COAL BED METHANE: OPPORTUNITIES AND CHALLENGES IN INDIA

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Abstract Energy deficit countries like India are heavily reliant on importing fuel. If the fuel is harnessed locally, it can help the country reduce its import dependency and build a secure energy future. To cater to the energy demand, various renewable energy options are being looked into. One such fuel option is coal bed methane (CBM), which comprises methane trapped in coal bed reservoirs that can be extracted and used as a fuel source to meet energy demands. Methane is a combustible hydrocarbon with varied uses ranging from commercial industries to a commonly used household fuel. India has the fifth largest coal reserves in the world and can harness the entrapped methane from the coal beds seams. As per India's regulatory body, the Directorate General of Hydrocarbons, India has prognosticated 92 TCF (2600 BCM) in 12 states of CBM resources. CBM is a clean and unconventional fuel resource that may help tackle the fuel shortage for India's expanding GDP. And to meet the energy constraint of the growing Indian economy, the potential of CBM needs to be explored. This paper focuses on the overview of CBM in India and analyses the techno-economic challenges, including investment opportunities, policy limitations, and technological bottlenecks.

Keywords:
Coal Bed Methane, Alternate fuel, CBM technology, Environment challenges, Economic opportunities

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1 Introduction

Technological advancement and constant population growth have led to an increase in energy demand. As such, the reliance on fossil fuels will keep skyrocketing; currently, the global demand for fossil fuels is at 80% (IEA, 2022). Efforts are made to harness energy through unconventional sources to reduce fossil fuel reliance. Further, the inflationary price pressure due to geopolitical tensions also adds to the volatility of trade markets. The need for an energy-secure future has led to research and exploration activities in the renewable sector. And SDGs, the seventh goal to "ensure access to affordable, reliable, sustainable and modern energy for all" by 2030, is propelling the energy commodity market to scope out energy-efficient fuel options (*Goal 7 | Department of Economic and Social Affairs*, 2015)

One such option is natural gas which comprises methane. The extraction of methane from coal bed reservoirs is called Coal Bed Methane (CBM), wherein entrapped methane is desorbed from the coal bed matrix. It is a result of geochemical and biological transformations happening at the sub-surface level. The volatile organic matter of the coal gets degraded by a synergistic action by bacteria at the subsurface level at high pressure and temperature into gas. The gas produced is then extracted through drilling (Singh et al., 1999).

CBM represents a sizeable unconventional source of natural gas (Beaton et al., 2006). Countries like USA and Canada are leading global producers of CBM. In the USA, CBM accounts for 2TCF/ year, i.e. 10% of total gas consumption (Boger et al., 2014). India is an energy deficit country and, for its growing economy, has a very high dependence on the import of oil and gas. As per Petroleum Planning & Analysis Cell (PPAC), India's oil import for FY 2021-22 has been 84.4%. The Indian government is gearing up to reduce gas imports and set a gas production target of 50 BCM by 2023-24. Production of CBM internally can help to cater to the energy demand to some extent and thus can help to build a resilient economy for India.

2 Methodology

An extensive literature review is done from EBSCO, Scopus, and Google databases. Research on coal bed methane and its significance in India's fuel energy mix has been gathered for this paper. The extent of CBM and its associated challenges have

been identified. The nation's policy initiatives and the corresponding policy impediments have been discussed. The paper's main argument revolves around the CBM's potential to produce accessible energy that can be harnessed locally, reducing India's reliance on imports and advancing the country's sustainable transition to energy security.

3 Literature Review

3.1 CBM genesis and biogenic production

Anoxic conditions facilitate the generation of biogenic methane from coal as the result of complex biochemical reactions by groups of bacteria during the decomposition of organic matter (Krüger et al., 2008; Beckmann et al., 2011; Guo et al., 2012, Gründger et al. 2015). CBM is extracted by drilling boreholes into the coal bed reservoir and injecting it with produced water (Thielemann et al., 2004). The reservoir is depressurised due to the influx of produced water, and the methane gets desorbed and ready for collection (Reddy et al., 2022). Figure 1 shows gGeneration of methane gas during coalification.

