

*Development of
Coal Based
Non-conventional Energy Resources:*
A step towards Clean Energy initiatives

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Presentation Outline

- **Global Warming: A Real Challenge**
- **Coal Utilisation: A concern for Environment**
- **Coal: A source of Clean Energy**
- **Implementation of Clean Coal Technology:**
 - Coalbed Methane (CBM)
 - Coal Mine Methane (CMM)
 - Ventilation Air Methane (VAM)
 - Coal Gasification
- **Development of renewable energy: A priority area**

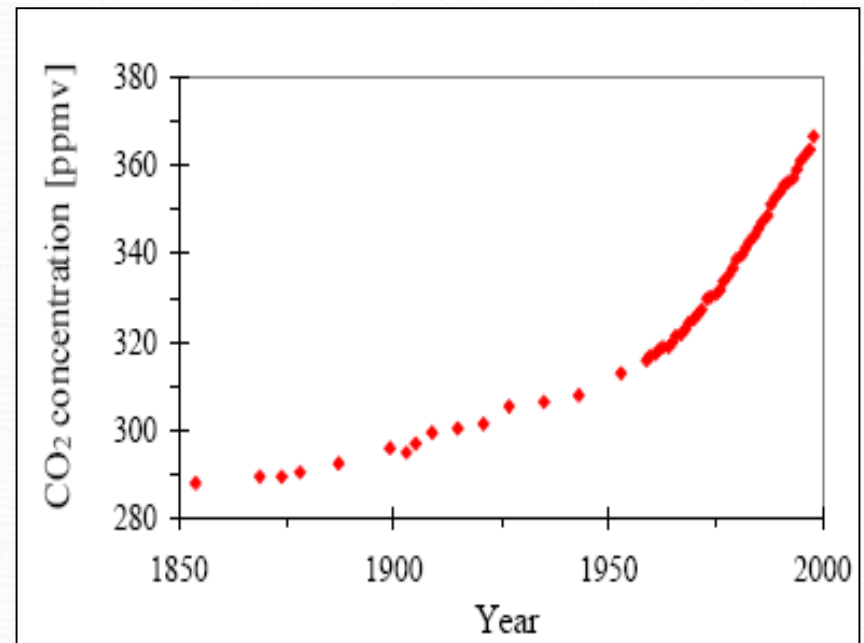
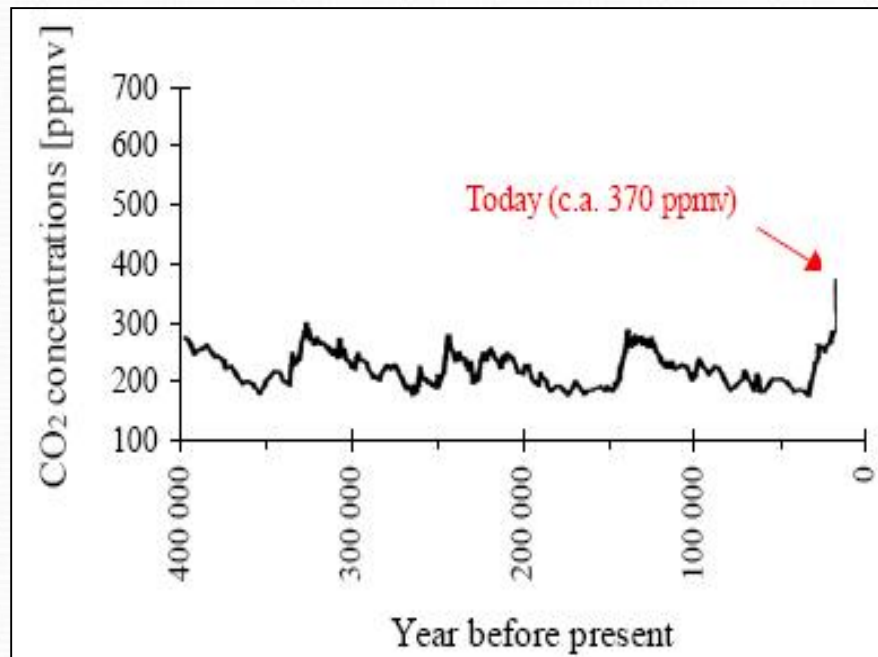
Global Warming: A real Challenge

- Global warming is the rise in average temp of the earth and its related effect.
- It is posing a threat and is the greatest challenge being faced today.
- It is now almost certain that the human related (anthropogenic) activities has contributed in accelerating global warming.
- Increase in emission of Greenhouses Gases is playing a major role.
- Efforts are being made to contain Global Warming and several protocols/agreements (Kyoto protocol, Paris agreement etc) are in place.
- Steps are being taken to reduce the GHG emissions and utilization of clean energy is being encouraged globally.
- In this effort Clean Coal Technology is being pursued for making usage of most reliable energy source coal environment friendly.

GHG and Climate Change

- A Greenhouse Gas (GHG) in the atmosphere absorbs and emits radiation within the thermal infrared range.
- This process is the fundamental cause of the greenhouse effect.
- The primary greenhouse gases in Earth's atmosphere are water vapor, Carbon dioxide, Methane, Nitrous oxide and ozone.
- Without greenhouse gases, the average temperature of Earth's surface would be about -18°C rather than the present average of 15°C
- Human activities since the beginning of the Industrial Revolution (taken as the year 1750) resulted 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 406 ppm in early 2017

Change in Atmospheric Concentration of CO₂

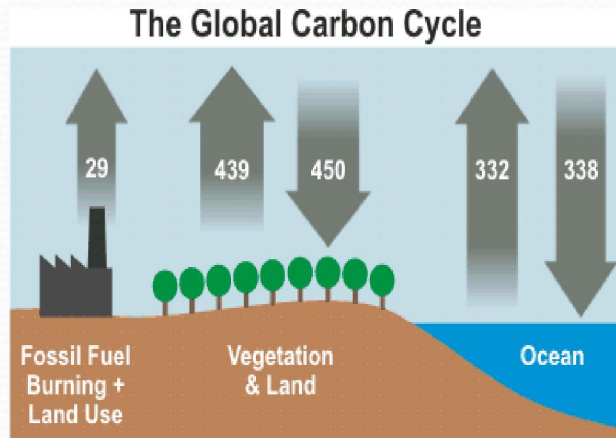


Atmospheric Concentration of CO₂

Before industrial revolution: 260-280 ppm

At present = about 406 ppmv in 2017

Global Carbon Cycle



Global carbon cycle. Numbers represent flux of carbon dioxide in gigatonnes (Source:IPCCAR4)

- Manmade CO₂ emissions are much smaller than natural emissions.
- Effect of fossil fuel burning and changes in land use, human CO₂ emissions are only around 29 gigatonnes per year
- Human CO₂ emissions upsets the natural balance

Daily CO₂

December 12, 2016: 404.44 ppm

December 12, 2015: 403.01 ppm

November CO₂

November 2016: 403.64 ppm

November 2015: 400.24 ppm

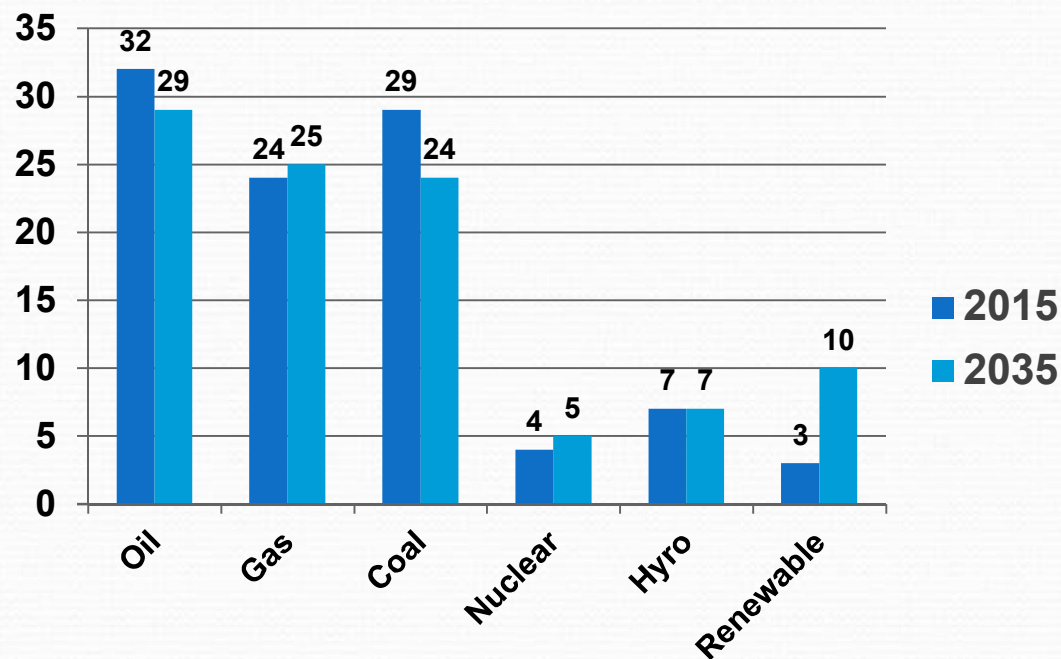


Coal Utilization:

A Concern for Environment

Coal Utilization: A Concern for Environment

- Coal plays an important in meeting global primary energy requirement.
- The BP Energy Outlook 2017 indicate that the share of coal will decrease from 29% in 2015 to 24% in 2035, mainly on account of environmental reasons.
- Graph based on data provided in BP Energy Outlook 2017

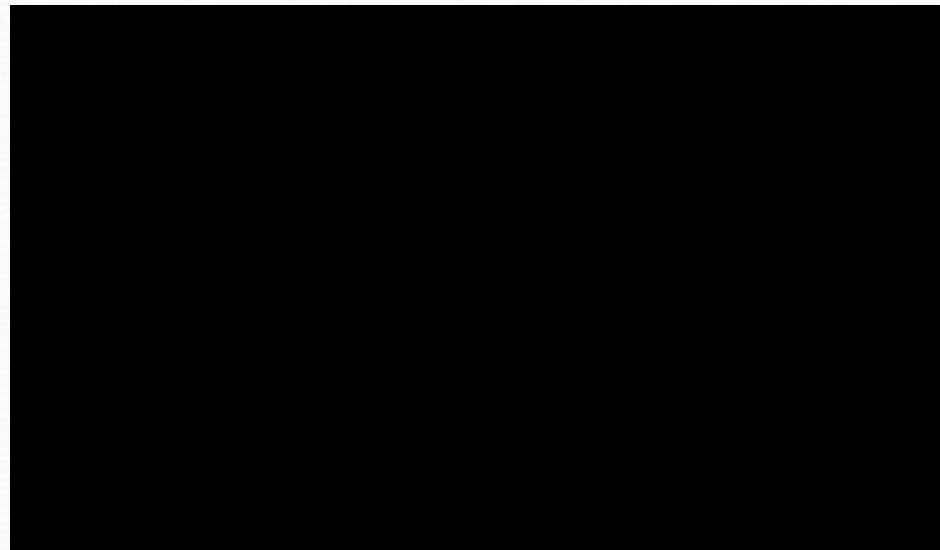
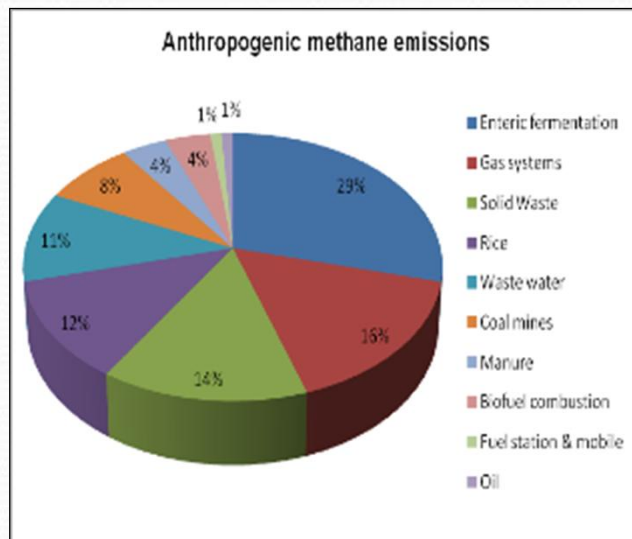


Coal Utilization: A Concern for Environment

- In spite of reliability of availability, favorable economics in energy generation, use of coal has adverse affect on environment.
- Efforts are also being made for making usage of coal environment friendly in pre, concurrent, post mining operations and its usage.
- The focus on environment protection, mine safety concern, raising energy demand gave impetus to development of Coal Based Clean Energy Resources like CBM, CMM, UCG, along with Shale gas.
- India is taking several pro-active steps to expedite development of these resources.

Coal Utilization: A Concern for Environment

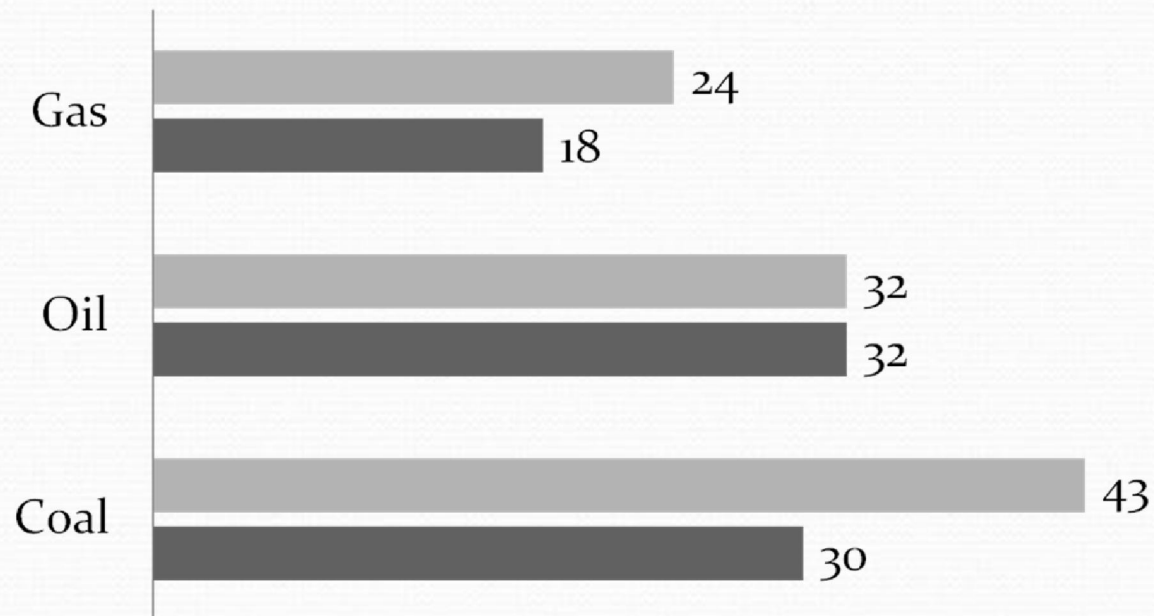
- Coal sector contributes to about 8% of the total anthropogenic methane emissions (USEPA estimate).
- Coal combustion results in greater CO₂ emissions than Oil and Natural Gas per unit of heat output.
- To curb these Green house emissions, India and other coal producing countries are making efforts to making its utilization environment friendly.



Coal Utilization: A Concern for Environment ...

