6 CANADA

6.1 Summary of Coal Industry

6.1.1 ROLE OF COAL IN CANADA

Coal is the most abundant fossil fuel in Canada, comprising 66.5 percent of all its fossil fuel reserves (CAC, 2003a). Coal accounted for 10 percent of the primary energy produced in 2006 (EIA, 2009). Canada exports more than 40 percent of its tonnage as coking coal for steelmaking to Asian countries and some to Europe and Latin America. Conversely, Canada imports coal for electricity generation—estimated at about 20 million tonnes (Mmt) in 2007—primarily from the United States, Colombia, Venezuela, and Russia (NRC, 2008). About 89 percent of the coal consumed in Canada is for thermal power generation and the remainder is used in the steel (7 percent), cement, and other industries.

The recoverable coal reserves in the country are estimated at 6.6 billion tonnes. Though Canada's coal production had been declining, dropping from 78.7 Mmt in 1997 to 66.4 Mmt in 2002 (EIA, 2005), coal production is again on the rise, reaching 68 Mmt in 2007 from 66 Mmt in 2004 and 62 Mmt in 2003 (IEA, 2007).

Table 6-1 quantifies recoverable reserves and recent coal production in Canada.

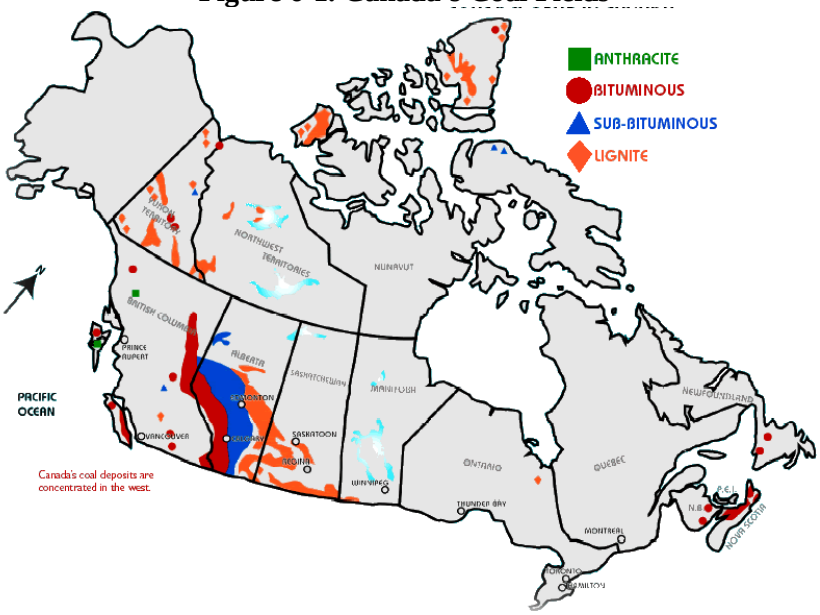
Table 6-1. Canada's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2006)*	3,471	3,107	6,578	13 (0.8%)
Annual Coal Production (2007)**	32.8	35.6	68.4	13 (1.1%)

Source: *EIA (2008); **IEA (2007)

Production occurs mainly in Alberta (43 percent), British Columbia (35 percent), and Saskatchewan (11 percent), as shown in Figure 6-1. Coal mines in eastern Canada, New Brunswick, and Nova Scotia are small operations.

Figure 6-1. Canada's Coal Fields



Source: CAC (2006)

6.1.2 STAKEHOLDERS

Table 6-2 identifies potential key stakeholders in coal mine methane (CMM) development in Canada.

Table 6-2. Key Stakeholders in Canada's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ The three giants in the coal industry (Luscar Ltd., Teck Cominco Ltd., and Fording Inc.) have merged to form the Elk Valley Coal Corp., with Teck Cominco as the managing partner. ▪ Western Canadian Coal Corp. ▪ Grande Cache Coal Corp. ▪ EnCana ▪ MGV Energy Inc. ▪ Apache Canada Ltd. ▪ Trident Exploration Co. ▪ Burlington ▪ Nexen ▪ Anadarko ▪ Talisman ▪ CDX ▪ Thunder ▪ Dominion ▪ APF ▪ Vectren ▪ Others	Project hosts

