Coalbed Methane

in British Columbia

***T**he Ministry of Energy and Mines has a mandate to support job creation through the responsible stewardship of British Columbia's energy and mineral resources. While yet to be developed, Coalbed Methane (CBM) could become a significant energy resource and generate social and economic benefits for British Columbians. The ministry's goal is to create an environment that will encourage responsible CBM development and ensure that the province has a more diverse energy supply for the future.*

British Columbia
Ministry of Energy and Mines

www.gov.bc.ca/em

What Is Coalbed Methane?

Note:
Throughout this brochure, terms have been bolded to indicate that they are defined in a terminology list on page 10.

Did You Know?

You can't see or smell natural gas. When it burns naturally it produces the same substances emitted when people breathe – carbon dioxide and water vapour. The odour associated with the natural gas delivered to our homes and businesses is an additive used as a safety measure to detect leaks.

One trillion cubic feet (Tcf) equals 1000 billion cubic feet (Bcf). One Bcf of natural gas supplies about four million households or ten million people (2.5 people per household) with their cooking, heating and hot water needs for one day.

Cover Photo:
Drill rig image used with permission of AEC Oil and Gas Company Ltd (AEC).

Coalbed methane (CBM) is the natural gas found in most coal deposits. CBM is created during coalification, the process by which plant material is converted into **coal** over millions of years (Figure 1). Under most circumstances, CBM consists of pure methane. It may also contain carbon dioxide (CO_2) and nitrogen (N_2).

Methane is contained within the **coal seam** where it is **adsorbed** or attached to the coal. Pressure from the overlying rock and the water within the coal cleats (natural fractures) keeps the methane adsorbed onto the coal.

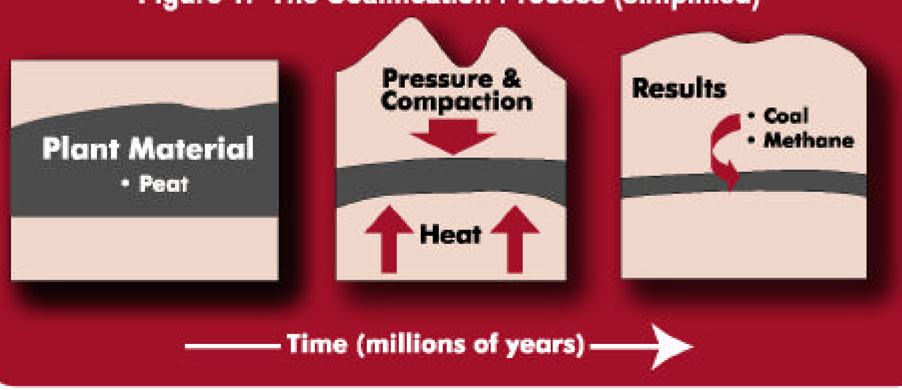
CBM is a clean-burning fuel, considered more environmentally friendly than oil, coal or even **conventional natural gas**. It contains few, if any, impurities and therefore requires minimal processing. In many cases it can go directly from the well to your home once trace amounts of water and CO_2 are removed.

CBM offers significant economic opportunities. Below 2,000 metres, CBM cannot be extracted at economic rates. Current estimates place British Columbia's CBM volume between 90-250 trillion cubic feet (Tcf) of gas in coals above a 2,000 metre depth. While only 20 per cent of this gas may be recovered, the marketable volume of 18-50 Tcf is equivalent to 25 to 75 years of gas supply at current production rates (for both domestic and export markets).

Although CBM may be found in areas of the province where people use natural gas, it is not yet produced there, so facts about this resource may be unfamiliar. Like the natural gas used widely today, CBM can be used to heat our homes, cook our food and generate our electricity.

The purpose of this brochure is to identify CBM's resource potential and to explain the issues relating to its exploration, development and production.

