EMD Coalbed Methane Committee
2015 EMD Mid-Year Leadership Meeting Report
November 19, 2015

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INTRODUCTION

Coalbed methane (CBM; i.e., 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.

EXECUTIVE SUMMARY

Production and reserves of natural gas from coal beds in the United States have declined since 2008 due, in part, to the drop in price for natural gas, but CBM is still an important resource globally. Research on CBM remains active, however, as indicated by the 49 technical papers published so far in 2015. These references have been added to the 79-page CBM bibliography available on the EMD members-only web site (http://emd.aapg.org/members_only/coalbed/index.cfm).

Mastalerz (2014, figure 7.3) included a map showing world CBM resources, production, and exploration activities as summarized below.

CBM Resources by Country (2010)
(from Mastalerz, 2014)

Country	2010 Resources, Tcf
Russia	2,824
China	1,100
Alaska	1,037
U.S. (minus Alaska)	700
Australia	500
Canada	500
Indonesia	435
Poland	424
France	368
Germany	100
UK	100
India	70

Ukraine	60
Zimbabwe	40
Kazakhstan	25

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, 2014a). CBM production declined to 1.466 Tcf in 2013 (EIA, 2014a; the next report release date is December 2015), the lowest level since 2001, representing 5.5% of the U.S. total natural gas production of 26.5 Tcf (Figure 1). Note that U.S. CBM production in EIA (2014a, Table 15) is different than in EIA (2014b, Table 1). According to EIA (2014a, Table 15), the top 8 CBM producing U.S. states during 2013 (production in Bcf) were Colorado (444), New Mexico (356), Wyoming (331), Virginia (93), Oklahoma (65), Alabama (62), Utah (50), and Kansas (30). Annual CBM production by U.S. state (through 2013) is available at EIA (2015a). Cumulative U.S. CBM production from 1989 through 2013 was 32 Tcf. CBM production continues even though few new wells are being completed, reflective of the very long productive lives of CBM wells.

According to EIA (2015a, data through 2013), annual peak CBM production in the top 8 CBM producing U.S. states during 2013 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.

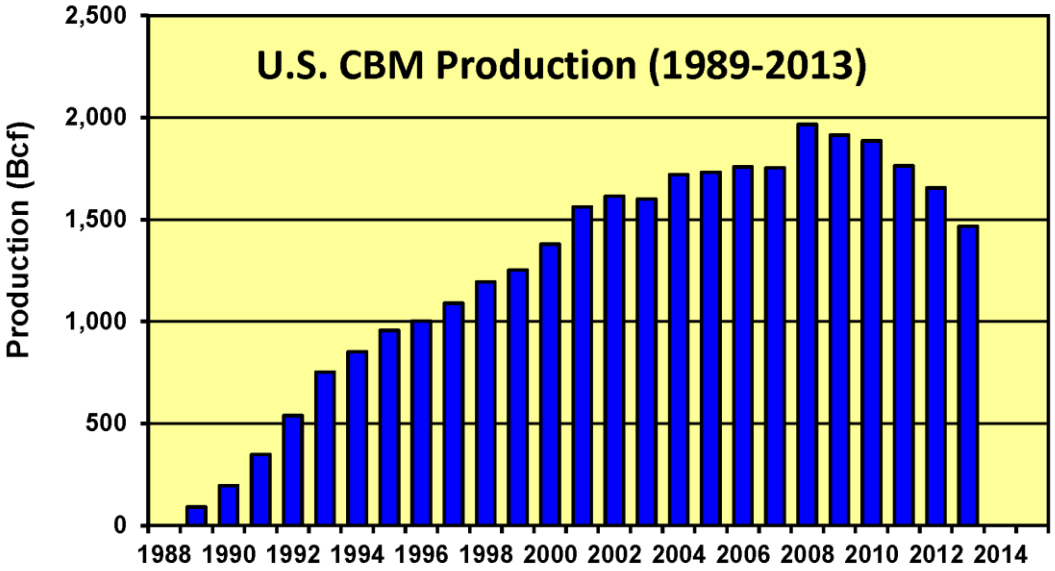

Figure 1. United States CBM production (1989–2013)(compiled from EIA).

