Adverse Effect of Methane Gas on Environment and Its utilization for Economic Growth

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ABSTRACT:

Coal is a major source of energy. It has stimulated India's industrialization and is being used to produce thermal electricity (around 70%) and in the manufacturing industries like textile, steel, chemicals, fertilizers, etc. The increased trend of coal production conjoined with venting of methane into the atmosphere is causing a serious concern about the environmental pollution, in as much, the methane has a global warming potential, 21 times greater than carbon dioxide on a molecule by molecule basis and 58 time by mass.*Indian coal seams has a vast Coal Bed Methane (CBM) potential in various coalfields.Methane is a potent green house gas emissions released into atmosphere by mining activities. Thus creating a hazardous situation for fragile atmosphere and 0zone layer.Methane is associated with coal as a by product in the coal formation process. It is trapped in coal beds and released during and after mining. This methane does cause disasters in underground coal nines. To reduce its hazards of emission and explosion, mines are ventilated with large quantities of air to reduce its percentage in mine air to a safe limit This diluted methane is released into the atmosphere and contributes to global climate change. Technologies are now available to recover the trapped methane from coal beds and thus provide an additional clean source of energy while reducing both escape of methane to the atmosphere and the mining hazard.*

KEY WORDS: Coal Mining, Green House Gas, Emission, Pollution, Explosion

INTRODUCTION:

Coal bed methane is a natural gas by-product of coal formation. During coal formation, organic matter is chemically broken down into simple organic compounds. Methane is a by-product of this break down. Coal is very porous but lacks matrix permeability. In other words, water can seep into coal but can't flow through it. Naturally occurring fractures in coal allow ground water to permeate the coal and provide the means through which the methane is stored in the coal bed. Due to coal's porous nature, methane gas produced during coal formation is absorbed into the coal bed and held in place by the weight of the surrounding groundwater Coal Bed Methane (CBM), a hydrocarbon (CH_4) in gaseous form has its origin

in the calcification process occurring over a period of millions of year out of accumulated plant material. Most of the CBM gas is in adsorbed state on the micro pores of the coal surface, thus coal is both the source and storehouse rock for CBM. A saturated CBM reservoir could contain up to five times the amount of gas contained in a conventional gas reservoir of comparative size, temperature and pressure. The quantity of methane present in coal seams increases with grade of coal and depth of coal seams(1).
Methane is a simple alkaline compound, which is an important part of natural gas. Its chemical formula is CH_4 and it is a colorless and odorless gas. Methane burned in the presence of oxygen produces water and carbon dioxide.
Methane is a gas that remains in the atmosphere for up to 15 years. This greenhouse gas is produced by many natural and human-influenced sources. Landfills, coal mines and wastewater treatment, natural gas and petroleum facilities are only a few of the sources that emit this gas. It is more than 20 times more effective than carbon dioxide at trapping heat in the atmosphere. It is, however, an important energy source.

Coal Bed Methane (CBM) and Coal Mine Methane (CMM):

CBM refers to methane that is found in coal seams. It is formed during the process of coalification, the transformation of plant material into coal. CBM is also known as virgin coal seam methane or coal seam gas. It is widely considered an "unconventional" source of natural gas.

Coal mine methane (CMM) represents wasted emissions to the atmosphere, while capture and use of CMM has benefits for the local and global environment. Specific CMM end-uses depend on the gas quality, especially the concentration of methane and the presence of other contaminants.
Abandoned mine methane (AMM):. Closed mines produce emissions of low- to medium-quality gas from diffuse vents, ventilation pipes, boreholes, or fissures in the ground.