Figure 1: The Coalification Process (simplified)



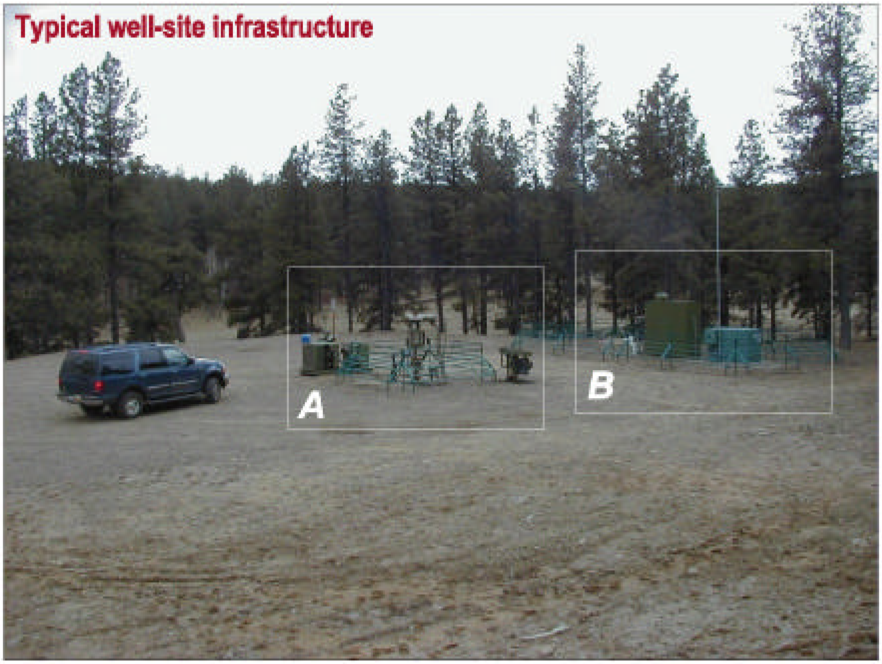
How Is Coalbed Methane Produced?

No two CBM sites are exactly alike. An area's geological history and the depth of its buried coal determine a coal's type and gas content. Still, conventional natural gas drilling techniques can develop almost any CBM deposit. However, before commercial CBM can be produced, testing is often completed on four or five wells in close proximity.

On the surface, a CBM drilling system looks much like one used in any oil and gas operation. In many cases, it most closely resembles the equipment used to drill water wells. The cover photo shows the equipment used to drill a test well in the Elk Valley in southeastern B.C. during summer 2000.

Underground, CBM's production system is unique (Figure 2). Typically, a steel-encased hole is drilled into the coal seam first. Unlike conventional reservoirs, which will produce gas through the well bore at high pressures, simply penetrating the coal seam will not cause the CBM to flow.

Generally, a fluid – sometimes a water-based nitrogen foam – must be pumped from the surface down the well bore and into the coal seam, a process known as **fracturing**. The fluid is forced into the existing natural fractures (cleat system) and widens them. Adding a material such as sand to this foamy mixture props open the cleats. Gas and water then flow through these enlarged and interconnected sand-filled fractures.

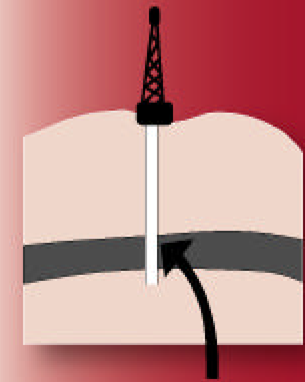


Typical well-site infrastructure

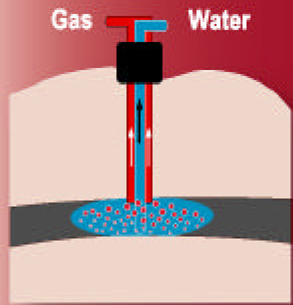
CBM wellhead

Gas- and water-metering station

**Figure 2:
CBM
Development Process**



Drill the coal section



Select a completion technique, produce and separate water and gas

Infrastructure Photos:
Raton Basin, New Mexico

To encourage the CBM to flow, the natural pressure in the coal seam must be decreased by **de-watering** the coal. A pump located at the wellhead removes the water that naturally occupies the cleats. This lowers the reservoir pressure along the particular coal seam, draws the gas out of the coal and allows it to flow into the well bore. Effective de-watering may take anywhere from several months to several years.

Upon reaching the surface (wellhead), the gas and water are separated and piped to a small metering facility where the production volume from each well is recorded.

The CBM is collected from a number of wells and then flows to a central compressor station (about the size of a two-car garage) where it is compressed into a pipeline for shipment. The water is sent to a central discharge point, and depending on quality and quantity, is either injected back into the ground, or used on the surface.

CBM production must be continuous to ensure a constant low-pressure gas flow and sustain a commercially viable operation. If a CBM well is shut down for an extended period after it has started producing gas, the water in the coal will collect at the well bore, requiring a repeat of the long de-watering process.