Stakeholder Category	Stakeholder	Role
Developers	▪ VWVulcan Energy of Canada, Ltd. ▪ Trident Exploration ▪ Husky Energy ▪ Nexen ▪ Red Willow ▪ Also see http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Universities, Research Establishments	▪ University of Montana (Water Quality Management) ▪ Alberta Research Council ▪ Natural Resources Canada ▪ Canadian Mineral and Energy Technologies (CANMET)	Technical assistance
Government Groups	▪ Natural Resources Canada ▪ Alberta Ministry of Energy ▪ British Columbia Ministry of Energy, Mines, and Petroleum Resources	Permitting and licensing
Professional Associations	▪ Canadian Association of Petroleum Producers (CAPP)	Technical assistance

Source: AAPL (2005)

6.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Practically all coal mined in Canada (97 percent) is extracted by surface mining methods. Vancouver Island in British Columbia has the only operational underground mine in Canada (CAC, 2003a). Table 6-3 provides statistics on Canadian coal mining.

Table 6-3. Canada's Most Recent Statistics for Coal Mining

Type of Mine	Production (million tonnes)	Number of Mines
Underground (active) mines – total	*0.47 (2001)	**1 (2003)
Surface (active) mines – total	*70 (2001)	**19 (2003)

Source: *Coal Stats (2001); **CAC (2003a)

The country largely produces bituminous coal, which accounted for 48 percent of its entire coal production in 2001. Sub-bituminous coal, mined in Alberta, forms the next largest component in Canada's coal production at 35 percent. No anthracite currently is mined in Canada, although some has been discovered in British Columbia. Lignite occurs in Saskatchewan and Alberta and is used to produce 65 percent of Saskatchewan's electricity.

The operational status of Canadian coal mines is illustrated in Figure 6-2, while Table 6-4 lists mine status by region.