EFFECT OF METHANE:

METHANE AS A GREEN HOUSE GAS: Green house gases when emitted to the troposphere allow sun-rays to penetrate to the earth but, due to specific properties of the gases, do not permit all of the heat to reradiate back to the atmosphere resulting in an increase in temperature of the earth surface. Methane's contribution in global warming is 18% after CO2 (66%) and followed by CFC (11%) and N2O5 (5%) (Prasad and Rai, 2000). Thus, Methane is a potent green house gas second only to carbon dioxide as regards to its concentration by volume in the atmosphere (2).
U.S. coal mines emitted nearly four billion cubic meters or 61 million metric tons of carbon dioxide equivalent ($MMTC0_2E$) in 2015. Between 1990 and 2015, U.S. emissions decreased by 40 percent, in large part due to the coal mining industry's increased recovery and utilization of drained gas and decrease in ventilation air methane emissions.
By 2020, global methane emissions from coal mines are estimated to reach nearly 800 $MMTCO_2E$, accounting for 9 percent of total global methane emissions. China leads the

world in estimated coal mine methane (CMM) emissions with more than 420 $MMTCO_2E$ in 2020 (more than 27 billion cubic meter. Other leading global emitters are the United States, Russia, Australia, Ukraine, Kazakhstan, and India.
At present global concentration of Methane is increasing by about 1% per annum Methane significantly contributing to global warming.

Association of methane with coal seam is a serious safety concern since the inception of mining,Methane (CH_4) is the second most important greenhouse gas (GHG) after carbon dioxide (CO_2). In fact, methane is more than 25 times more potent than CO_2 on a mass basis over a 100-year time period. Coal mine methane (CMM) represents wasted emissions to the atmosphere, while capture and use of CMM has benefits for the local and global environment.

Explosion:

Methane is extremely flammable and will easily cause explosions. It can leak unnoticed into structures and spaces, and a tiny spark can ignite the undetected gas. Explosions from methane gas are extremely strong, and the damage is devastating. The explosions associated with methane gas are not limited to the space that has the highest concentration, but anywhere it has seeped. It may be in one room, or it can travel through an entire city block.
Moreover Methane is an explosive gas in concentrations of 5.4 - 14.8% in air under normal underground environmental condition with explosion severity maximising at methane concentration of 9.4% (Misra, 1989). 40% of the disaster that took place in Indian coalmines between 1908- 1995 are due to methane explosion accounting for 839 fatalities (Singh et al., 1999). The risk of disaster associated with methane is increasing with increased coal production particularly from deeper seams. To ensure safety, the concentration of methane gas is constantly monitored at working places and maintained below 1.25% at every place by increasing fresh air(3).

Many companies in the United States are trying to reduce emissions of methane through management methods and technologies.

Relation to Carbon Monoxide

Natural gas is 97 percent methane, and problems arise when there is an insufficient air supply available for ventilation. Carbon monoxide, a by-product of methane gas, is a clear, odorless, colorless, tasteless, non-irritating gas. It is, however, very deadly. Symptoms of carbon monoxide poisoning include headache, dizziness, nausea, confusion, seizures, unconsciousness, rapid heartbeat and high blood pressure. Carbon monoxide attacks the central nervous system and may cause hallucinations and heightened emotions, sometimes causing the victim to have "supernatural experiences." Many times, the milder symptoms are mistaken for other things, such as flu, depression, chronic fatigue syndrome and migraines. Many people suffer permanent heart damage after exposure to carbon monoxide, and as many as 500 people a year lose their lives to the gas.

Methane gas is not considered immediate dangerous to humans by inhalation:
Exposure to methane gas in air with low oxygen levels may cause dizziness, headaches and a feeling of fatigue with no lethal effects. (4)

Effect on Mine workers: Asphyxiation
Methane is nontoxic on its own but can become lethal when it combines with another gas. Methane causes asphyxiation by displacing oxygen. It may produce symptoms of dizziness and headache, but these often go unnoticed until the brain signals the body to gasp for air. This happens too late, and the individual collapses. Because of the lack of oxygen, the result is usually death.

The symptoms of methane gas exposure are not seen, as soon as the person comes in contact with the gas. The symptoms take certain amount of time before they are seen, as methane is less dense than air.

