

AAPG

Energy Minerals Division

**EMD Coalbed Methane Committee Report
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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 underground coal mining operations.

Production of CBM in the United States continued to decline in 2017 while CBM proved reserves increased by 12%. CBM is still an important resource globally. Research on CBM remains active, however, as indicated by >80 technical papers published in 2018.

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

The 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 trillion cubic feet (Tcf) in 2008 (EIA, 2009b, 2010, 2018c). CBM production declined to 980 billion cubic feet (Bcf) in 2017 (EIA, 2018a), the lowest level since 1996, representing 3.6% of the U.S. total natural gas production of 27.3 Tcf (EIA, 2018b; **Figure 1**). According to EIA (2018a, their Table 15; 2018c), the top 7 CBM-producing U.S. states during 2017 (production in billion cubic feet, Bcf) were Colorado (338), New Mexico (234), Wyoming (135), Virginia (99), Alabama (62), Oklahoma (36), and Utah (36). Annual CBM production decreased for each state over the previous year except Alabama (EIA 2018a; **Figure 2**). Cumulative U.S. CBM production from 1989 through 2017 was 36.7 Tcf.

According to EIA (2018a), annual peak CBM production in the top 7 CBM producing U.S. states during 2017 occurred in the following years: Colorado (2010), New Mexico (1997), Wyoming (2008), Virginia (2009), Alabama (1998), Oklahoma (2007), and Utah (2002)(Figure 2).

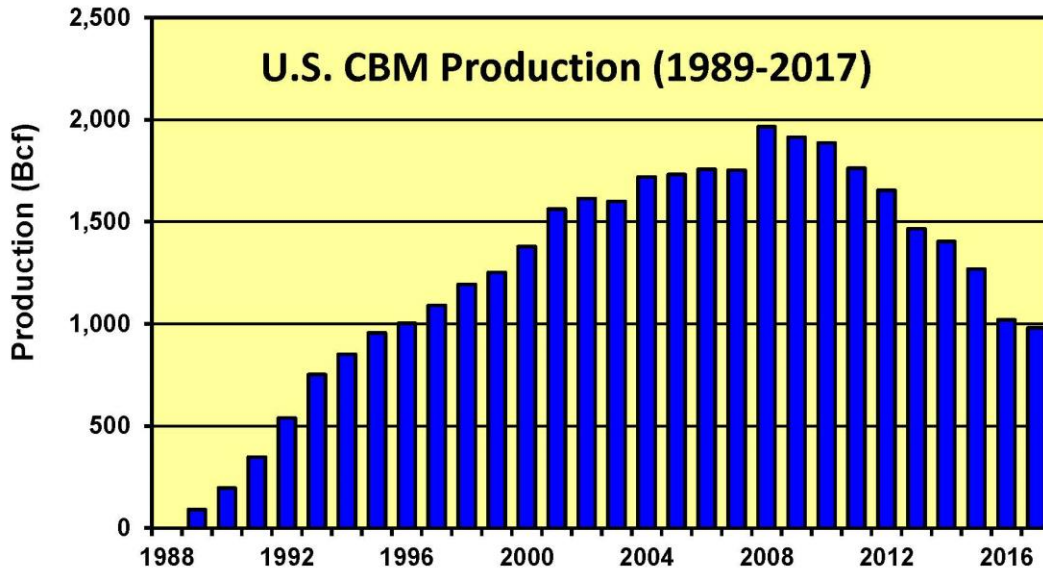


Figure 1. United States CBM production (1989–2017; compiled from EIA, 2018a).