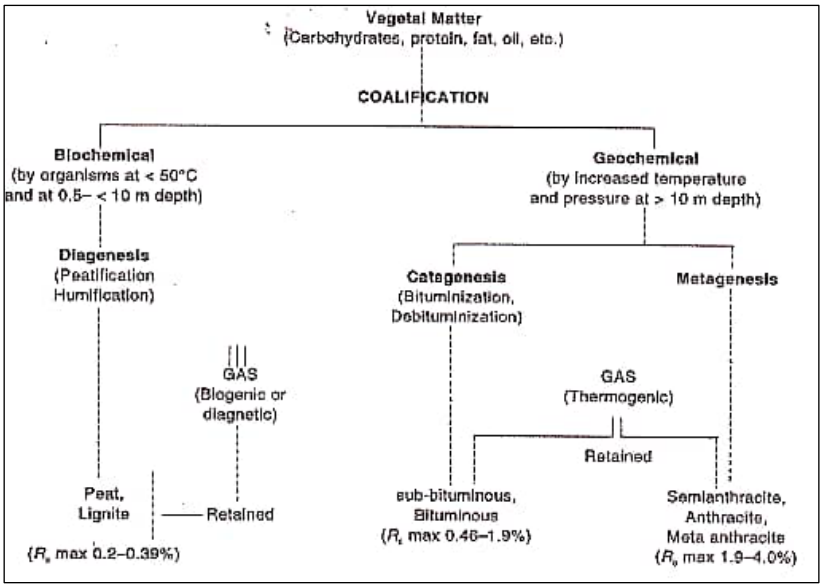

Figure 1: Generation of methane gas during coalification
Source: Singh et al. (1999)

Factors like coal type, rank, volatile matter, and fixed carbon affect methane adsorption capacity. Methane gas generation can get impacted due to coal maturity and rank, i.e. the deep-seated coal on maturation can generate more methane than shallowed coal bed (Ojha et al., 2011).

3.2 Economic opportunities of CBM in India

Methane sold in the CBM market comprises secondary biogenic methane, thermogenic methane, residual thermogenic carbon dioxide and heavy hydrocarbons. The value of the product by the manufacturer or creators of the goods is sold at 'factory gate' values to downstream manufacturers, wholesalers, distributors and retailers or, in some cases, directly to the end customers. Annual growth of 5.6% is expected in the CBM market for the year 2023 from its current size of $17.82 billion (*Coal Bed Methane (CBM) Market Size, Trends and Global Forecast To 2032*, 2023).

One of the significant CBM-producing countries is the US. However, the Asia Pacific region is expected to be the fastest-growing market. Countries like India, China and Indonesia are the major contributors to the growth due to the increase in drilling activities in these areas. Europe and Australia have been significant contributors to the market and are aggressively expanding to new regions (*Coal Bed Methane (CBM) Market - Global Summary & Outlook*, 2020).

India is one of the fastest-growing economies in the world, and its energy requirement to drive growth is also constantly growing. And to cater to this demand, domestic production should be prioritised, and sustainable alternatives must be explored. Meeting energy demand helps build a more robust economy for any country. India ranks fifth in terms of the largest coal reserves in the world. The coalfield beds that have the potential for CBM extraction are indicated in Figure 2.

India has set a target for natural gas to account for 15% of its energy mix by 2030, up from the current 6.7%, while the global average of more than 20% (*Government Sets Target to Raise Share of Natural Gas in Energy Mix to 15% by 2030 - The Economic Times*, 2022). In 2021, domestic gas production reached 32 BCM and catered to 50% of the consumption, lowering imports by 3.4%. Suppose the prognosticated 92 TCF (2600 BCM) of CBM resources can be optimised. In that case, it is estimated by the

Government of India that the total CBM production may be increased to 4MMSCMD (Million Metric Standard Cubic Meters per Day i. e. equivalent to approximately 1 TCF). The reserves are spread across the states as indicated in Table 1 by the Ministry of Petroleum and Natural Gas (MoPNG) *(EXP AND PROD - UN CONVENTIONAL HYDROCARBON | Ministry of Petroleum and Natural Gas | Government of India - Ministry of Petroleum And Natural Gas, 2019).*