Figure 6-2. Status of Canada's Coal Mines

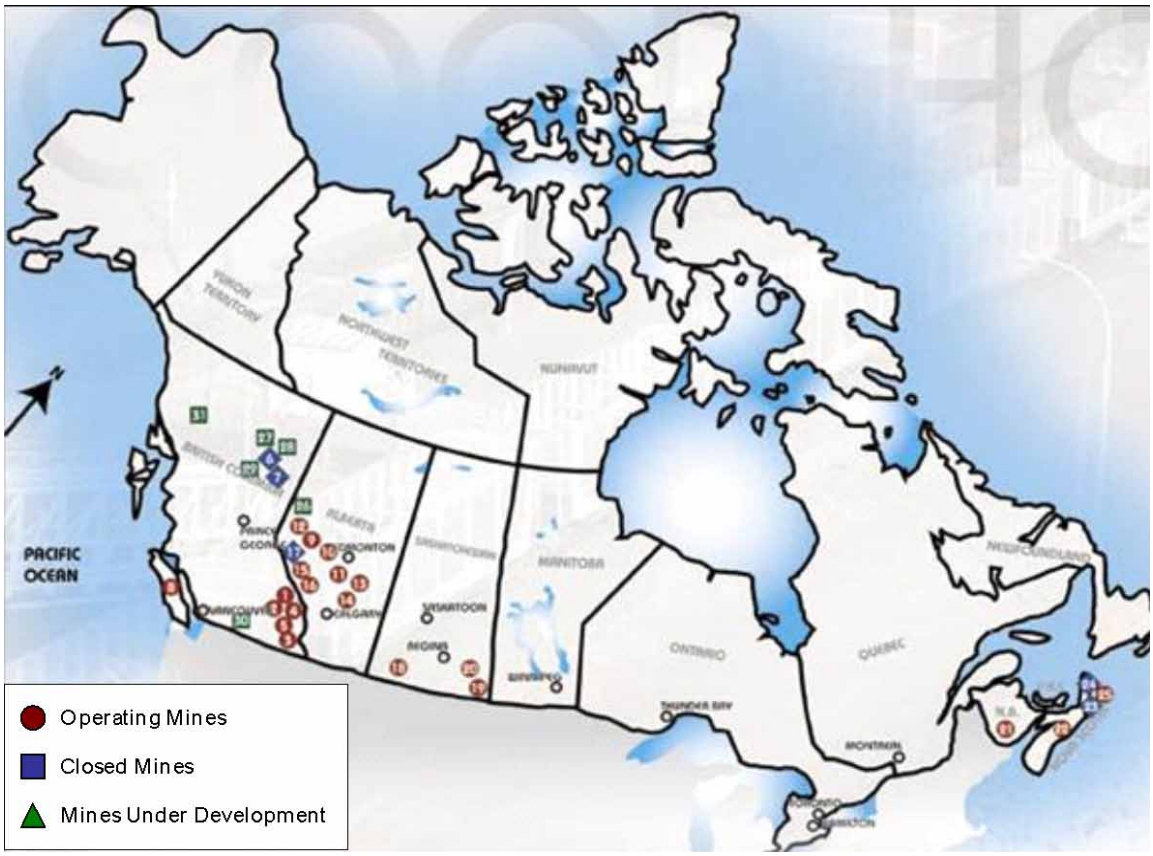


Table 6-4. Status of Canada's Coal Mines

Region	Operating Mines		Closed Mines	Mines Under Development
British Columbia	1. Fording River 2. Greenhills 3. Coal Mountain Trend*	4. Line Creek 5. Elkview 8. Quinsam 29. Wolverine Creek 27. Willow Creek (Brule)	6. Bullmoose (2003) 7. Quintette (2000) Basin Coal Mine (2008)	28. Burnt River 30. Tulameen 31. Mount Klappan
Alberta	9. Highvale 10. Whitewood 11. Genesee 12. Obed Mountain	13. Paintearth 14. Sheerness 15. Cardinal River (Cheviot Creek) 16. Coal Valley 26. Grande Cache	17. Gregg River (2000) Luscar (2004)**	
Saskatchewan	18. Poplar River 19. Bienfait	20. Boundary Dam		

Region	Operating Mines		Closed Mines	Mines Under Development
New Brunswick			21. Salmon Harbour (2009)	
Nova Scotia	22. Stellarton (nee Pioneer) Greenhills Development - Florence***	25. Point Aconi/Brogan***/ Sullivan and Toronto Road Mines**	23. Phalen (1999) 24. Prince (2001) Evans (2003) **	

Note: Number by mine name indicates location on Figure 6-2
Source: CAC (2006); *USGS (2008); **Atlas (2009); ***Nova Scotia (2009)

The coal deposits in central and southern parts of Alberta and Saskatchewan lie in blankets of uniform thickness close to the surface, while the coal around the British Columbia/Alberta border run into mountainous terrain and the seams can be as thick as 15 meters, deeply buried and inclined, making mining a challenge. In eastern Canada, Nova Scotia contains the largest coal deposits. The largest one, Sydney coalfield, has 11 seams that are 1.0 to 4.5 m thick and is located under the ocean. Economics posed challenges to extracting that coal, however, and the mines were closed. Furthermore, the mining conditions are quite difficult and dangerous in the region as evidenced by an explosion and fatalities at the Westray mine. The coal in Ontario has a low-heat value and is not exploited. Finally, the potential of coal deposits in the northern half of the country have yet to be explored (CAC, 2003a).

The Canadian coal industry has undergone major restructuring recently with the consolidation of mining companies starting in 2003. The three giants in the coal industry – Luscar Ltd., Teck Cominco Ltd., and Fording Inc. – merged to form the Elk Valley Coal Corp. (EVCC), with Teck Cominco as the managing partner of EVCC. As part of the deal, Luscar Energy Partnership bought the thermal coal assets of Fording to become the largest producer of thermal coal in Canada. Luscar's assets include the undeveloped coalfields, royalty interests, mining service contracts, and an interest in a joint mining venture. With these mergers, Luscar Coal Ltd. and EVCC are in charge of 99.5 percent of the entire Canadian coal production, operating all 15 large-scale mining operations (>1 Mmt per year) (NRC, 2005). In 2008, Teck bought out the Fording Canadian Coal Trust (Mining Exploration News, 2008).

Although domestic consumption of coal has declined recently, coking coal exports are on the rise with an increasing demand for metallurgical coal worldwide, especially as China turns into an importer of coking coal. EVCC has increased metallurgical coal production and opened the Cheviot Creek Pit near Hinton, Alberta. The production was 2.0 Mmt peryear of coking coal in 2008. In recent years, six more mining projects have been or are under development by individual companies, five in British Columbia (Licensees: Western Canadian Coal Corp., Northern Energy and Mining, and Aurora Coal) and one in Alberta (the now active Grande Cache). In eastern Canada, Nova Scotia is taking steps to restart coal mining, although a contract has not yet been assigned.

6.2 Overview of CMM Emissions and Development Potential

6.2.1 CMM Emissions from Operating Mines

There are no CMM utilization projects in Canada. Table 6-5 summarizes the country's CMM emissions.

