development Phase ; planned to drill 500-600 wells
Pilot Phase work yet to start	Average well production 5000-8000 Cu.m
Short time Exploratory Test well produced ~3500m3/day	Expected Production on full field deliverability -2.5 - 4.5 MMSCMD
No projection of production can be made	Drilled about 230 wells Present Production- 0.8 MMSCMD

Non Fuel Use of Coal

— Tarit Baran Das*

Abstract

The proven colossal coal reserves and the aromatic macro-molecular components present in coal, makes it ideal feed stocks for industrial chemicals and carbon-based materials such as basic chemicals, plastics and fibers. These chemicals and carbon based materials are derived mostly from petroleum and natural gas. Coal is now being recognized as an important potential source for producing carbon materials and chemicals and therefore is an area for future coal research and development. However, the traditional source of coal chemicals, tars or liquids obtained as by-products of coke ovens, has steadily decreased in the last few decades. The main hurdles towards the use of coal for producing chemicals and carbon materials include its structural complexity, processing difficulties, heterogeneity of organic matrix, inorganic impurities, processing costs and negative environmental impact. The number of chemicals that may be produced from coal is boundless. Major chemicals currently being produced from coal include mono-ethylene glycol, di-methyl either, olefins, acetic acid, formaldehyde, urea, ammonia, acetylenes, vinyl chloride monomer, poly vinyl chloride, butane diol, vinyl acetate monomer, acrylic acid, acrylonitrile, naphthalene derivates as well as humates agrichemicals from lignite. High value – low volume products which include activated carbon, carbon electrodes, carbon fiber and composite materials like carbon nano tubes and graphene may be sourced from coal feed stocks.

1.0 Introduction

Indian economy is one of the fastest growing major economies of the world. India is the 3rd largest energy consumer in the world, but ranks 47th in terms of per capita energy consumption. Coal dominates India's energy consumption matrix accounting for 56% of primary energy consumption. India has committed reduction of emission intensity of its GDP by 33–35% by 2030 from 2005 level to combat climate change. India targets to achieve renewable energy capacity of 175 GW by 2022 and 40 percent of installed capacity from non-fossil fuel based energy resources by 2030.

The provision of secure, affordable and sustainable energy is one of the major challenges for the fast-growing economy of India. The overarching objectives of Indian energy policy are to provide access and affordability, given the large number of Indians still lacking access to modern forms of energy and the importance of energy in fueling industrialization, urbanization and infrastructure development. However, in recent years, environmental concerns have risen up the ranks of policy priorities. This has been due to the worsening of environmental challenges such as local air pollution and water scarcity, as well as increasing cognizance of the threats posed by global climate change to Indian sustainable development.

The outlook of commercial use of coal is basically governed by two conflicting factors; using an abundant, low cost and secure domestic energy resource and the necessity to comply with increasingly stringent environmental control requirements. The most significant uses of coal are in electricity

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generation, steel production, cement manufacturing as well as liquid and gaseous fuels derived from coal through conversion processes. Other users of coal include alumina refineries, paper manufacturers, and the chemical and pharmaceutical industries.

The combustion of coal for power and heat generation is predicted to gradually reduce as nations seek to lower CO_2 emissions. The non-fuel uses of fossil fuels, particularly coal, may become more important in the future. The existing non fuel use of coal includes , i) Gasification of coal to make synthesis gases and other chemicals; ii) use of coal in manufacturing carbon based materials like activated carbon, carbon molecular sieves, and 'high value- low volume carbon based nano scale graphitized products, iii) use of coal tars from carbonization for making aromatic chemicals like creosote oil, naphthalene, phenols and benzene, iv) ammonia gas recovered from coke ovens is used for manufacture of ammonia salt, nitric acid and agricultural nitrogenous fertilizers; v) use of coal tar pitch for making carbon fibres which are extremely strong and light weight reinforcement materials.