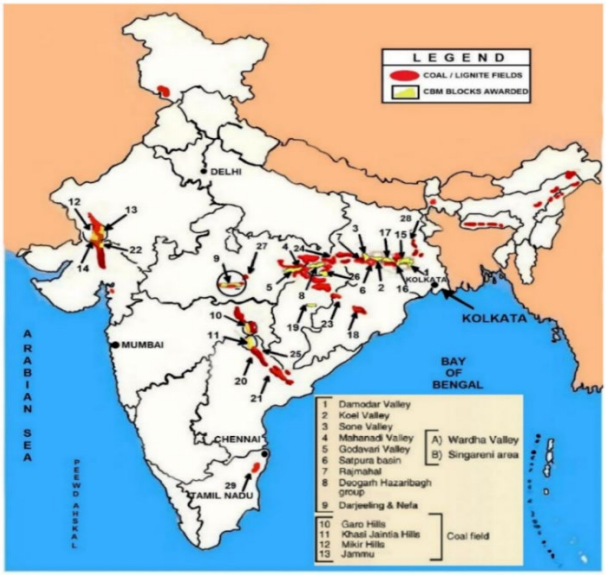

Figure 2: Classification of coalfields based on CBM potential, India
Source: Panwar et al. (2022).

Table 1: Total CBM resources by MoPNG, India

S. No.	State	Estimated CBM Resources (BCM)
1	Jharkhand	722.08
2	Rajasthan	359.62
3	Gujarat	351.13
4	Orissa	243.52
5	Chattisgarh	240.69
6	Madhya Pradesh	218.04
7	West Bengal	218.04
8	Tamil Nadu	104.77
9	Andhra Pradesh	99.11
10	Maharashtra	33.98
11	North East	8.5
	Total CBM Resources	2,599.40

3.3 Price trend of methane across the world

It is observed that the price of methane for developed countries is higher compared to a non-developed country which is mainly on account of taxation policy imposed locally. The US is an exception where the price of gas is kept low. The average price of methane worldwide is about 1.23 US Doller per litre (*Methane Prices around the World*, 2023).

Below is the price trend of methane in significant countries in UD Dollars per litre.

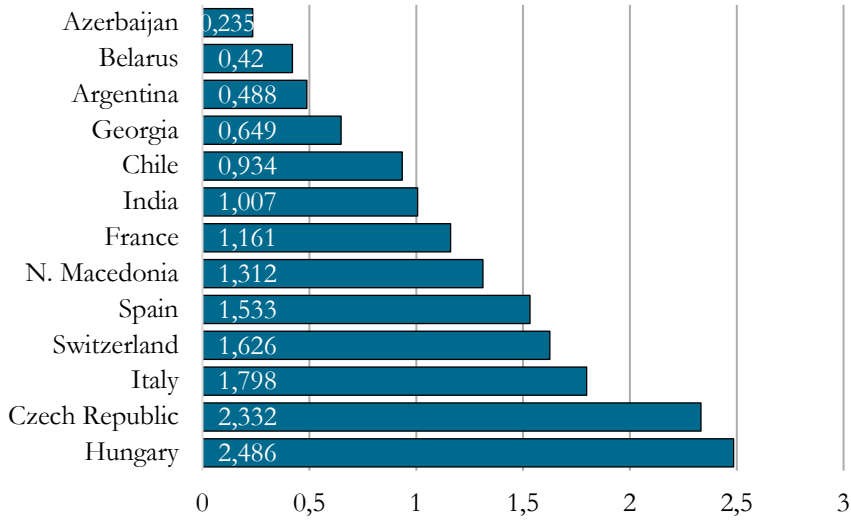

Figure 3: Country-wise methane pricing, Mar-2023 (litre, US Dollar)
Souce: Coal bed methane (2023).

3.4 Environmental challenges associated with CBM extraction

Management of the produced water associated with CBM production poses a primary environmental concern. The pressurised water is pumped into the reservoir to desorb the gas from the coal bed. And like conventional reservoirs, once the peak gas rate is achieved, the water saturates, and methane is then collected (Surya et al., 2008). During the process, the produced water discharged needs to be properly

disposed of as it has a potential impact on the surrounding habitats due to high salinity and sodicity levels (Mendhe et al., 2017).