Table 6-5. Canada's CMM Emissions (million cubic meters)

Emission Category	1990	1995	2000	2005	2006	2007	2008
Underground mine	84.54	67.15	20.29	4.60	6.61	6.64	5.66
Post-underground mine	-	-	-	-	-	-	-
Surface mine	49.50	52.79	46.15	46.22	43.03	46.87	47.14
Post-surface mine	-	-	-	-	-	-	-
Total	134.03	119.94	66.44	50.82	49.65	53.51	52.80

Source: UNFCCC (2010)

6.2.2 CMM EMISSIONS FROM ABANDONED COAL MINES

In 2003, there were at least three abandoned underground mines in Canada (CAC, 2003b). No specific information about CMM from abandoned mines is available at this time.

6.2.3 CBM FROM VIRGIN COAL SEAMS

Assessing the extent of coalbed methane (CBM) prospects in Canada has only recently started. The results are illustrated in Figures 6-3, 6-4, and 6-5 on following pages. According to the Canadian Gas Potential Committee, however, they could be anywhere between 5.3 and 13 trillion cubic meters (TCM). These estimates are from exploration mainly in the Western Canada Sedimentary Basin. Table 6-6 lists the major Canadian CBM exploration sites.

Table 6-6. Canada's Major CBM Reserves

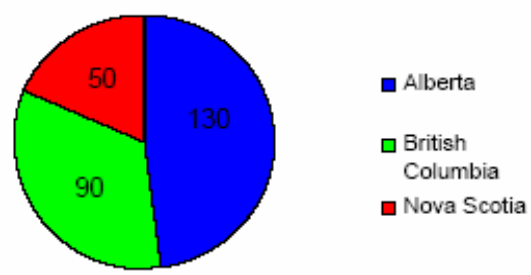
Location	Reserves (trillion cubic meters)
Horseshoe Canyon	1.04
Pembina (including Ardley)	0.84
Mannville	4.76
Alberta/BC Foothills (Gates/Mist Mtn)	3.7

Source: AAPL (2005)

Alberta's reserves could range from 3.8 to 11.6 TCM (ACR, 2003). The primary CBM potential areas in Alberta are the Ardley, Horseshoe Canyon, and the Mannville coal zones, with the Upper Manville being the gassiest zone. Alberta offers particularly favorable conditions for CBM development as the geology of CBM deposits are relatively simple and uniform over a wide area (Amazouz, 2006). Within British Columbia, the major concentration is in the northeast and to a much lesser extent in the southeast of the province, amounting to a total of 2.5 TCM (BC, 2002). Nova Scotia forms the third largest portion of the Canadian CBM reserve.

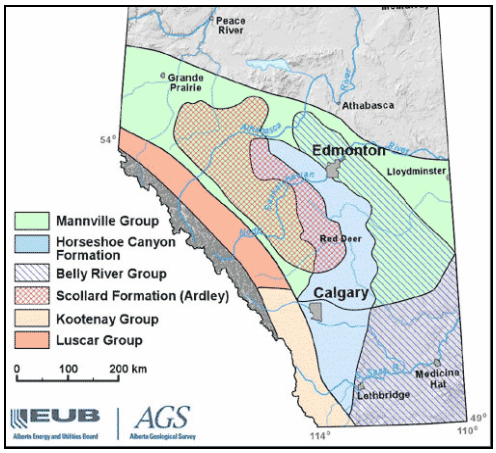
Figure 6-3. Location of Probable Economically Recoverable CBM Reserves in Canada

(trillion cubic feet)



Source: Alberta Energy and Utilities Board (2004)

Figure 6-4. Primary CBM Potential Areas in Alberta



Source: Alberta Energy and Utilities Board (2004)

The CBM industry is very new in Canada compared to its neighbor, the United States. However, in Alberta alone, there were more than 3,500 CBM wells in place by 2004, with most of these concentrated in Alberta and British Columbia (Snyder, 2005). A forecast report projected annual CBM production of 14.5 billion m^3 by 2015 for all of Canada (NAEWG, 2005; Amazouz, 2006).