2.0 Coal-to-chemicals through processing of coal tar and coal gasification

The long-established coal-to-chemicals (CTC) industry directly processes coal tar obtained from Coke manufacturing plants, which is then used to manufacture a host of everyday products such as pharmaceuticals, dyes and preservatives.

The coal-to-chemicals (CTC) industry has two distinct branches: the production of chemicals from coal tar, itself a by-product of coal coking; and the gasification of coal to produce synthesis gas which may be catalytically converted to liquid fuels, methanol, DME, polymers like olefins and a host of other carbon based products and chemicals.

2.1 Coal tar to chemicals and polymers

Before 1945 about 75% of all the organic chemicals in the world were based on coal-derived liquids. The processing of coal tars from by-product coke ovens into useful chemicals is mature technology. With the advent of vast petroleum resources in the world during the 1940s, crude oil gradually became the dominant chemical feedstock by 1960. Currently, petroleum and natural gas account for more than 90% of the major industrial organic chemicals. These resources are the primary sources of the seven basic organic chemical building blocks: ethylene, propylene, butadiene, benzene, toluene, the xylenes, and methanol. However, coal tars still remain an important source of aromatic chemicals.

Typically, a tonne of coal will yield between 30–45 litres of tar. The tar composition varies but contains approximately 50% pitch, the remaining light tar fraction has over 300 components principally phenolic compounds, light aromatic oils (2%), naphthalene (10%) and creosote (33%). The heavier pitch contains a toluene insoluble fraction (73%), beta resins (13%) and residue classed as quinoline insoluble matter. The high heterogeneity, processing cost and potential carcinogenicity and combustibility of coal tar act as deterrent for its use as organic chemical feedstock. The wide range of chemicals and every day products derived from coal tar includes dyes, solvents, surfactants, shampoos, perfumes, preservatives, rayons , nylons and many more. Raw coal tar consists of a complex mixture with hundreds of aromatic compounds (benzene, phenol, naphthalene, and creosote oil) comprising the lighter fraction and the heavier aromatic tar pitch tends to be used directly, for example as in roadway sealants and as a binder in the manufacture of industrial electrodes.

2.2 Coal gasification

Coal gasification offers a versatile and clean method of converting coal into not only electricity but also hydrogen and other valuable products. Gasification, a thermo-chemical process, breaks down the coal into its basic chemical constituents. In modern gasifiers, coal is typically exposed to steam and carefully controlled amounts of air or oxygen under high temperatures and pressures. Under these conditions, molecules in coal break apart, initiating chemical reactions that typically produce synthesis gas (syngas), hydrogen (H2), carbon monoxide (CO) and other gaseous compounds.

Advantages of gasification include:

- *product flexibility:* a variety of commodities can be produced from the syngas including methanol and ammonia which are key building blocks for further chemical synthesis,
- *low emissions:* gasification produces lower emissions due to the high temperatures and pressures used to produce the syn gas,
- *feedstock flexibility:* gasification plant designs have been developed to accommodate various grades of coal including lignite, and
- high efficiency: steam produced by a gasification process can be effectively integrated to meet the needs in a chemical plant.

Typical syngas contains about 25-30% hydrogen and 30-60% carbon monoxide along with a few other gaseous components. Gasification results in the major proportion of the feed fuel heating value being associated with the CO and H2 components of the syn gas and their relative amounts depend on the gasifier technology. Most processes utilising syn gas require a certain H2/CO ratio. In non-fuel applications, the raw syngas is passed to a shift convertor in which the water gas shift reaction is employed to change the H2/CO ratio. The majority of syngas used worldwide in 2012 from all fuels was for the production of chemicals, liquid fuels and power generation. In the case of coal, of the total syngas produced, 49% is used for FT (Fischer-Tropsch) liquids, 32% for chemicals, 11% for power generation and 8% for gaseous fuels. Syngas generated from gasification can be used to produce pure hydrogen which can be used as an intermediate in the production of chemicals such as ammonia. A mixture of H2/CO generated from syngas can be used to produce chemicals such as methanol and pure CO can be used to produce chemicals such as acetic acid. Coal gasification, as discussed above, is already applied widely in the production of chemicals and fertilisers. A number of products can be developed using these processes: ultra-clean petroleum and diesel, synthetic waxes, lubricants, chemical feed stocks and alternative liquid fuels such as methanol and dimethyl ether (DME).