Water disposal: subsurface water injection site

Intermediate pressure compressor station

What is the Current Level of CBM Activity in British Columbia?

Although British Columbia has vast CBM potential, commercial production has yet to take place in the province or anywhere else in Canada. However, the United States derives more than eight per cent of its annual natural gas production from CBM. That equals more than twice B.C.'s annual natural gas production and over four times the amount currently consumed in the province.

According to the Geological Survey of Canada and the B.C. Ministry of Energy and Mines, areas with a high potential for CBM include the Peace River area in the northeast, the Fernie-Elk Valley area in the southeast, Vancouver Island and several interior coalfields (Figure 3).

The Elk Valley near Sparwood was the most active CBM exploration area in the year 2000. The company exploring this area consulted with the public, First Nations and local industry and promoted the use of local services and contractors. To minimize environmental impact, the company used existing trails and logging roads wherever possible. As with conventional oil and gas exploration, the company's activities were subject to the regulations of the Oil and Gas Commission and the Worker's Compensation Board.

With the exception of Vancouver Island, the province owns most CBM rights in B.C. For privately held properties, companies must negotiate with landowners for the right to produce CBM.

Did You Know?

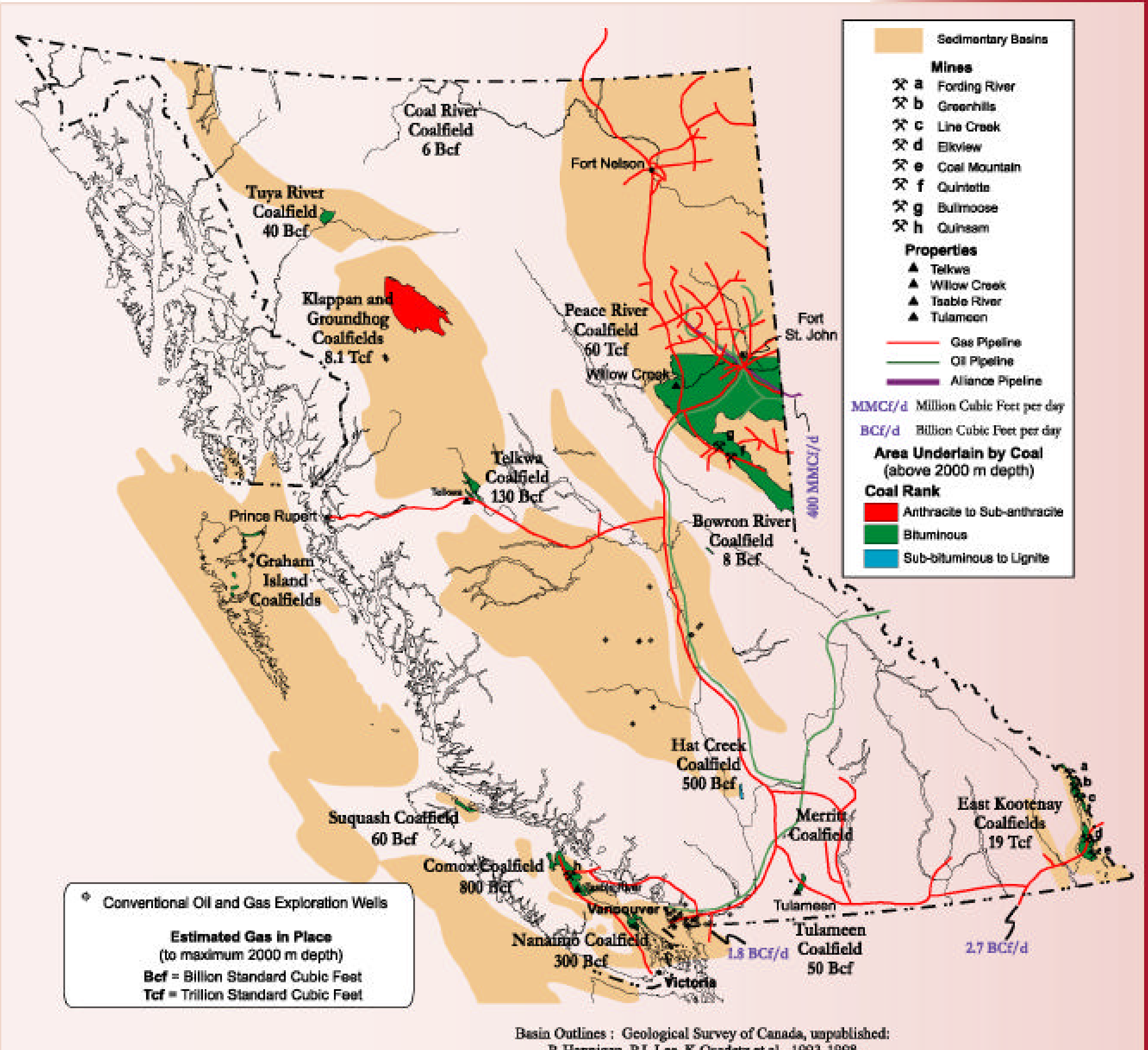
Estimates for CBM potential in the coalfields on Vancouver Island alone indicate about 1 Tcf. If 20 per cent of this gas were produced, it would be enough energy for every gas customer on Vancouver Island for about 25 years.

