

**EMD Coalbed Methane Committee
2016 EMD Mid-Year Leadership Meeting Report
December 7, 2016**

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EXECUTIVE SUMMARY

Coalbed methane (CBM; also known as coal-bed methane, coalbed natural gas, coal seam gas) is a type of unconventional natural gas generated and stored in coal beds. Sorbed gas is released and produced from coal following the reduction of hydrostatic pressure with the removal of water from coal cleats and other fractures during drilling. Coal mine methane (CMM), on the other hand, is gas produced in association with coal mining operations.

Production of natural gas from coal beds in the United States continued to decline in 2014 while reserves increased. [Note: United States CBM production and reserves data comes from the EIA. The next report release date is December 2016 for 2015 data.] CBM is still an important resource globally. Research on CBM remains active, however, as indicated by the 40 technical papers published in 2016. These references have been added to the 85-page CBM bibliography available soon on the EMD Coalbed Methane Committee web site

<http://www.aapg.org/about/aapg/overview/committees/emd/articleid/24810/committee-emd-coalbed-methane>).

Mastalerz (2014, figure 7.3) included a map showing world CBM resources, production, and exploration activities as summarized below, modified by data from Kelafant (2016).

CBM Resources by Country		
Country	Mastalerz (2014) 2010 Resources, Tcf	Kelafant (2016) Tcf
Russia	2,824	
China	1,100	1,300
Alaska	1,037	
U.S. (minus Alaska)	700	
Australia	500	203
Canada	500	801
Indonesia	435	
Poland	424	
France	368	
Germany	100	
UK	100	

India	70	120
Ukraine	60	
Zimbabwe	40	
Kazakhstan	25	27
Southern Africa		110

Annual CBM Production by Country (2010 data) (from Mastalerz, 2014)	
Country	Production, Bcf
U.S. (minus Alaska)	1,886
Canada	320
Australia	190
China	50
Alaska	1
Russia	0.5
India	0.4
Kazakhstan	0.4

STATUS OF U.S. COALBED METHANE ACTIVITIES

EIA (2009a) shows a map of U.S. lower 48 states CBM fields (as of April 2009). U.S. annual CBM production peaked at 1.966 Tcf in 2008 (EIA, 2009b, 2010, 2015a). CBM production declined to 1.404 Tcf in 2014 (EIA, 2015a; the next report release date is December 2016), the lowest level since 2001, representing 5.0% of the U.S. total natural gas production of 28.1 Tcf (Figure 1). Note that U.S. CBM production in EIA (2015a, Table 15) is different than in EIA (2015b, Table 1). According to EIA (2015a, Table 15), the top 8 CBM producing U.S. states during 2014 (production in Bcf) were Colorado (412), New Mexico (373), Wyoming (264), Virginia (108), Alabama (78), Oklahoma (61), Utah (47), and Kansas (27). CBM production increased over the previous year for Alabama, New Mexico, and Virginia (Figure 2). Annual CBM production by U.S. state (through 2014) is available at EIA (2016a; next release date is December 31, 2016). Cumulative U.S. CBM production from 1989 through 2014 was 33.4 Tcf. CBM production continues even though few new wells are being completed, reflective of the very long productive lives of CBM wells. As many U.S. CBM fields approach late maturity in an environment of low commodity price, operators are working to optimize operations and reduce lifting costs. In the Black Warrior Basin of Alabama, for example, compressors are being used to produce large numbers of mature wells on vacuum, which has resulted in increased gas production and reduced pumping and water handling costs.

According to EIA (2016a, data through 2014), annual peak CBM production in the top 8 CBM producing U.S. states during 2014 occurred in the following years: Colorado (533 Bcf in 2010), New Mexico (597 Bcf in 1997), Wyoming (573 Bcf in 2008), Virginia (111 Bcf in 2009), Oklahoma (82 Bcf in 2007), Alabama (123 Bcf in 1998), Utah (103 Bcf in 2002), and Kansas (47 Bcf in 2008)(Figure 2). The web site <http://www.wyohistory.org/essays/coalbed-methane-boom-bust-and-hard-lessons>

provides a history of Wyoming CBM production. U.S.G.S. (2014) includes hyperlinks to USGS CBM assessment publications and web pages.