2.3 Coal to liquids

Coal-to-liquids (CTL) describes both direct coal liquefaction technologies and coal gasification, combined with Fischer-Tropsch (also known as F-T) synthesis to produce liquid fuels. Direct liquefaction works by dissolving the coal in a solvent at high temperature and pressure. The process is highly efficient, but the liquid products require further refining to achieve high grade fuel characteristics. The F-T synthesis was first developed in Germany during the early decades of the 20th century and has been further developed and improved in South Africa by Sasol. The F-T reaction

involves passing hydrogen and carbon monoxide in a specific ratio over iron catalysts at elevated temperatures and pressures. The fixed-bed system employs a precipitated iron catalyst. Predominantly heavy hydrocarbons of an aliphatic nature are produced with carbon chains up to 100. These straight-chain hydrocarbons yield waxes and high quality diesel oil, which is also used as raw material for the production of high quality biodegradable detergents. The fluid-bed system, based on catalytic cracker technology, has the advantage of high production capacity and scale-up potential. The quantity of ethylene obtained is augmented by ethane cracking. The light olefins can be used as petrochemical feedstock or refined, for example by polymerization, and the product added to the motor fuel pool. The product cut in the gasoline range yields gasoline by using conventional refinery techniques. The oxygenated chemicals, when sold as such, fetch higher prices than when sold as motor fuels.

3.0 Carbon-based Materials

Coal can be used for making not only the industrially important materials such as coke, pitch, and activated carbon and carbon molecular sieves, carbon fibres, but also for making new carbon materials such as fullerenes and carbon nano tubes. It can also be used for making materials that have potential agricultural and industrial applications such as humic acids and coal/polymer composites.

3.1. Carbon fiber from coal tar pitch

Carbon fibre is a long, thin strand of material approximately 0.01 mm in diameter composed mostly of carbon atoms. The carbon atoms are bonded together in microscopic crystals aligned parallel to the long axis of the fibre. The crystal alignment results in a high strength fibre that has exceptional thermal properties. About 90% of the carbon fibre produced is made from polyacrylonitrile (PAN). The remaining 10% is made from coal tar pitch or petroleum heavy oil feed stocks. production. The successful substitution of polyacrylonitrile by coal tar pitch (pitch process) is believed to be a more economical route to carbon fibre. The market for carbon fibre is growing rapidly with notable carbon fibre products in sporting goods, automotive, aerospace and wind turbine blades. The demand for lightweight carbon fibre is set to increase dramatically in the next decades, as it is an important contributor to improved energy efficiency in transport. Carbon fibre is both lighter and stronger than steel or aluminium which makes it an attractive alternative material to reduce the weight of all types of vehicles with the advent of transport electrification and applications to aerospace industries. The use of carbon fibre is already established in the aerospace industry.

3.2 Activated Carbon from coal

Activated carbon is a highly porous material possessing a disordered layered structure of carbon atoms obtained from thermal and steam treatment of a carbonaceous feedstock. It can be made from a variety of carbonaceous materials such as coconut shells, wood, peat, lignite and bituminous coal. The preparation of activated carbon from coal is generally a 2-step process: in the first stage a prepared coal (beneficiated to remove ash) is carbonized at medium heat to remove all volatile matter; the second activation stage opens the structure of the coal to provide a high porosity substrate. The carbonised product undergoes activation by steam treatment at the higher temperature of 900°C to 1100°C. The steam slowly combines with carbon in a steam reforming reaction; this partially removes carbon and

creates a high porosity surface within individual pores. By adjusting the exposure time and process conditions the porosity may be modified to synthesize the required grade. The resultant activated carbon is crushed and screened to the required particle size or milled to provide powdered activated carbon.