The first Canadian methane production began in 2002 in the Horseshoe Canyon region in Alberta. The Horseshoe Canyon coals are dry and relatively close to the surface, enabling easy gas recovery. Therefore, these fields accounted for 90 percent of the producing wells in Alberta in 2005 (Snyder, 2005), generating more than 2.8 million m^3 per day of methane. Alberta's CBM production in 2005 totaled 2.5 billion m^3 (Amazouz, 2006). By 2008, there were 6000 wells producing 5.2 billion m^3 per year, all located in Alberta (International, 2008). By 2010, a total of 14,000 wells had been drilled (not all of which are active) and production is approximately 7.2 billion m^3 per year (Ember, nd).

Table 6-7 provides highlights of significant methane production projects in Canada.

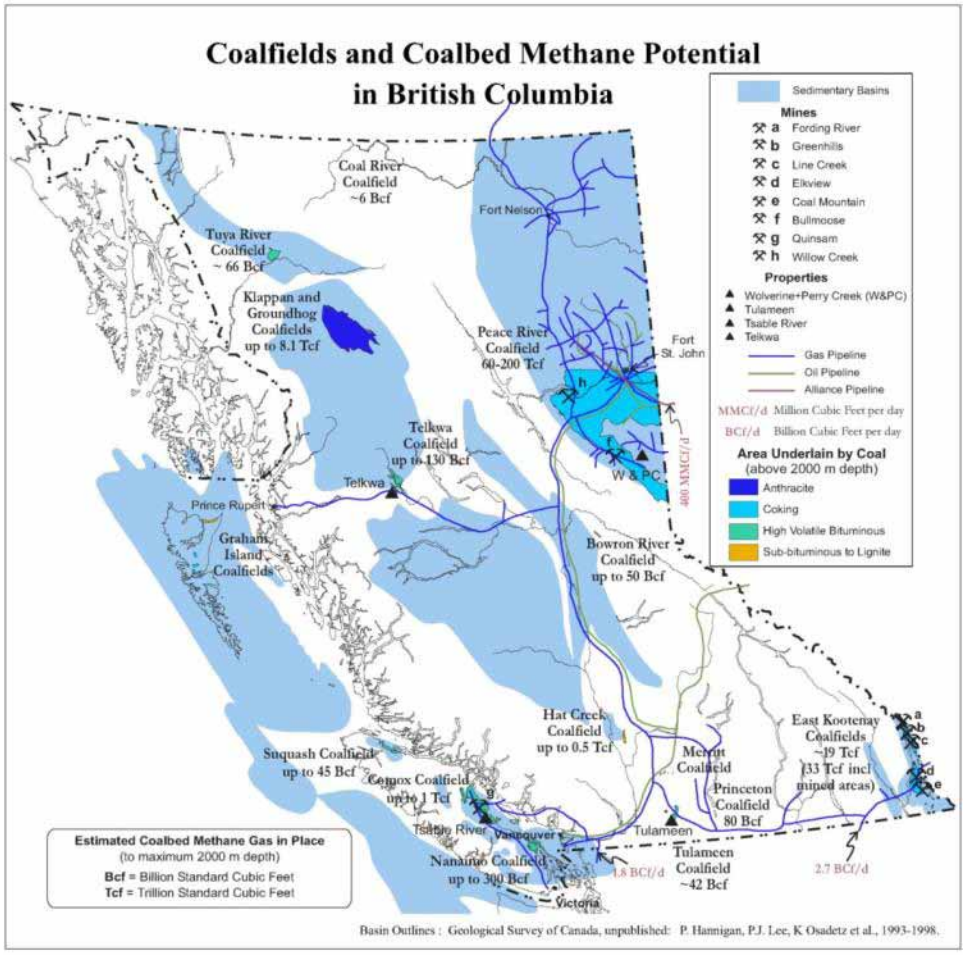
Table 6-7. Profile of a Joint Venture between EnCana and MGV Energy, the Most Productive Project in Canada

Site	Mine Type (active/abandoned, etc.)	Average Methane (CH_4) Used / Emissions Avoided (million m^3/day) (2004)	Project Operating Period	Use of Methane
Horseshoe Canyon, Alberta	N/A	0.48 from 577 wells (1.68 from 1,000 wells predicted for 2005)	2003–present	N/A
Nevis field, Southern Alberta	N/A	.98	2003–present (expected to last 15–20 years)	N/A

Site	Mine Type (active/abandoned, etc.)	Average Methane (CH_4) Used / Emissions Avoided (million m^3/day) (2004)	Project Operating Period	Use of Methane
Between Campbell River and Nanaimo in Vancouver Island, British Columbia	Active underground mine	Peak production of 2.24 in 2009–2010 (on average, 4.2 thousand m^3/day per well)	2002–2017	Homes, business and industry

Source: EnCana (2004); Apache (2005); VWV (2001)

Figure 6-5. CBM Potential in British Columbia



Source: BC (2002)

Additional CBM Exploration and Production

A number of companies have explored CBM projects on Vancouver Island where the coal rank is bituminous with cumulative coal seam thickness of 23 feet. Priority Ventures Ltd. conducted some test drilling in 2001, while Quinsam Coal Corporation allied with CornerStone Gas to explore CBM development on the island (BC, 2009).