So far, activity in B.C. has focused on exploration, that is, assessing the potential for CBM development. However, even the exploration process has generated income for the province. Recently, bidding in Crown land petroleum and natural gas sales for CBM exploration and production rights generated over $20 million in provincial revenue. These funds can provide important benefits to British Columbians such as health care and education.

Did You Know?

Existing natural gas pipelines already serve many areas in B.C. with high CBM potential. For the future, this will help keep transportation costs down and minimize the level of new surface disturbance.

Figure 3: Coalfields and coalbed methane potential in British Columbia



Basin Outlines : Geological Survey of Canada, unpublished: P. Hannigan, P.J. Lee, K. Osadetz et al., 1993-1998.

Coalbed Methane and Conventional Natural Gas: A Comparison

Coalbed methane and conventional natural gas share common production methods and advanced exploration technologies, including drilling equipment, pipelines and compressor systems. However, there are significant differences, a few of which are outlined below.

Well Sites/Pad Sizes

During standard drilling operations, a conventional gas well will affect a surface area measuring 120 by 120 metres (1.44 hectares). Larger areas may be used to accommodate rigs used for **directional** or deep drilling. Since CBM wells are usually shallower by comparison, smaller rigs and smaller surface areas may be used. Once CBM drilling is complete and the well is connected to the pipeline, the area can be reduced to just large enough for a wellhead and pump, a liquids separator and dehydrator, metering equipment and an optional water tank. Later, some of the area can be re-vegetated and re-contoured, leaving little long-term surface impact.

Well Spacing

CBM wells are subject to the spacing and target areas defined under the Petroleum and Natural Gas Act. Currently, British Columbia requires approximately 640 acres for each conventional natural gas well. This equals a subsurface drainage area roughly the size of 50 football fields for each well. However, U.S. experience indicates that CBM wells may need to be closer together than conventional gas wells.

Typical spacing for U.S. CBM wells is one per 320, 160, or 80 acres. Closer spacing allows the wells to work together to reduce the area pressure, ensures optimum production and increases ultimate gas recovery.

Casing/Drilling

A normal drilling operation for a CBM well involves drilling a hole about 20 centimetres in diameter down to the coal seam. Steel or plastic casing lines portions of the hole. Spaces between the casing and bedrock are filled with cement. This combination of casing and cement prevents the exchange of fluids or gases between the well and surrounding rocks or surficial materials, and ensures that drinking water is protected.

Production Profile

During start-up operations, a conventional natural gas well produces large volumes of gas and very little water. Over time, gas production decreases while the water increases, until the gas reserve is depleted or the volume of water becomes too great. Conversely, CBM wells produce large quantities of water at first and only small amounts of gas. During the initial de-watering phase (usually several months), gas production increases steadily while the amount of water decreases (Figure 4). Eventually, production levels begin to resemble a conventional gas well and the gas reserve gradually declines until it is no longer economically viable. However, even with its longer lifespan, a typical CBM well produces less gas at a much lower rate than a conventional well.

Note:

1 hectare = 10,000 square metres, or 2.47105 acres.