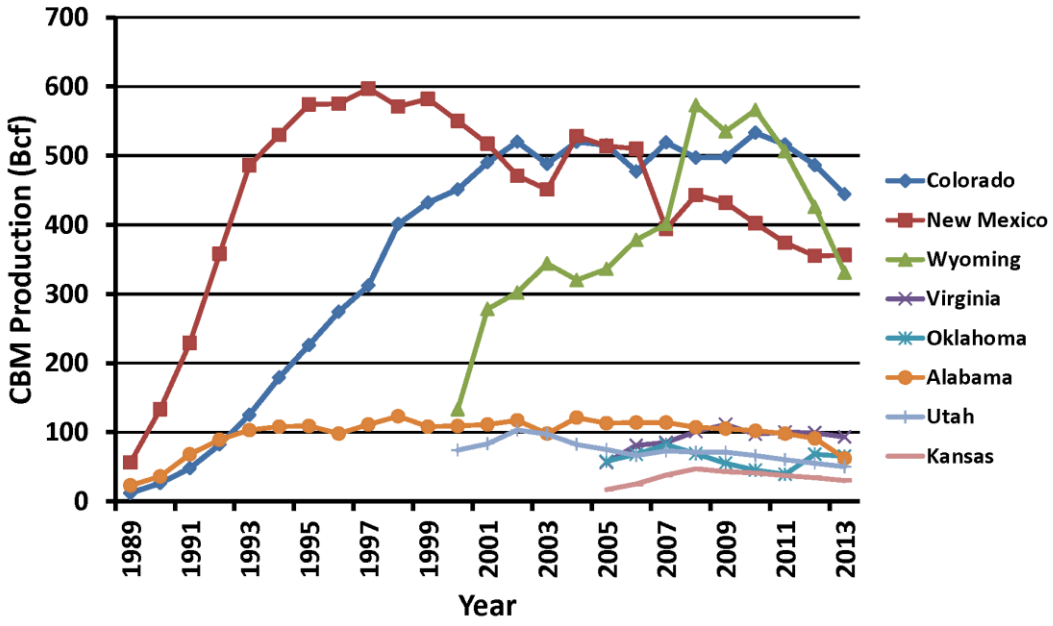

Figure 2. Annual CBM production of the top 8 U.S. states during 2013 (1989–2013; compiled from EIA, 2015a).

United States annual CBM proved reserves peaked at 21.874 Tcf in 2007 (EIA, 2009b, 2010, 2014a), and declined to 12.392 Tcf in 2013 (EIA, 2014a), the lowest level since 1999, representing 3.5% of the U.S. total natural gas reserves of 354 Tcf (Figure

3). Annual CBM proved reserves by U.S. state (through 2013) is available at EIA (2015b).

