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National Coal Gasification Mission

(100 MT Coal Gasification by 2030)

Mission Document

Ministry of Coal
Government of India
New Delhi
September, 2021

Foreword

India has a reserve of 307 Billion tonnes of thermal coal and about 80% of coal produced is used in thermal power plants. With environment concerns and development of renewable energy, diversification of coal for its sustainable use is inevitable. Coal gasification is considered as cleaner option compared to burning of coal. Gasification facilitates utilization of the chemical properties of coal. Syn Gas produced from Coal gasification can is usable in producing Synthetic Natural Gas (SNG), energy fuel (methanol & ethanol), ammonia for fertilizers and petro-chemicals. These products will help move towards self-sufficiency under *Atmanirbhar Bharat Abhiyaan*. In line with the above objective, Ministry of Coal has taken initiative for utilizing coal through coal gasification and as such this Mission document has been prepared to achieve 100 MT coal gasification by year 2030.

I am thankful to Shri Pralhad Joshi, hon'ble Minister for Coal, Mines and Parliamentary Affairs for encouraging the Ministry in this endeavor. I am indebted to Dr Anil Kumar Jain, Secretary Coal for his keen guidance in making the Mission document and Dr V. K. Saraswat, NITI Aayog for his unstinted support in gasification efforts. I would also like to appreciate the contributions made by Technical Division of MoC, CMPDI Delhi, CIL, CIMFR, M/S PDIL, M/S Delloitte and Shri Ripunjay Bansal, Consultant to Secretary Coal through their timely inputs. I also take this opportunity to thank Shri Peeyush Kumar, Director (Technical), MoC who made invaluable contribution in finalizing this report. I hope this document which set the roadmap for country in achieving the Mission will be useful in meeting the coal gasification objectives.

(Vinod Kumar Tiwari)
Chairman, Implementation Committee and
Additional Secretary
Ministry of Coal
Government of India

Mission Document of National Coal Gasification Mission

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List of Abbreviations

1. AFT – Ash Fusion Temperature
2. BHEL – Bharat Heavy Electronics Limited
3. BP – British Petroleum
4. BT – Billion Tons
5. CAGR – Compounded Annual Growth Rate
6. CAPEX – Capital Expenditure
7. CCL – Central Coalfields Limited
8. CEA – Central Electricity Authority
9. CIL – Coal India Limited
10. CMPDI – Central Mining Planning and Design Institute
11. CSR – Corporate Social Responsibility
12. CSIR-CIMFR – Council of Scientific and Industrial Research – Central Institute of Mining and Fuel Research
13. CTL – Coal-to-Liquids
14. CTO – Coal-to-Olefins
15. DAP – Di-Ammonium Phosphate
16. DME – Di-methyl Ether
17. DMF – District Mineral Fund
18. DOE – Department of Energy (Government of US)
19. DRI – Direct Reduced Iron
20. DST – Department of Science and Technology
21. ECL – Eastern Coalfields Limited
22. EFG – Entrained Flow Gasifier
23. EIA – Energy Information Administration
24. FBG – Fluidised Bed Gasifier
25. FCIL – Fertilizer Corporation of India Limited
26. GAIL – Gas Authority of India Limited
27. GST – Goods and Services Tax
28. GW – Gigawatt
29. IEA – International Energy Agency
30. IEEFA - Institute of Energy Economics and Financial Analysis
31. IGCC – Integrated Gasification Combined Cycle
32. IRR – Internal Rate of Return
33. JKM – Japan Korea Marker
34. JSPL – Jindal Steel and Power Limited
35. KWh – Kilowatt-hour
36. LBNL - Lawrence Berkeley National Laboratory
37. LCOE – Levelized Cost of Electricity
38. LNG – Liquified Natural Gas
39. LPG – Liquified Petroleum Gas
40. LSTK – Lump-sum Turnkey
41. MBG – Moving Bed Gasifier
42. MEG – Mono-Ethyl Glycol
43. MEITY – Ministry of Economy, Industry and Trade (Government of Japan)
44. MT – Million Tons

45. MTO – Methanol-to-Olefins
46. MTPA – Million Tons Per Annum
47. MW – Megawatt
48. NETL – National Energy Technology Laboratory
49. NIT – Notice Inviting Tender
50. NITI – National Institution for Transforming India
51. NLC – Neyveli Lignite Company
52. NMET – National Mineral Exploration Trust
53. NSP – National Steel Policy
54. OPEX – Operational Expenditure
55. PDIL – Projects & Development India Limited
56. PM – Particulate Matter
57. PMC - Project Management Consultant
58. R/P Ratio – Reserve –to-Production Ratio
59. RCF – Rashtriya Chemicals Fertilizers
60. SCCL – Singareni Collieries Limited
61. SCG – Surface Coal Gasification
62. SECI – Solar Energy Corporation of India
63. SECL – South Eastern Coalfields Limited
64. TFL – Talcher Fertilizers Limited
65. TWh – Terawatt-hour
66. WCL – Western Coalfields Limited

1. Introduction

Coal is the most abundant and important fossil fuel in India. The coal production in India touched 730 MT in the financial year 2019-20 (provisional) & 716MT in the financial year 2020-21 (provisional)[1] despite the downturn in demand due to COVID-19 pandemic. 80% of the coal produced is consumed in thermal power plants[2] representing about 55% of the total fuel source for power in India[3] along with lignite.

1.1. Need for Coal Gasification

The world moves towards cleaner forms of energy, India, being a signatory to the Paris Agreement, 2016 has declared three quantitative climate change goals as its Nationally Determined Contribution (NDC)[4]:

a) Reduction in emissions intensity of Gross Domestic Product (GDP) by 33 to 35 percent by 2030 from 2005 level

b) Achieving about 40 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030

c) Creating an additional carbon sink of 2.5 to 3 billion tonnes of carbon dioxide equivalent through additional tree & forest cover by 2030

1.2. Atmanirbhar Bharat Abhiyaan:

Honourable Prime Minister of India in his 75th Independence Day speech has mentioned that India will have to pledge to become energy independent before its 100 years of Independence. At present India is heavily dependent on imports for its oil and gas needs. For the steel making process through blast furnace route requires coking coal which is mostly imported from Australia, USA and other countries. Hydrogen produced from Syn gas will also help in meeting the energy need of the country.

In the past, number of efforts has been made to gasify coal in India. Fertiliser plant at Sindri used to gasify coal for production of fertiliser in 1960s (now closed). JSPL in its Angul plant is operating gas based DRI plant by domestic coal. Talcher Fertilizer Limited (TFL) is also going ahead with mixing of pet coke in high ash domestic non-coking coal for urea production.

In order to achieve 100 MT coal gasification projects in India by 2030, Ministry of Coal has taken several steps. All coal companies have been advised to appoint a

[1] Production and Supplies, Ministry of Coal Website
[2] Year End Review 2020 - Ministry of Coal, Press Information Bureau
[3] Power Sector at a Glance – All India, Ministry of Power Website
[4] Key Declaration on Climate Change to be signed at the India CEO Forum on Climate Change, Press Information Bureau

nodal officer and to prepare an action plan for gasifying at least 10% of their coal production. Further, in all future commercial coal block auctions, a provision has been made for 20% rebate in revenue share for the coal used for gasification purpose provided the coal quantity used for gasification is at least 10% of total coal production.

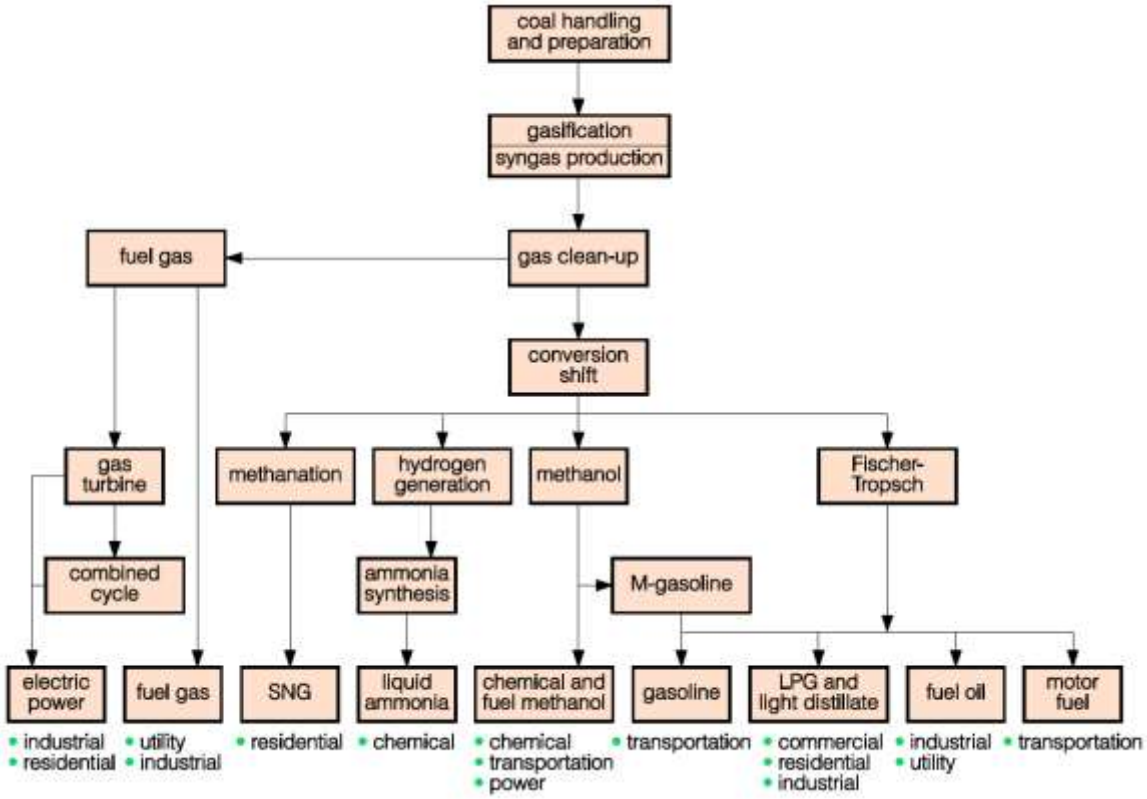
On the request of Ministry of Coal, NITI Aayog had constituted a Steering Committee under the Chairmanship of Member, NITI Aayog. A technical standing committee of experts constituted by NITI Aayog assists this steering committee. MoC has also constituted an implementation committee involving all industry stake holders under the chairmanship of Additional Secretary, Ministry of Coal. Further, a resource group consisting of experts from CIMFR, IIT Bombay, IIT ISM Dhanbad and IIT Madras has been constituted to take care of research need for the gasification mission.

Setting up of coal gasification plant is a capital-intensive work and will require at least 48 months of time. Further, the experience of coal gasification in India is limited. As such the success of initial coal gasification projects is very important for the national mission.

In order to implement various coal gasification projects, it has been planned to set up various gasification projects in phases. In phase I, the project based on low ash coal available in CIL will be taken up. CIL will take care of mining of coal and marketing of the product and the gasification and product conversion plant will be set up on BOO/BOM/LSTK contract basis. Considering the low availability of low ash coal, gasification plants will be set up based on high ash coal and with concessions given for commercial mining of coal it is expected to reach the goal of 100 MT gasification by 2030.

India has a huge reserve of coal of about 344 BT of non-coking coal out of which about 163 BT is proved reserves and with the current rate of consumption; it is expected to last for more than 5 decades. About 80% coal is used in thermal power plants. With environment concerns and development of renewable energy, diversification of coal for its sustainable use is inevitable. Coal gasification is considered as cleaner option as compared to burning of coal and has diversified use of coal in other form of energy.

Syngas can be used to produce **Gaseous Fuels** such as Hydrogen, Substitute Natural Gas (SNG or Methane), Di-Methyl Ether (DME), **Liquid Fuels such as** Methanol, Ethanol, Synthetic diesel and **Chemical and Petrochemicals** like Methanol derivatives, Olefins, Propylene, Mono-Ethylene Glycol (MEG), nitrogenous fertilizers including Ammonia, DRI, Industrial Chemicals along with Power Generation. Entire value chain of the process is as follows


coal handling and preparation
gasification
syngas production
gas clean-up
fuel gas
conversion shift
gas turbine
methanation
hydrogen generation
methanol
Fischer-Tropsch
combined cycle
ammonia synthesis
M-gasoline
electric power
fuel gas
SNG
liquid ammonia
chemical and fuel methanol
gasoline
LPG and light distillate
fuel oil
motor fuel
• industrial • residential
• utility • industrial
• residential
• chemical
• chemical • transportation • power
• transportation
• commercial • residential • industrial
• industrial • utility
• transportation

2. Coal Resources in India

With 344 BT of coal resources including 163 BT of proved reserves, India has the 4th largest reserves of coal in the World. The total World proved reserves of coal are 1074 BT and India accounts for around 10% of the global reserves. US has the largest coal reserves followed by Australia and China.