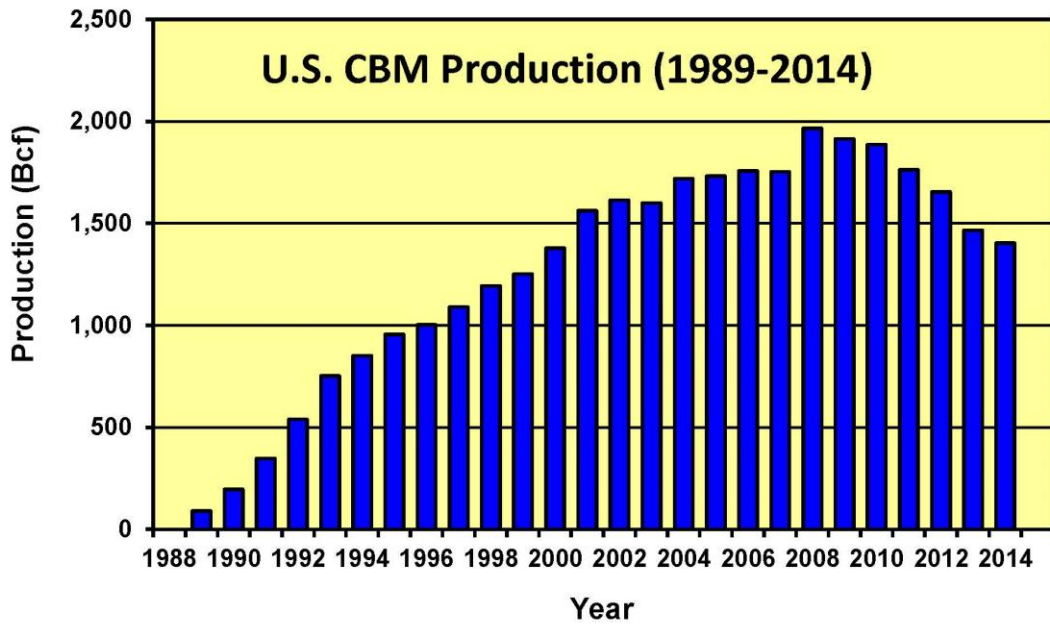


Figure 1. United States CBM production (1989–2014; compiled from EIA).

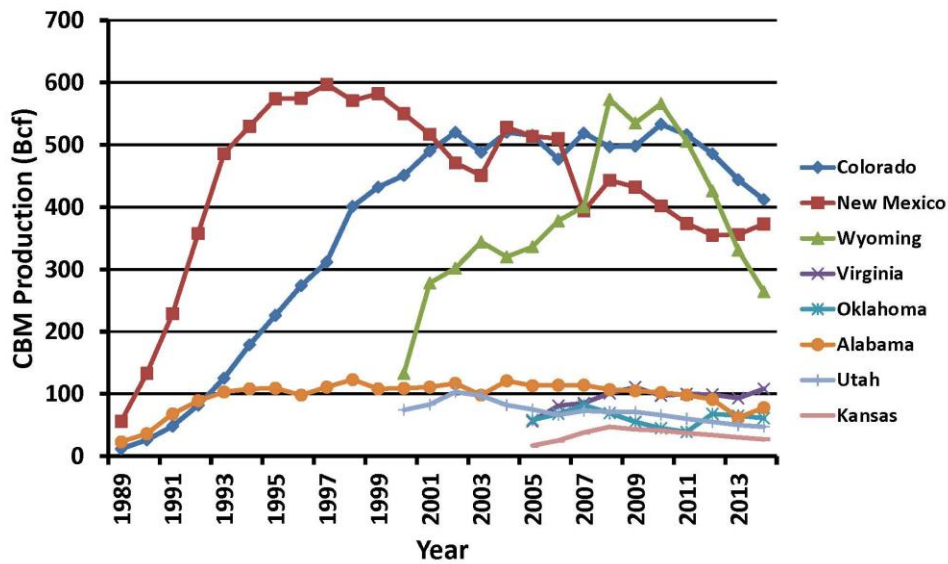


Figure 2. Annual CBM production of the top 8 U.S. states during 2014 (1989–2014; compiled from EIA, 2015a, Table 15).

United States annual CBM proved reserves peaked at 21.874 Tcf in 2007 (EIA, 2009b, 2010, 2015a), with a jump from the previous year to 15.696 Tcf in 2014 (EIA, 2016b) representing 4.2% of the U.S. total natural gas reserves of 369 Tcf (Figure 3).

Annual CBM proved reserves by U.S. state (through 2014) is available at EIA (2016b; next release date is December 31, 2016).