Anthropogenic CO₂ Emission

■ CO₂ Emission % ■ Energy Share %

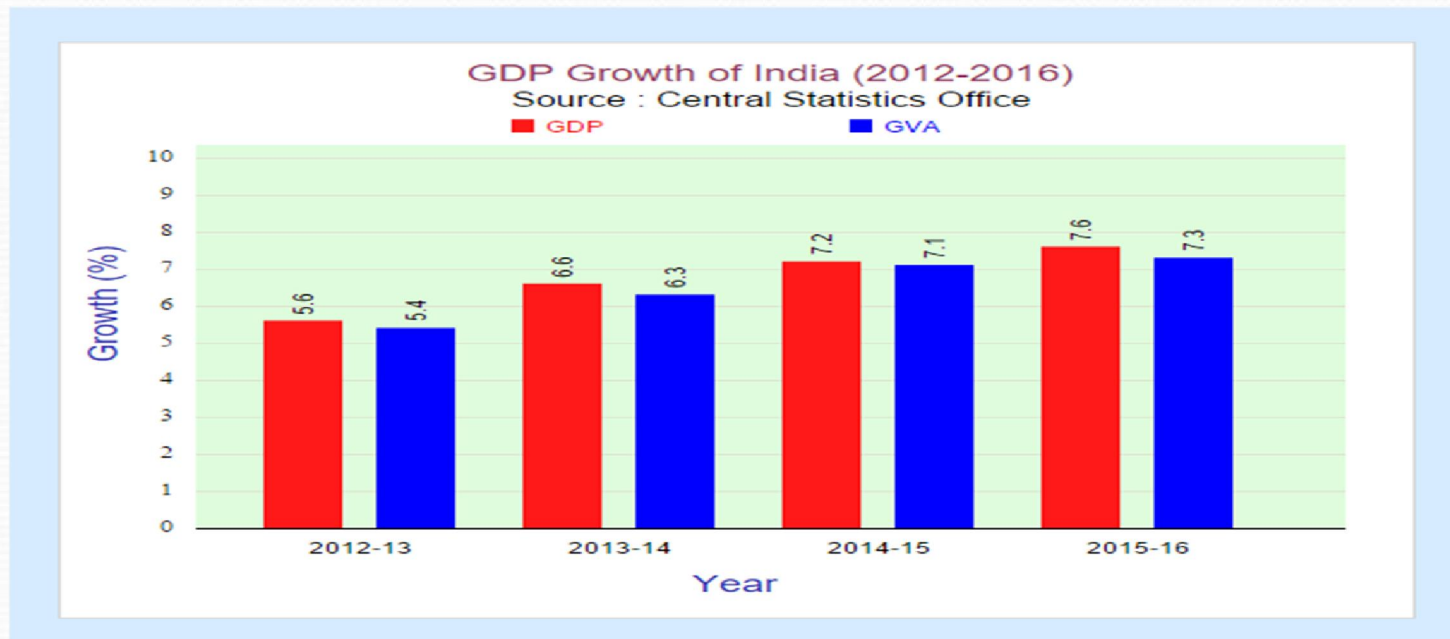


India's Energy Senario

- There are four key objectives of India's energy policy: **Access at affordable prices, Improved security and Independence, Greater Sustainability and Economic Growth.**
- In relation to its population, India is poorly endowed with energy resources.
- Its share in the world population is 17% but the shares in the world gas, oil and coal reserves are only 0.6%, 0.4% and 7%, respectively.
- This has meant heavy dependence on imports even at a rather low level of energy consumption, putting strain on economy.
- Further, the Govt programs like **100 Smart Cities, Housing for All by 2022, Power for All by 2022** will increase the energy demand many fold.

India's Energy Senario...

- The GDP growth of India is hovering over 7.5 %, destined to increase in coming years.
- India is facing challenge in meeting its ever-increasing energy demand for sustainable growth

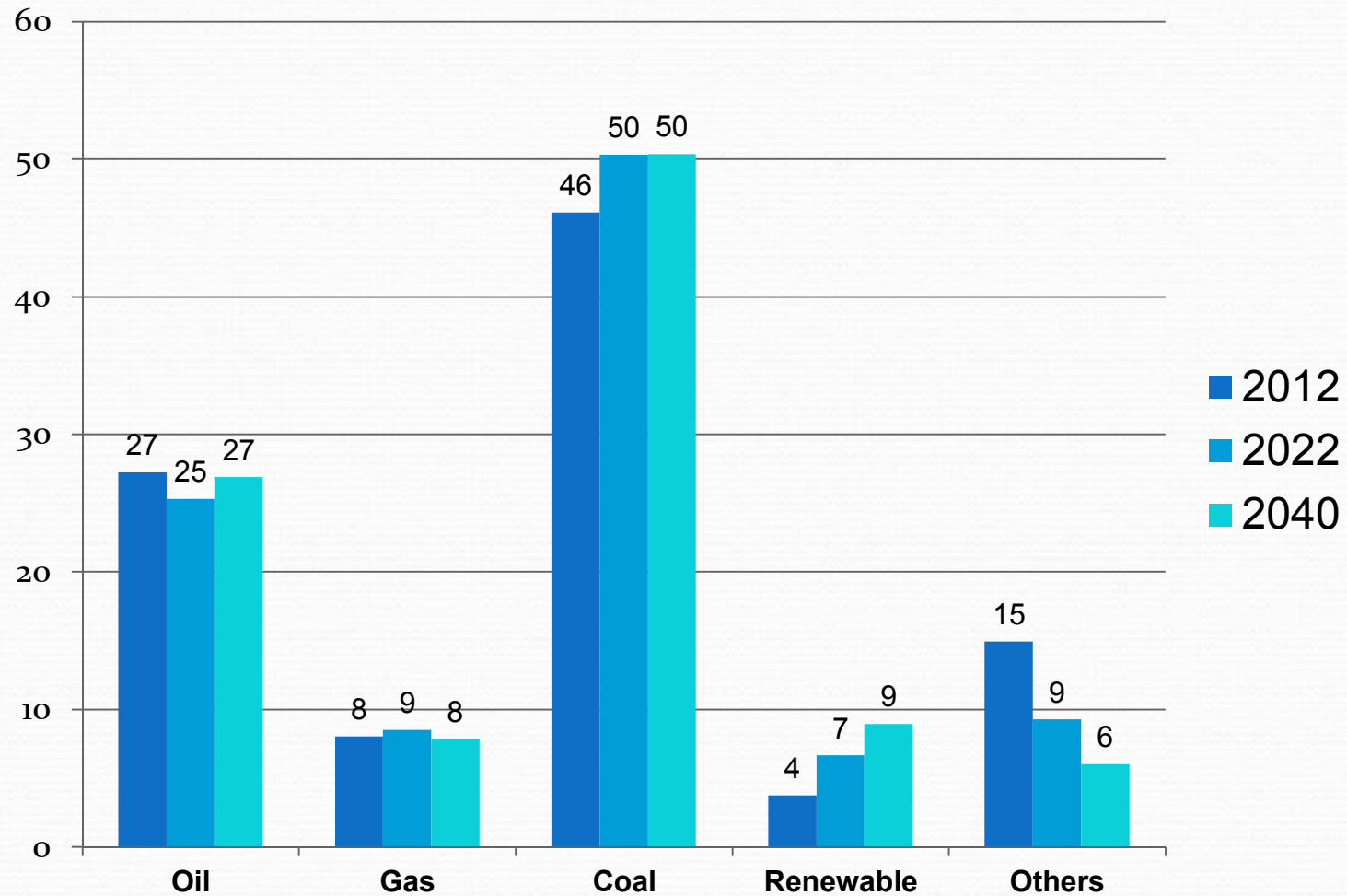


India's Energy Senario

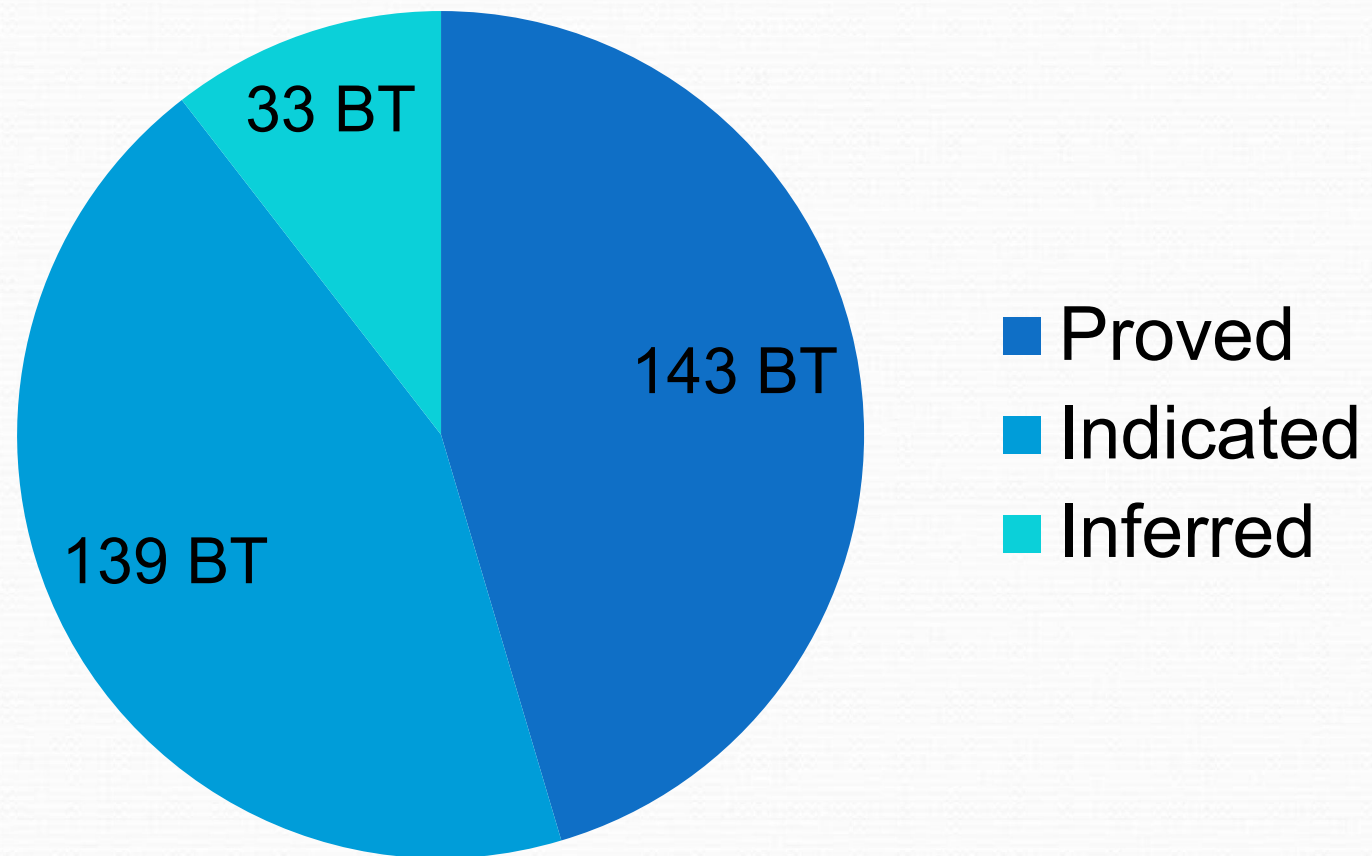
- Coal is the main source of energy supply and meets about 55% (Internationally 29%) of energy requirement.
- With substantial reserve coal is likely to dominate in the foreseeable future.
- Augmenting production from conventional resources and to initiate/expedite development of other non-conventional/renewable energy resources is therefore important.
- **The role of renewable energy in supply scenario is getting prominent and it is targeted to generate 175 GW of renewable energy by 2022 etc. from its present level of 57 GW to achieve synergy.**