Headaches may be triggered by getting exposed to methane gas. This sign was also observed in the school in Texas, where a methane gas blast killed about 300 students and faculty members.

Exposure to high levels of methane gas depletes the oxygen level in the body, causing difficulty in breathing and suffocation.

If the oxygen level in the body depletes to anything less than 12%, the person can become unconscious and prove to be lethal in some cases.

Since the levels of oxygen in the body depletes, the body tries to make it up by using the oxygen contained in the bodily fluids. This basically leads to dehydration.

Nausea and vomiting are also methane gas poisoning symptoms. There are chances that a person can collapse due to exposure to methane gas. Another symptom is heart palpitations. It causes an uncomfortable sensation of the heart beating rapidly, abnormally and out of sequence .Due to the depletion of oxygen in the body, it gives rise to cognitive problems. The person is inattentive, has memory loss and poor judgment. These symptoms aggravate, when the exposure to this gas is more. Exposure to methane gas also causes dizziness and blurred vision. This symptom reduces, when the person moves away from the area that is high in methane gas concentration.

Detection:
Like smoke detectors and carbon monoxide detectors, methane detectors are available to alert when dangerous gases are present. The audible alarm is a safeguard against poisoning from the deadly gas and from explosions that can result from methane leaks.

Considerations :Methane levels can vary from one area to another. It occurs naturally through sources such as wetlands, termites, freshwater bodies, oceans, permafrost and wildfires. The majority of natural methane emissions come from wetlands, with termites being the second-largest natural source.

Environmental Effects of Coal Bed Methane:
Methane that is released into the atmosphere before it is burned is harmful to the environment. Because it is able to trap heat in the atmosphere, methane contributes to climate change. Although methane’s lifespan in the atmosphere is relatively short compared to those of other greenhouse gases, it is more efficient at trapping heat than are those other gases. And while there are natural processes in soil and chemical reactions in the atmosphere that help

remove methane from the atmosphere, it is important for all human activities that contribute methane to the atmosphere to be conducted in ways that reduce their methane emissions. This includes the development of processes to capture methane that would otherwise be released to the atmosphere and use it as a fuel.

While methane doesn't linger as long in the atmosphere as carbon dioxide, it is initially far more devastating to the climate because of how effectively it absorbs heat. In the first two decades after its release, methane is 84 times more potent than carbon dioxide.

Water Depletion:

One of the environmental effects of coal bed methane extraction is the immense quantity of water pumped out of the coal bed aquifers. On average, approximately 12-15 gallons of water per minute are pumped from each well. During the initial phase of production, water is pumped at a very high rate. The extracted water is typically discharged into local streams or reinjected into the ground. Where the coal bed groundwater is relatively pure, surface discharge is the most common method of disposal. Smaller quantities are sometime stored in large pits for evaporation but this method is inefficient to deal with massive quantities of extracted groundwater. The removal and disposal of so much groundwater raises several concerns.

One concern is that drainage of a coal bed aquifer will cause shallower aquifers to drain into the cavity created by the coal bed water extraction. This is a particular concern for local landowners relying on well water pumped from shallow aquifers, which is often the case, as aquifers used for domestic water wells tend to be shallower than coal bed aquifers. In several reported cases, local water wells have gone dry after coal bed methane operations have begun.

A similar concern exists for coal bed aquifers that are tributaries to surface waters or adjacent groundwater aquifers, i.e., coal bed aquifers that contribute to other water sources. The drainage of tributary coal bed aquifers can cause a corresponding decline in the water levels of the contributory water sources. Consequently, water depletion from coal bed methane operations can have a significant impact on residents, farmers and businesses relying on affected water supplies.

One of the promising new energy source:

Coal Bed Methane (CBM), is the gaseous hydrocarbons. Hydrocarbon sector plays a vital role in the economic growth of the country. It is, therefore, extremely necessary to have a long term policy for the hydrocarbon sector so as to enable the country to meet the future energy needs. The Hydrocarbon Vision — 2025 lays down a frame work which could guide the policies of the Hydrocarbon sector for the next 25 years (6).