3.3 Industrial electrodes from coal

The favored form of carbon for industrial electrodes is graphite or graphitized petroleum needle coke that offers high mechanical strength, low thermal expansion, high purity, vibration resistance, and chemical inertness. Carbon electrodes possess high thermal and electrical conductivity suitable for tip temperatures that approach 10,000°C in steel making. These electrodes are used in a number of industrial applications covering: electric furnace steel production; refining furnaces; ferroalloy production, industrial silicon manufacture; yellow phosphorus; corundum; aluminum; submerged arc furnaces and other electric arc smelting furnaces, and nuclear reactor engineering. Compared to carbon electrodes, graphitized electrodes have a lower coefficient of thermal expansion, and significantly higher flexural strength for heavy duty uses.

The majority of coal sourced needle (or crystallised) coke for synthetic graphite electrodes is produced in Japan and is typically utilised for ordinary grade electrodes (RP), while graphite or petroleum needle coke are preferred for high power (HP) and ultra-high power (UHP) applications.

3.4 Carbon nano-tubes and Graphenes from Coal

Carbon nano tubes and graphene are new forms of carbon that may be obtained from raw coal or products obtained from coal. The preferred feedstock for carbon nanotubes are simple gases such as methane and carbon monoxide which can be obtained from coal processing. The amorphous, semi-crystalline structure of coal and the presence of contaminants makes its use more challenging, but actually may be advantageous for certain synthesis methods for graphene.

3.5 Conversion of lignite to Agrichemicals

Lignite is the lowest rank of coal, often referred to as brown coal, and is used almost exclusively as fuel for steam-electric power generation. Lignite has a long history of use as a fertilizer. Lignite products could play an important role in counteracting the deterioration of fertile land, a global problem caused by intensive farming practice, erosion and drought caused by changing climate conditions. Lignite humate products are prepared either by chemical techniques utilizing nitric acid, hydrogen peroxide or ozone, or by novel methods that avoid the use of chemicals, using either using air in an oxidative ammonolysis conversion, or a microbial technique that converts lignite to humates and methane gas.

4.0 Conclusion

Industrial chemicals and carbon-based materials such as basic chemicals, plastics and fibres are currently derived mostly from petroleum and natural gas. Materials and chemicals from coal are now recognised as an important, practical and profitable source and therefore are an area for future coal utilisation research and development. The proven large coal reserves and the aromatic molecular structures present in coals could be ideal feed stocks for the olefins, polymers and engineering plastics that have many applications and markets. However, the traditional source of coal chemicals, tars or

liquids from by-product coke ovens, has steadily decreased in the last decades. So, although the opportunities are increasing for new applications and markets for coal chemicals, the traditional source of those chemicals continues to decline. The main issues facing the use of coal in chemicals include its structural complexity, processing difficulties, presence of many components in organic matrix at each stage of conversion, inorganic impurities, capital investments, processing costs and environmental impact.

The non-fuel uses of coal involve utilising coal as a raw material and using chemical processes to turn it into gas, liquids, solid fuels and other chemical products. It has been used historically in the chemical industry since the 1950s. Numerous different products have coal or coal byproducts as components including soap, aspirins, solvents, dyes, plastics, fibres (such as rayon and nylon), specialist products (such as activated carbon, carbon fibre and silicon metal). New technologies have been and continue to be developed that use coal as feedstock for the production of chemicals. The latest developments have seen coal chemicals moving to coal-todimethyl ether (coal-to-DME), coal-to-olefins (CTO) and coal-to-glycol (CTG). Lignite resources may find a new market in the production of agricultural products capable of improving soil quality and counteracting the increasing problem of desertification. Methods are emerging to produce humates from lignite in the absence of chemical reagents. One method employs microbial conversion of lignite to humic products, and the other oxidative ammonolysis method reintroduces oxygen and nitrogen into the lignite internal structure. The large-scale deployment of lignite humates provides a means to significantly improve land reclamation, regenerating the fertility of soils.