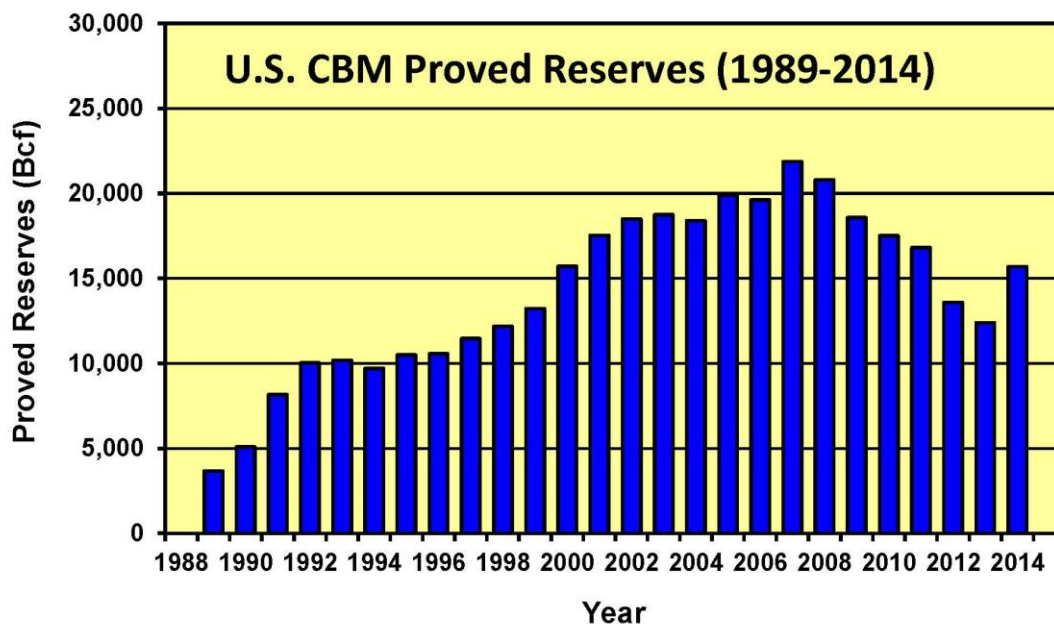


Figure 3. United States CBM proved reserves (1989-2014; compiled from EIA).

The EPA Coalbed Methane Outreach Program (<https://www.epa.gov/cmop>) has information on U.S. coal mine methane, including a map of CMM recovery at active and abandoned U.S. coal mines.

STATUS OF INTERNATIONAL COALBED METHANE ACTIVITIES

Australia

Towler et al. (2016, p. 254) provided “An overview of the coal seam gas developments in Queensland”, in which they reported “In the 2014/2015 fiscal year Queensland produced 469 Bcf of gas, of which 430 Bcf was CSG” from the Bowen and Surat basins. The most recent Queensland Government petroleum and coal seam gas report is available at <https://publications.qld.gov.au/dataset/queensland-petroleum-and-coal-seam-gas>.

From EIA Australia International energy data and analysis <http://www.eia.gov/beta/international/analysis.cfm?iso=AUS> (accessed October 20, 2015).

Australia has sizeable, untapped natural gas resources in the form of coalbed methane (CBM), known as coal seam gas in Australia, and shale gas. Australian officials estimate that economically recoverable CBM reserves in 2012 were 33 Tcf, mostly contained in the Surat Basin and Bowen Basin in Queensland. Commercial production from CBM began in

1996 and totaled 246 Bcf in 2012, accounting for almost 13% of total natural gas production, according to BREE.

Many CBM projects are still being explored, and production is not targeted for another few years. Investors face challenges with project delays based on greater public resistance to potential environmental impacts. Australia is attempting to balance its dual interests of increasing investment and exploitation of these resources as well as developing them in a sustainable and environmentally safe way. NSW, Queensland, and the federal government have increased environmental regulations, particularly those related to water use and disposal and land rights in CBM and shale gas projects. Queensland established more austere water safety and management policies for CBM producers. In 2012, NSW replaced the moratorium it imposed in 2011 on hydraulic fracturing with a Strategic Regional Land Use Policy that restricts CBM production near residential areas and small industries. South Australia, which houses part of the Cooper Basin, was the first province to publish extensive guidelines for gas development. The guidelines intend to encourage investment and development of these projects while outlining environmentally safe extraction practices.