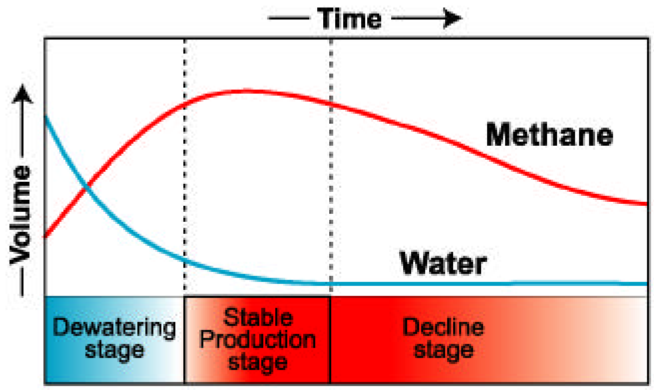
1 acre = 0.4047 hectares.

640-acre well spacing = 259 hectares; 1 well per square mile.

320-acre well spacing = 129.5 hectares, 2 wells per square mile.

160-acre well spacing = 64.75 hectares; 4 wells per square mile.

Figure 4: Generalized production profile for CBM



Composition of Gas

Conventional natural gas consists primarily of methane, typically 80-90 per cent. It also contains other hydrocarbons (such as ethane, propane, and butane), as well as other gases (including nitrogen, helium, carbon dioxide and hydrogen sulphide). When hydrogen sulphide, or "sour gas", is present in conventional natural gas the gas must be treated before it enters the pipeline that takes it to your home.

However, CBM is generally a "sweet gas" and of pipeline quality, except in some regions where higher levels of carbon dioxide must be separated and removed. Typically, it consists of more than 95 per cent methane, with small amounts of carbon dioxide and nitrogen. Tests on gases recovered from CBM operations indicate no danger from hydrogen sulphide or any other sulphur components, even with high-sulphur coals. In this respect, CBM is a cleaner, safer, more environmentally friendly fuel than many other energy sources, including conventional natural gas.

Production Lifespan/Well Duration

All natural gas wells vary in the duration of production. Depending on various factors, including size and management techniques, a conventional gas well in Canada can produce for three to 25 years. Current estimates for the average production life of a CBM well vary from ten to as many as 40 years. However, this is impossible to verify as U.S. commercial production has been underway for only about 25 years.

Infrastructure

CBM operations require gas and water-gathering systems. Plastic pipes carry low-pressure gas to a central compressor station where the gas is pumped into an intermediate-pressure steel pipeline. The gas eventually enters a main, high-pressure pipeline where it is carried to market.

Water is collected in storage tanks at the well and transported by truck to a disposal site or moved by pipeline to a suitable central disposal site. Usually, to minimize surface impact, both the gas and water pipelines are buried adjacent to access roads.

Did You Know?

Although the water produced from CBM wells is usually of good quality, it is normally not the same water that is drawn from water wells for drinking purposes. Generally, CBM wells extract formation waters at deeper levels below the surface than drinking-water wells. The two water sources are commonly separated by impermeable rocks and therefore do not interact.

Did You Know?

Initially, a CBM well may produce from 50 to over 1,000 barrels of water per day for several months or more. This water may be re-injected into deep aquifers, below potential groundwater zones.

How Will CBM Development Affect Me?

The Environment

Air Quality

Generally, because CBM is nearly pipeline quality upon production, it does not require extensive processing, thereby eliminating a source of potential emissions.

Compressors move the gas from the well to the pipeline system. To minimize the levels of exhaust, CBM-burning engines can be used to drive the compressors. The compressors must undergo frequent testing to ensure they meet strict air-quality standards. In many cases, electrical compressors may be used, further reducing emissions.

Therefore, when CBM can displace other fuel sources such as coal, oil and conventional natural gas, its use will reduce the impacts on air quality.

Sound

At the surface, producing CBM wells are relatively quiet. Small motors (usually electric) pump the water. The gas-powered compressors that move the gas along the transmission pipelines are equipped with strict sound-reduction systems. These measures include mufflers, baffles, sound-limiting enclosures and placement away from residences. Electrical compression can also dramatically reduce noise impacts. Generally, most sound disturbances originate from drilling and well-servicing and are of limited duration. After production, underground pipelines can be used to eliminate the noise and traffic of trucking the produced water to disposal sites.

Wildlife Protection

The effect of CBM development on wildlife occurs primarily from surface disturbances – during the construction of well sites and the pipeline network. To protect both domestic and wild animals, well facilities are fenced and pipelines are buried underground where necessary. CBM operators are also subject to the general wildlife measures outlined in the Forest Practices Code. Once the well is depleted, the law requires the operator to restore the area close to its original state.