2.1. Category Wise Breakup of Coal Resources

A detailed analysis of the Indian coal reserves by category and depth is given in the tables below:

Break-up of Coal Resources (MT) in India – Category wise as of 1.04.2020					
Coal Type	**Proved**	**Indicated**	**Inferred**	**Total**	**% Share**
Prime Coking	4,668	645	0.00	5,313	1.5
Medium Coking	14876	11245	1863	27984	8.1
Semi Coking	529	992	186	1707	0.5
Sub-Total of Coking	**20,073**	**12,882**	**2,049**	**35,004**	10.1
Non-Coking	1,42,804	1,37,386	27,203	3,07,393	89.4
Tertiary Coal	594	121.17	909	1624	0.5
Grand Total	**163,471**	**1,50,389**	**30,161**	**344021**	100.00
% Share	47.5	43.7	8.8	100	

Table 2.1 - Source: GSI Coal Inventory'2020

It is evident from Table 2.1 that 90% of the coal reserves in India constitute non-coking coal or thermal coal which is primarily used for power generation and in industries such as cement and brick-kilns. Whereas approximately 10% of the reserves are coking coal reserves which are majorly used in steel production process. India imports a quarter of its coal requirements.

2.2. Depth wise Breakup of Coal Resources

Break-up of Coal Resources (MT) in India – Depth wise as of 1.04.2020					
Depth Range (m)	**Proved**	**Indicated**	**Inferred**	**Total**	**% Share**
0-300	118082	65704	9122	1,92,907	56.1
300-600	26882	66600	15009	1,08,492	31.5
0-600 *(for Jharia only)*	8399	6	0	8,405	2.4
0-600(Non-Coking)	5657	445	0	6,102	1.8
600-1200	4451	17634	6030.	28,115	8.2
Total	**1,63,471**	**1,50,389**	**30,161**	**3,44,021**	**100.00**

Table 2.2 – Source: GSI Coal Inventory'2020

It is evident from Table 2.2 that around 56% of the total coal resources or 72% of the total proved reserves lie up to the depth of 300 metres. The shallower the depth, easier the mining. More than 90% of the coal production in India is done through open-cast mining, which is usually up to a depth of 300 metres, whereas the rest is done through underground mining.

The above tables make it clear that India has huge reserves of coal. Therefore, it would be beneficial for India if it finds a sustainable way of using these reserves as the world including India is gradually transitioning away from coal toward cleaner fuels in the wake of climate change. The use of domestic coal reserves becomes even more important, especially when India does not have other sources of fuel – crude oil and natural gas, 82% and 45% of the requirement of those fuels is met through imports. This exposes India to the vagaries of price volatility and supply insecurity.

2.3. Grade wise Breakup of Non-Coking Coal

Break-up of Non-coking Coal Resources (MT) in India – Grade wise as of 1.04.2020							
	G1-G3	G4-G5	G6	G7-G8	G9-G14	G15-G17	**Grand Total**
Measured	1413	5384	12170	20655	100596	2586	**142804**
Indicated	1336	5031	12783	23775	92851	1610	**137385**
Inferred	27203						**27203**
							307393

Table 2.3 – Source: GSI Coal Inventory'2020

2.4. R/P Ratio of Different Countries as of 2020

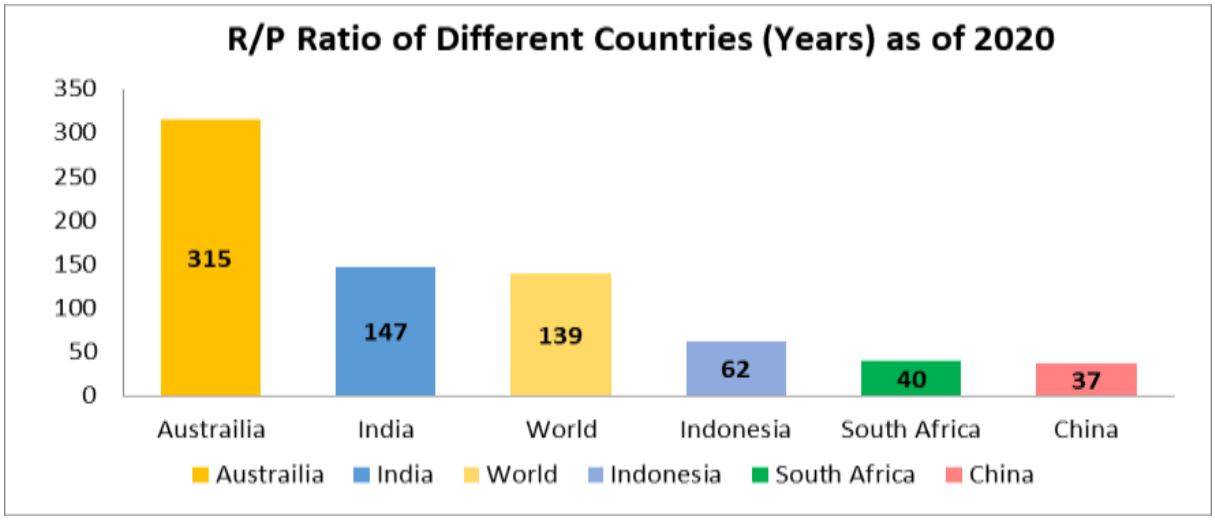


Figure 2.1 – Source: BP Statistics 2021

Figure 2.1 shows that the proved reserves of coal for India will last 147 years if India produces its coal at the current level as of 2020. This implies that India must figure out a sustainable way to use its coal reserves, otherwise this resource would remain buried under the ground as the transition towards cleaner fuels accelerates.

3. Gasification Potential Study of Indian Coal

In view of the potentiality of converting indigenous coal resources to different energy forms and chemicals, NITI Aayog is presently exploring roadmap and suitable technology options for surface coal gasification in the Indian context. In this perspective, a Technical Committee on Surface Coal Gasification has been constituted by (S&T), NITI AAYOG.

In the minutes of the fifth meeting of Technical Committee on Surface Coal Gasification (SCG) held on 17.05.2018 under the Chairmanship of Sri V.K. Saraswat, Member (S&T),NITI AAYOG, it was decided that the detailed analysis of the coal from potential operational mines/blocks with respect to Surface Coal Gasification (SCG) should be carried out jointly by CMPDIL, Ranchi and CSIR-CIMFR, Dhanbad. The findings and recommendations of the report published under the title “Gasification Potential Mapping of Indian Coals and utilization strategy” are listed below:

3.1. Important Coal Properties in View of Gasification

Gasification Potential Mapping of high ash Indian coals have been carried out as per the following coal characterization matrix:

Figure 3.1: Coal Characterization Matrix

Coal choice is the least flexible factor considering economic, geographical and political reasons. Therefore, it is necessary to adopt a coal gasifier, which best suits to the properties of the coal to be processed. The important coal properties which affect the gasifier performance are to be determined from proximate and ultimate analysis, cold and hot crushing strength, gasification reactivity & surface area, ash fusion temperature (AFT), slag behaviour, ash composition, caking index, rank and, petrographic characteristics, etc.

3.2. Experimental Methodology

The experimental methodology to carry out this exercise is constituted by the following steps, these are respectively: collection of coal samples from different mines, sample preparation, proximate and ultimate analyses, specific surface area, true density and reactivity, mechanical strength of coal, char and aggregates, ash fusion temperature, ash chemical composition, base-acid ratio and ash slag temperature, caking index and swelling number, petrographic analysis. Based on these scientific experiments recommendations were given for different potential seams of different mines.

3.3. Recommendations

Recommendations for different potential seams of different mines are as shown below:

1. **MCL, Talcher, Bhubaneswari OCP, Seam 2**
   Recommendations: High-temperature EFG seems the most suitable gasifier option for this coal and can also be handled in a low-temperature refractory lined EFG. This coal can also be handled in MBG and FBG, however, care should be taken in view of agglomeration due to iron & calcium content.
2. **MCL, Talcher, Bhubaneswari OCP, Seam 3**
   Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option for this coal. This coal can also be handled in MBG and FBG.
3. **MCL, Talcher, Jagnnath, Seam 2**
   Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option for this coal. However, washing/blending with low ash feed recommended. This coal can also be handled in MBG and FBG.
4. **MCL, Talcher, Kaniha area, Seam 2**
   Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX& OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.
5. **MCL, Talcher, Balram, Seam 2**
   Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However,

high ash content will attract high CAPEX &OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.

6. **MCL, Talcher, Bharatpur, Seam 2**
   Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option for this coal. However, washing/blending with low ash feed recommended. This coal can also be handled in MBG and FBG. However, care should be taken to avoid agglomeration in FBG.
7. **MCL, Talcher, Ananta OCP, Seam 2**
   Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.
8. **MCL, Talcher, Lingraj OCP, Seam 2**
   Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.
9. **MCL, Talcher, Lingraj OCP, Seam 3**
   Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX & OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.
10. **MCL, Talcher, Hingola, Seam 8**
    Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.
11. **MCL, IB Valley, Lakhanpur OCP, Lajkura Seam**
    Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.
12. **MCL, IB Valley, Kulda OCP, Lajkura Seam 2(Orient)**
    Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX & OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.
13. **MCL, IB Valley, Kulda OCP, Lajkura Seam 2**
    Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.

14. **MCL, IB Valley, Belpahar, IB Seam**

    Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG. However, care should be taken to avoid agglomeration in FBG.

15. **MCL, IB Valley, Rampur, Top-Bottom Composite Seam**

    Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option for this coal. This coal can also be handled in MBG and FBG. However, care should be taken to avoid agglomeration in MBG & FBG.

16. **MCL, IB Valley, Samaleswari OCP**

    Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option. However, washing/blending with low ash feed is recommended. This coal can also be handled in MBG and FBG. However, care should be taken to avoid agglomeration in MBG & FBG.

17. **MCL, IB Valley, Lajkura, Level 1 Top Seam**

    Recommendations: Membrane lined high-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG.

18. **MCL, IB Valley, Lajkura, Level 2 Bottom Seam**

    Recommendations: Membrane, as well as refractory lined EFG, may be a suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose a high thermal penalty. This coal can also be handled in MBG and FBG but a high probability of agglomeration due to the high iron content and low AFT.

19. **CCL, Ashoka Mines, Lower Dakra Seam**

    Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose the high thermal penalty. This coal can be also handled in MBG after washing/blending with low ash feed and in FBG without washing or blending with low ash feed. However, care should be taken to avoid agglomeration in MBG and FBG.

20. **CCL, Urimari Mines, Upper Balkudra Seam**

    Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose the high thermal penalty. This coal can also be handled in MBG and FBG.

21. **CCL, Urimari Mines, Lower Balkudra Mines**

    Recommendations: Membrane lined High-temperature EFG may be the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise impose the high thermal penalty. This coal can also be handled in MBG and FBG.

22. **CCL, North Urimari Mines, Argada A+B Seam**

Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX &OPEX otherwise it will impose higher thermal penalty. This coal can also be handled in MBG and FBG with care to avoid agglomeration due to its weakly caking nature.

23. **CCL, Magadh Mines, One Bottom Seam**

Recommendations: Membrane lined High-temperature EFG may be the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX & OPEX otherwise impose the high thermal penalty. This coal can also be handled in MBG after washing or blending with low ash feed. FBG may be other option.

24. **CCL, Amrapali Mines, One Combined Seam**

Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX & OPEX otherwise impose the high thermal penalty. This coal can also be handled in MBG after washing or blending with low ash feed. FBG may be other option.

25. **CCL, Purnadih Mines, Lower Middle Dakra Combined Seam**

Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX & OPEX otherwise impose the high thermal penalty. This coal can also be handled in MBG after washing or blending with low ash feed. FBG may be other option.

26. **ECL, Mohanpur mines, Seam A**

Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option after washing/blending with low ash coal. However, high ash content will attract high CAPEX & OPEX otherwise impose the high thermal penalty. This coal can also be handled in MBG after washing or blending with low ash feed. FBG may be other option. However, care should be taken to avoid agglomeration in FBG and MBG due to its weakly caking nature.