The following Table 1 reveals the perspective planning of fuel options

TABLE 1: Hydrocarbons

Hydrocarbon Vision 2025. (All figures In percentages)					
Year	**Coal**	**Oil**	**Gas**	**Hydro**	**Nuclear**
1997 - 98	**55**	**31**	**07**	**02**	**01**
2001 - 02	**50**	**32**	**15**	**02**	**01**
2006- 08	**50**	**32**	**15**	**02**	**01**
2010 - 11	**53**	**30**	**14**	**02**	**01**
2024 - 25	**50**	**25**	**20**	**02**	**03**

(Source: Up to 2011 from Technical Note on Energy, Planning Commission, Go N. of India. (1998- 99.)Beyond this period the figures have been extrapolated)

From the figures above, it can be seen that share of coal in future projections is slightly coming down from the current contribution. Share of Natural Gas is going up substantially. Apparently these projections take into account import of natural gas from Iran /Bangle Desh.

Coal accounts for 97% of the Fossil energy resources in India. Resource to current Production ratio taken in mathematical terms reveals that for Oil it is 15 years; for Natural Gas 23 years and for Coal, it is 250 years. The total economically

Coal, which has large available resources, in future, 1¯nus provide higher contribution to the .commercial energy of the country. Exploitation of CBM will help the enhanced availability of natural gas.

CBM Resource In India

India is the third largest coal producer in the world and has substantial coal resources (213.9 bl.Tonnes) as identified on 1.1.2001 by Geological Survey of India of which 84.4 bl. are proved reserves) State of Jharkhand has the highest percentage of coal resources of the country - 69.2 bl. tonnes (32%). Around 95 mil.tonnes of coal Is produced in the states of Madhya Pradesh and Chattisgarh which is about 30% of the total coal production of the country. The high rank of coal and its burial depth adds to the methane retention and generation capacity of coal. In Indian context, these conditions are mostly present in Jharia, Bokaro, North Karanpuraand Sohagpur Coalfields.

The CBM resource as per. Directorate General of Hydrocarbons (DGFi), Ministry of Petroleum & Natural Gas (MoP & NG) is tabulated here under (Table2):

Table 2: Prognosticated Resource of CBM

SI.	State	Coalfield / Block	Area of delineated block(Sq. KM)	Prognosticated CBM Resource as per DGH	
				In trillion cubic feet	In billion cubic meter
1	West	a. North	232	1.030	29.17
		b. Eastern	500	1.850	52.38
		c. Birb	250	1.000	28.32
Sub Total			**982**	**3.88**	**109.87**
2.	Jharkhand	a. Jharia	69.20	2.407	68.16
		b. East & West	93.37	1.590	45.02
		c. North	340.54	2.181	61.75
Sub Total			503.11	**6.178**	**174.93**

Coal bed methane extraction is one of the nation's fastest growing alternative energy industries, currently accounting for approximately seven percent of the nation's natural gas supply. Coal bed methane extraction is a process for collecting methane reserves from coal deposits. The increasing demand for alternative energy sources and cleaner burning fossil fuels will undoubtedly continue to stimulate growth in this emerging industry. Although coal bed methane is touted as "clean" energy; the extraction of coal bed methane has significant environmental consequences on the local ecology. At particular risk are local residents, farmers and businesses relying on ground and surface water for domestic purposes (6).

Methane emitted from coal mines from three primary sources of CMM:

- Degasification systems at active underground mines. Also commonly referred to as drainage systems, these systems employ vertical and/or horizontal wells to recover methane before mining takes place to help the ventilation system keep the in-mine methane concentrations sufficiently low (well below the explosive limit) to protect miners.
- Ventilation air methane (VAM). This refers to the very dilute methane that is released from underground mine ventilation shafts. Although it is typically less than 1 percent methane, it is the single largest source of CMM emissions globally.