Primary Energy Supply Scenario (%)

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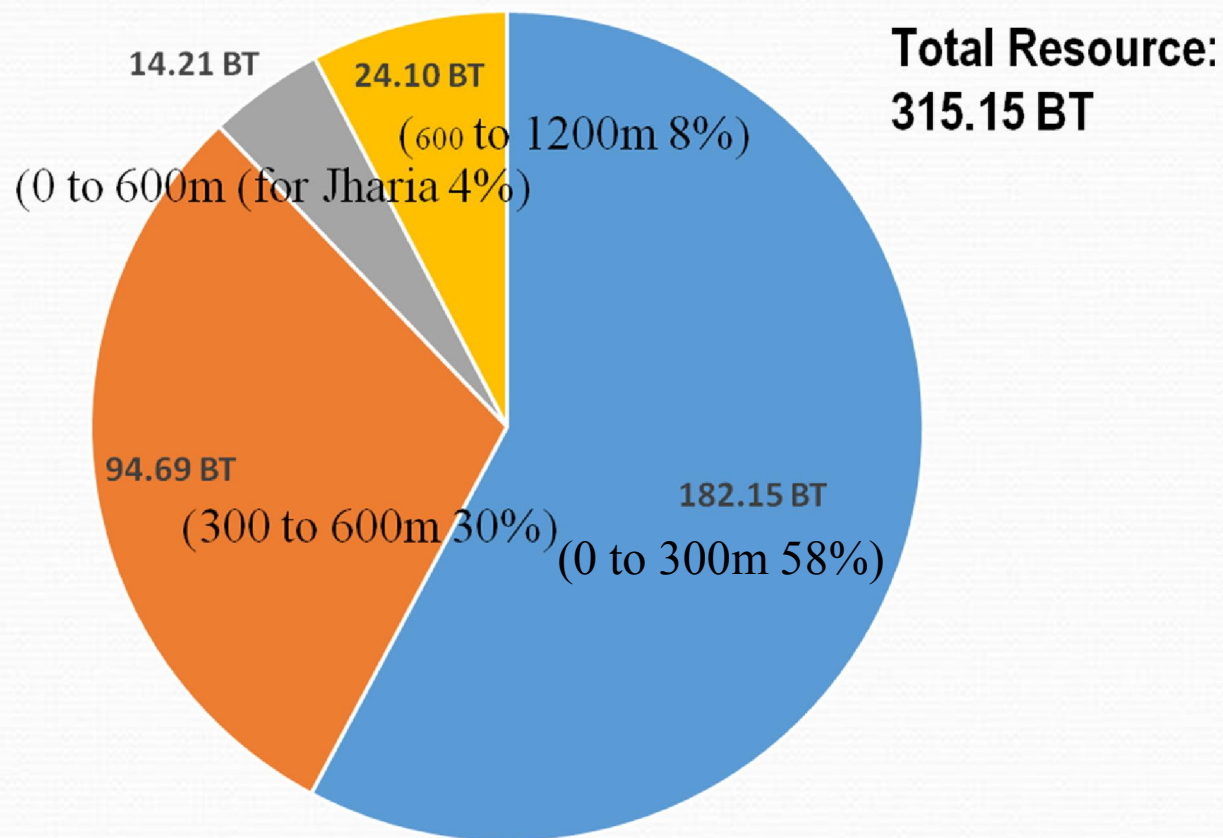


Indian Coal Reserves 315 Billion Tonnes (BT) as on April 2017



Depth-wise Resources of Coal in India

(as on 01.04.2017)



Clean Coal Technology:

Making usage of coal environment friendly

- According to UN IPCC (Inter-governmental Panel on Climate Change), the burning of coal is a major contributor to global warming.
- Clean Coal Technology (CCT) is a collection of technologies developed to mitigate the environmental impact of coal energy generation is implemented in three phases:
 - **Pre/concurrent to mining: Development of Coal based non-conventional resources like CBM, CMM, UCG etc**
 - **Pre-combustion: Coal washing**
 - **Combustion: Modernization in combustion technology**
 - **Post-combustion: capture of CO₂ and its utilisation**

**COAL BASED NON
CONVENTIONAL RESOURCES:
CBM, CMM, VAM**

Why Coal-based Non-conventional resources ?

Non Conventional Coal Based Energy Resources viz CBM, CMM, VAM, UCG etc are:





COALBED METHANE

Coalbed Methane (CBM)

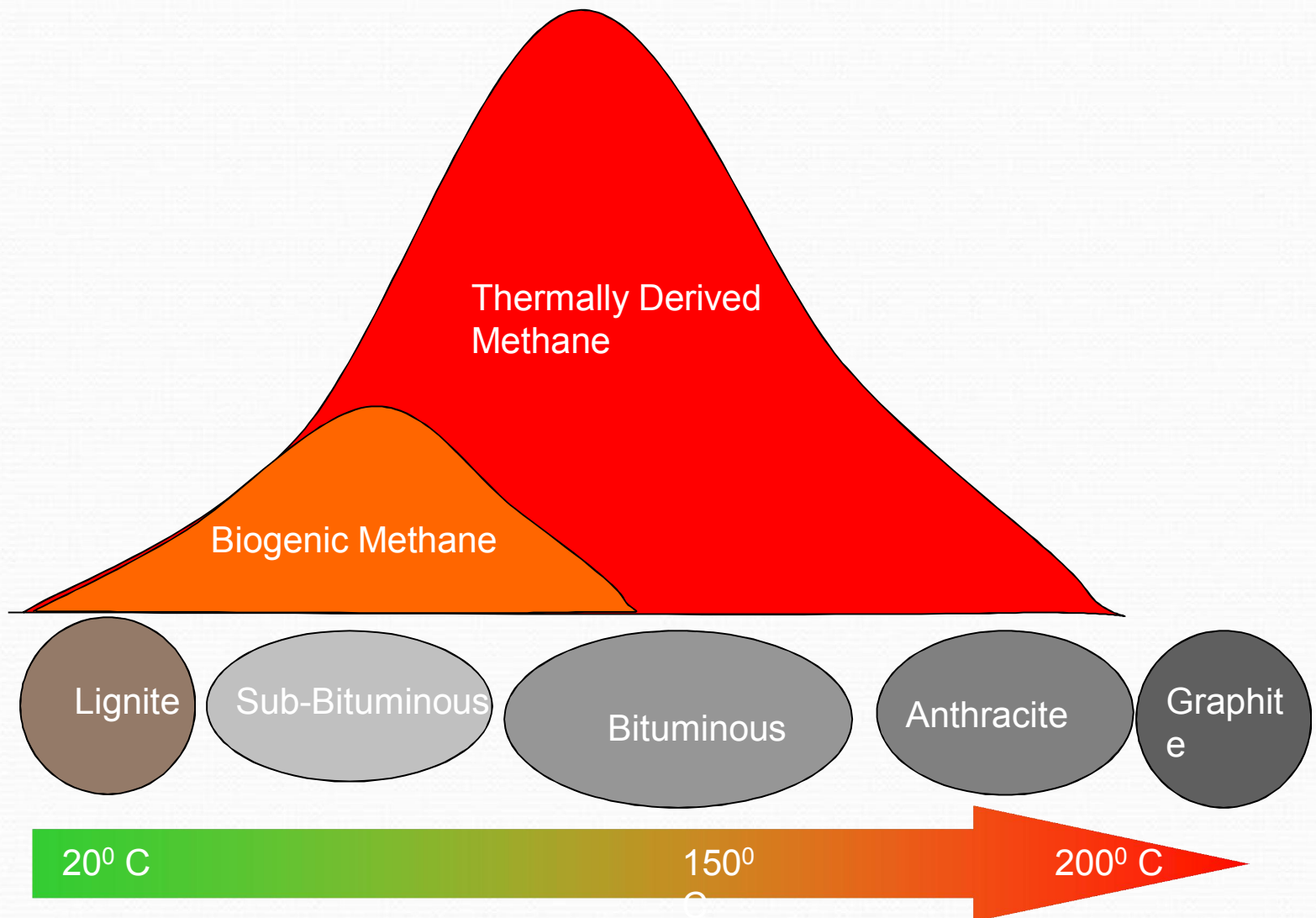
- Methane is a potent greenhouse gas with GWP of 25.
- Methane and other gases, like, CO₂, Co, N etc are generated during the process of coal formation, part of which remains stored in the coal beds and associated porous strata.
- Since methane constitutes generally over 90% of the gases generated and trapped; the coal seam gas is popularly called (CBM).
- Traditionally considered as a mining hazard.
- Become explosive if concentration of methane in the mine environment ranges between 4 to 14%.
- With the advancement in harnessing and utilisation technology CBM is a potential source of clean energy from otherwise wasted resource.