Flores (2013, figure 9.15) included a map showing coal seam gas (CSG) potential in Australia noting that the coal beds range in age from Permian to Tertiary in about 30 coal-bearing basins. Blewett (2012) included maps showing the distribution of demonstrated black coal resources and gas resources in Australia. CSG reserves in 2012 are divided into six coal basins in eastern Australia: Surat Basin (69%), Bowen Basin (23%), Gunnedah Basin (4%), Gloucester Basin (2%), Sydney Basin (1%), and Clarence-Moreton Basin (1%)(Flores, 2013). The Australia country analysis brief is available at EIA (2015c).

An interactive map of coal seam gas wells in Australia (unknown date) is available at <http://www.abc.net.au/news/specials/coal-seam-gas-by-the-numbers/>. An interactive map of coal seam gas wells in New South Wales as of July 25, 2016 is available at <http://www.resourcesandenergy.nsw.gov.au/landholders-and-community/coal-seam-gas/facts-maps-links/map-of-csg-wells>. Relatively few wells are producing gas, while most of the wells have been plugged and abandoned.

China

CBM production in the first half of 2016 in China was 3.64 billion m³ with a growth of 8%, reported by the China Coal Bed Methane Industry Market Research Report (Figure 4; <http://www.chyxx.com/industry/201608/436189.html>). Estimated 2016 annual CBM production from virgin coal is 19 billion m³, of which up to 9.2 billion m³ is utilized domestically. The North China area is the main CBM production area with 82.84% of the total CBM production in China (<http://www.chyxx.com/data/201610/455528.html>). The Qinshui Basin in Shanxi Province, North China, has CBM proved reserves of 280 billion m³ as of mid February, 2016; annual CBM production in this basin is up to 4.3 billion m³

and the CBM daily production is more than 2.3 million m³ (<http://coal.in-en.com/html/coal-2333146.shtml>). The potential CBM geological units in the Qinshui Basin are still in an exploration stage, but both vertical and horizontal wells, and staged fracturing techniques, are planned to different coals.

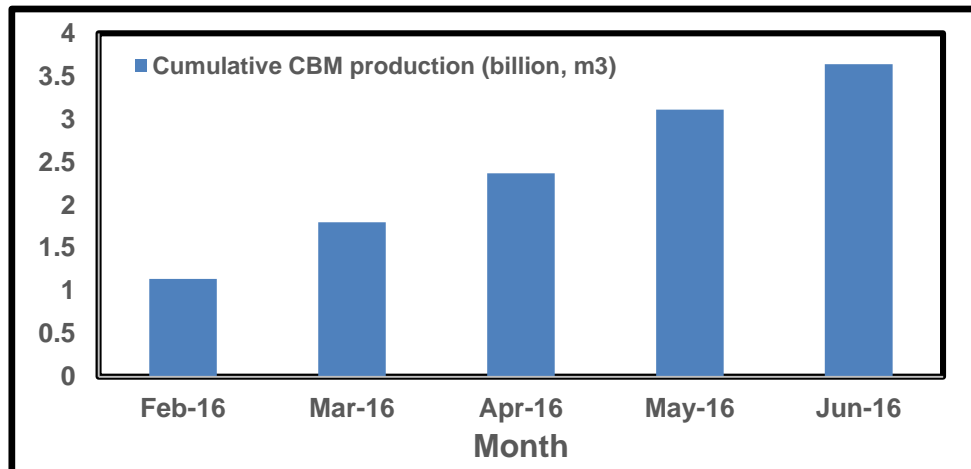


Fig. 4. China CBM production in the first half of 2016.

In 2015, 45 coal mine gas accidents happened with the deaths of 171 people (year-on-year decrease of 8.2% and 37.1%, respectively). CMM in China is available at <https://www.epa.gov/cmop/coal-mine-methane-china>.

Canada

A map showing natural gas fields and CBM potential in Alberta, Canada is at http://www.energy.alberta.ca/NaturalGas/Gas_Pdfs/map_Fields.pdf. General information on coalbed methane in Alberta is available from the Alberta Geological Survey (<http://ags.aer.ca/activities/coalbed-methane>) and Alberta Department of Energy (<http://www.energy.alberta.ca/OurBusiness/753.asp>, <http://www.energy.alberta.ca/OurBusiness/754.asp>). The Alberta Energy Regulator (<http://www.aer.ca/rules-and-regulations/by-topic/coalbed-methane>) regulates CBM production in Alberta. Rottenfusser et al. (2002) and Beaton et al. (2004) discussed CBM potential of the Alberta Plains and Foothills.