27. **ECL, Chitra Mines, Chitra Seam**

Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option. This coal can also be handled in MBG and FBG.

28. **ECL, Jhanjhra Mines, R-V Seam**

Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option and can also be handled in a low-temperature refractory lined EFG. This coal can also be handled in MBG and FBG. However, care should be taken to avoid agglomeration in FBG and MBG.

29. **ECL, Kotthadih Mines, R-VI Seam**

Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option. This coal can also be handled in MBG and FBG. However, care should be taken to avoid agglomeration in FBG and MBG.

30. ECL, Sonepur Bazari, R-VI Seam

Recommendations: Membrane lined High-temperature EFG seems the suitable gasifier option. This coal can also be handled in MBG and FBG. However, care should be taken to avoid agglomeration in FBG and MBG due to its weak caking nature.

4. Gasification Technology

The gasification technology is now marching towards maturity with the history that dates back to 1800s. The first patent was granted to LURGI GmbH in Germany in the year 1887. In 1940, commercial coal gasification was used to provide “town gas” for streetlights in both Europe and United States. Since then, many coal gasification plants have come up in the world for the downstream production of chemicals like methanol, ammonia etc. and combined cycle power generation. Appropriate technology selection depends upon the characteristics of coal feed and the end product required from the coal gasification island. A large number of products can be produced based on coal gasification.

4.1. Coal Gasification Process

Coal gasification offers a practical means of utilizing coal for meeting stringent environmental control requirements. In the gasification process, sulphur present in the coal is converted to hydrogen sulphide (H_2S) and minor amounts of carbonyl sulphide (COS). These sulphur compounds can be easily and economically removed from gas streams by a wide variety of commercially available processes (i.e., acid gas removal systems). The separated acid gas is further processed to recover elemental sulphur. After the acid gas removal treatment, only few ppm of sulphur remains in the coal gas. Nitrogen oxides (NO_x) are not formed to any appreciable extent in the reducing atmosphere of coal gasification. The particulate content in the fuel gas after gasification is negligible since the gas cleaning steps (hot cyclones, water scrubbing or hot gas cleaning) capture almost all the particulate.

Except for hot gas clean up, other two systems are commercially established and practiced. Most part of the wash water is recycled and the residual waste waters from gasification plants can be effectively treated. The coal gasification plants do not produce any scrubber sludge which need careful and costly disposal.

Though ash handling is an issue while using high ash Indian coals, the coal ash from gasifier is not hazardous and its leaching effect is very low. The fine ash generated in the processes using pulverized coal feed may be used for value added products like manufacturing of fly ash bricks. In slagging type of Gasifier wherein slag is produced as a bottom product instead of ash, this slag can be gainfully employed in cement industries and simultaneously eliminating the problem associated with handling of ash.

Coal gasification process has several other advantages besides minimum environmental impacts which are briefly discussed below. A broad range of coals with varying ash content, coal fines, middling and washery rejects can be

successfully gasified. Coal can be fed to the gasifier in the form of crushed coal of 5 to 50 mm size, coal fines, pulverized coal or coal water slurry depending upon the generic type of gasification process (i.e., moving bed, fluidized bed and entrained bed). Oxygen enriched Air or oxygen can be used as gasification medium. If oxygen is used in a coal gasifier instead of air, carbon dioxide is emitted as a concentrated gas stream. In this form, it can be captured more easily and at lower costs for ultimate disposition in various sequestration approaches. By contrast, when coal burns or is reacted in air, 80 percent of which is nitrogen, the resulting carbon dioxide is much more diluted and is costlier to separate from the much larger mass of gases flowing from the combustor or gasifier. Carbon conversion efficiency of as high as 99% can be attained in the gasification process. The major advantage of gasification is that coal is converted into a gaseous fuel which is easy to handle and is a clean form of energy. In the gaseous form, it enables to substitute petroleum products and natural gas. The synthesis gas has wide range of applications. It can be used in Integrated Gasification Combined Cycle (IGCC) system for efficient and clean generation of electric power. It is suitable for the manufacturing of hydrogen and basic chemicals such as ammonia, methanol, substitute natural gas, CTL (coal to liquid), as reduction gas in steel industry etc. It can be used in complex of plants for the simultaneous production of electric power, chemicals/ fertilizers, reduction gas and fuels which also improve the economics of coal gasification.

4.2. Categories of Coal gasification Technologies

Different Surface Coal Gasification process technologies broadly categorized on the basis of type of gasifiers in use are as follows:

(i) Moving Bed or Fixed bed Dry bottom (FBDB)
(ii) Fluidized Bed (back mix reactors)
(iii) Entrained Bed (plug flow reactors)

The process technologies may further be classified according to feed use and heat recovery e.g., use of pulverized coal as dry or in slurry form and heat recovery in form of steam generation or direct quenching there by generating process vapour along with the gasifier effluent gas. All these have to be analysed carefully while selecting a technology. The aforesaid categories of Coal Gasification Technologies have been described below:

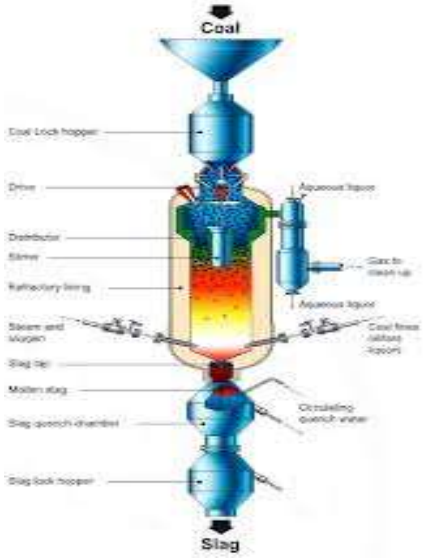
(i) Moving Bed / Fixed Bed Type Gasifier

Moving bed type gasifier is among the various types of Gasifiers commercially operated. It operates with a counter current flow of oxidant through a series of reaction zones – gradually changing from coal-coke-tar-ash. The moving bed reactor requires sized coal, generally in the range of 5-50 mm with a limitation on the fines

content (-6 mm) in the feed. Air blown gasifiers do not exceed ash melting point whereas oxygen blown moving bed gasifiers can be either dry ash or slagging.

Dry ash gasifier uses considerable excess process-steam, required to control the bed temperatures below the ash fusion point to avoid formation of clinkers. Highest bed temperature is generally maintained below the ash fusion point. Dry- ash Removal System is highly suitable for High-ash Indian Coals having High Ash Fusion Temperatures.

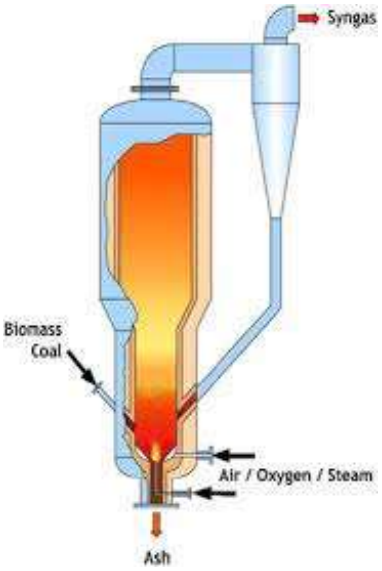
Slagging gasifier: Highest bed temperature is allowed to exceed ash fusion point producing slag. It operates at pressure around 30 kg/cm^2 and around1100^{O}C. This process is highly suitable for non-caking and weakly caking high ash coal with a high fusion point of ash more than 1400^O C. Slagging type with a bath of molten slag at the bottom has different reaction zones viz., drying, devolatilization, gasification and combustion. The char from devolatilization is partly gasified by steam and CO_2 while the residual char is burnt with the oxygen input.



(ii) Fluidized Bed Type Gasifier

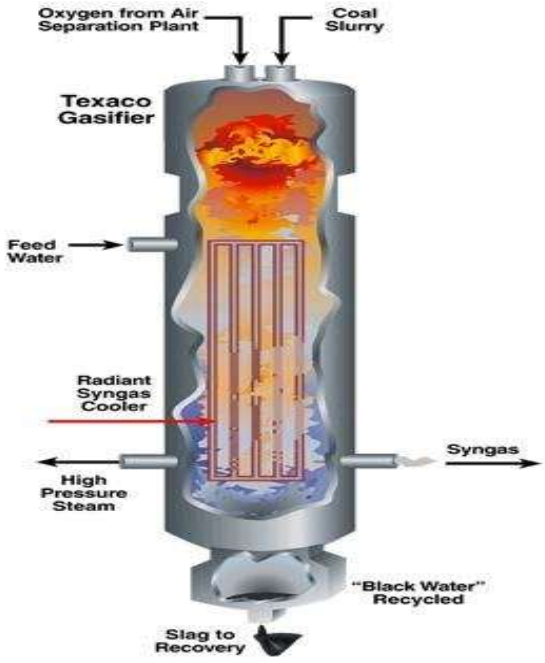
Fluidized bed gasifier is fed with 5 to 50 mm size coal as well as pulverized coal which is fluidized and gasified by the oxidant gas either oxygen or air. The reactor operates around 30 kg/cm^2 pressure and at a temperature well below the ash fusion temperature of coal, typically ranging from 800 to 1050^{O}C depending on the feedstock characteristic. As a result of maintaining constant low temperature, clinker formation and possible defluidisation of the bed is prevented.

Low temperature operation makes fluidized bed gasifiers ideal for reactive coals. Due to the restricted flow of oxidant most of coal particles do not burn completely but form char particles which are entrained the raw gas exit gasifier. This necessitates separation and recycle of substantial quantity of char particles.



(iii) Entrained Flow Type

In this fine coal feed and oxidant are fed co-currently. As a result, oxidant and steam is entraining the coal particles. This results in high throughput and high carbon conversion efficiencies. Entrained flow type gasification is the cleanest and efficient type of coal gasification. The entrained flow gasifiers are widely used abroad. It is ideal for coal with low ash content. If ash content of coal fed in entrained flow gasifier is high, considerable part of energy will be consumed in melting & slagging the ash content of high ash coal resulting in lower gasification energy.



5. Coal Gasification Products: Sectoral Potential

5.1. Chemicals and Petro-chemicals

Coal to Liquids is an upcoming industry which can play a vital role in India's chemical and petrochemical industry as majority of chemicals and petrochemicals are derived from products which are derived from crude oil and natural gas. Coal can be used to make the following products:

a) Methanol

b) Ethanol

c) Olefins – (Primarily - Ethylene and Propylene)

d) DME, Acetic Acid and Formaldehyde

5.1.1. Methanol

Natural gas to methanol is an established process, however, coal is also being used to produce methanol in some parts of the World, mainly China. India having abundant reserves of coal can produce methanol from coal.

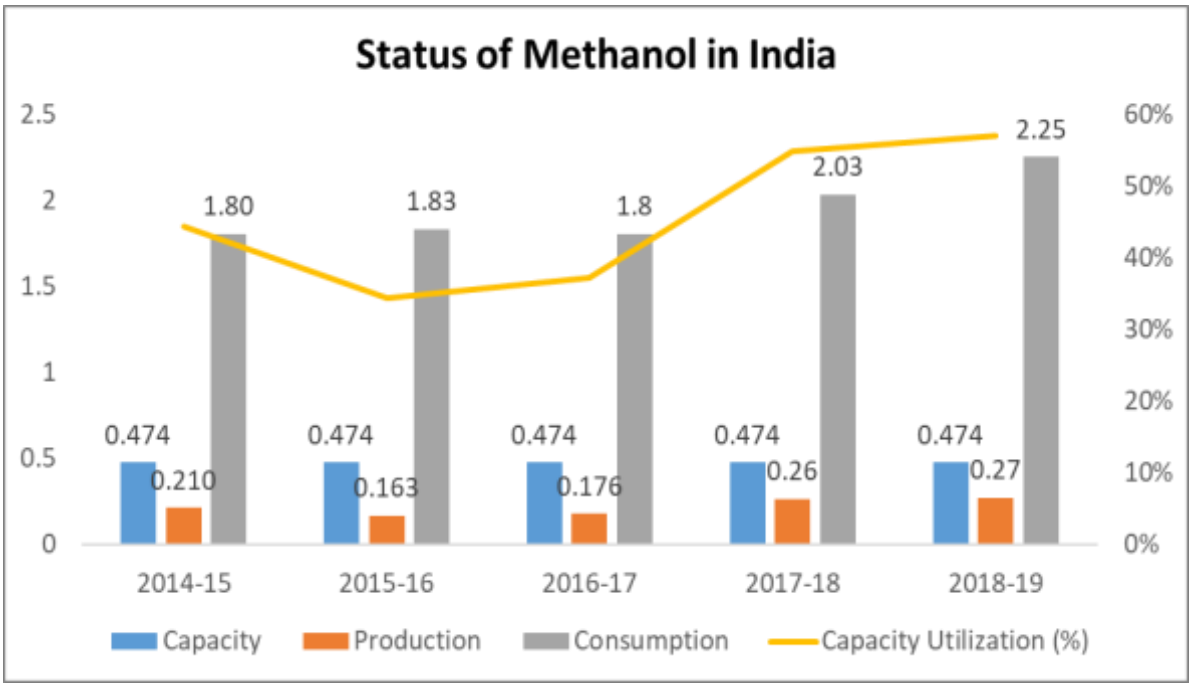


Figure 5.1 – Source: Chemical and Petrochemical Statistics 2019

Conversion Efficiency of Coal to Methanol:

It is estimated that 2.7-3 tons of coal would be required to produce 1 ton of Methanol. Therefore, 5-6 MT of coal would be required to produce around 2 MT of Methanol. Also, methanol can be used as a feedstock to produce Olefins, DME and Acetic Acid, however, Olefins are currently produced from natural gas and naphtha.