Coalbed Methane: genesis

Two distinct processes control the generation of methane and other gases in coal:

- **Biogenic**
- **Thermogenic**

Coalbed Methane: genesis.....



Factors Influencing Storage Capacity Of Methane

➤ ***Internal Surface area of Coal***

Coal has very large micro porous surface area, as large as 150-350 m²/g, hydrocarbon gases are adsorbed in monolayer on the microspore surfaces.

➤ ***Rank of coal***

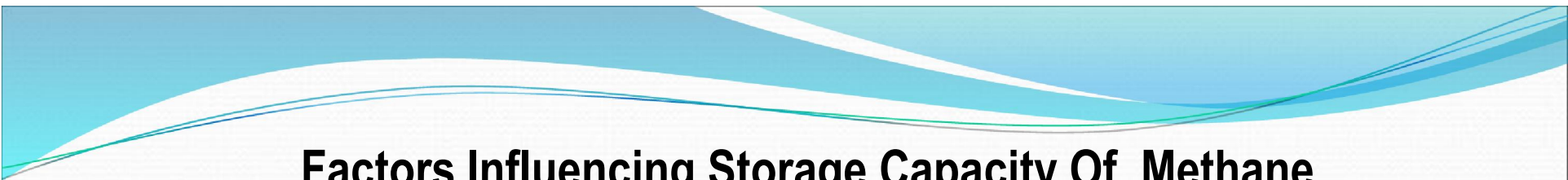
Capacity increases gradually from high-volatile Bituminous B to low-volatile Bituminous rank, but declines sharply with further increase in rank to Anthracite

➤ ***Maceral Composition***

The different maceral constituents of coal have different gas adsorption capacities.

- Vitrinite-rich coals have highest methane sorption capacity (204 m²/g),
- Inertinite-rich coals have lowest sorption capacity(36 m²/g).

➤ ***Most of the Indian coals are inertinite rich, which may be one of the reasons for being less gassy, compared to vitrinite rich coals of China, America and Australia***



Factors Influencing Storage Capacity Of Methane

➤ ***Moisture content***

Low-rank coal has a tendency to hold water in many of the sorption sites. Thus, as moisture decreases with increasing coal rank, methane sorption capacity also increases..

➤ ***Mineral Matter***

The inorganic constituents present in coal, known as “mineral matter”, have no adsorptive capacity to hold gas.

➤ ***Reservoir Temperature & Pressure***

- Increasing pressure results in increased storage capacity, whereas increased temperature results in decreased storage capacity.
- At higher ranks (medium-volatile bituminous rank and higher), coals may have generated more methane than they can store.

Parametric Evaluation of A CBM Prospect

➤ Gas Content

- High gas content of coal (Direct measurement)
- Adsorptive capacity of coal
- Lesser degree of under saturation

➤ Permeability

- Most important consideration for CBM producibility
- Coal is a low permeability reservoir, coal matrix having negligible permeability
- Natural Fracture system called cleats are pathways for migration of fluids from coal beds to well head.

➤ Hydrology

- Hydrodynamics strongly affects CBM producibility
- Basin ward migration of ground water is controlled by tectonic/ structural setting
- Coal seam gas remain in equilibrium in coalbed reservoir under hydrostatic pressure



Planning for CBM Production

CBM production is carried out in following phases

- **Exploration Phase (2-3 years)**
- **Pilot Phase (3 years)**
- **Development Phase (5 years)**
- **Commercial production (20-25 years)**

Planning for CBM Production....

Exploration Phase (2-3 years)

Drilling of Slimholes

- *Lay, disposition, depth, and distribution of coal seams*
- *Direct measurement of gas content of coal seams*
- *Construction of Adsorption Isotherms*
- *Qualitative and petrographic studies*
- *Petro-physical studies*
- *Micro-cleat studies*
- *Permeability of coal seams*
- *Structural set up*
- *Gas-in-place resource assessment.*

Planning for CBM Production

Pilot Phase (3 years)

- Pilot wells are drilled for assessment of producibility and recoverable reserves by simulating data generated during exploration phase using software.
- Fairways are located.
- Drilling and well completion technology established
- Market survey for sale of CBM carried out.
- Submission of Development Plan for Govt. approval

Development Phase (5 years)

- Based on Pilot assessment, wells are planned for exploitation and recovery of CBM from the target seams for the entire property.
- Establishing surface installations, pipelines, gas gathering stations etc.

Commercial production (20-25 years)

- Planned development of Wells in phased manner for recovery of CBM in desired quantity.