CBM production in Canada comes mainly from Cretaceous and Tertiary coals in the Western Canada Sedimentary Basin (Flores, 2013). According to the Alberta Energy Regulator (ST59; <http://www.aer.ca/data-and-publications/statistical-reports/st59>), there were 36 CBM development wells in 2014 and no CBM exploratory or development wells during 2015 or 2016 in Alberta. According to Alberta Energy (<http://www.energy.alberta.ca/OurBusiness/754.asp>), the first commercial coalbed methane project in Alberta was announced in 2002 and there were 19,269 CBM wells in Alberta, Canada as of December 31, 2012. The Alberta Geological Survey web site (2016) reported an estimated CBM resource in Alberta of up to 500 TCF (divided into 148 TCF for Upper Cretaceous/ Tertiary – Plains, 321 TCF for Mannville coals - Plains, and 31 TCF for the foothills/mountains)(Alberta Energy Regulator, 2015, p. 5-25). Historically most of the CBM production in Alberta was from the Horseshoe Canyon and

Belly River Formations with some deep wells to the Mannville Formation coals (<http://www.energy.alberta.ca/OurBusiness/754.asp>). Wynne and Beaton (2011) compiled a coal and CBM database for the Alberta Plains area. According to the Alberta Energy Regulator (2015, p. 5-35), 90 new CBM and CBM hybrid (recompletion) vertical wells were completed in the Horseshoe Canyon play area in 2014 while no new CBM wells were completed in the Mannville Corbett play. Canadian average daily CBM production rates have declined since 2009 while the number of producing wells has reached a plateau of around 20,000 (Figure 5). Alberta CBM rules and directives are at <http://www.aer.ca/rules-and-regulations/by-topic/coalbed-methane>.

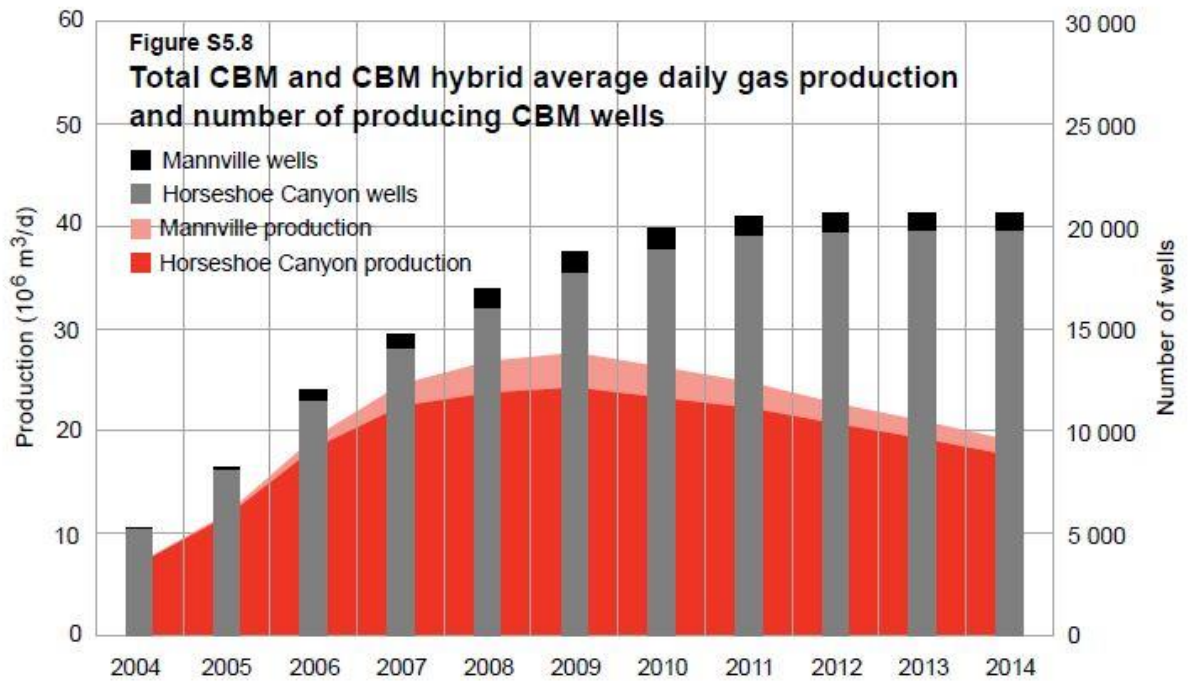


Figure 5. Canada CBM average daily gas production rates and number of producing wells from 2004–2014 (from Alberta Energy Regulator, 2015, p. 5-35).

