

Coal Bed Methane, Features, Extraction, Impacts, Production in India

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Unconventional gases are energy resources trapped in difficult geological formations like coal seams, shale and tight rocks. Coal Bed Methane (CBM) emerged from efforts to improve coal mine safety by removing methane before mining. With rising energy demand, depleting conventional gas reserves and climate concerns, CBM has gained importance as a cleaner burning fossil fuel that enhances domestic energy security while utilizing existing coal resources more efficiently.

Coal Bed Methane

Coal Bed Methane is a form of **natural gas** that is mainly composed of methane and naturally stored within Coal Seams through adsorption. Unlike conventional natural gas trapped in sandstone reservoirs, CBM is adsorbed onto the internal surfaces of coal micropores and fractures. It is called **“Sweet Gas”** because it lacks hydrogen sulphide and contains minimal heavier hydrocarbons, making it suitable for industrial and utility use. Once considered only a mining hazard, CBM is now widely used for power generation, industrial fuel, vehicle fuel (CNG) and methanol production, especially in energy deficient economies.

Coal Bed Methane Features

Coal Bed Methane possesses distinct geological and chemical characteristics that differentiate it from conventional hydrocarbons and shape its extraction and usage patterns.

- **Unconventional Gas Nature:** CBM is stored through adsorption in coal micropores rather than free flowing reservoirs, making extraction technically complex but resource efficient.
- **Gas Composition:** It primarily contains methane with minimal heavier hydrocarbons like propane or butane, resulting in cleaner combustion and lower particulate emissions.
- **Dual Porosity System:** Coal seams have matrix porosity for gas storage and cleat fractures for gas flow, defining CBM reservoir behavior.
- **Sweet Gas Quality:** CBM generally lacks hydrogen sulfide, reducing corrosion risks and processing requirements compared to sour natural gas.
- **Safety Significance:** **Methane** accumulation in coal mines causes explosions, making CBM extraction critical for mine safety and disaster prevention.
- **Lower Energy Density Variability:** Heating value depends on methane purity and gas with less than 92% methane may require blending for pipeline use.

Coal Bed Methane Extraction Process

Coal Bed Methane extraction relies on pressure reduction techniques rather than hydraulic fracturing, making it operationally distinct from shale gas development.

- **Drilling into Coal Seams:** Steel cased wells are drilled 100 to 1500 meters deep into coal beds saturated with methane rich water.
- **Water Removal Stage:** Pumping out groundwater reduces hydrostatic pressure, enabling methane to desorb from coal surfaces.
- **Desorption Mechanism:** Gas release follows the Langmuir isotherm, where decreasing pressure increases methane liberation from coal matrices.
- **Gas Water Separation:** Extracted fluids are separated at the surface, with methane directed into pipelines or compressors.
- **Permeability Evolution:** Coal shrinkage during gas release increases fracture permeability, often raising gas production over time.
- **Produced Water Handling:** Water may be reinjected, treated, evaporated, or reused depending on its chemical composition.

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Coal Bed Methane Production in India

India's vast coal reserves provide strong geological potential for Coal Bed Methane development as an alternative domestic gas source.

- **Coal Resource Advantage:** India has the world's fifth largest proven coal reserves, creating favorable conditions for CBM extraction.

- **Estimated CBM Potential:** National CBM resources are estimated between 700 and 950 billion cubic meters, highlighting strategic energy value.
- **Policy Initiation:** The CBM policy introduced in 1997 placed CBM under natural gas regulations administered by the Ministry of Petroleum and Natural Gas.
- **Awarded Blocks:** Thirty three CBM blocks covering 16,613 sq. km across 12 states have been awarded through four bidding rounds.
- **Gas-in-place Estimates:** Out of 62.4 TCF of prognosticated CBM resources, 9.9 TCF has been confirmed as gas-in-place.
- **Production Status:** As of March 2016, CBM production stood at 1.637 MMSCMD from four operational blocks.
- **Commercial Pioneers:** Great Eastern Energy Limited became India's first commercial CBM producer in 2007, supplying CBM based CNG.
- **Operational Blocks:** Essar's Raniganj East block is active, while others in Jharkhand, Odisha and Madhya Pradesh remain under development.

Coal Bed Methane Production Across World

Coal Bed Methane has emerged as a significant unconventional gas source across multiple continents with varied geological and regulatory contexts.

- **United States:** CBM production reached 1.76 TCF in 2017, accounting for 3.6% of total U.S. dry gas output. U.S. CBM production peaked at 1.97 TCF in 2008, mainly from Colorado, Wyoming and New Mexico.
- **Australia:** Coal seam gas supplies about 10% of Australia's gas production, with reserves estimated at 33 TCF. Bowen, Surat and Sydney basins form Australia's CBM production backbone since commercial operations began in 1996.
- **Canada:** Alberta alone holds up to 500 TCF of CBM resources, though commercial production remains limited.
- **United Kingdom:** Despite estimated gas-in-place of 2,900 bcm, only about 1% is economically recoverable so far.
- **Kazakhstan:** Preliminary studies suggest 900 bcm of CBM, representing 85% of national gas reserves.

Coal Bed Methane Impacts

Coal Bed Methane development generates mixed economic, environmental and social outcomes requiring balanced policy assessment.

- **Energy security enhancement:** CBM reduces dependence on imported natural gas by utilizing domestic coal based energy resources.
- **Lower emissions than coal:** Electricity generation from CBM produces less than half the greenhouse emissions compared to coal based power.
- **Mine safety improvement:** Pre-mining methane removal reduces explosion risks in underground coal operations.
- **Employment generation:** CBM projects create skilled and semi skilled jobs in drilling, gas processing and pipeline infrastructure.

- Methane leakage risk: Fugitive methane emissions during extraction significantly impact climate due to methane's high **global warming** potential.
- Produced water concerns: Saline and chemically contaminated water can pollute soil and water bodies if poorly managed.

Coal Bed Methane Challenges

Coal Bed Methane development faces technical, environmental, economic and governance related challenges across producing regions. To address these challenges various integrated methods can be applied as highlighted here:

- High capital intensity: CBM wells have high initial costs with lower early gas output compared to conventional reservoirs.
- Economic viability issues: Low gas prices reduce investment attractiveness and delay cost recovery for operators.
- Methane emission risks: Methane has 72 times higher warming potential than **CO₂** over 20 years, raising climate concerns.
- Water pollution threat: Produced water may contain salts, heavy metals and radionuclides harmful to ecosystems.
- Groundwater depletion: Large scale dewatering depresses aquifers, with Australia extracting over 126,000 million litres annually.
- Accident hazards: Deeper CBM operations increase risks of ignition, explosions and infrastructure damage.
- Regulatory fragmentation in India: Overlapping jurisdiction between coal and petroleum ministries delays integrated resource development.

Way Forward:

- Integrated governance: Harmonizing coal and gas regulatory frameworks can reduce bureaucratic delays and investment uncertainty.
- Gas pricing reforms: Market linked pricing mechanisms are crucial to attract private investment in capital intensive CBM projects.
- Advanced technology adoption: Enhanced drilling, reservoir modeling and microbial methane recovery can improve extraction efficiency.
- Environmental safeguards: Mandatory environmental impact assessments and water treatment norms must guide CBM operations.
- Methane abatement programs: Capturing fugitive methane before mining can reduce emissions and improve energy recovery.
- Public private partnerships: Leveraging private sector finance and expertise can address technological and managerial gaps.
- Research support: Institutions like TERI demonstrate the role of innovation in improving CBM recovery through microbial techniques.