West Fraser Timber Co, with VWVulcan Energy of Canada, Ltd., applied for freehold rights on the island. VWVulcan planned for tests in 2002 with 10 wells to explore the regional production capacity; an additional 500 to 600 production wells were also planned to be drilled in the following five to six years. With an expected well life of 15 years, total gas to be recovered over the period was estimated at 7 million m^3 (of the projected 14–28 million m^3 of total recoverable resource). These projects have stalled, however, with fluctuations in natural gas prices and the worldwide economic downturn.

Trident Exploration worked with Husky Energy to develop CBM in the Fenn Rumsey area. The joint venture started in 2002, was extended in 2004, and planned to drill some 400 exploratory wells by 2006 (Husky, 2005). In a second project, Trident worked with Nexen and Red Willow to start the first CBM venture in the Mannville formation in Alberta (Jones, 2005), and by 2008, they had completed 650,000 m of drilling in Mannville (Trident, 2008). Royal Dutch Shell has licenses for tenure to explore for CBM in the Kaplan area of northwest British Columbia (Shell, nd). BP has tenure at its CBM project at Mist Mountain in southeast British Columbia (BP, 2010).

By mid-2008, approximately 60 CBM exploration wells had been drilled outside of Alberta but no commercial production existed. The British Columbia and Nova Scotia coals generally exhibited low permeability, and coals in Ontario and Saskatchewan showed insufficient gas for commercial production (International, 2008). But by December 2008, GeoMet Inc. began the first commercial delivery of CBM from the Peace River project in British Columbia (Allbusiness, 2009). By January 2009, Nova Scotia also had three CBM projects, two of which are Stealth Ventures Inc. projects in Cumberland and Stellarton basins. The third project is in the Sydney basin of northern Nova Scotia (Prospect Profile, 2009).

6.3 Opportunities and Challenges to Greater CMM Recovery and Use

Canada is a signatory to both the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (see Table 6-8). As an Annex I Party, its emissions target under the Kyoto Protocol is to achieve a 6 percent reduction of 1990 greenhouse gas (GHG) emission levels by 2010.

Table 6-8. Canada's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 12, 1992	December 4, 1992
Kyoto Protocol	April 29, 1998	December 17, 2002

Source: UNFCCC (2004); UNFCCC (2005)

Canada promotes clean energy projects to reduce its GHG emissions and emission credits could be one form of CBM project financing (ASB, 2004).

6.3.1 Market and Infrastructure Factors

The major issues that concern the Canadian CBM industry are geology, land consolidation and access, freehold leases, water disposal (both brine and fresh), regulatory matters, and CBM technology (Ziff, 2004). In general, all CBM projects are private-industry-driven in Canada, with companies typically forming partnerships to commercially develop CBM projects.

Canada joined the Global Methane Initiative (formerly Methane to Markets Partnership) in July 2005. Canada's efforts thus far, however, have been largely limited to the oil and gas industry (Canada is a member of the Oil and Gas Subcommittee). Long-term consumption of natural gas is expected to grow

steadily in Canada, while domestic production of conventional natural gas is believed to have peaked in 2003 (Amazouz, 2006). The expected shortfall will be met by a number of alternative natural gas resources:

- Mackenzie Delta and Beaufort Sea fields
- Other remote gas fields (north of 60th parallel)
- Liquefied natural gas importation
- Offshore East Coast and West Coast gas fields
- CBM reserves estimated at 4.7 TCM (CAPP, 2004)

Canada is also pursuing other avenues of alternative gas resources. In 1996, Natural Resources Canada's Canmet Energy Technology Centre – Varennes initiated the development of a catalytic reactor that could, both technically and economically, recover the methane of coal mine ventilation air. The technology, called CH4MIN, recovers the energy of the dilute ventilation air methane, with an efficiency varying between 40 and 95 percent, depending on the methane concentration in the ventilation air (Amazouz, 2006). Researchers at Canadian Mineral and Energy Technology in Quebec developed CH4MIN technology in 1995. CH4MIN is currently at the industrial demonstration development stage and has run large pilot-scale projects at the Phalen Coal Mine in Nova Scotia. The company is exploring the economic viability of CH4MIN in China, but no commercial-scale implementation is planned in Canada (CH4MIN, 2003).