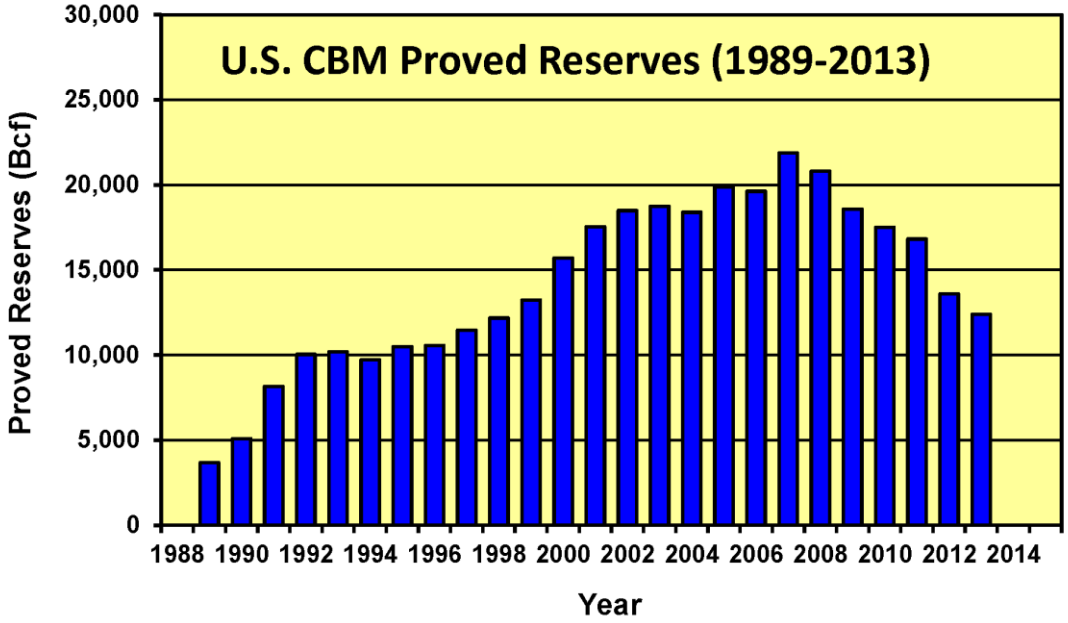

Figure 3. United States CBM proved reserves (1989-2013)(compiled from EIA).

The EPA Coalbed Methane Outreach Program (http://www3.epa.gov/cmop/index.html) has information on U.S. coal mine methane. CMM monthly news, upcoming events, and recently released publications are available at http://www3.epa.gov/cmop/newsroom/index.html.

STATUS OF INTERNATIONAL COALBED METHANE ACTIVITIES

Australia

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).

China

A map showing coal basins and CBM resources in China is at https://www.globalmethane.org/tools-resources/coal_overview.aspx. EIA (2015d) reported that CBM production from wells and underground coal mines in China was 441 Bcf in 2012. Tao and others (2014) indicated there were 12,574 CBM wells in China at the end of 2012; the Southern Qinshui Basin is the largest CBM producing basin in China. The first CBM exploration well in China was drilled in 1991 (Zhang and others, 2014). Flores (2013) indicated that a significant amount of the CBM resources in China are from coal mine methane (CMM) with the first CMM project in 1991. Information on coal mine methane activity in China is in EPA (2015). According to Dodson (2014), "Chinese shale gas production fell so far short of expectations that the Asian behemoth quickly turned to CBM" and "CBM may well find itself relied on increasingly in China, as the country looks to offset its coal dependence."

According to the EIA Today in Energy (September 30, 2015; http://www.eia.gov/todayinenergy/detail.cfm?id=23152):

> Over the past 25 years, China has attempted to develop its substantial CBM resources, estimated by China's Ministry of Land and Resources (MLR) at more than 1,000 trillion cubic feet (Tcf). Currently, there are more than 20,000 wells producing a total of 0.36 billion cubic feet per day

(Bcf/d) of CBM in China. However, CBM well productivity in China is significantly lower than in countries such as Australia and the United States. CBM development in China has focused on the Ordos and Qinshui Basins of Shanxi Province. Although these two basins are considered to have China's best geologic conditions, they still face significant geologic challenges (low permeability, under-saturation) that reduce well productivity.

From EIA China International Energy Data and Analysis (accessed September 30, 2015; http://www.eia.gov/beta/international/analysis.cfm?iso=CHN):