Potential of Methanol consumption:

M15 Fuel: BIS has notified M15 fuel for automobile sector wherein 15% methanol can be blended with Gasoline. In addition to the present domestic methanol consumption, about 5-7 Million tonnes more can be utilised in M15 fuel with 30 million Tonnes of consumption of gasoline.

Pharma Sector: Methanol acts as solvent for many of the bulk drugs and there is a need to identify the potential requirement of methanol by 2030.

5.1.2. Ethanol

Under the national policy on bio fuels 2018, Government of India with effect from 01.01.2003 resolved to supply 5% ethanol blended petrol under its First-Generation Ethanol blended petrol(EBP). Government of India has also advanced the target for 20% ethanol blending in petrol (also called E20) to 2025 from 2030. Ministry of Petroleum and Natural Gas is in the process of modifying National Policy on Bio fuels 2018, to include production of ethanol also from coal gasification route. Primary discussions with licensors such as Synata Bio (USA) revealed that ethanol can be produced in a cost-effective manner from Syn Gas. Oil companies have also shown interest to buy cost effective ethanol and this will help in reducing imports.

Ethanol is envisaged for being a downstream product from syngas obtained by coal gasification. Opinions were voiced regarding fermentation of syngas to meet the demand of ethanol blending projected by 2025-26. India's net import of petroleum stood at 185 million T putting the cost at 55 billion USD, which is used primarily for products in the transportation sector. NITI Aayog has laid out a roadmap for ethanol blending preponing the target from the earlier 2030 to 2025. Additionally, ethanol has medical applications as an antiseptic and disinfectant. It is also used as a chemical solvent and in the synthesis of organic compounds.

Ethanol Demand Projection in India

Supply Year	Projected Petrol Sales (MMT)	Requirement of ethanol for blending in Petrol (Cr. Litres)
2021-22	31	437
2022-23	32	542
2023-24	33	698
2024-25	34	988
2025-26	35	1016

Table: 5.1

Source: Roadmap for Ethanol Blending in India 2020-2025, Report of Expert Committee, NITI Aayog

Currently, ethanol is obtained from biochemical processes using sugar, starch and oilseed-based feedstocks. However, these first-generation bio-based ethanol feedstocks have some concerns regarding food supply & security, limited impact on emission reduction and impact of land & water usages. Second generation ethanol feedstock have also emerged using feed such as energy crops, municipal wastes,

forest & agricultural residues. However, the major challenge related to production of ethanol through the biochemical route is the lower conversion achievement.
Synata Bio has designed an advanced syngas to ethanol technology to ferment syngas. The plant design includes utilization of unique and proprietary anaerobic microorganisms which provides higher hydrogen uptake and increases overall yield to ethanol. Syngas introduced at the bottom of the bioreactor and injection technology maximizes syngas dissolution and mass transfer. A sterile seed train of reactors is employed to grow the necessary population of Synata Bio's proprietary microbes to populate the production reactors. The production reactors produce a liquid product stream, "broth", containing the dilute ethanol product (about 2.5%-3% w/v) in water that is distilled and dehydrated to produce the desired high purity ethanol, prior to being sent to the finished product tanks.

5.1.3 Olefins (Primarily- Ethylene and Propylene)

Olefins are currently produced from natural gas and naphtha. Natural gas is a scarce natural resource in India as it imports almost 45% of its requirement. Moreover, Naphtha is derived from crude oil which is again an imported commodity as India imports around 82% of its crude requirement. Therefore, coal to methanol and then further production of olefins would help India to substitute the use of imported products to produce olefins. The production of olefins is about 9 MT in India from crude oil however economics of product is to be examined for setting up plant since about 3 tons of Methanol are required to produced 1 ton of olefins.

5.1.4 DME, Acetic Acid and Formaldehyde

Production of DME in India is insignificant, whereas approximately 0.16 MT of Acetic Acid is produced. DME can be blended with LPG and India currently imports 50% of its LPG requirement of around 21 MT per year. A 20% DME blend with LPG is feasible and can open an opportunity to substitute LPG imports by DME which is produced from domestic coal. Therefore, 2 MT of DME would be required assuming a 20% blend for around 10 MT of LPG imported. 1.4 units of methanol are required to produce 1 unit of DME.

Acetic Acid (CH_3COOH), popularly known as Vinegar, is a clear liquid with a pungent odour, sharp taste and is widely used as a food preservative. The most common route for its production is the carbonylation of methanol. GNFC is the only producer in India using methanol to acetic acid route – therefore, low cost of methanol is imperative to make acetic acid competitive.
Formaldehyde is the simplest form of aldehyde (HCHO) which is a colourless gas with a pungent odour. Formaldehyde is used in the production of household products, building materials, glues and adhesives, resins etc. It is commonly produced through the dehydrogenation of Methanol, so Methanol to Formaldehyde is

a common route. Like Acetic Acid, availability of low-cost Methanol becomes important to competitively produce Formaldehyde.

5.2 Fertilisers and NH3 based products

Hydrogen available in Syn Gas can be utilised for manufacturing ammonia (NH3) which is a feed stock to Urea, Ammonium nitrate and there are many other applications of ammonia.

5.2.1 Urea

Department of Fertilisers have made a plan to ensure meeting demand of urea through domestic production and accordingly revival of old plants and new fertiliser plants have been planned.

Urea demand-supply projections in India for FY25

(fig. in MT)

Year	Urea Demand	Urea Supply			Demand Supply Gap
		Existing Units	New/Revived Units	Total	
FY19	31.773	26.27	0	26.27	-5.503
FY20	32.482	26.27	1.33	27.6	-4.882
FY21	33.179	26.27	3.87	30.14	-3.039
FY22	33.863	26.27	5.14	31.41	-2.453
FY23	34.425	26.27	7.68	33.95	-0.475
FY24	35.085	26.27	7.68	33.95	-1.135
FY25	35.724	26.27	7.68	33.95	-1.774

Table: 5.2

Urea (Figures in MT)			
	Production	Import	Consumption
2014-15	22.6	8.8	31.4
2015-16	24.5	8.5	33
2016-17	24.2	5.5	29.7
2017-18	24.0	5.9	29.9

Table 5.3 – Source: Fertilizer Scenario 2018

To have a medium- term scenario for potential investment, it is recommended that the demand projections till 2030 may be taken up for planning of future fertiliser plants based on coal gasification as have been tried in case of Talcher Fertiliser Plant.

5.2.2 Di-Ammonium Phosphate (DAP)

DAP is the 2nd most sought after fertilizer in India. Ammonia can be produced through SCG plants, but the other raw material Phosphoric Acid is import dependent due to low availability of phosphate minerals in India. This comes under non

regulated sector and Department of Fertiliser may look into production of DAP under Atmanirbhar Bharat Scheme.

Di-Ammonium Phosphate (DAP) (Figures in MT)			
	Production	Import	Consumption
2014-15	3.4	3.8	7.2
2015-16	3.8	6	9.8
2016-17	4.4	4.4	8.8
2017-18	4.7	4.2	8.9

Table 5.4 – Source: Fertilizer Scenario 2018

5.2.3 Ammonium Nitrate (AN)

Ammonium Nitrate is an important constituent for manufacturing of explosives in open cast mines and at present there is an import of about 2.5 million tonnes of AN. Most of the domestic manufacturers are importing ammonia and producing ammonia through imported Natural Gas and these plants are situated on the western part of the country. The consumption centers are in the eastern part and are more inclined to imported AN received from Vizag port. Department of Chemicals may formulate a strategy for production of AN from domestic sources.

5.3 Hydrogen

Currently hydrogen is playing as an important part of the world energy scenario as ‘Net Zero’ Targets has been announced by many nations and companies and the voice for decarbonizing the Energy Sector, not only the Electric Sector is being strong. The green hydrogen will also enhance renewables deployment.

Coal can be a competitive source to produce hydrogen in India, however, the emissions from coal-based hydrogen are double that of gas based. Hydrogen production is sensitive to electricity and gas prices, whereas in the case of coal, the price also depends on capex and opex. India unlikely to be competitive for hydrogen produced from gas, low cost of renewable electricity presents an opportunity, though the cost of electrolysers is high. Dovetailing Coal to Hydrogen with the existing Gasification Projects is a low hanging fruit. Methanol being a promising hydrogen carrier and methanol prices being discovered around INR 22/Kg, a separate detailed analysis on hydrogen production from coal should be done. CIL can produce low-cost electricity for electrolysis through pit head plants, though the hydrogen produced will not be green, which is the Global emphasis.

5.4 Steel Making

As per National Steel Policy, India is expected to build a capacity of 300 million tonnes of steel per annum to cater to demand of around 255 mtpa by 2031. To support this demand and the necessary production process, the requirement of coal

would be to the tune of 300 mtpa of which around 165 mt would be coking coal, 35 mtpa coal for PCI (pulverized coal injection) and around 100 mt would be non-coking coal for DRI (direct reduced iron or sponge iron prod).

Coke is an essential input for production of steel and currently about 0.9 Tonne of coke is required to produce 1.0 Hot Metal (HM) through blast furnace route. Indian coking coals are inferior to imported coking coals in terms of ash and other properties. At present, SAIL & TATA use about 90% of imported coking coal in the blend and rest 10% through indigenous sources.

CO and H_2 of Syn gas are important reducing agent for steel making and are environment friendly method of steel making through DRI route. JSPL has already set up a plant for steel making through Gas based DRI. Promotion of setting up of such plant for steel making thus reducing the dependence of coking coal which is mainly imported is recommended as Atmanirbhar Bharat Abhiyaan

5.5 Pharmaceutical Sector

India has an ambitious plan of producing APIs indigenously rather importing from China. The potential of Syn Gas requirement is being examined by Department of Fertilizers for making APIs and also methanol as solvent.

6 Global Experience in Coal Gasification

Global coal gasification market is expected to reach around 3,89,825 MW by 2026, growing at a CAGR of approximately 10.8%.[5] Fertilizer segment is anticipated to hold the major market share. Ammonia production by coal gasification has increased the demand for fertilizers. Another segment with a good growth rate, above 10.5%, is power generation. Growing trend of Integrated Coal Gasification Combined Cycle (IGCC) power plants worldwide has increased the opportunities. Demand for coal gasification technology has increased in fuel gas production, owing to the increased use of synthetic natural gas. By region, the global coal gasification market is segmented into North America, Asia Pacific, Europe, Latin America, and the Middle East and Africa.

a) Region dominating the coal gasification market is Asia Pacific. China contributed the highest market share in 2017. Other countries, such as India and Japan, are also promising markets for coal gasification.

b) North America is likely to show a good rate of growth. The U.S. contributed the majority market share in the year 2017.

c) Moderate market growth is likely to be registered in the European region. Germany contributed the majority share in 2017.

d) The Middle East and Africa and Latin America are likely to witness good market growth.