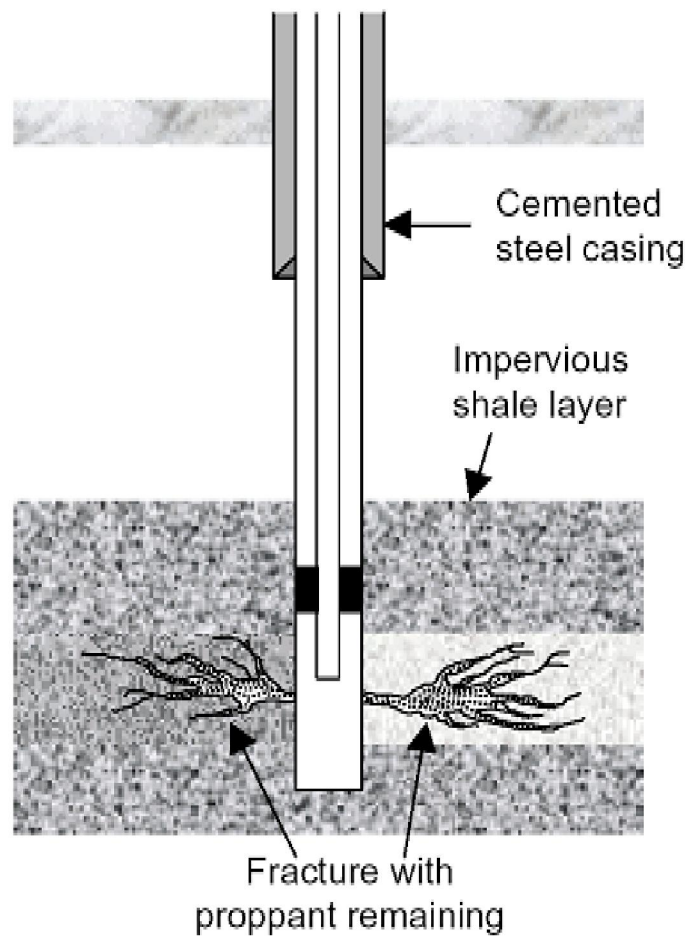
Drilling of wells



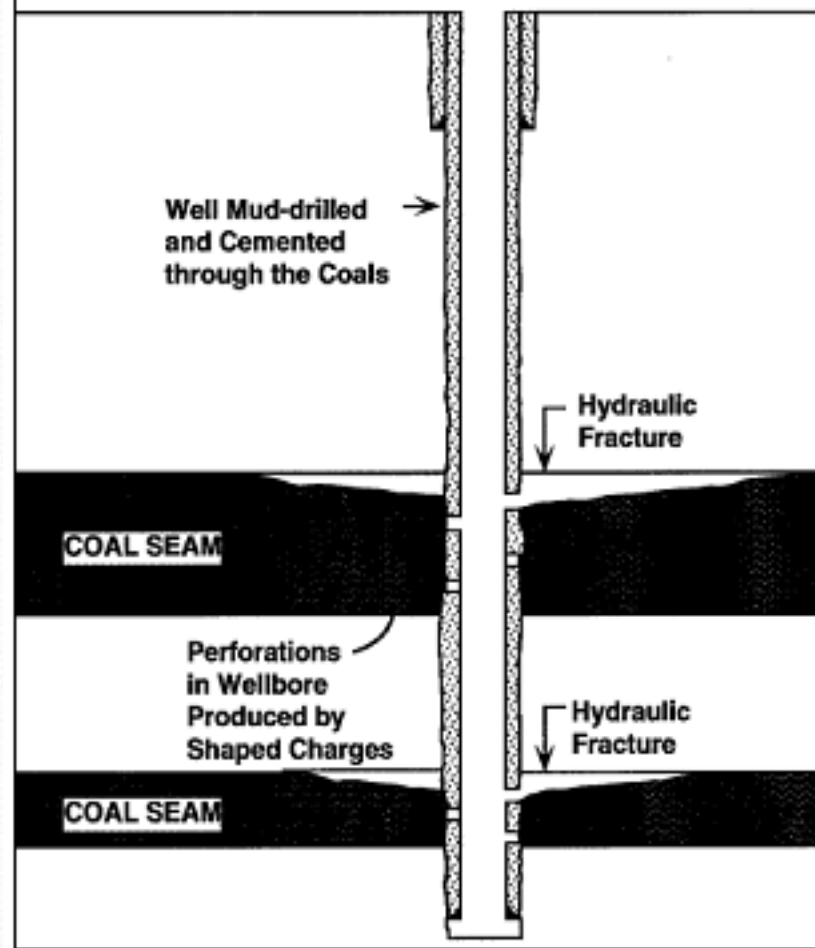
Drilling Rig in operation at Moonidih

Cementation & Hydro fracturing

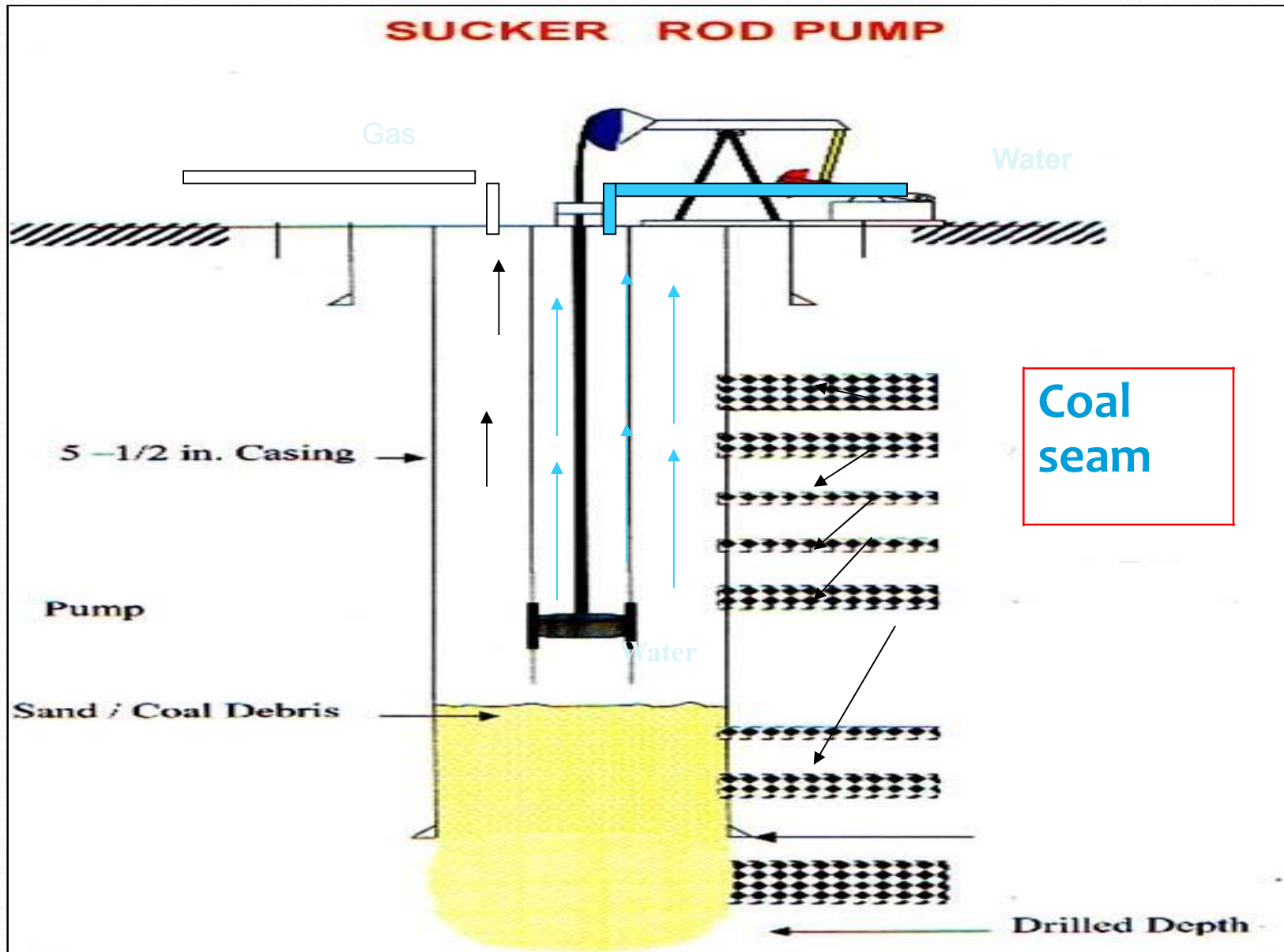
Hydraulically Fractured Well



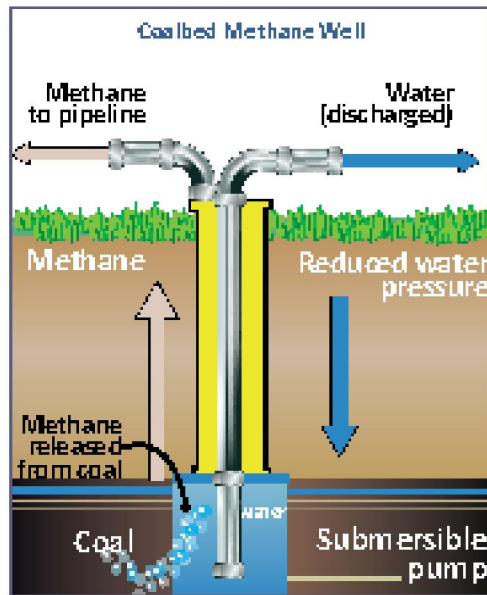
Hydraulic Fracture Completion



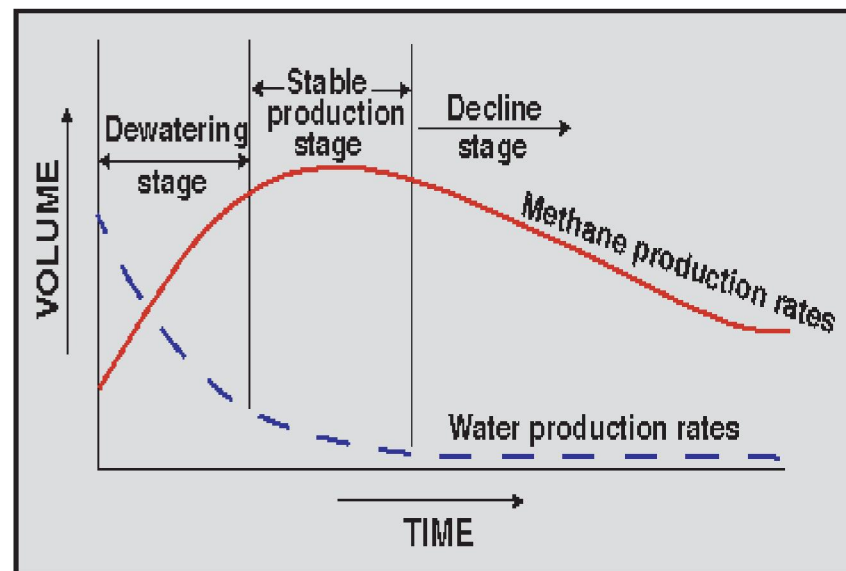
Schematic diagram of Recovery of CBM



Coalbed Methane (CBM) Production



Typical CBM Well



CBM Production Profile

CBM Development: International Scenario

- The United States is the world's leading producer of CBM where it is meeting over 8% of the Natural Gas requirement.
- Global CBM production totals around 162 MMSMD from USA, Canada, Australia, China, and India with USA dominating with nearly 140 MMSMD of production.
- In Australia also CBM made up about 10% of country's gas production (As on 2013). Likely to provide up to 50 % of the Australian east coast natural gas supply by 2020 (source: USEPA).
- CBM production in China is 4.2 MMSCMD, whereas in India it is about 1.77 MMSMD which is likely to increase soon.