Water Quality

Water production and disposal is a key issue in CBM development. De-pressuring the coal seam can generate large volumes of water of varying quality. Drilling and production regulations require that water produced from natural gas operations, including CBM, be moved to an underground formation, unless otherwise permitted. Testing of the produced water determines the disposal method. Groundwater is protected by lining drill holes with casing and cementing holes from production levels to the surface (Figure 5). These procedures are designed to protect drinking water sources, fish habitat and local vegetation.

Surface Discharge of Water

In the United States, water-quality testing indicates that CBM-produced water is generally of good quality (low total dissolved solids and chlorides). After rigorous testing, water that meets quality standards may be permitted to flow into surface drainage or into ponds and seep back into the soil or evaporate naturally. The Oil and Gas Commission, in consultation with the Ministry of Environment, Lands and Parks, will review surface discharge options on a case-by-case basis.

Subsurface Water Injection

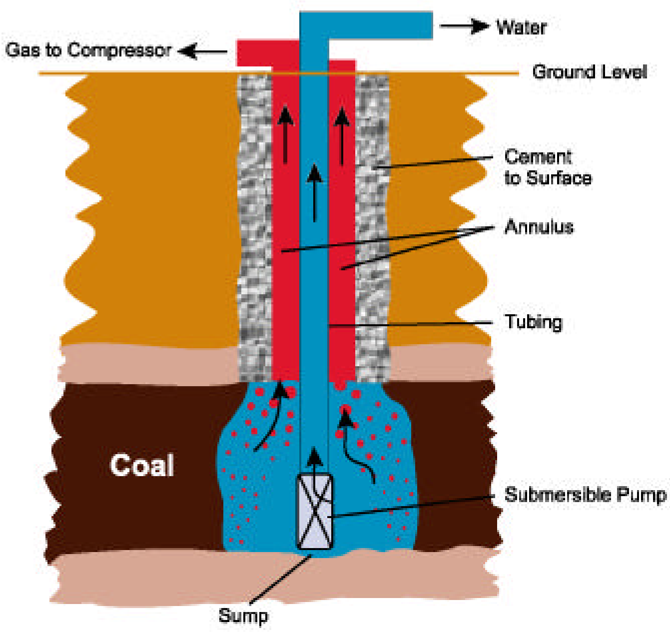
When the composition or volume of the produced water makes surface disposal inappropriate, subsurface water is injected into deep wells (see photo, page 3). Water that tests high in total dissolved solids (including salts) is injected into suitable underground formations only after approval from the Oil and Gas Commission.

Plugging and Abandonment

Wells are plugged and abandoned once all recoverable gas has been extracted. The Oil and Gas Commission monitors the process to ensure that it conforms to all provincial regulations. In general, cement is used to permanently seal the flow of gas and water from the coal.

Figure 5:

Schematic diagram of open-hole completion technique for a typical CBM well. Modified from diagram used by the Wyoming State Engineer's Office.



Did You Know?

The average annual salary in the U.S. CBM industry is $40,000 per year (about $60,000 Cdn.) CBM development in Wyoming's Powder River Basin, one of the largest in North America, will generate an estimated 7,000 new jobs for the local economy. In addition, more than $1.4 billion U.S. has been invested in industry infrastructure and drilling in the last five years.

CO_2 Sequestration

The Alberta Research Council is leading a group of organizations in pilot projects to exploit deeply buried coal beds as permanent geological storage areas for carbon dioxide (CO_2).The projects include enhanced CBM recovery and CO_2 disposal, two mutually beneficial activities. Pilot projects and research are underway now in Alberta and Colorado.

CBM Safety Items

Worker Safety

The Workers' Compensation Board (WCB) is an administrative agency that operates under the authority of the Workers' Compensation Act. The WCB makes regulations to establish standards and requirements for the protection, health and safety of workers, including those employed by the oil and gas industry.

Pipeline Safety

Although accidents are rare, CBM like conventional oil and gas is highly flammable and explosive. Safety measures integral to modern pipeline systems include leak detection and automatic shutdown mechanisms. Because CBM is produced at very low pressure, there is virtually no chance of explosion as control is easily maintained during drilling or production.

Flaring

Whenever possible, **flaring** is limited to brief periods and is regulated by the Oil and Gas Commission. Flaring may be necessary during initial testing, completion stages or during **workovers** to improve production.