Other, more minor sources of methane from coal mines include surface mines and post-mining activities (coal continues to emit methane as it is stored in piles and transported).
How Is Coal Bed Methane Extracted?
In order to commercially produce coal bed methane, it is necessary to decrease the water pressure within the coal bed. When the pressure is decreased, the methane gas naturally desorbs from the coal and migrates through the coal bed.

This natural phenomenon is the basis for coal bed methane production. In extracting methane from coal beds, a well is drilled down to the coal bed and the sides of the well are then encased in concrete. A water pump is dropped down into the coal bed and the top of the well is sealed with a venting pipe to collect the methane. Large amounts of groundwater are pumped out of the coal bed, causing a corresponding decrease in water pressure. The decreased water pressure allows the methane to escape from the coal and migrate along the coal fractures and up into the well. The methane is then pumped from the well through the venting pipe where it is compressed and sold.

CBM Policy Framework

The idea of CBM as an energy source did not take shape or existed when the Acts and Regulations like Oilfields (Regulation & Development) Act, 1948; the Petroleum & Natural Gas Rules, 1959: the Coal Bearing Areas (Acquisition &Development) Act, 1957, the Mines & Minerals (Regulation & Development) Act, 1957 were framed. CBM, therefore, was not covered under any of these statutes including Acts and Rules governing Oilfields and Coal mines in India(7).

After the Economic Liberalization Policy in early 1990s, India too became aware of CBM as a eco-friendly clean source of energy. Initially, the Ministry of petroleum & Natural Gas staked its administrative jurisdiction on the plea that CBM is a hydrocarbon, and therefore a natural gas as defined in the Oilfield (Regulation &Development) Act, 1948 and the Petroleum & Natural· Gas Rules, 1959, On the other hand the Department of Coal considered CBM to have an inextricable association with coal, and its exploration / exploitation is therefore bound to impinge directly on the present and / or future mining of coal and safety of coal mining in general. The contention, therefore, was that the administrative jurisdiction of CBM exploitation should logically be with the Ministry of Coal.

Ws. Modi McKenzie (subsequently changed to Great Eastern Energy Corporation) were allotted a Block In Raniganj Coalfields. M/s. Modi McKenzie, after allocation of the CBM Block and entering into a MOU with Coal India Ltd., started exploration activities in the assigned area. Two deep bore holes were made during May 1996 to May 1997 at Surajnagar and Poradiha in District of Burdwan, West Bengal. Coal Bed Methane content was found to be encouraging for exploitation. Subsequently, Government of West Bengal, a Statutory Authority to issue an Exploration License, raised an objection to the exploration activities before obtaining a proper exploration license. As CBM was not covered under any Statute, the issue could not be resolved for quite some time. However, this issue has been subsequently resolved and the Block Is now under active exploration (6).

Exploration In, 1997, the Government of India decided that CBM should be taken as a natural gas and all the laws applicable to natural gas should apply to CBM development. The Ministry of Petroleum & Natural Gas thus was considered to be the Administrative Ministry for CBM development In India who would steer, regulate and monitor CBM exploration and exploitation in close consultation with Ministry of Coal.(5)

GEF / UNDP -001 CBM Project CBM recovery and commercial utilization is an important step jointly by the Government of India and International Organization. GEF/UNDP in this direction, with a funding of Rs. 76.85 crores. Broadly, the project funding (6).

The project is under implementation by Ministry of Coal Mines at Sudamdih Moonidih Projects of BCCL Dhanbad, Jharkhand. CMPDIL, Ranchi is the Implementing agency with BCCL Dhanbad as the Co-implementing agency.