As an industry practice, the produced water undergoes desalination, degassing, and removal of suspended solids, organic compounds, heavy metals, and others is carried out. After improvements and toxicity checks, the treated water can then be used for irrigation, deep well injection, aquifer storage, livestock watering, surface water discharge, and impoundment in infiltration ponds, evaporation ponds, or zero-discharge ponds. The treatment of the produced water incurs high expenditures, so the produced water's toxicity determines its usability. Therefore garnering public acceptance is challenging (Mendhe et al., 2017).

Nevertheless, the advantage of CBM extraction is that it helps capture methane, a potent greenhouse gas (GHG), thereby lowering GHG emissions. CBM capture also helps ensure mine safety, as methane in coal reservoirs has explosive tendencies. Methane is a potentially valuable alternative fuel used to produce electricity in transportation, such as CNG, and in various other commercial industries. Furthermore, if harnessed locally, it provides additional revenue, which can help bolster the country's fuel economy (US EPA, 2015).

3.5 Policy challenges in CBM extraction in India

While CBM has immense potential in India, the progress on CBM has been relatively low. The government had awarded 33 blocks in 4 rounds of bidding from 2001 to 2008, of which only five blocks have commenced commercial production. After 2010, new licenses for CBM exploration were not granted. At the same time, the gestation period for exploration, discovery, development, and production has a high lead time of over 5 to 7 years. With inherent long production cycle for any block to materialise, combined with the limited focus in the past by the government, has kept the development of CBM in India on a slow track (ETEnergyworld, 2022).

One of the significant challenges witnessed for the blocks awarded was land acquisition. CBM projects usually are spread across a large area of land. At such widespread locations, local and sociopolitical issue has significantly delayed the commencement of work. Another challenge observed is that the statutory approvals pertaining to clearance from Environment and Forest department and other local

authorities are delayed after the land acquisition. While the government had introduced the Single Window System wherein the interested organisation had to submit information for trade facilitation at a single agency rather than multiple agencies for faster implementation of projects, however, at the field level, it did not achieve its intent. Administrative challenges have also been observed between the petroleum and coal ministries as the CBM areas overlap the coal blocks. Mining license and joint approval challenges have become a bottleneck at the field level. The formula-based gas price fixation by the government, on many occasions, made the overall investment not economically viable.

Moreover, if levied, any imposition of tax similar to the Carbon Tax will be detrimental to the entire project. Without the flexibility of the gas pricing and the clarity on the taxation module, bidders have been conscious of investing in CBM in India. While India launched the auction of CBM blocks in 2021 with more liberal terms under the new policy initiative such as Hydrocarbon Exploration and Licensing Policy (HELP) and Open Acreage Licensing Programme (OALP), the result of the same is yet to be perceived (ETEnergyworld, 2022).

4 Discussion

It is of pivotal importance for India to increase its production of local fuel to cater to its growing energy demand and for a sustainable economy. Optimisation of CBM has to be among one of the critical areas of focus for the government to achieve its goal. While steps are being made towards the same, the following four strategy points need to be addressed for it to succeed.

i) Easy of operation and implementation

From awarding the CBM blocks to getting the site ready for production, it has to be executed in close coordination with the concerned authorities to ensure faster implementation and time reduction of a bottleneck at multiple stages during the process.

ii) Project viability

The pricing mechanism needs to be developed, keeping the global pricing trend and volatility of the worldwide trade market in consultation with the investors. This will help mitigate long-term and short-term setbacks associated with price inclusivity.

iii) Long-term sustenance assurance

In order to cater to the extensive CBM project timeline, measures need to be taken for the viability and redressal of any future challenges, including sociopolitical issues or geopolitical issues. Further, assurance is provided for the agreed duration of the project to ensure that it becomes viable.

iv) Clarity and transparency

Administrative challenges, pricing bottlenecks, and vague taxation policies must be addressed with more concrete and clear procedures. The policies should be transparent throughout the project duration, and the decision-making process from the investor's point of view should also be incorporated.

5 Conclusion

While CBM technology will continue progressing, India's policy environment will determine the field's purpose. The government will help draw in foreign investment if it takes a committed and targeted approach to the abovementioned issues. Hence assisting India in lowering its imports and supplying its own energy needs.

Methane's contribution to the energy mix could increase due to CBM. Compared to fossil fuel alternatives, methane collected using CBM is a cleaner fuel choice, containing 50–60% less carbon dioxide. If locally available resources are used effectively, imports can be reduced, aiding India's transition to an energy-secure future economy.

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