Economic Opportunities

Jobs

One of the most important benefits of CBM development is job creation. In the United States, drilling, well operation and well servicing have provided many benefits to local communities. In B.C., CBM development could diversify the economies of communities like Tumbler Ridge, where the Quintette coal mine closure resulted in job losses and increased economic challenges.

CBM development opportunities include the establishment of local drilling supply and service industries; pipeline and facility construction; facility maintenance and operations; and equipment and water transportation. Spinoff benefits to local communities can contribute significantly to local economies through hotel, catering, and other service industries. Fort St. John, today's centre of B.C.'s oil and gas industry, enjoys one of the highest employment rates in Canada and some of the highest wages in the province.

Local Energy Supplies

The widespread distribution of CBM potential in B.C. means that natural gas supplies could be available locally. Not only could this result in lower costs for consumers, but it could also improve reliability and provide opportunities for the development of new business and industry.

Terminology

Adsorption/adsorbed -Adsorption refers to the molecular bonding of a gas to the surface of a solid (for example coal).

Anthracite Coal - The highest rank of coal, anthracite is used primarily for residential and commercial space heating. It is a hard, brittle and black lustrous coal. Unlike bituminous coals, anthracite contains a high percentage of fixed carbon and a low percentage of volatile matter. The heat content of anthracite ranges from 22-28 million BTU (British Thermal Units) per ton.

Bituminous Coal - A dense black or dark brown coal, bituminous coal is used as a fuel, primarily in steam/electric power generation. It is also used in manufacturing and in producing coke. Bituminous coal is the most abundant coal in active B.C. mines. Its heat content ranges from 21-30 million BTU per ton.

Coal - Coal is a readily combustible, black or brownish-black rock comprised of more than 50 per cent carbonaceous material by weight and more than 70 per cent by volume, including inherent moisture. Coal is formed from plant remains that have been compacted, hardened, chemically altered, and metamorphosed by heat and pressure over geologic time.

Coal Rank - Coals are classified according to their progressive alteration from lignite (lowest rank) to anthracite (highest). The standard ranks of coal include lignite, sub-bituminous coal, bituminous coal and anthracite, and are based on fixed carbon, volatile matter, heating value, and coking (see coke and coking coal properties).

Coal Seam - A coal seam refers to a bed of coal lying between a roof and floor. It is also called a "bed" in the coal industry.

Coke (Coal) - A solid carbonaceous residue derived from low-ash, low-sulphur bituminous coal. The volatile constituents are driven off by baking at temperatures as high as 2,000 degrees Fahrenheit. Coke is used as a fuel and as a reducing agent in smelting iron ore in a blast furnace. It is grey, hard and porous and has a heating value of 24.8 million BTU per ton.

Coking Coal - Coking coal refers to bituminous coal suitable for making coke.

Conventional Natural Gas - Natural gas consists of a mixture of hydrocarbon compounds, primarily methane, and small quantities of various non-hydrocarbons that exist in a gaseous phase or in solution with crude oil in natural underground reservoirs.

De-watering - The process of removing water from a coal seam in the vicinity of a producing gas well. The water in the coal is pumped to the surface and an appropriate disposal method is determined based on water quality and quantity. De-watering is required to reduce pressure within the coal seam which in turn allows the methane gas to be released from the coal.

Directional Drilling - An intentional deviation of the wellbore from its natural path. This method can be used when local topography (e.g. river banks or other water bodies) prevents vertical drilling. Under normal conditions, vertical drilling is used (i.e. the bottom of the hole is located beneath the drill rig).

Flaring - Flaring is the burning of natural gas as a means of disposal. It is restricted primarily to short-term testing, well workovers or exceedingly rare emergency situations.

Fracturing - Hydraulic fracturing is conducted to increase well productivity by injecting fluids at high pressure to create a more fractured and therefore permeable area. It is maintained by propping with sand to hold the fractures open.

Lignite - The lowest rank of coal, often referred to as brown coal, lignite is used almost exclusively as fuel for steam-electric power generation. It has a heat content ranging from 9-17 million BTU per ton.

Sub-bituminous Coal - Sub-bituminous coal's properties range from those of lignite to those of bituminous coal. The heat content of sub-bituminous coal ranges from 17-24 million BTU per ton.

Spacing and Target Area - The area required for, or allocated by regulation to, a well for producing petroleum or natural gas.

Workover - CBM wells may require additional work, or a workover, to maintain or improve production levels. Examples include well-bore flow stimulation by perforating or fracturing, installing water pumps in CBM wells, or cleaning. These activities require temporary rig setup on the well.