Most of China's CBM volumes are from basins in the North and Northeast, the Sichuan basin in the Southwest, and the Junggar and Tarim basins in the West. FGE reported that CBM production in 2014 was an estimated 584 Bcf, up from about 475 Bcf in 2013, from both surface wells and coal mines. China's NEA set the most recent 2020 target for production at 1.4 Tcf of CBM, half from extraction of coal, and half from surface mining. Most of the CBM production is from coal mine extraction, which hinders higher utilization rates because some of the methane gas that seeps from the underground mines is vented. Current utilization rates are about 45%, and China intends to reduce the production waste and increase consumption of coalbed methane. Although CBM production is increasing, company developers face regulatory hurdles, technical challenges, lack of pipeline infrastructure from linking coal-mining areas to gas markets, high development costs, and competition with other forms of natural gas supply. At times, there are conflicting interests between governing bodies when dealing with mineral and land rights. The local governments hold rights to coal mines, whereas the central government has rights to natural gas and CBM. China's State Council issued a policy guideline in September 2013 encouraging investment in CBM exploration and development and more pipeline infrastructure through financial incentives and tax breaks to producers and reform of local price controls.[76]

China's first commercial CBM pipeline became operational in late 2009, linking the Qinshui Basin with the West-to-East pipeline. Several other pipelines, mostly in the Shanxi Province of north central China, have become operational, and several more are under construction. China also uses many small liquefaction plants and trucks to transport CBM to demand centers.

The Energy Studies Institute (December 5, 2014: http://esi.nus.edu.sg/docs/default-source/esi-policy-briefs/china-cbm-slow-start-and-still-work-in-progress.pdf?sfvrsn=2) has a detailed policy brief on China CBM.

SYNOPSIS
China has large potential reserves of coalbed methane (CBM) but despite more than 20 years of exploration, progress has been slow and production from surface wells in 2013 amounted to only 3 billion cubic metres (bcm). CBM surface well production is unlikely to meet the official target of 16 bcm set for 2015. In the last two years, the central government has removed a number of structural and administrative obstacles, and these moves support the measures introduced earlier aimed at stimulating CBM exploration and production. China's CBM production from surface wells could rise substantially in the long-term but the prevailing technical challenges and above-ground policy and management constraints remain, impeding near-term growth.

Referring to a report by the China Securities Journal, the Want China Times web site (May 21, 2015: http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20150521000004&cid=1102) indicated that "China has the world's third largest CBM resource base of 36.8 trillion cubic meters and around 10 trillion cubic meters are exploitable among them. While 23 billion cubic meters of exploitable CBM is projected to be produced, it will help bridge nearly one-third of the supply and demand gap of natural gas in China, which is estimated to reach 69.3 billion cubic meters in 2015."

According to Natural Gas Asia (September 22, 2015; http://www.naturalgasasia.com/xinjiangs-first-demonstrative-cbm-project-to-come-online-next-month-16612): A CBM demonstration product was expected in the Xinjiang Province in western China in October 2015, designed to produce 30 million cubic meters of CBM annually.

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. The Alberta Department of Energy (http://www.energy.alberta.ca/NaturalGas/754.asp) has general information on Alberta, Canada CBM. The Alberta Energy Regulator (http://www.aer.ca/rules-and-regulations/by-topic/coalbed-methane) regulates CBM production in Alberta.

Taylor and others (2008; http://www.cprm.gov.br/33IGC/1324175.html) summarized CBM development in Canada.

CBM production in Canada comes mainly from Cretaceous and Tertiary coals in the Western Canada Sedimentary Basin (Flores, 2013). According to the web site http://www.energy.alberta.ca/NaturalGas/750.asp, there were 19,269 CBM wells in Alberta, Canada as of December 31, 2012. The Alberta Geological Survey web site (2015) 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, 2014, 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. According to the Alberta Energy Regulator (2014, p. 5-33), 130 new CBM and CBM hybrid (recompletion) vertical wells were completed in the Horseshoe Canyon play area in 2013 while no new CBM wells were completed in the Mannville Corbett play. Figure 4 illustrates that Canadian average daily CBM production rates have declined since 2009 while the number of producing wells has reached a plateau of around 19,000.