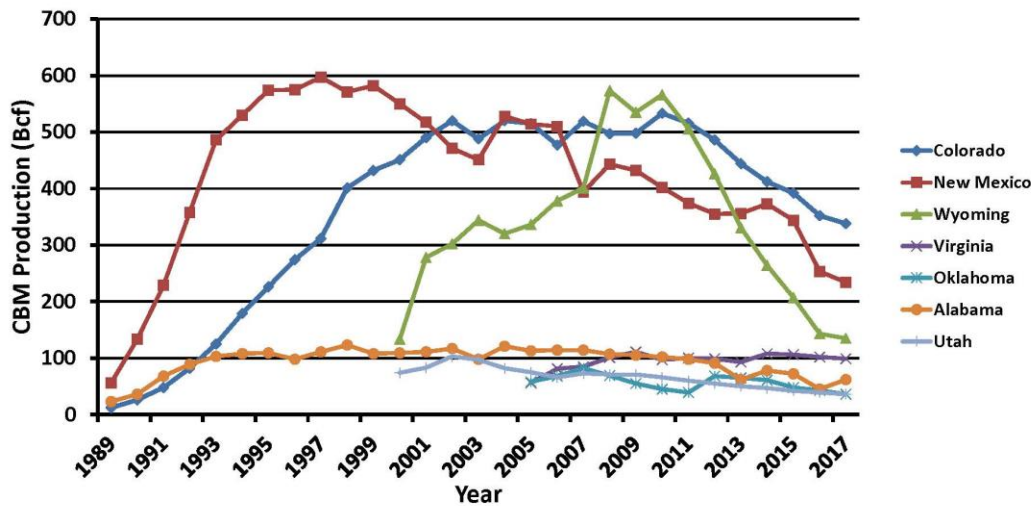


Figure 2. Annual CBM production of the top 7 U.S. states during 2017 (1989–2017; compiled from EIA, 2018a, c).

U.S.G.S. (2014) is a map and report of assessed coalbed-gas resources in the United States (<https://pubs.usgs.gov/dds/dds-069/dds-069-ii/>). U.S. annual CBM proved reserves peaked at 21.87 Tcf in 2007 (EIA, 2009b, 2010, 2018d) and declined to 11.878 Tcf in 2017 (EIA, 2018a) representing 2.7% of the U.S. total natural gas reserves of 438 Tcf (EIA, 2018a, e; **Figure 3**). Annual CBM proved reserves by U.S. state (through 2017) are available at EIA (2018d).

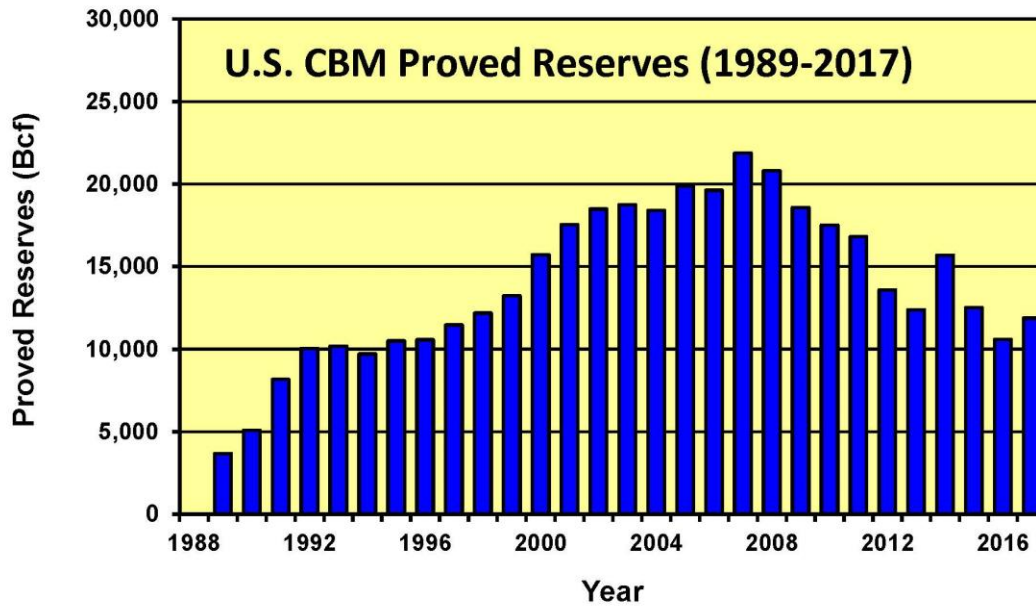


Figure 3. United States CBM proved reserves (1989-2017; compiled from EIA, 2009b, 2010, 2018a).