The Ministry of Energy and Mines and the Oil and Gas Commission are developing appropriate processes to govern this new industry and we welcome your views and opinions.

For more information about Coalbed Methane, visit our Web sites:

www.gov.bc.ca/em www.ogc.gov.bc.ca

or contact:

Coalbed Methane Strategy

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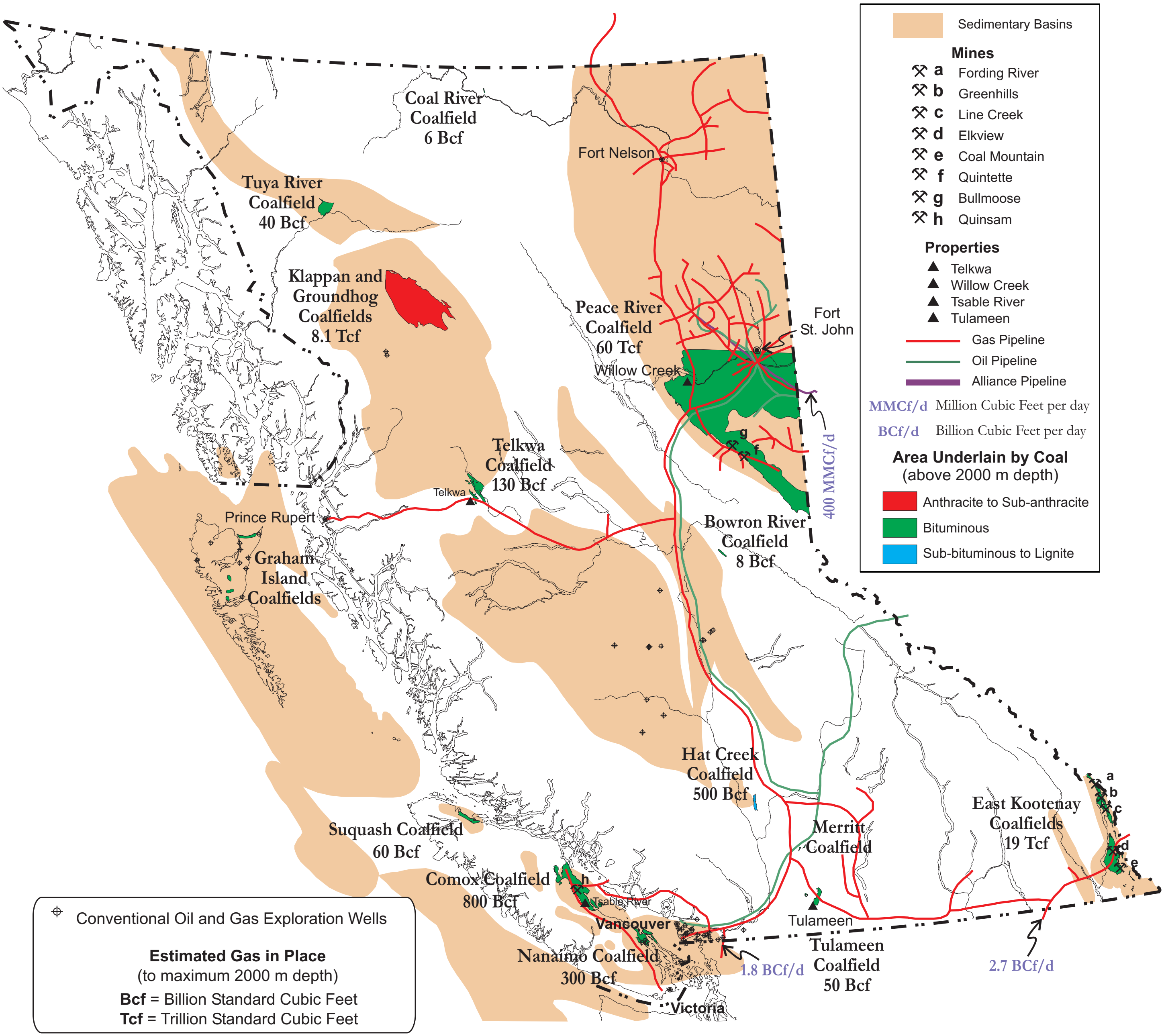
Coalfields and coalbed methane potential in British Columbia



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