Besides capacity building for CBM recovery in the country, the project demonstrate CBM exploration including reservoir modeling, CBM recovery from underground long holes, CBM recovery from surface vertical holes with cement and hydro fracturing techniques. Recovery of CBM shall also be demonstrated of worked panels through holes. The project shall also demonstrate utilization CBM by generating on site power and compressing CBM and bottling the same use in vehicles/domestic sector. Project is in the process of ordering CBM after floating global tenders through UNIDO Vienna being the equipment procure agency for the project. Once the equipment is at site say in 8 to 9 months tire, Exploration and exploitation activities shall start on ground in both the projects,

Now advanced Technology is readily available to recover methane — the major component of natural gas — from coal mines. Specific CMM end-uses depend on the gas quality, especially the concentration of methane and the presence of other contaminants. Worldwide,

Exploration and Exploitation of CBM Blocks In India:

After clearance and in consultation with Ministry of Coal, the Ministry of Petroleum & Natural Gas, Govt. of India, through a Global Tender Notice, has recently offered seven (7) Blocks, to technically and financially competent foreign and Indian companies, to bid for the exploration and production of CBM. The companies may bid for one or more blocks, either singly or in association with other companies with up to 100% participating interest (8).

The following Five Companies have bid for 6 blocks (Table 3 and 4). No. bid was received for CBM block in Satpura, Maharastra.

TABLE 3: Blocks Allotted to companies

SI.	Name of the Party	Blocks Bid by the Party	Blocks allotted
1.	O.N.G.C. - IOC Consortlam	Bokaro, Raniganj (East), Sohagpur (West) & NorthKarnpura	Bokaro& North Karanpura
2.	Reliance Industries Ltd.	Bokaro, Raniganj (East), Sohagpur (West) North Karanpura, Sohagpur (East) &Barmer Basin (Lignite)	Sohagpur (West), Sohagpur (East) &Barmer Basin (Lignite)
3.	Essar Oil Ltd.	Bokaro, Raniganj (East), &North Karanpura	Raniganj (East)
4.	Great Eastern Energy Coporation	Raniganj (East)	Nil
5.	New Mark Co. Ltd. USA	Bokaro, Raniganj (East), &Sohagpur (East)	Nil

TABLE 4: The salient details of the seven blocks on offer are given below:

SI. No.	State	Coalfield	Block -	Approx Area (Sq. Km)	CBM Resources	
					TCF	BCM
1.	West Bengal	Raniganj	East Raniganj	500.00	1.50	42.48
2.	Jharkhand	Bokaro	Bokaro	95.00	1.59	45.03
3.	Jharkhand	North Karanpura	North Karanpura	340.00	2.18	61.73
4.	Madhya	Sohagpur	East	495.00	1.75	49.00
5.	Madhya	Sohagpur	West	500.00	1.30	36.816
6.	**Madhya**	**Satpura**	**Satpura**	500.00	**1.30**	**36.816**
7.	Rajasthan	Barmer Basin	North Barmer	410.00	0.3178	9.00

NOTE: TCF - Trillion Cubic feet, BCM - Billion Cubic Meters.

Benefits of Coal Seam Methane for Captive Power

- **Alternative disposal of a problem gas** whilst simultaneously harnessing it as an energy source
- **Extreme profitability** with overall efficiency of up to 90% in the case of combined heat and power, and 43.4% in the case of power generation alone.

Brief description of the specific options for utilization:

a. Power Generation

CBM can be ideal fuel for co-generation Power plants to bring in higher efficiency and is preferred fuel for new thermal power plant on account of lower capital investment and higher operational efficiency.

b. Auto Fuel in form of Compressed Natural Gas (CNG)

CNG is already an established clean and environment friendly fuel. Utilization of recovered CBM as fuel in form of Compressed CBM just like CNG for mine dump truck is already part of National CBM demonstration project. For improvement in environmental conditions in Opencast mines as well as finding on site use of recovered CBM, dumpers being used in open cast mines in and around Sohagpur Area could be converted to operate on compressed CBM.