6.1 China[6]

a) The Chinese government's initiatives in its 11th and 12th five-year plans have boosted the gasification industry in the country.

b) China produces more than 90% of its ammonia through coal gasification.

c) China is expected to increase the uptake of large-scale coal-to-SNG projects and possibly scale up various coal-to-oil technologies projects, which in turn, would supplement the gasification market.

[5] https://www.globenewswire.com/news-release/2018/12/12/1665746/0/en/Global-Coal-Gasification-Market-Expected-to-Reach-3-89-825-MW-By-2026-Zion-Market-Research.html

[6] https://thedailychronicle.in/news/198919/global-gasification-market-2020-top-countries-data-to-showing-impressive-growth-by-industry-trends-share-size-top-key-players-analysis-and-forecast-research-by-360-market-updates/

China case study[7]

a. The coal chemical industry, which includes gasification technology, accounts for about 5% of China's total coal consumption.

b. Higher self-reliance in energy supply and lower risk of oil and gas supply from abroad are the major drivers of coal gasification related industries.

c. China has been pushing for coal gasification in a major way by adopting proven western-developed gasifiers to gain operational experience.

d. It is the only country in the world, where large-scale coal gasification related industries play a significant role in economic development.

e. China started importing the western Coal gasification technology in 1950. Coal gasification technology was of major importance to China as it moved to prioritize, develop and use its energy resources.

f. Western gasifiers have a strong presence in China. Air Products, Siemens, KBR, GTI, Air Liquide are prominent western gasifiers in China.

g. Role of Coal Gasification in Ammonia/Urea: NH3 capacity is approx. 70 MTPA (~30% of the world) and urea capacity is approx. 80 MTPA (~40% of the world).

h. Role of Coal Gasification in Methanol: China has become by far the largest producing country in the world, representing 54% of world methanol capacity (~80 MTPA) and 48% of world methanol production in 2018.

i. China is the incremental methanol supplier to the world. Around 70% of China methanol is produced from coal.

j. Role of Coal Gasification in Ethylene Glycol (EG): Capacity of coal-based EG is approx. 2.5 MTPA (~30% of China total).

k. Role of Coal Gasification in Methanol to Olefin (MTO): Capacity of coal-based Olefin is approx. 13mt/a (~25% of China's total).

[7] https://usispf.org/wp-content/uploads/2019/11/final-Concept-Paper-on-the-Coal-Gasification-Opportunities-in-India_final-High-Res.pdf

6.2 United States

Coal gasification projects started in the 1990's in the US, however, it did not have a very successful experience. Efforts to gasify coal for power generation have failed, technologically and financially. Only two of the 25 coal-gasification electricity generating plants proposed in the U.S. since 2000 have ever come online: Southern Company's Kemper plant in Mississippi and Duke Energy's Edwardsport plant in Indiana.

Under pressure from the Mississippi Public Service Commission for having logged billions of dollars in cost overruns at Kemper and one of the reasons being the technological problems with the gasifier, the Southern company affiliate, Mississippi Power which started operations in 2014 had announced in 2017 that it will halt burning the coal at its facility, leaving Edwardsport as the only plant gasifying coal. Edwardsport, which started operations in 2013, has been plagued by technological problems and is still not running properly. Because of its operational problems and huge construction cost overruns, Edwardsport's electricity is wildly expensive.

Most importantly, the natural gas prices in the US crashed post the shale oil and gas revolution which meant that the cost of producing electricity using natural gas was lower than that for coal. With abundant oil and gas reserves, sufficient production of oil and gas and declining cost of renewables – solar and wind, US is unlikely to gasify coal for power generation or for producing chemicals in the future since natural gas provides a much cheaper and technologically established option for the same.

6.3 Japan

Japan has done quite a lot of research on coal gasification, especially IGCC technology and is continuing its R&D efforts in the clean coal technology space. The reliance on coal plants increased more after the Fukushima disaster in 2011. Many Japanese corporations such as Mitsubishi, Nakoso and others have developed IGCC technologies because of which Japan supports clean coal technology. According to the Ministry of Economy, Industry and Trade (MEITY), Japan will retire the inefficient older coal plants by 2030 but will continue to use Ultra-supercritical and IGCC plants. There have been two IGCC plants in operation with a total capacity of 800 MW. And another plant is likely to be added with a capacity of 543 MW this year. Therefore, Japanese have not shunned the coal gasification projects like the US, they are gradually moving ahead with this technology.

7 Indian Efforts in Coal Gasification

In the past, number of efforts has been made to gasify coal in India. These efforts started in year 1960s and are continuing even now with varying capacities/scales. Most of them are aiming for self-reliance for India by using high ash domestic coal with end products like fertilizer (urea), power generation and methanol. Some Indian companies have gained experience while successfully commissioning gasification project abroad.

7.1 Coal Gasification: Past Indian scenario

In the past, several efforts have been made to gasify coal in India. Fertiliser plant at Sindri used to gasify coal for production of fertiliser in 1960s (now closed). JSPL in its Angul plant had tried mixing of imported coal with domestic coal for gasification process (currently in-operational or running sub optimally). Talcher Fertilizer Limited (TFL) is also going ahead with mixing of pet coke in high ash domestic non-coking coal for Syn Gas production. BHEL has set up a pilot plant in Trichi and has produced 6.2 MW power but the plant has faced many issues in handling high ash coal. M/s Thermax has also set up a pilot plant for coal to methanol production with DST funding under the aegis of NITI Aayog in Pune. L&T has commissioned many gasifiers in China and are in the business of erection and commissioning of gasifiers.

7.2 Existing Coal Gasification Plants in India

(i) CO and H_2 of Syn gas are important reducing agent for steel making and are environment friendly method of steel making through DRI route. Jindal Steel & Power Limited has installed world's first DRI plant based on Coal gasification technology by using domestic coal which is already operating in Angul District of Orissa for steel making. The Syn Gas project started in 2007 and commissioned in 2014. It is a technology demonstrator and can be very important for expanding the way for Sustainable and Green Development of India. With NSP of 300 Mt crude steel by 2030, the adoption of Coal Gasification technology will create a new segment of capacity addition in India, therefore minimising the need of imported coking coal.

(ii) BHEL has set up a pilot plant in Trichi and has produced 6.2 MW power but the plant has faced many issues in handling high ash coal.

(iii) M/s Thermax has also set up a pilot plant in 2014 for coal to methanol production with DST funding under the aegis of NITI Aayog in Pune.

(iv) L&T has commissioned many gasifiers in China and are in the business of erection and commissioning of gasifiers.

7.3 Ongoing Surface Coal Gasification Projects

Setting up of coal gasification plant is a capital-intensive work. Further, the experience of coal gasification in India is limited. As such the success of initial coal gasification projects is very important for the national mission. It has been planned to set up two gasification projects on pilot basis one on high ash coal blended with pet coke and the other from low ash coal for the purpose of establishing technology. Details of these two projects are as mentioned below:

7.3.1 Talcher Fertiliser Plant

A joint Venture Company named Talcher Fertilizers Limited (TFL) comprising of RCF, CIL, GAIL and FCIL has been constituted (2016) to set up a Surface Coal Gasification based integrated fertilizer complex using high ash coal from nearby Talcher Coalfields mixed with pet coke from Talcher refinery with an Investment of Rs 13277 cr. Coal blended with pet-coke up to 25% shall be gassified to produce syngas, which shall be converted into Ammonia and subsequently to 1.27 Mt tonnes of neem coated Urea annually. TFL Board approved coal gasification technology of M/s Air Products (earlier M/s Shell) for the proposed plant. Exclusive subsidy policy for urea produced through coal gasification route by TFL has been approved by the cabinet in 2021. This will ensure concession rate/subsidy for the urea produced through coal gasification route by TFL for a period of 8 years from the date of start of production and will be determined by providing 12% post tax IRR on equity.

Hon'ble Prime Minister of India had laid the Foundation Stone of the plant at Talcher on 22.09.2018. M/s Projects & Development India Limited (PDIL) is the Project Management Consultant (PMC) for this project. The project is being implemented on partial Lump Sum Turn Key (LSTK) basis. LSTK tenders for major plants (Coal Gasification & Ammonia-Urea) are under evaluation. NIT for Captive Power Plant and other Off-sites & Utilities are under preparation by the consultant. Currently, all pre-project works such as Commissioning of Water System, Supply-cum-Erection for Power Works, Land Development etc. are progressing in full swing.

7.3.2 Dankuni Coal to Methanol Plant

In pursuance to initiatives towards development of Clean Coal Technology and alternate use of coal, CIL has floated a tender for engagement of an agency on BOO basis for setting -up a coal-based Methanol plant of a 2050 MTDA (0.676) capacity in the premises of Dankuni Coal Complex (DCC) near Kolkata. Coal sourced from Raniganj coalfields shall be gassified to produce syngas which shall be subsequently converted into methanol. The project will come up with an investment of about Rs 5800 Crs and 1.5 MT Coal will be supplied from Sonepur Bazari Mines of ECL.

7.3.3 Other proposed projects

CIL has further identified four different coal gasification projects in ECL, SECL, WCL and CCL wherein methanol, ammonia, ammonium nitrate and urea are expected to be produced. The pre-feasibility report has been prepared by PDIL and CMPDI has been engaged as a principle implementing agency for the project getting completed. NLCIL has also taken up one lignite to methanol project at Neyveli.

8 Indian Strategy for the Future of Coal Gasification

Honourable Prime Minister had announced a vision of 100 MT Coal Gasification by 2030. At present most of the coal produced in India is utilised in thermal power plants for power generation. Due to environmental concerns, in all likelihood, the requirement of coal for thermal power generation will reduce in long run. Accordingly, there is a need to find an alternative use of coal to prolong the life of coal and utilise the natural resources available in the country.

8.1 Challenges

Coal Gasification utilises chemical property of coal and as such availability of consistent quality of coal for the entire project life is an important factor. There are many other challenges for the successful running of surface coal gasification projects which can be summarised as:

(i) Availability of coal having gasification potential and of consistent quality as a feed stock is utmost important. There should be an appropriate linkage policy for this purpose.

(ii) The quality of coal available in India is mostly of low rank high ash coal. Technology for conversion of high ash coal to syn gas is one of the major challenges. There is a need to develop indigenous technology suited to Indian coal.

(iii) Capital requirement for setting up of these plants is high and huge capital will be required to achieve the mission. Further, due to uncertainty and dependence on foreign licensors for Syn Gas conversion, the cost of various products produced domestically may not be at par with the imported products. Specially methanol produced from Coal may not be competitive with methanol produced from Natural Gas.

(iv) The lack of experience in the domestic sector for SCG is also a challenging factor. This is mostly because there is little expertise in domestic sector for coal gasification.

(v) Infrastructure requirement such as land, water, electricity will play an important role in establishing SCG projects. Further, development of market for various products and transportation cost from point of production to consumption centre will also be important.

(vi) Use of M15 fuel as transport fuel, blending of DME with LPG and establishing Syn Gas to ethanol conversion technology will be key in achieving the Mission.

(vii) The coordination between various stakeholder Ministries such as P&NG, Chemical and Fertilisers, Steel, Coal, Power etc. is also important for the success of various SCG projects.

8.2 Setting up of National Coal Gasification Mission

In order to create awareness among all stake holders and to prepare an implementable road map with specific responsibilities, Ministry of Coal has decided to set up National Coal Gasification Mission. The Mission is created with an aim to take up following objectives which is required for the vision of achieving 100 MT coal gasification by 2030.

a) Mapping of gasification potential of coalfields specially in North east
b) Development of indigenous technology suitable for various feed stock (low ash coal, coal mixed with pet coke and high ash coal)
c) Development of suitable business model for setting up of various projects
d) Marketing strategy for end products
e) Policy support with a view to encourage Atmanirbhar Bharat Scheme
f) Coordination with various stake holding Ministries
g) Providing quantifiable targets to various companies and monitoring the implementation of activities.

8.3 Organisational Structure

In order to take up this mission, number of committees has been formed and nodal officers in various organisations have been created. Efforts taken so far as mentioned below:

8.3.1 Steering Committee

To provide policy direction for Coal to Chemical economy; to advise and recommend institutional mechanism and assign role to various stakeholders; assign role to various stake holder including Ministries and to facilitate and recommend policy decisions for making coal to chemical economy viable and implementable, a committee under chairmanship of Hon Member, NITI Aayog has been constituted. The committee is having the following members:

1) Dr V.K.Saraswat, Member, NITI Aayog,Chairman
2) Secretary, Ministry of Coal
3) Secretary, Ministry of Chemicals and Fertilisers
4) Additional Secretary, NITI Aayog
5) Additional Secretary, Ministry of Coal
6) Shri Neeraj Sinha, Adviser (Energy), NITI Aayog
7) Shri Rajnath Ram, Adviser Energy, NITI Aayog: Member Secretary
8) Ms Vartika Shukla, Director EIL
9) Shri R P Sonde, VP Thermax

NITI Aayog has also constituted a Technical Standing Group for supporting the Steering committee for technological advances & feasible options for the coal Gasification.