Further on the research and development (R&D) front, the Alberta Research Council has been collaborating with the American, Canadian, and other governments to improve CBM recovery efficiency (ACR, 2003). Non-nuclear government research and development spending is managed by Natural Resources Canada. The Program of Energy Research and Development (PERD), managed by Natural Resources Canada's Office of Energy Research (OERD15), is the major source of government funding for non-nuclear public and private research and development. Natural Resources Canada's Energy Technology Branch (ETB), which includes three laboratories in the Canada Centre for Mineral and Energy Technology, is the largest federal participant in, and manager of, non-nuclear science and technology programs. ETB receives a large share of PERD funds.

Canadian infrastructure is also being adapted to keep in step with its growing CBM/CMM industry. The Alberta Energy and Utilities Board recently approved Canada's major pipeline network for natural gas transportation, TransCanada PipeLines, to reconfigure its system to allow the low-pressure intake of CBM (Jones, 2005). CBM has to compete with other sources of Canadian gas in order for it to be purchased by pipelines that transport the gas to the United States or Canadian consumers.

6.3.2 REGULATORY INFORMATION

Initially, there was controversy regarding the ownership of CBM rights in Canada since coal and natural gas come under different jurisdictions. CBM rights in both British Columbia (BC) and Alberta now follow the legal framework for natural gas. The provinces own and can sell the rights to develop CBM at their discretion. The *Coalbed Gas Act* clearly attributes all CBM rights to the owners of natural gas mineral rights and none to the owner of coal rights (ASB, 2004). Canadian regulations enforce consultation with affected stakeholders and governments before development begins (CAPP, 2003). In BC, a potential producer must get Petroleum and Natural Gas tenure rights before production (BC, nd). In Nova Scotia, the *Petroleum Resources Act* recognizes coal gas as a distinct resource but has included it with the definition of petroleum as "coal gas, existing in its natural condition in strata." A specific coal gas agreement is also required before exploration, development, or production of CBM (Blakes, 2006). In

Saskatchewan, CBM is defined by The Petroleum and Natural Gas Regulations of 1969 and is administered just like any other petroleum or natural gas development (Saskatchewan, nd).

Canada does not have federal tax credit incentives in place to stimulate investment in CBM technologies because legislative power rests largely with provincial governments. BC relies on a royalty incentive program to encourage CBM production. Recent amendments to the BC Petroleum and Natural Gas Royalty Freehold Production Tax Regulation allow water treatment costs to be included in the producer's cost of service allowances for CBM wells, place the production threshold at 17,000 m^3 per day before a royalty is imposed on a CBM well, and raise the royalty credit on each well to $50,000 (BC Royalty, nd).

In the *Petroleum and Natural Gas Act*, CBM projects are not subject to well-spacing regulations (more wells are often required per field compared to natural gas resources) and CBM production data can stay confidential for an extended period (ASB, 2004).

CBM producers are subject to strict rules that apply at every stage of project development. All the federal and provincial wildlife and environmental laws and the elaborate industry-specific regulations apply to the CBM producers as well (CAPP, 2003).

6.4 Profiles of Individual Mines

Ardley and Lower Edmonton Mines, Alberta

General Overview

Total mining area, squared kilometers (km^2)	Several hundreds
No. of coal seams	1–30
Total methane resource	0.84 trillion cubic meters
Rank of coal	Sub-bituminous, high-volatile
Cumulative thickness	Up to 25 meters
Depth of mining	200 to 700 meters
Moisture	Dry
Gas content average	1.87 m^3/tonne
Mining method	Surface

Upper Mannville Mines, Alberta

General Overview

No. of coal seams	2–5
Total methane resource	4.76 TCM
Rank of coal	Bituminous
Cumulative thickness	Up to 20 meters
Depth of mining	800 to 1500 meters
Moisture	High (dewatering required)
Gas content average	9.4–15.6 m^3/tonne
Mining method	Surface

Source: Sproule (2004)

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