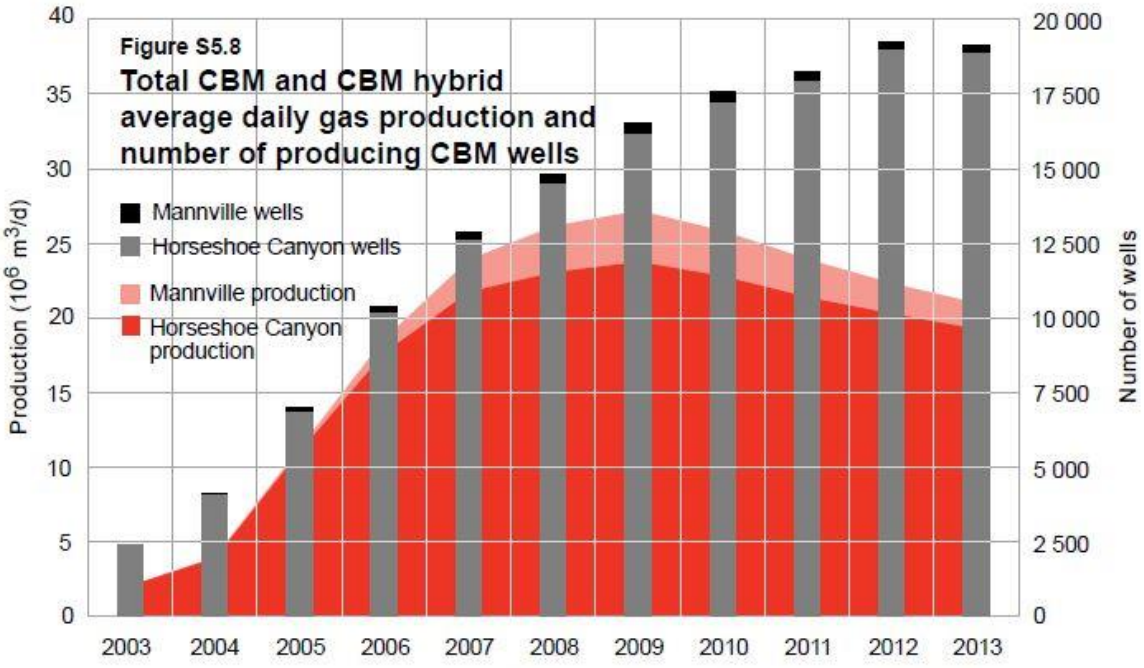

Figure 4. Canada CBM average daily gas production rates and number of producing wells from 2003–2013 (from Alberta Energy Regulator, 2014).

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Alberta Geological Survey web site, 2015, Alberta coal occurrences and potential coalbed methane exploration areas: http://www.ags.gov.ab.ca/energy/cbm/coal_and_cbm_intro.html; accessed September 30, 2015)

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EIA, 2014b, Natural gas annual, 2013: U.S. Energy Information Administration, 205 p. http://www.eia.gov/naturalgas/annual/
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Zhang, S., S. Tang, Z. Qian, Z. Pan, and Q. Guo, 2014, Evaluation of geological features for deep coalbed methane reservoirs in the Dacheng Salient, Jizhong Depression, China: International Journal of Coal Geology, v. 133, p. 60-71.

Upcoming Meetings Focusing on CBM & CMM:

November 12-13, 2015: 15th International Symposium on CBM/CMM and Shale Gas in China, Beijing, China http://www.nios.com.cn/c/index_en/latestnews/16274.html

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

USGS Produced Waters Database:
http://energy.cr.usgs.gov/prov/prodwat/index.htm

Government

U.S. EPA Coalbed Methane Outreach Program: http://www.epa.gov/coalbed/

U.S. EIA Coalbed Methane Maps:
http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm

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:
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

Montana Coalbed Methane: http://www.deq.mt.gov/CoalBedMethane/default.mcpx

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/NaturalGas/561.asp

Alberta Geological Survey CBM:
http://www.ags.gov.ab.ca/energy/cbm/
http://www.ags.gov.ab.ca/energy/cbm/coal_and_cbm_intro2.html

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

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

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