India

Bhattacharya (2016, p. 51) reported that “India contains 60.6 billion tonnes of coal...could contain up to 4.6 trillion m³ of gas.” Of 33 CBM exploration blocks awarded since 2001, only three blocks are producing gas. “The lack of commercial production stems from factors including the lack of detailed reservoir characterization, the lack of professional training for domestic companies, and the lack of equipment and advanced CBM technology in the most productive basins” (Bhattacharya, 2016, p. 51).

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http://ags.aer.ca/publications/ESR_2002_06.html
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Coalbed Methane Calendar

- April 11-12, 2017: North American Coalbed Methane Forum 57th session in Pittsburgh, PA. <http://www.nacbmforum.com/conference.html>
- September 5-8, 2017: 34th Annual International Pittsburgh Coal Conference, Pittsburgh, PA. Session 9 is on “Coal bed methane and shale gas”. <http://www.engineering.pitt.edu/pcc/>

EMD Coalbed Methane Committee Web Links

General

Coalbed Methane Links:

http://explorationgeology.com/public_html/General_Geology/General_Geology_CBM.html

North American Coalbed Methane Forum: <http://www.nacbmforum.com>

Data

U.S. Bureau of Mines CBM Content Database: <http://gswindell.com/blmcoalb.htm>

Government

U.S. EPA Coalbed Methane Outreach Program: <https://www.epa.gov/cmop>

U.S. EIA Coalbed Methane Maps: <http://www.eia.gov/maps/maps.htm#coalbed>

U.S. Geological Survey:

<http://energy.usgs.gov/OilGas/UnconventionalOilGas/CoalbedGas.aspx>

U.S. Geological CBM Fact Sheets:

Coal-bed methane: Potential and concerns: <http://pubs.usgs.gov/fs/fs123-00/>

Water produced with coal-bed methane: <http://pubs.usgs.gov/fs/fs-0156-00/>

Coalbed methane project in the Powder River Basin, Wyoming:

<http://pubs.usgs.gov/fs/2006/3132/>

U.S. EIA CBM Reserves and Production (Table 15):

<http://www.eia.gov/naturalgas/crudeoilreserves/index.cfm>

U.S. EIA CBM Production:

http://www.eia.gov/dnav/ng/NG_ENR_COALBED_A_EPG0_R52_BCF_A.htm

U.S. EIA CBM Reserves:

http://www.eia.gov/dnav/ng/ng_enr_coalbed_a_EPG0_R51_Bcf_a.htm

Montana Coalbed Methane: <http://bogc.dnrc.mt.gov/coalbedmeth.asp>;

http://bogc.dnrc.mt.gov/webmapper_intro_cbm.asp

Oklahoma coalbed methane: <http://www.ou.edu/content/ogs/research/energy/coal.html>

Wyoming Oil & Gas Conservation Commission CBM: <http://wogcc.state.wy.us/>

Alberta CBM Resources and Production:

<http://www.albertacanada.com/business/industries/og-natural-gas-and-coal-bed-methane.aspx>

Alberta Department of Energy:

<http://www.energy.alberta.ca/>

Alberta Geological Survey CBM:

<http://ags.aer.ca/activities/coalbed-methane.htm>

CBM Asia (Specializing in Indonesian CBM): <http://www.cbmasia.ca/What-Is-CBM>

Australian Government:

<http://www.ga.gov.au/data-pubs/data-and-publications-search/publications/oil-gas-resources-australia/2005/coalbed-methane>

New South Wales Government:

<http://www.resourcesandenergy.nsw.gov.au/landholders-and-community/coal-seam-gas/the-facts>

Australia Coal Seam Gas:

<http://www.naturalcsg.com.au/>

Education/Information

Coalbed Methane Association of Alabama: <http://coalbed.com/>

Coalbed Methane Education (British Columbia):

<http://www.empr.gov.bc.ca/MINING/GEOSCIENCE/COAL/Pages/default.aspx>

<http://www.empr.gov.bc.ca/Mining/Geoscience/Coal/CoalBC/CBM/Pages/default.aspx>

Coalbed Methane on Wikipedia: http://en.wikipedia.org/wiki/Coalbed_methane

Coalbed Methane Basics: <https://www.spec2000.net/17-speccbm.htm>

Coalbed Methane Primer: <http://bogc.dnrc.mt.gov/PDF/Web%20Version.pdf>

World Coal Association:

<http://www.worldcoal.org/coal/coal-seam-methane/coal-bed-methane/>

Montana Earth Science Picture of the Week: <http://formontana.net/coalbed.html>

Coal Seam Gas Australia: <http://www.aplng.com.au/home/what-coal-seam-gas>