8.3.2 Implementation Committee

Ministry of Coal has also constituted an implementation committee under the Chairmanship of Additional Secretary (Coal). This group consists of the following members on development of Surface Coal Gasification by ensuring implementation of policies on Coal Gasification and taking up various projects on commercial scale basis:

1. Shri Vinod Kumar Tiwari, Additional Secretary, Ministry of Coal, Chairman
2. Adviser, Energy, NITI Aayog
3. Joint Secretary MoP&NG
4. Joint Secretary Ministry of Chemical and Fertiliser
5. Project Adviser, Ministry of Coal
6. CMD NLCIL
7. Director, Technical CIL
8. Director, IOCL
9. Director, GAIL
10. Director T/ CM Peeyush Kumar, Ministry of Coal, Member Secretary

The terms of references of the committee are as under:

a. Study the efforts made so far in taking up gasification projects by various companies.
b. Study worldwide practice of gasification.
c. Fix up actionable points for each stake holders and monitor for its implementation
d. Formulate implementation action plan
e. Suggest changes in present policies
f. Identify projects for implementation including coalfields, site for project and marketing strategies
g. Monitoring of commissioning of projects

8.3.3 Resource Group

Ministry of Coal has also created a Resource Group of academic and research institutions for research activities related to Coal Gasification. The members of this group are listed below:

1) Central Institute of Mining and Fuel Research (CIMFR), Dhanbad
2) Department of Mining Engineering, IIT ISM Dhanbad
3) Department of Mining Engineering, IIT Kharagpur
4) Department of Chemical Engineering, IIT Madras, Chennai
5) Department of Chemical Engineering, IIT Bombay, Mumbai

The group has been assigned the task to prepare a technology road map for Coal Gasification and conversion of Syn gas to various end products. The work will include establishing:

i. State of the art analytical hub for characterization, understanding coal towards gasification vis-à-vis selection of matching gasifier as well as utilization pattern and strategies.

ii. Laboratory scale to pilot scale fluidization, gasification facilities along with expertise for design of pilot scale, demo-scale gasifiers, performance evaluation, techno-economic feasibility towards methanol, chemical feedstock, SNG, DRI, Fertilizer etc.

(Letters of constitution of all 3 committees are enclosed at annexure I, II and III)

8.4 Research and Development

Various research and development programs are currently going on for the overall growth of coal gasification sector in India. Some pilot projects are on their way to make the establishment and smooth running of large-scale commercial projects in the future. Some of these projects are shown below:

8.4.1 Indigenous Gasifier Development Programs

Sl. No.	Organization	Facility	Specifications	Operational study	Present status	Remarks
1.	CSIR-CIMFR, Dhanbad	1.5 TPD Oxygen Enriched Pressurized Fluidized Bed Gasification (PFBG) Pilot Plant Installed in Dec, 2020	ID: 200 mm MOC: Refractory lined Temp: 1050 ^{o}C Pressure: 10 kg/cm^2 Capacity: 1.5 TPD Gasifying agent: Oxygen + Air + Steam	Established gasification for high ash coal from Talcher, MCL (Ash 36 & 42%) with 50% Oxygen enrichment & steam	In operation for more oxygen loading and subsequent syngas improvement. Gasification of coal from another sources & Biomass.	250 kg/day Methanol generation pilot plant development & integration with 1.5 TPD PFBG plant is in progress.

2.	CSIR-CIMFR, Dhanbad	0.5 TPD Air-Blown Pressurized Fluidized bed gasification (PFBG) Pilot Plant Installed in Mar, 2009	ID: 100 mm MOC: High temperature alloy Electrically heated Capacity: 0.5 TPD Gasifying agent: Air + Steam Temperature: 1000 ^{o}C Pressure: 3 kg/cm^{2}	Established air blown gasification for high ash (27-49%) coal, coal-biomass (4 Nos) blends successfully. Design data used for upscaling.	In operation	Established smooth feeding, ash withdrawal and fluidization without operational problems like agglomeration clinker formation.
3	EIL (R&D) Gurgaon	Fluidized Bed Gasifier	200 mm ID (*refractory lined with 2 stage cyclone) and gas cleaning system and ground flare system* *Coal feed rate capacity: 3.6 TPD* O2 & Steam blown Designed for 30 bar operated up to 6 kg/cm2	Under operation for coal (ash ~ 42%) with Oxygen & Steam	In operation to overcome issues related to the coal fines carryover and syngas quality improvement.	Targeted for CTL
4	BHEL, R&D Hyderabad	Fluidized Bed Gasifier	*refractory lined Coal federates 1.2 TPD Oxygen/*Air blown with steam Temperature: 1050 ^{o}C Pressure: 1.2 ata	Operated for coal with ash content 28% - 45% with air & steam, upgradation for operation with oxygen & steam in progress	In operation to establish oxy-blown mode	Establishing Syngas to Methanol Pilot Plant at the downstream of the gasifier is in progress.
5	BHEL, Trichy	Fluidized Bed Gasifier	*refractory lined Coal federates 168 TPD* Air blown with steam Temperature:	Operated in air-blown mode for IGCC	Needs major revamping	--

			1050 °C Pressure: 10 bar			
6	Thermax, Pune	1 TPD fluidized bed coal gasification pilot plant Established in 2014	Type: Bubbling fluidized bed Coal feed rate Capacity: 1 TPD Pressure: up to 0.3 bar	Tested Coals: South African, Indonesian and Indian coal	Active	--
7	Thermax, Pune	6 TPD fluidized bed coal gasification pilot plant	Type: Bubbling Coal feed rate Capacity: 6 TPD Pressure: upto 6 bar	Tested Coals: Variety of Indian coal. (Can also handle other SA/Indonesian coal)	under pre-commissioning stage (Aug 2021)	demonstration of coal to methanol under progress

8.4.2 Other efforts for Pilot and demonstration project

a. M/s Synata bio in collaboration with M/s Thermax is planning to set up a Coal to Ethanol demonstration plant of 20K capacity to establish the technology of bio conversion of Syn Gas to Ethanol.

b. CMPDI in collaboration with GTI, USA is planning to set up a pilot project for production of Hydrogen with CCUS technology.

8.5 Implementation Strategy

In order to take ahead the Vision of 100 MT coal Gasification by 2030, Ministry f coal has chalked out implementation strategy which include:

1. Gasification potential mapping of entire coalfields
2. Setting up of commercial scale plants for various feed stocks based on available gasification technologies
3. R&D efforts and completing pilot scale and demonstration scale studies in developing technologies suited for Indian coal.
4. Developing policy framework for making available coal to proposed projects to be set up both in public and private sector
5. Providing policy support for ensuring financial viability of projects

6. Coordinated approach with all stakeholders including Ministries for establishing the entire value chain.

The Ministry of Coal has planned to execute the vision of establishing the commercial scale projects in a three-fold implementation strategy:

Phase I: Setting up project on Pilot basis

The Ministry of Coal has aimed for gasification of 4 MT of coal through 2 projects – The Talcher Fertilizer Plant & the Dankuni Methanol Plant. The Talcher Fertilizer Plant will be based on gasification of high ash coal with blending of petcoke and will be accomplished through a joint venture of Coal India Limited (CIL), Rashtriya Chemicals & Fertilizers (RCF) and GAIL India Limited. The methanol plant at Dankuni will utilize low ash coal sourced from the eastern part of the country and will be implemented through Build-Own-Operate (BOO) mode.

Phase II: Upscaling efforts towards coal gasification

Coal India Limited, which is the major coal producer of the country has identified 4 key gasification projects across its subsidiaries, Eastern Coalfields Limited (ECL), South Eastern Coalfields Limited (SECL), Central Coalfields Limited (CCL) & Western Coalfields Limited (WCL) to gasify 6 MT of coal and produce various downstream products such as methanol, ammonia & synthetic natural gas (SNG).

Phase III: Gasification of 90 MT coal

After successfully setting up technology in the Phase II, more projects shall be identified. Stakeholders are expected to be active participants in the gasification roadmap for India for which Ministry of Coal shall extend support for sourcing of coal.

8.6 Infrastructure Requirement

Coal gasification projects will need a dedicated infrastructure to be able to get them on ground. Availability of basic facilities such as land, water and feedstock, which is coal, is extremely important for these projects to get kick-started. Investors could either join hands with any of the PSU's, most likely CIL, or independently go for the projects. Initially, the former approach is likely to yield better results as CIL can readily provide basic amenities such as land, coal and water that will fast-track the implementation because land acquisition can be an arduous process in India. Here, there is a distinction between upstream and downstream infrastructure. Upstream infrastructure largely comprises coal gasification technologies that will gasify coal to produce syngas and consequently other downstream products. Whereas the downstream infrastructure will focus on the product specific pipelines and the

infrastructure required for different products. For example, methanol is a corrosive product, so, it will require a corrosion resistant pipeline and automobiles are also likely to be calibrated to use methanol-gasoline blends or diesel-DME blends. Moreover, India will require testing facilities and centres for conducting experiments. Therefore, the Government must simultaneously think about creating the requisite infrastructure as it plans to implement the 100 MT target of gasifying coal.

8.7 Generating Local Interest

The implementation of the projects will require coordination of various central, state, and local Government offices. And it becomes extremely important to get the active support of the local population to successfully implement the projects. Benefits to the locals in the form of jobs and social infrastructure such as hospitals, schools, providing clean drinking water etc., through CSR activities will fetch their support. The projects must be designed in a way to have minimal impact on local air quality, water, and soil.

8.8 Funding Requirement and Business Models

Infrastructure development will call for a massive infusion of capital in the system. The Government has to take calls based on specific projects whether to jointly develop the infrastructure projects with private partners or fund them by itself. The Government will attract various private investors through financial tools such as Viability Gap Funding, long term off-take contracts, creation of special economic zones and low cost of capital. Several business models such as Build Own Operate, Build Own Operate Transfer, and Build Own Transfer can be used depending upon the specific project and investor.

8.9 Inter-Ministerial Collaboration

The National Coal Gasification Mission's objective to gasify 100 MT of coal will definitely require collaboration amongst the Government at various levels – Central, State and Local. As seen from table 9.1, the different products that could be produced through coal gasification will require coordination of the respective Ministries as well. For example, if methanol is blended with gasoline and the transportation of methanol is done through inter-state pipelines – this will require close coordination of Ministry of Coal, Ministry of Petroleum & Natural Gas, and the State Governments. Moreover, the support from the local Governments will play a key role in implementing the projects. A three-tier Institutional Frameworkhas been created to steer the National Coal Gasification Mission and it would be one of the most important tasks of the teams to ensure coordination and collaboration between various departments. Since coal gasification involves different Ministries, it would be

efficient for the Government to have a single team of members to interact with investors interested in coal gasification projects.

8.10 Policy Decisions and Statutory Approvals

The Government would need to take some major and path breaking policy decisions to create a technologically and economically feasible environment to push coal gasification in India. For example, blending of methanol with gasoline may require the Government to forego some of its tax revenue on gasoline to make Methanol economically viable and similar might be the case with DME blending with LPG or diesel. The policy decisions and statutory approvals will have to provide a level-playing field for the private and public sector companies to attract serious investment. The policy makers would strive to eliminate any distortions in the market for the different products produced through coal gasification route.

8.11 Institutional Integration

There have been numerous research efforts going on in different universities, laboratories, and PSU's sporadically on the coal gasification process. There is an urgent need to consolidate all of them and bring them under one umbrella to avoid reinventing the wheel and have better collaboration. The Resource Group should bring different institutions working on coal gasification together. A lack of industry-academia collaboration results in developing technologies or solutions that are seldom scalable. Therefore, a better coordination would help researchers to focus on the relevant issues and problems faced by the industry and this would make the research of academicians more applicable and relevant.