C.Cooking fuel in domestic sector

In place of burning coal, bottled compressed CBM, which Is a very convenient and eco-friendly fuel could be used for cooking by the population in and around coalfield area.

d. Fuel for Industrial Use

In view of the superior combustion properties of CBM, it may provide an economical and eco-friendly fuel for a number of industries like cement plant, refractory, Rolling mills etc. According to survey carried out by MECON (I) Ltd., there is demand of 5000000 Nm^3 of natural gas / CBM in the Jharkhand state alone for industrial purposes.

e. Feed stock for Fertilizer

CMM is most often used for power generation, district heating, boiler fuel, or town gas, or it is sold to natural gas pipeline systems. CMM can also be used in many other ways: Coal drying

- Heat source for mine ventilation air
- Supplemental fuel for mine boilers
- Vehicle fuel as compressed or liquefied natural gas (LNG)
- Manufacturing feedstock
- Fuel source for fuel cells

CONCLUSION:

The Clearinghouse seeks to promote the deployment of CMM recovery and end-use technologies in India to reduce methane emissions. The Global Methane Initiative (GMI) International CMM Projects Database currently identifies 21 potential CMM recovery projects in India. However, the majority of these are at the “initial idea” stage and most of them have since been dropped due to the inability to receive a concession to develop the project. Through GMI, U.S. EPA awarded a grant to the Central Institute of Mining and Fuel Research to conduct a feasibility study on CMM recovery and utilization in the Jharia, Bokaro, and Raniganj coalfields. The project provided data on CMM/VAM/AMM emissions in key gassy coal regions of India. VAM data was collected from 10 working mines. More recently, EPA’s CMOP program funded a pre-feasibility study for pre-mine drainage at the Sawang Mine located in the Bokaro coalfield. The study will examine the economics of utilizing long, in-seam boreholes to drain gas from the deeper, un-mined portions of the mine.

CMM EMISSIONS FROM ABANDONED COAL MINES

About 5 percent of abandoned mines in India are considered gassy, assuming the same percentage as active mines reported in the First National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). No additional information is available on abandoned mine methane (AMM) in India at this time, although several studies are proposed to gain more information on AMM emissions volumes in India’s major coalfields (*GMI Projects Database, 201*0). CBM FROM VIRGIN COAL SEAMS Estimates of India’s CBM potential varies. The Directorate General of Hydrocarbons estimates that deposits in 44 major coal and lignite fields in 12 states of India, covering an area of 35,330 km2, contain 3.4 trillion cubic meters (m3) of CBM depending on the rank of the coal, depth of burial, and geotectonic settings of the basins as estimated by CMPDI.

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Reference:

1) Rudra Malay ,The Impact of Coal Characteristics on CBM Prospectivity of Barakar Coals of Damodar Valley Coalfields, Adapted from oral presentation at AAPG International Convention and Exhibition, Milan, Italy, October 23-26, 2011

2) Srivastava Kundu Monika, India’s methane emissions stable: study ,Business Line, , https://www.thehindubusinessline.com/profile/author/Monika-Kundu-Srivastava

3) Pandey J.K ,Methane mitigation in indian coal mining. Central Mining Research Institute, Dhanbad-INDIA, https://pdfs.semanticscholar.org/c2eb/1d494ebc11d0bc36bf4559c01142b50f8d71.pdf

4)Methane: Your Environment, Your Health | National Library of Medicine https://toxtown.nlm.nih.gov/chemicals-and-contaminants/methane

5)Statistics Related to Climate Change - India 2015 Government of India Ministry of Statistics and Programme implementation Central Statistics Office http://www.mospi.gov.in/sites/default/files/publication_reports/climateChangeStat2015.p

6) Gautam NN,Prospects of Coal Bed Methane Exploitation in 21st century in india, The Thrust In Coal Industry in 21st Century,BCCL,Dhanbad,May 2003:66-77

7)Agarwal PC, CoalBelt Methane Recovery and Commercial Utilization Project, The Thrust In Coal Industry in 21st Century, BCCL,Dhanbad,May 2003:180-183

8) ET Energy World, India's Coal Bed Methane production jumped more than 44 percent to 565 MMSCM last fiscal, ET Energy world, https://energy.economictimes.indiatimes.com/