CBM Development: India's Perspective

- CBM related studies in India started during early 90s by CMPDI
- Consequent to announcement of CBM Policy in 1997,
- 33 CBM blocks (area 6613 sq km, resource 1.7 TCM) have been allotted through 4 rounds of global bidding.
- The data dossiers on most of the blocks were prepared by CMPDI which facilitated award of blocks. The dossiers were highly appreciated.
- Lot of activities has been carried out and several exploratory and pilot wells have been drilled in many allotted blocks.

CBM Development: India's Perspective ...

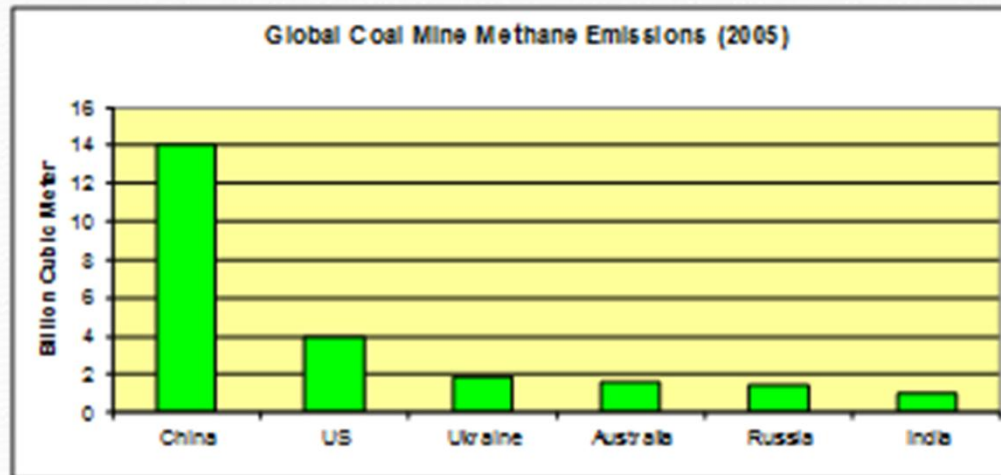
- Consequent to taking up exploratory/pilot studies in the blocks, so far 280.34 BCM has been established as Gas in Place reserve of CBM
- Going by the official estimate CBM is likely to contribute to five per cent of national gas production very soon
- An amount of Rs 10000 crores has been collectively invested by the operators in allotted CBM blocks.
- The current CBM production grew more than 44 percent in 2016-17 to around 565 million standard cubic metres (MMSCM) (1.7 MMSCMD) as compared to 393 MMSCM in 2015-2016 (1.1 MMSCMD).
- This comes as a major boost for the government's efforts to cut down India's import dependence for energy supply. The total CBM production is expected to be around 4 MMSCMD soon.



COAL MINE METHANE

Coal Mine Methane (CMM)

- CMM is a harnessing of methane from areas where coal mining is either going on or projectised.



- Over 1 BCM of methane is annually released from coal mining operations in India (Source:USEPA).
- As the country is increasing its coal production year after year, methane emission will be much higher in coming years.
- Harnessing and gainful utilisation of this otherwise wasted resource is a priority area.

Coal Mine Methane (CMM)

- Harnessing methane ahead of mining (CMM):
 - Ensures future mining safe for gassy mines,
 - Prevents release of methane to the atmosphere
 - Provides additional energy from the otherwise wasted resource.

Coal Mine Methane: International Scenario

- CMM development is encouraged in all the coal producing countries and is getting Govt support.
- Majority of projects making use of captured methane is in China, USA, Poland, Ukraine, Czech Republic, Germany (AMM) and the United Kingdom (AMM).
- USA encouraged tax policies for development of unconventional source of natural gas including CBM and CMM.
- Ukraine implemented Green Tariff Law that provides a feed-in tariff for CMM up to 20 years.
- Ukraine also adopted CMM law to legally clarify CMM and also issued CMM lease with coal lease to mine operators.

Development of CMM: CMPDI's Endeavor



CBM Rig unit in operation



Hydro-fracturing unit at CBM Well

Development of CMM: CMPDI's Endeavor



S R Pump at Moonidih



CMM Based Generator

CIL/CMPDI initiative for Development of CBM/CMM

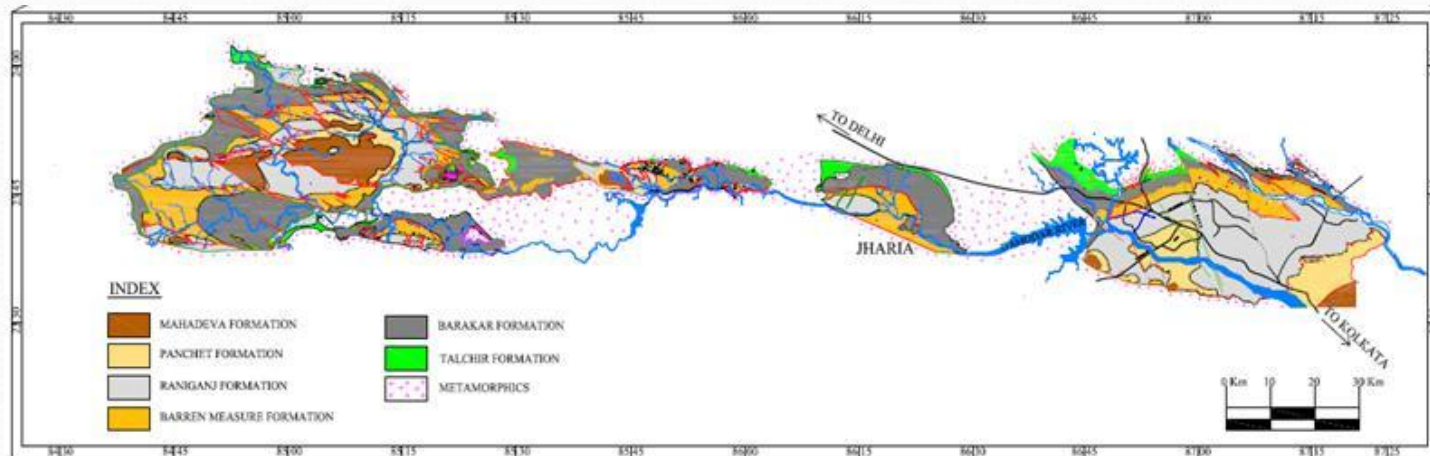
- Attempts were made to degasify a gassy mine Amlabad Mine of Jharia Coalfield in early 70's.
- Successful implementation of CMM Demonstration Project under a UNDP/GEF/MoC funding at Moonidih mine, BCCL proving efficacy of CMM development in Indian geo-mining condition.
- Generating CBM specific data for enhancing the resource base, created state of art lab for taking related studies.
- Pursuing commercial development of CBM in two CBM blocks located in Jharia and Raniganj with ONGC.
- Initiated actions for commercial development of CMM in 5 blocks within CIL areas and pursuing for getting competent approval.
- Also assessed potentiality of CMM in projectised areas of OC mining areas for pre-drainage.

Development of CBM/CMM: Recent Initiatives

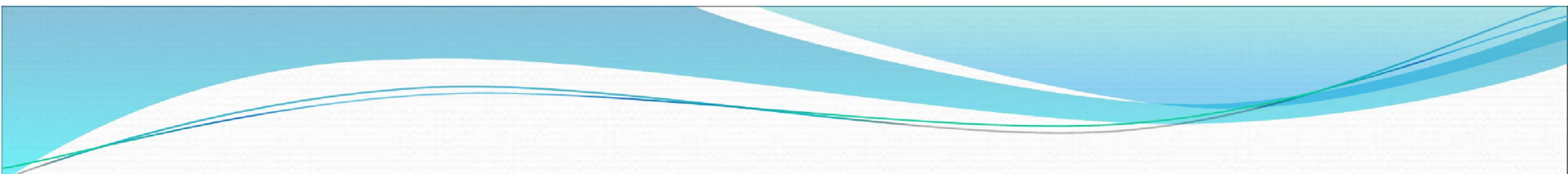
Govt. of India Initiatives for Development of CBM/CMM in CIL Leasehold

- MoPNG issued a notification on 3rd Nov'15 specifying modalities for CBM operations by CIL
- However, some clarifications on the notification related to grant of PML, time schedule for submission of FDP, operational mechanism etc. sought from MoPNG and the same is awaited

Development of CBM/CMM: Recent Initiatives by CIL/CMPDI



- Primaface, Damodar Valley Coal field appears promising for CMM development
- Potential blocks within Raniganj CF, ECL & Jharia CF, BCCL identified
- Action plan has been chalked out for commercial exploitation of CMM
- Process for selection of suitable Service Provider for Pre-drainage of methane in Moonidih Mine of BCCL for mine safety and enhancement of coal production has been initiated. The methane produced will be utilized for power generation
- Action is also being taken for extraction of methane from virgin coal seams lying within the leasehold of CIL Mines



Challenges to be Overcome CBM/CMM Development

- Commercial production of CBM/CMM in India will be challenging on account of the following-
 - Administrative Challenges
 - Technical Challenges
 - Safety and Environment issues

Challenges in CMM Development

- Coal Mining in India is >100 years old;
- High vertical density of seams (cumulative coal thickness >100m);
- Fire/Water logged areas;
- Concurrent Coal mining & CMM operations to be carried out;
- Target seams for CMM development:
 - Virgin Coal Seams lying below the active mining/worked out/goaved/abandoned areas;
- The CMM extraction from such areas are technically challenging and poses safety concern;
- Assessment for CBM Gas-in-Place and Reservoir Modeling under de-stressed condition;

Ventilation Air Methane (VAM)

- The return air of ventilation shafts contain methane, typically less than 1 %.
- Substantial amount of methane is vented into the atmosphere due to mining operations.
- VAM constitutes about 50% of the total CMM emissions.
- Recovery and gainful utilisation of such low concentration methane from VAM is a technological challenge.
- Few VAM projects have been successfully commissioned in Australia, China and the USA.