9 Policy Supports in Coal Gasification Sector and Way Forward

A number of efforts have been taken to provide support to private sector and public sector for setting up of Coal Gasification plants. This includes concessions in revenue share for commercial auction of coal blocks. If the successful bidder consumes the coal produced either in its own plant(s) or plant of its holding, subsidiary, affiliate, associate for coal gasification or liquefaction or sells the coal for coal gasification or liquefaction process, a rebate of 20% on the revenue share quoted by the successful bidder will be allowed on the total quantity of coal consumed or sold or both for gasification or liquefaction on an yearly basis, subject to the following conditions:

i. At least 10% of scheduled coal production as per approved mining planfor that year shall be consumed or sold for gasification or liquefaction;

ii. Coal Controller's certification would be required for the quantity of coal consumed or sold or both for gasification or liquefaction.

MoC has also proposed to give freedom to Coal India Limited for utilising coal for its own gasification projects at a rate to be decided by CIL. Further, all coal companies have appointed nodal officers for taking up coal gasification projects in their company. However, due to dependence on foreign licensors for technology and competition from other feed stock such as natural gas, there is a need to provide incentives and policy support to companies for taking up coal gasification projects..

NITI Aayog's 'Methanol Economy' programme is aimed at reducing India's oil import bill, greenhouse gas (GHG) emissions, and converting coal reserves and municipal solid waste into methanol. Although slightly lower in energy content than petrol and diesel, methanol can replace both these fuels in the transport sector (road, rail and marine), energy sector (comprising DG sets, boilers, process heating modules, tractors and commercial vehicles) and retail cooking (replacing LPG [partially], kerosene and wood charcoal). Blending of 15% methanol in gasoline can result in at least 15% reduction in the import of gasoline/crude oil. In addition, this would bring down GHG emissions by 20% in terms of particulate matter, NOx, and SOx, thereby improving the urban air quality

9.1 Way ahead for taking up Mission

Ministry of Coal had organized an international webinar under the Chairmanship of Honorable Minister of Coal on 31.8.2020 wherein NITI Aayog, representatives of various Ministries, research organizations, private and public sector coal companies and technology providers.

Further, Coal India Limited, on behalf of the Ministry of Coal, conducted the stakeholder consultation involving industry and coal consumers for coal gasification on 8th June 2021 over video conferencing.

Based on various consultations made, the following actionable points have emerged for the mission:

9.1.1 Allocation & Linkages

a. The best suited condition for the lower maintenance and operational cost for the optimum performance of the gasifiers is when the feedstock is not diversified. Grant of long-term Fuel Supply Agreements will ensure the supply of coal from a single source helping to curb the sensitivity of the gasifiers due to the difference of physical and chemical properties of coal from different sources.

b. The identification of mines with better Grade of Coal suitable for Surface Gasification will help the stakeholders to identify assets for future auctions. Keeping in the mind about the mega gasification projects, allocation of coal blocks will be better option than long term coal linkages as far as the pricing of coal is concerned.

9.1.2 Gasification Technology Adoption

There is a need to develop research and development facilities on similar lines of China to promote gasification technology in India. Optimum process configuration has to be selected with CAPEX and OPEX in view while addressing impurities in syngas and metallurgical challenges.

Adoption of Carbon Capture, Utilization & Storage (CCUS) technology for control of carbon emissions needs to be examined. It can be based on model adopted by USA for enhanced oil and hydrocarbon recovery leading to an additional recovery of 10% oil in some cases.

9.1.3 Downstream Products

a. For the marketability and the upcoming demand of various products like ammonia, urea, methanol, ethanol and other chemicals the need for a balanced poly-product portfolio design would be critical to ensure market resilience and to promote economically sustainable coal gasification in line with the risk hedging strategy used by established players like SASOL. Policy introduction for the substitution of naphtha as feedstock for chemical products needs to be framed. Further, MoP&NG is to modify National Policy on bio fuels to include ethanol produced through coal gasification route.

b. The syngas obtained from the coal gasification can be used to obtain multiple products like methanol, DME, olefins etc. of which India is a net importer presently.

One of the major challenges is the end-product prices are market driven and it is essential for coal-based gasification products to be price-competitive with imported products. The separation of Sulphur from crude oil to produce a cleaner oil also requires huge quantities of hydrogen obtained from the gasification process.

c. The coking coal imported for steel making causes a huge outflow of Forex from the country. Syngas can be made available for steel making through the Direct Reduced Iron (DRI) route and increase in usage of Electric Arc Furnace (EAF) and Direct Reduced Iron (DRI) will and also help towards reduction of import bill for furnace oil.

d. Coal to syngas route can be adopted for ammonia production with the liberated carbon dioxide being used to produce urea in a single complex, thus contributing to lower carbon emissions and lowering the import of ammonia and urea (around 2.5 million MT of ammonia & 7-8 million MT urea are being imported into the country presently). But the differential higher CAPEX of 30-40% for a coal gasification-based ammonia plant makes it less attractive for fertilizer sector than a natural gas-based plant. However, India being an importer of natural gas, can leverage the vast reserves of coal to substitute natural gas as the primary feedstock for ammonia production.

9.1.4 Business Model for Surface Coal Gasification Projects

Various business models were deliberated during discussions wherein coal may be offered at a discount for SCG projects and Coal India may be offered equity in the venture.It will ensure long term tie up with the key raw material supplier and secure supply of key feedstock coal at a discounted price.

EPC model of project implementation can also be taken up by companies where a reputed EPC contractor develops the project from commencement to final completion. The owner or principal of the EPC project provides the EPC contractor with a detailed design including technical and functional specifications, in order for the EPC contractor to build and deliver the project to the "turn of the key", within a specified time period. An EPC contract is often a fixed price contract or an all-encompassing lump sum contract and any shortfall of costs is a risk that rests with the EPC contractor, making cost control their number one priority.

Build-Own-Operate (BOO) will be a suitable model as it will bring substantial benefits to the owner. Build, Own, Operate (BOO) is also a widely recognized mode of implementation of a project where the project owner grants the right to finance, design, build, operate and maintain a project to an independent entity, which retains ownership of the project. The primary advantages of BOO model are de-risking the project owner from various risk associated with technology, process integration, construction, operations & maintenance and it offers long term reliability and efficiency if a renowned BOO operator backed by strong execution background and financial capability is selected for the project.

9.2 Incentives, Policy Enablers

9.2.1 **Waiver of GST Compensation Cess of Rs. 400/ tonne of coal:**

It is imperative to note that coal gasification provides a cleaner and alternative approach for utilization of coal. In view of the above, the GST compensation cess of Rs. 400 per tonne on the quantity of coal consumed and/ or sold for coal gasification is proposed to be waived. If GST compensation cess is removed on coal, then the tentative reduction in the cost of production of Methanol is expected to be around Rs. 800-900 per MT. This will not entail any revenue loss as the waiver is proposed only on incremental coal use for gasification purpose.

9.2.2 **Reduction in additional Cess and Duties:**

The landed cost of coal is almost double than the notified price of coal on account of high rail freight, levy of royalty (14% of the cost of coal), additional duty & cess (GST @ 5% of cost of coal, DMF @30% and NMET 2% of Royalty and GST compensation Cess @Rs 400 per tones) etc. It is thus proposed to reduce the royalty and freight charges and provide waiver on application of GST on coal, to make coal gasification competitive. With waiver of GST on coal (5%) and 15% reduction in freight charges for coal and final product, the cost of final product (Methanol) may further be reduced by ~Rs. 650-750 per MT. Due to curtailment of GST compensation cess and additional duty on coal, the tentative reduction on aggregate price of final product (Methanol) may be in the range of Rs. 1,450-1,650 per MT.

9.2.3 **Tax holiday for 15 years for coal gasification projects:**

Tax holiday for 15 years may reduce the average cost of production of methanol by Rs. 700-1000 per MT and the same may further increase depending upon the scale of operation and profitability of the company.

9.2.4 **Subsidy for purchase of capital equipment**

Subsidy for purchase of capital equipment may be provided and depending on the quantum of capital subsidy (say 15-25% of capital cost) the venture may reduce cost of production of methanol in the range of Rs.600-Rs.1100 per MT.

9.2.5 **Interest Rate Subvention**

Interest Rate Subvention @ 20-30% may be provided thereby reducing the interest burden on coal gasification projects and improve the bankability of these projects. Interest rate subvention of 20-30% may reduce average cost of production of methanol by Rs. 400 - 600 per MT.

9.2.6 **Hike in custom duty on import of Methanol:**

Almost 90 % of domestic methanol requirement is met through imports. To promote domestic production and discourage diversion of idle or additional capacities in foreign market, additional custom duty may be imposed on import of Methanol (presently at 10%). A tentative impact of Rs. 2,000 to Rs. 2,500 per MT through hike in custom duty or introduction of additional levy on imported methanol may prove to be beneficial for domestic players.

9.2.7 **Import duty exemption:**

Import duty exemption for capital goods for setting up coal gasification projects may be considered. The incentives should be on the same lines as given to the petroleum sector for upstream projects as these projects are also going to make available oil and gas substitutes.

9.3 Other Incentives / Policy Measures for Coal Gasification

In addition to the fiscal incentives, following incentives/ policy measures are proposed to promote gasification of coal in India:

9.3.1 **Roadmap for Methanol Blending in India:**

In line with the roadmap for Ethanol Blending in India by 2025, a policy regarding M15 blend i.e. 15% blending of methanol with petrol is proposed to be introduced by Niti Aayog suggesting specific responsibilities of Union Ministries, State Governments, refineries and vehicle manufacturers for the production, supply and gradual rollout of methanol blending in petrol and provision of subsidies to incentivize methanol blending.

9.3.2 **Funding of research and development in the field of coal gasification**:

There is a need to earmark adequate annual budget for funding research and development in the field of coal gasification.

9.3.3 **Lease of land under Coal Bearing Areas (Acquisition and Development) Act, 1957**:

MoC propose to lease land under CBA Act, 1957 for development of pit-head surface coal gasification projects. This shall help in reducing the logistics cost and improving the overall profitability and viability of the project.

9.3.4 **Allocation of long-term coal linkages through auction:**

For coal gasification projects, homogenous quality of coal is essential to reduce the operational expenditure. Therefore, policy support needed so that coal gasification can be considered for a direct linkage without the auction route on notified price for

Power sector. The initial floor price shall be the relevant CIL/ SCCL ROM price for regulated sector and the tenure of the linkages shall be for up to the life of the End Use Plant (in line with the policy and methodology adopted for auction of coal linkages for medium term and long term under paragraph B(iii) of SHAKTI Policy).

9.4 Way Forward

The below course of action may further assist to achieve the goal of using 100 MT of coal for coal gasification by 2030.

a) Focused group discussions may be held with the potential companies (who may want to be BOO operator) to sense their interest and to understand their critical expectations.

b) Allocation of ear-marked land for development of pit-head surface coal gasification projects. This shall significantly reduce logistics cost and improve the overall profitability and viability of the project.

c) Introduction of policy regarding M15 blend & provision of subsidy to refineries to incentivize blending and provision of subsidy of methanol shall be in line with ethanol. It has been envisaged that the target of substituting 10% crude oil imports by 2030 can be met under the M15 programme and M15 has the potential to achieve up to 20% crude oil import substitution by 2030.

d) Introducing economical financing options for SCG projects. Lower rate of interest coupled with flexible repayment option shall reduce the burden of debt trap for SCG projects. The stakeholders are of the common opinion that CAPEX financing is a major impediment to implement SCG projects.

e) Exemption of GST Compensation Cess, reduction of duty on raw coal to make domestic product competitive, such policy-driven measures are a major need for domestic players, which will make price of final products highly competitive and at par with global standards.

f) Rationalizing domestic coal prices on an integrated basis to ensure viability of coal gasification.

g) Development of Single window clearance system for requisite approvals for surface coal gasification projects & creation of guideline templates for smooth acquisition of regulatory & statutory approvals.

h) Incentives may be given to steel producers for usage of coal gasification. It shall also minimise GHG emission and reduce foreign exchange outflow through reduction in import of coking coal.

i) Investment and fund allocation for capacity building for capital equipment manufacturing in the country. In line with “Atmanirbhar Bharat Abhiyan” capacity building for capital equipment manufacturing industries shall act as catalyst in reducing import of heavy machineries and spares. The reduction dependence on imports for critical machineries and spares shall provide reliability of supply to the

domestic producers and eradicate the uncertainty like exchange rate fluctuation, customs policy, etc. related to cross border transactions.

j) A common platform may be designed to provide all the relevant information about SCG projects like details of most widely accepted technologies, case studies from around the world, research papers, key success stories, policy driven incentives and road map for undertaking mega projects. It may act a ready reckoner for MSME as well as large scale industrialist and may also be utilised as an interactive platform to voice opinion of all stakeholders.

k) A reward and recognition policy may be introduced to honour companies/ventures achieving given targets in the coal gasification projects. The facilitation and recognition of successful and profitable ventures shall inspire others to undertake investment in SCG projects.

l) Facilities may be established and funded to undertake research and development in the field of coal gasification projects. It shall assist in the development of SCG projects in the country and cater to the requirements of the industry.

m) A robust and time bound fiscal incentive policy may be introduced like tax holiday, exemption of duties or capital subsidies. The policy may be restricted to companies which commence production in next 3-4 years. It shall provide ready incentive to interested parties and fast-track the construction activities and project implementation which is critical to the common objective of our nation of utilising 100 MT of coal per annum for gasification.