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Author's brief Introduction

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Professional Experience

- As Production Engineer in a reputed Refractory Manufacturing Company
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- Joined CSIR- CIMFR (erstwhile CFRI) in 1989 as Scientist

Areas of Expertise

- Energy & Environment
- Coal resource quality assessment
- Utilization of solid inorganic wastes for building material production
- Trace elements in Indian coal/lignite
- Influence of inorganic materials present in coal/lignite during utilization
- Mercury emissions from point sources

Planning for Increased Coal Production

— S. Saran*

Abstract

Coal dominates India's energy consumption matrix, accounting for 56% of primary energy consumption. Coal contributed the lion's share to electricity generation (76%).

However, the Indian energy sector is gearing up for major transformation in the coming years. Considering the limited reserve potentiality of petroleum & natural gas, eco-conservation restrictions of large hydroelectric projects, geo-political perception of nuclear power, and limitations of capacity and storage of solar power, coal is likely to continue occupying center-stage of Indian energy scenario till about 2040.

Ensuring adequate availability of coal and minimum possible import of coal depends largely upon efficient exploration, focused project planning and implementation, creation of matching evacuation infrastructure, and effective management of constraints in opening/operating the coal mining projects.

The overall coal demand is likely to be around 1274 Mt by FY 2024. Coal India Limited, with the major responsibility to supply coal, is expected to contribute about 880 MT by FY 2024 and 1 Bt by FY 2026.

To augment coal supply from sources other than CIL/SCCL, allocation/auction of 200+ coal blocks for captive/commercial mining is being taken up by Ministry of Coal. Operationalization of CIL's newly allotted blocks and enhanced use of MDO modes in CIL mines, in conjunction with deployment of high capacity mining technology like continuous miners, powered support long-wall, high-wall miners, and surface miners need to be taken up in a time bound manner.

Elimination of road transport of coal from the environmental protection viewpoint is another necessity. Time bound actions plans and regular monitoring for their timely implementation is of key importance. Emphasis is also needed on speedy commissioning of critical railway projects for transportation of coal to consumers.

Thus, enhancement of coal production coupled with adoption of clean coal evacuation modes and deployment of mechanized mining machinery, at the same time addressing constraints in mine operations well in time are the top-most priority for coal sector.

*Chairman cum Managing Direcor, CMPDI

Coal Block Auctions

— Shouvik Majumdar*

Abstract

Post the cancellation of coal block allocation by Supreme Court, The government passed the coal Mines (Special Provisions) Act 2015 with a view to maintain continuity in coal production in the country. The blocks were offered in different tranches over the period 2015-18. The initial tranches saw An enthusiastic participation from the coal consuming industry players but there is a negative trend in the participation in recent tranches.

The presentation highlights the key issues faced by successful bidders in bringing the allocated blocks into production. It also suggests key remedial measures that may be taken up by the Government to bring back the interest of industry in buying coal blocks in India.

Author's brief Introduction

Mr. Shouvik Majumdar

Vice President
Hindalco, Mumbai

A professional in the field of Mining & Geology with over 26 years of experience in Non-ferrous minerals & coal industry and proven skill-sets in Acquisition, Planning, Budgeting, Strategy and Production. He completed his M.Sc Tech (in Applied Geology) from Jadavpur University, Kolkata and Business Management in Marketing from Kolkata. He is a Member of the Australasian Institute of Mining & Metallurgy (AusIMM). Post completion of his academics, he worked in INDAL, CESC in various capacities. Since 2003, he is working with HINDALCO and handled various domestic and international assignments.