Development of VAM: Indian Scenario

- Gassy U/G mines are target for VAM project development
- CMPDI has recently generated VAM specific data in several D-III mines of ECL, BCCL and CCL.
- Few mines have been prima-facie found to be potential for VAM project, subject to feasibility study.
- VAM project under NCEF contemplated by CMPDI and a project under formulation with CSIRO, Australia at Moonidih mine, BCCL.
- The proposed project will aim for mitigation/utilization of VAM
- This will be the pioneer effort to bring VAM technology in India



GASIFICATION OF COAL: SURFACE AND UNDERGROUND

Gasification of Coal

- India is endowed with vast coal reserves (about 7% of World's Proved Reserves) which is boosting country's economy and coal gasification is considered an important strategy for low carbon energy development.
- Coal may be gasified underground (UCG) or on Surface (Surface Gasification)
- Gasification of coal produces Syngas which is a mixture of Hydrogen, Carbon monoxide, Methane, Carbon Dioxide and other unsaturated Hydro-Carbons etc
- Technology is available for converting Syngas in to *Ammonia, Fertilizers, Substitute Natural Gas (SNG)* and many other Chemicals e.g. *Methanol, Olefins for petrochemicals, Acetic acid* etc. in addition to conventional use as an *energy source* either for electricity or heat at present.



SURFACE GASIFICATION OF COAL

Surface Gasification Of Coal

- Ministry of Coal through has shown keen interest for surface gasification of Coal for production of Methanol and Fertilizers.
- NITI Aayog has shown interest for development of a coal gasification Demonstration Plant in Jharkhand for production of 100 T/day of Methanol
- After success of Demonstration Plant, it will be converted to Commercial production
- Site selection is yet to be finalized

Surface Gasification of Coal

- *The Dankuni Coal Complex of CIL* for Surface Coal gasification is being revived
- EOI has been floated by CIL for commercial production of Methanol from Raniganj coal. Draft Feasibility Report has been prepared by PDIL
- *Talcher Fertilizer Ltd* , a Joint Venture Company of Coal India, GAIL, RCF and FCI has been allotted a coal block in Talcher Coalfield, Odisha for production of Urea from coal gasification with a capacity of 3850 T/Day
- Recently Ministry of Coal has identified *10 regionally explored blocks* for the purpose of surface gasification/coal based fertilizers/coal to methanol /coal to liquids/ coal to poly-chemicals, etc.



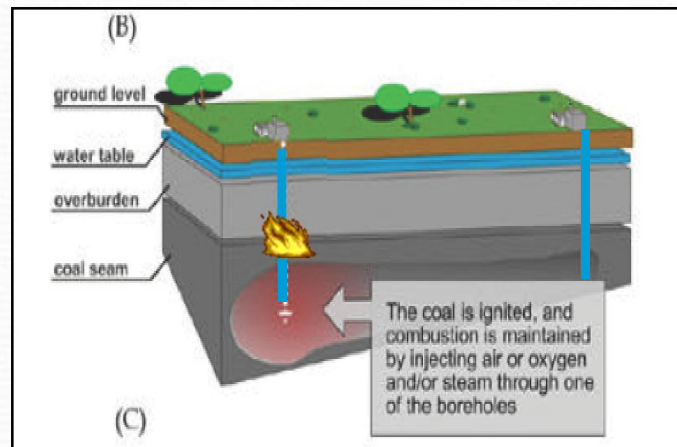
UNDERGROUND GASIFICATION OF COAL

Underground Coal Gasification: Definition

- The UCG is a physico-chemical process of conversion of coal into gaseous energy source *in-situ*, commonly known as synthesis gas or syngas.
- Technology is based on management of underground gasifier without making mines
- The product gas is mixture of hydrogen, carbon monoxide, methane, carbon dioxide & higher hydrocarbons, which can be used to create many products, viz. *electric power, chemical feedstock, liquid fuels, hydrogen, synthetic gas etc.*
- Calorific value in the range of 850 to 1200K.Cal/NM³ for air injection, which may be increased to 2500-3000K.Cal/NM³ with oxygen injection

UCG Process

- Drilling of two adjacent boreholes into coal seams –one serving as injection well while the other as production well
- Coal is ignited, combustion is maintained by injecting air/oxygen & steam
- Formation of linkage between the boreholes, Down hole ignition of coal seams
- Coal seam gasification by injecting gasifying agents, and
- carrying the resulting gas outside via the production well



UCG Development: Recent Initiatives

- *The Govt approved a policy framework for development of UCG in coal and lignite bearing areas, in December 2015,*
- Policy is broadly similar to the existing policy for CBM development : blocks to be offered through competitive bidding on revenue sharing basis
- A duly constituted Committee will be responsible for identification of the areas, deciding about blocks to be put up to bidding or awarding them to PSUs on nomination basis
- IMC has identified few blocks for offering to PSU.
- CMPDI has been made nodal agency by MoC for development of bid documents, work programme, conducting bidding process etc.
- Very soon few coal / lignite blocks will be awarded for UCG



Renewable energy in India



Renewable energy in India: Priority Area

- India was the first country in the world to set up a ministry of non-conventional energy resources, in the early 1980s.
- India's overall installed capacity has reached 329.4 GW, with renewable accounting for 57.5 GW as of 14 June 2017.
- 61% of the renewable power came from wind, while solar contributed nearly 19%.
- Large hydro installed capacity was 44.41 GW as of February 2017 and is administered separately by the Ministry of Power.
- From 2015 onwards the Govt began laying down actionable plans for the renewable energy sector under its ambit to make a quantum jump, building on strong foundations already established in the country.



Renewable energy in India: Priority Area

➤ **MNRE renewable electricity targets have been up-scaled to grow to 175 GW by the year 2022, including:**

- **100 GW from solar power,**
- **60 GW from wind power,**
- **10 GW from bio power and**
- **5 GW from small hydro power**

➤ **The ambitious targets would see India quickly becoming one of the leading green energy producers in the world and surpassing numerous developed countries.**

➤ **The government intends to achieve 40% cumulative electric power capacity from non fossil fuel sources by 2030.**

Renewable energy in India: Priority Area

- With the encouragement and liberal policies of the Govt, the development of solar energy is continuing at a great pace.
- Further. efficient use of materials, improved manufacturing process, improvement in cell efficiency, decrease in prices of solar inverters and other ancillary parts in the electrical system is facilitating its development.
- Deutsche Bank, in its recent market research report has estimated that levelized cost of solar in India is expected to reach USD 0.04 per kWh by 2022 from current USD 0.06 per kWh.
- Even after assuming a slower decrease in the prices thereafter, the prices are still expected to reach around Rs 1.9-2.0 per kWh by 2025 which is comparable to coal based generation cost then.

Renewable energy in India: Priority Area

- Another key determinant of the inflexion point will be emergence of storage solutions.
- Battery storage cost has reduced substantially from over USD 1000 per kWh to around USD 250 kWh over last few years and is expected to go down further.

CONCLUSION

- Coal will remain an important source of energy supply internationally.
- In India it will continue to remain major source of energy supply in foreseeable future in any energy mix scenario
- Coal utilization particularly for power generation has environmental issues and to overcome this, clean coal technology is being pursued with right earnest.
- This will facilitate significant decrease in methane and environment unfriendly gas emission and make environment clean
- Development of coal based clean energy resources like CBM/CMM/Gasification will enhance clean energy supply
- In addition, there will be major role of renewable energy resources in augmenting the clean energy supply which is also a priority area of the Govt.



Thank You
T H A N K Y O U