ANNEXURES

Annexure I

File No: M-12026/8/2016-Part File (Coal)
Government of India
NITI Aayog
(Energy Vertical)

NITI Bhawan, Sansad Marg
New Delhi-110001
Dated: 8th May, 2020

OFFICE MEMORANDUM

Subject: Constitution of Steering Committee & Technical Standing Group for Indian Coal Gasification Mission.

A meeting was held between Member (VKS), NITI Aayog and team of Ministry of Coal lead by Secretary (Coal) on 11th March, 2020 in NITI Aayog (copy of MoM enclosed) on Coal Gasification Mission.

2. As per para 2 (point 1) of the said minutes of meeting, the Competent Authority has constituted Steering Committee on Coal Gasification Mission under the Chairmanship of Dr. V.K. Saraswat, Member, NITI Aayog to provide direction & monitoring of the Indian Coal Gasification projects with the following compositions:

Composition of the Steering Committee

1.	**Dr. V. K. Saraswat, Member, NITI Aayog**	**Chairman**
2.	Secretary (Coal), Ministry of Coal	Member
3.	Secretary, Ministry of Chemicals & Fertilizers	Member
4.	Special Secretary, NITI Aayog	Member
5.	Additional Secretary, M/o Coal	Member
6.	Shri Neeraj Sinha, Adviser (S&T), NITI Aayog	Member
7.	Shri Rajnath Ram, Adviser (Energy), NITI Aayog	Member-Convenor
8.	Ms Vertika Shukla, (R&D) EIL	Member
9.	Shri RR Sonde, VP Thermax	Member

3. Chairman of Steering Committee has constituted a Technical Standing Group for supporting the Steering Committee for technological advances & feasible options for the coal gasification with following compositions.

Composition of Technical Standing Group

1.	**Dr. V. K. Saraswat, Member, NITI Aayog**	**Chairman**
2.	Shri Anil Jain, Secretary (Coal), Ministry of Coal	Member
3.	Shri RR Sonde, VP Thermax	Member
4.	Prof SR Chakravarti, IIT Mumbai	Member
5.	Prof Shantanu Roy, IIT Delhi	Member
6.	Shri Prakash Chouhan, CIMFR	Member
7.	Mr Rajesh Kumar Gupta, Head Hindalco, Sambalpur	Member
8.	Mr Arya Jena, Adani	Member
9.	Mr Ajit Sapre, (R&D) Reliance	Member

4. The Steering Committee may Co-opt member from any Central/ State Government Official/ Expert/ Think-tank to assist the Steering Committee. Committee may consult relevant stake holders including State Governments/Central Govt. Departments, Industry associations etc. to supplement its work.

5. Terms of Reference (ToR) of the Committee:

a. To provide policy direction for Coal to Chemical Economy
b. Advise and recommend institutional mechanism for Coal to Chemical Economy
c. Assign roles to various State holders including Ministries
d. Facilitate and recommend policy decisions for making Coal to Chemical economy viable and implementable
e. Advise on technological advances and feasible options

6. This issues with the approval of competent authority.

(Manoj Kumar Upadhyay)
Senior Research Officer
Telephone: 011-23096757

To,

1. **Shri Anil Jain, Secretary Coal, Ministry of Coal (secy.moc@nic.in)**

2. Shri Chhabilendra Roul, Secretary, Ministry of Chemicals & Fertilizers (fertsec@nic.in)
3. Shri Vinod Kumar Tiwari, Additional Secretary (as.moc@nic.in)
4. Shri R R Sonde, VP Thermax (r.sonde@thermaxglobal.com)
5. Prof S R Chakravarti, IIT Mumbai (src@iitm.ac.in)
6. Prof Shantanu Roy, IIT Delhi (shantanu.roy@chemical.iitd.ac.in)
7. Shri Prakash Chouhan, CIMFR (pdchavan@cimfr.nic.in, chavanpd@gmail.com)
8. Ms Vertika Shukla, (R&D) EIL (vartika@eil.co.in)
9. Shri Rajesh Kumar Gupta, Head Hindalco, Sambalpur
10. Shri Arya Jena, Adani (arya_jena07@yahoo.com)
11. Shri Ajit Sapre, (R&D) Reliance (ajit.sapre@ril.com)

Copy to: NITI Aayog

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6. PS to Adviser (Energy), NITI Aayog (rajnath-pc@nic.in)

Annexure II

No.34018/04/2016-CRC-I
Government of India
Ministry of Coal

Room No. 622-A, Shastri Bhawan,
New Delhi, 3rd June, 2020

OFFICE MEMORANDUM

Subject: Constitution of Resource Group of academic and research institutions for research activities related to Coal Gasification, underground mining and dealing with Jharia fire.

The undersigned is directed to convey the approval of the Competent Authority for constitution of Resource group of academic and research institutions as mentioned below:

(a) Central Institute of Mining and Fuel Research (CIMFR), Dhanbad.
(b) Department of Mining Engineering, IIT ISM Dhanbad
(c) Department of Mining Engineering, IIT Kharagpur
(d) Department of Chemical Engineering, IIT Madras, Chennai
(e) Department of Chemical Engineering IIT Bombay, Mumbai

2. Lead organisation for the group will be on rotation basis of two years who will coordinate with other institutes and interact with Ministry. CIMFR, Dhanbad will work as a lead organization with immediate effect and this assignment will be rotated among member institutions as per approval of Ministry.

3. Terms of References for this Resource Group will be as under-

(a) The group will prepare a technology road map for Coal gasification and conversion of SYN gas to various end products. The work will include establishing:

i. State of the art analytical hub for characterization, understanding coal towards gasification vis-à-vis selection of matching gasifier as well as utilization pattern and strategies.
ii. Laboratory scale to pilot scale fluidization, gasification facilities along with expertise for design of pilot scale, demo-scale gasifiers, performance evaluation, techno-economic feasibility towards Methanol, Chemical feedstock, SNG, DRI, Fertilizer, etc.

(b) The group will provide Technical assistance to BCCL, ECLJRDA and ADDAin stabilization of affected unstable area and extinguishing of fire in Jharia and Raniganj coalfields

(c) Technical assistance in adoption of latest technology in underground mining. Collaboration with industry in issues such as strata control, methodology of extraction of locked pillars and conducing related research.

4. A permanent cell at all institutions will be created with financial support from Ministry of Coal and CIL R&D funds to have dedicated researchers/ scientists for the purpose. Funds for other research projects will be sourced on case to case basis. Lead institution

-1/2-

will examine the annual requirement of fund and submit the report in a month's time to MoC for considerations.

This has the approval of competent authority.

(Hitlar Singh)
Under Secretary to the Government of India
Tel- 23382269

To,

1. **Director, Central Institute of Mining and Fuel Research (CIMFR), Dhanbad**
2. **HoD, Department of Mining Engineering, IIT ISM Dhanbad**
3. **HoD, Department of Mining Engineering, IIT Kharagpur**
4. **HoD, Department of Chemical Engineering, IIT Madras, Chennai**
5. **HoD, Department of Chemical Engineering IIT Bombay, Mumbai**

Copy to:

1. **Director, IIT ISM Dhanbad**
2. **Director, IIT Kharagpur**
3. **Director, IIT Madras, Chennai**
4. **Director, IIT Bombay, Mumbai**
5. **Chairman, CIL**
6. **CMD, NLCIL**
7. **CMD, SCCL**
8. **CMDs of CMPDI/BCCL/ECL/WCL/MCL/SECL/CCL/NCL**

Copy for information to:

PSO to Secretary (Coal)/Sr. PPS to AS (Coal)/PPS to JS (BPP)/PS to Director (T)

- 2/2 -

I/12591/2020

File No.34018/04/2016-CRC-I

Annexure III

F.No. 34018/04/2016-CRC-I
Government of India
Ministry of Coal
*****

Room No. 622-A, Shastri Bhawan,
New Delhi, Dated 29th July, 2020

Office Memorandum

Subject : Constitution of Implementation Committee on Development of Surface Coal Gasification- reg.

The undersigned is directed to convey the approval of the Competent Authority for constitution of Implementation Committee with the following members on development of Surface Coal Gasification by ensuring implementation of policies on Coal Gasification and taking up various projects on commercial scale basis:

S.No.	Name	Organization	Status
1	Additional Secretary	Ministry of Coal	Chairman
2	Adviser (Energy)	NITI Aayog	Member
3	Joint Secretary	MoP&NG	Member
4	Joint Secretary	Ministry of Chemicals and Fertiliser	Member
5	Project Adviser	Ministry of Coal	Member
6	CMD	NLCIL	Member
7	Director (Tech)	Coal India Limited	Member
8	Director	IOCL	Member
9	Director	GAIL	Member
10	Shri Peeyush Kumar	Ministry of Coal	Member

2. The committee may co-opt any member as per requirement.

3. The terms of references of the committee are as under:
   a. Study the efforts made so far in taking up gasification projects by various companies.
   b. Study worldwide practice of gasification.
   c. Fix up actionable points for each stake holders and monitor for its implementation
   d. Formulate implementation action plan
   e. Suggest changes in present policies
   f. Identify projects for implementation including coalfields, site for project and marketing strategies
   g. Monitoring of commissioning of projects

This issues with the approval of the Competent Authority.

-sd-
(Hitlar Singh)
Under Secretary to the Govt. of India
Email:hitlar.singh85@nic.in

To,
All members of the committee.

Copy to:
1. PSO to Secretary (Coal)/PPS to Additional Secretary(Coal)
2. Shri V.K. Saraswat, Member, NITI Aayog
3. Shri Peeyush Kumar, Ministry of Coal.

File No.17011/1/2015-CRC-I
238552/2020/O/o US(CCT,MPS,CPIAM)

Annexure IV

F No.: 17011/01/2015-CRC-I
Government of India
Ministry of Coal
Room No. 622-A, Shastri Bhawan,
New Delhi, 23rd July, 2020

OFFICE MEMORANDUM

Subject: Constitution of Working Group to address marketing issue of Methanol, ammonium nitrate, olefins, SynGas (SNG) etc produced through coal gasification process from proposed CIL projects

The undersigned is directed to convey the approval of the Competent Authority for constitution of working group with following members:

1. Director T, CIL
2. Director, R&D, IOCL
3. ED-Business Development, GAIL
4. Shri Rajnath Ram, Adviser, Energy, NITI Aayog
5. Shri Peeyush Kumar, MoC Member Secretary

2. The committee will address marketing issue of Methanol, ammonium nitrate, olefins, SNG, etc. produced through coal gasification process from proposed CIL projects and examine the following in detail and give its recommendations from time to time:

a. Present status of import and utilization of methanol in India.
b. Projected regional demand of Methanol & SNG (by 2025, 2030, 2040)
c. Possibility of blending Methanol with Petrol (Motor Spirit) as per M15 standards and actions to be taken for its implementation or utilization of SNG for other applications.
d. Viability Assessment based on existing pricing methodology of OMCs.
e. Policy Support by GOI to make SCG based Methanol/SNG competitive with imported Methanol/LNG. It may study various models (like TFL project regarding 12% equity IRR, subsidies, Viability Gap Funding, etc.) and make recommendations suited to developing coal based methanol.

This issues with the approval of the competent authority.

-sd-
(Hitlar Singh)
Under Secretary to the Government of India
Tel- 23382269

To,

All members of the committee

Copy to:

PSO to Secretary (Coal) & Secretary P&NG/Sr. PPS to AS (Coal)/ PS to Director (T).