New Technologies for Coal Mining

— Vivek Bhatia*

Abstract

Coal mining in India is at a cross roads. It is abundantly clear, that despite a strong push towards renewable power generation, coal based thermal power will remain a core part of power generation in Indian. On the one hand, the demand for coal will continue to rise driven by greater electrification - of transportation (railways and vehicles), of rural areas, and in general due to a rapidly growing economy. On the other hand, India is struggling to keep up with the pace of coal demand due to a variety of factors. Environmental factors, social factors further complicate the operational challenges of mining coal in India. As a result, often we face a precipitous decline in coal buffers at power plants, a growing dependence on imported coal (which affects negatively the balance of trade) and greater risks in the mining operations which remain under stress.

It is well understood that changes in status quo are only realized through the judicious application of new technologies and ideas. Mr. Bhatia would share through the presentation new ideas which may be leveraged to dramatically increase the quantum of coal mining as well as measures to regain stranded assets as well as improving operational performance and safety in the mining process.

Author's brief Introduction

Mr. Vivek Bhatia

MD & CEO and Member of the Board of thyssenkrupp Industries India Pvt. Ltd.

With effect from 1st January, 2019, Mr. Vivek Bhatia took on the role of Managing Director & CEO and Member of the Board of thyssenkrupp Industries India Pvt. Ltd. (tkII).

In addition to this role, he is also Global CEO Operating Unit Energy & Sugar, a member of the Management Board of Business Unit Mining and a member of the Global Leadership Team at Business Area Industrial Solutions of thyssenkrupp AG.

Prior to this, he was CEO Asia Pacific region at thyssenkrupp AG, driving group activities for all thyssenkrupp companies in the region. Prior to this, he was the Head of Strategy, Markets and Development for the Asia Pacific region, based in Singapore.

Before joining thyssenkrupp, Vivek was with the Boston Consulting Group in India, as member of the leadership team for Sustainability, Industrial Goods, Corporate Development, and Operation practices and sector co-lead in India for the Engineered Products & Projects sector. In 2013, he was awarded a BCG Olympics Gold Medal for the most insightful and impactful client work in the region. Prior to BCG, he worked as a design engineer for refineries and pipelines at Engineers India Limited.

Vivek has extensive business experience across metals & mineral processing, oil and gas, renewable energy equipment, power equipment (production as well as T&D), engineered/capital goods, sugar, cement and building materials. He has worked across multiple business functions including strategy, operations and organization on topics such as growth/diversification, joint ventures & technology transfers, business turnaround/transformation, working capital management, operations design and re-engineering, organization design and performance management systems.

Vivek holds an MBA (from IIM Calcutta), M. Tech. (Gold Medalist from IIT Delhi) and B.E. (with honours from University of Delhi).

Understanding and Extracting the Latent Value in Coal

— Richard A. Horner*

Abstract

Globally coal is expected to experience sluggish growth through 2022 [1]. While coal will continue to be used as a fuel resource to generate energy in many countries such as China, India, Japan, South Korea and USA in substantial quantities for years to come, use as a feedstock for making petrochemicals and other non- energy products offers new opportunities too. Increasingly, in the US this feature is attracting significant R&D dollars, notably through Federal funding [2,3]. The Government of India has conclusively recognized the importance of coal beneficiation as part of its push to recover the latent value in its naturally occurring coal resources too [4].

Demand for metallurgical coke is rising [5]. Metallurgical coke is made by destructive distillation of coal – (generally bitumous types) in special high temperature ovens in the absence of oxygen until a greater part of the volatile matter is driven off, resulting in a high carbon content solid – Coke. There are a range of process approaches to make coke [6]. High coke prices and increasing demand, have stimulated increasing interest in converting sub-bitumus coal into coke too. Until recently, The State of Wyoming was transforming its sub-bitumous coal resources from its Kemmerer mine into salable metallurgical coal [7]. A promising emerging coal beneficiation approaches for upgrading low-quality coal-deashing it, is the Kobe steel Hyper-coal [8] technology which uses solvent extraction to de-ash the run-of-mine (ROM) coal, offering a process route to upgrade high-ash content coal into metallurgical coke as well as producing other valuable co-products.

De-ashing Wyoming Powder River Basin (PRB) sub-bitumous coal with simple but effective solvent systems has shown to be feasible and possible in the laboratory using a proprietary thermo-chemical process rout developed at the University of Wyoming. Early indications from laboratory studies reveal that demineralizing and dewatering sub-bitumous coal can generate respectable yields of high quality extract and residual materials that could be converted into metallurgical coke, and as a co-product, high performance polymeric materials and coal chars, for such duties as agricultural soil amendments or as a feed to further process into activated carbons and other porous carbons. Most recent experimental pathways have included demineralization of coal deploying the properties of hydrophobicity and hydrophilic behavior [8]. Results will be presented from the

ongoing program. The understanding and comprehension of molecular structure, physics and chemistry of coal, built upon systems engineering principles, is required to appreciate and identify the potential to beneficiate and upgrade low rank coals.

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Author's brief Introduction

Mr. Richard A. Horner

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Richard has worked in the field of energy resources and their exploitation since graduating from University of Birmingham, England with a degree in materials science in the late 1970's. He is a Sloan Fellow (year 2000) from London Business School.

Richard worked for BP for 23 years in various technology management and business development position around the world, before joining Saudi Aramco where he managed research and technology development projects for 14 years. In March 2014, he moved to the University of Wyoming (UW), where he currently occupies the position of Director for Special Projects and Emerging Technology within the School of Energy Resources. In this role he is spearheading a distinguished Sate funded multi-million dollar carbon engineering and applied science program, which focuses upon the future of coal. This initiative seeks to identify opportunities for Wyoming Powder River Basin coal as a resource to manufacture non-energy and fuel products.

NTPC meeting its Coal requirement - Road Ahead

— Sariputta Mishra*

Synopsis:

NTPC is India's largest energy conglomerate with roots planted way back in the Year 1975 to accelerate power development in India. Since then it has established itself as the dominant power major with presence in the entire value chain of the power generation business. From fossil

fuels it has forayed into generating electricity via hydro, nuclear and renewable energy sources. NTPC has an installed capacity of 55,786 MW, plans to become a 130 GW company by the Year 2032.Asof now NTPC caters to 1/4th of India's power requirement and is the 10th largest power utility globally in terms of capacity. To strengthen its core business, the corporation has diversified into the fields of power trading, rural electrification, ash utilisation and coal mining as well.

One of the major business risk identified is securitising coal in terms of quantity, quality and cost ,for its Thermal Power Stations.To mitigate this major risk, NTPC has forayed into Coal Mining Business during last one decade. Currently thermal grade coal requirement of NTPC is pegged at around 200 MTY. This is largely sourced from mines of Coal India Ltd and SCCL supplemented by its own captive coal & import.

After stepping into coal mining business in pre-deallocation era , it faced few years of initial turmoil in terms of land acquisition and global competitive bidding for out-soursing mode of mining operation. However of-let it has consolidated its foot print since 2016 and massive expansion plan executions are largely on track. Govt of India sofar has allocated ten coal blocks of 7.2 Billion Te of coal reserves in the States of Jharkhand, Odisha and Chattishgarh. NTPC has drawn up an ambitious plan to reach 50 Million Tonne per year from current level of 7 Mio Te in next five years. It endeavours to reach the peak capacities of 100 MTY by 2030-31.

To hive-off its coal mining business and with the consent of Niti Ayog & Ministry of Power Govt. of India, NTPC has recently launched a wholly owned Coal Subsidiary . The Coal Mining Head Quarter has been set up at Ranchi which oversees functioning of all the coal mines. It is equipped with in-house Mine Planning, Engineering cells apart from Safety, Envt wing etc.

Last year its Pakri Barwadih Mine in Hazarinagh produced 6.81 Million Tonnes and Dulanag Mines in Sundergarh produced 0.5 Million Tonnes. This year NTPC is hopeful of exceeding 12 Million Tonnes. Alongwith the two operational mines in current year three more mines are getting added in Raigarh & Hazaribagh districts. Govt. of India and concerned State Govt have been providing tremendous support in furthering the interest of the power giant.

The impact of captive sourcing of coal in NTPC has started showing significant positive outcomes in the performance of its various Thermal Stations in terms of secured quality ,consistent sourcing and above all the landed cost of thermal energy. This encourages the entity to ramp up its capacity faster in coming years. NTPC is confident of optimizing its mining capacity with faster ramp up within the stipulated time frame.

*Head of Mining, NTPC, Ranchi.

While operation in two mines are with partnership of M/s. Thriveni Earth Movers & M/s. Sainik Mining as MDO of Pakribarwadih & Dulanga Mines respectively, NTPC is also contemplating to step into departmental mining or mining with limited out-sourcing mode in few of its coal block. This is solely to develop its own in-house expertise in the field of mining. To negotiate inherent challenges and to bring in excellence in all sphere, several tie-ups with globally reputed firms are on the anvil to bring in latest technology and sustainable mining operations.

Its Pakribarwadih Coal Mine in Hazaribagh has already emerged as one of the best coal mine in the country in terms of productivity safety and mining practices. NTPC's long term partner M/s. Triveni Earth Movers Ltd. who is the MDO in Pakribarwadih has been negotiating the challenges very effectively with all round support of State, Centre & NTPC team. It has set an ambitious target of setting its footprint in the coal industry as a globally reputed miner in upcoming days.

The Mining equipments deployed by M/s.Thriveni are one of the largest capacities and the operations are managed by a professionally competent team with global out reach. In a couple of years of its stepping into the partnership it has earned several laurels for its performances. A brief interaction with the team will flash out appreciable work culture getting introduced.

Author's brief Introduction

S.P. Mishra

Head of Mining
NTPC, Ranchi

Sh. S.P. Mishra, presently working as Head of Mining, NTPC , is a perfect blend professional who has experience of both public sector and private sector. Previously he worked for M/s Gujrat Ambuja as Joint Vice President and Director of Coal Business in ACC Cement Private Ltd.

In a nutshell, his professional chronology is here under.

- Worked in one of the project out of 6 mines of BCCL, operated in out sourcing mode of mining in the year 2004- 2005
- Instrumental in trial of Hydraulic Mining at Satabdhi mines of BCCL
- Instrumental in benchmarking Blast -free Mining at Talabira Open cast project of Hindalco in proximity to Hirakud Dam with the deployment of Surface Miner & Ripper –Dozer.
- Worked as 1st project officer of Bhubaneswari Open cast Project one of the Largest Open cast mine from conceptualization to ground breaking.
- Instrumental in commencement of Mining in Bicharpur under Ground Mine of ACC Ltd ahead of schedule opening.
- Rich composite experience in both Govt. and Private

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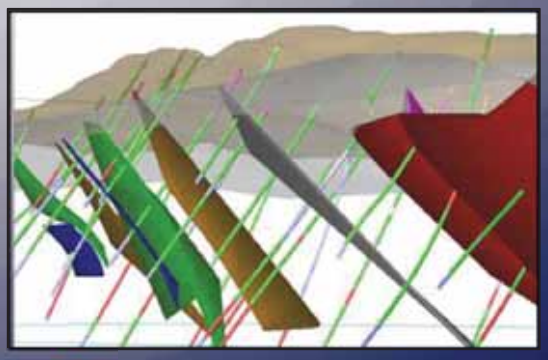

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