STATUS OF INTERNATIONAL COALBED METHANE ACTIVITIES

The International Energy Agency (<https://www.iea.org/ugforum/ugd/cbm/>) has CBM production data by country for Australia (2000-2014), Canada (2000-2014), China (2006-2014), Czech Republic (2000-2014), France (2000-2014), Germany (2000-2014), India (2007-2014), Poland (2000-2014), Russia (2010-2014), Ukraine (2012-2014), United Kingdom (2000-2014) (**Figure 4**). Most countries have <1 billion cubic meters (Bcm) CBM production per year. Countries with the highest CBM production (in Bcm) in 2014: China (14.1), Australia (7.6), and Canada (7.2). For comparison, reported CBM production by the IEA for the U.S. in 2014 was 37.1 Bcm.

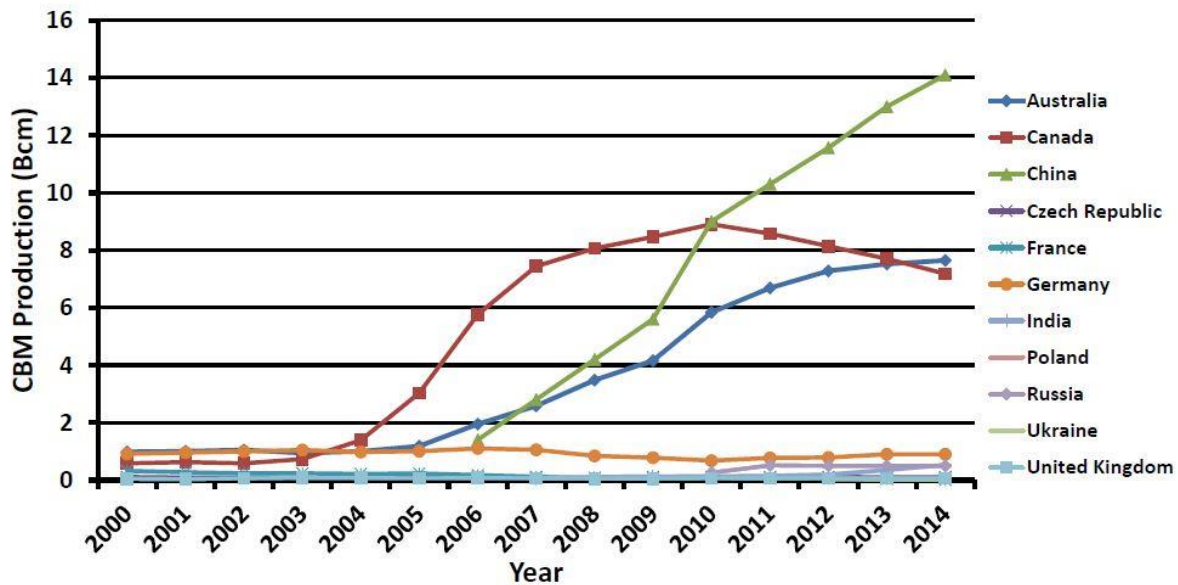


Figure 4. World CBM production from International Energy Agency (2000-2014; <https://www.iea.org/ugforum/ugd/cbm/>).

U.S. Geological Survey International CBM Resource Assessments

Africa, 2016, Kalahari Basin Province (<https://pubs.er.usgs.gov/publication/fs20173003>)

Africa, 2016, Karoo Basin Province (<https://pubs.er.usgs.gov/publication/fs20163103>)

China, 2015, Ordos Basin Province (<https://pubs.er.usgs.gov/publication/fs20153087>)

Indonesia, 2018, Kutei and Barito Basin Provinces
(<https://pubs.er.usgs.gov/publication/fs20183055>)

Indonesia, 2016, Sumatra Basin Provinces
(<https://pubs.er.usgs.gov/publication/fs20163089>)

Australia. Information on Australian coal seam gas (CSG; data through 2005) is available on the Australian Government Geoscience Australia web sites (<http://www.ga.gov.au/scientific-topics/energy/resources/petroleum-resources/coal-seam-gas>; <http://www.ga.gov.au/data-pubs/data-and-publications-search/publications/oil-gas-resources-australia/2005/coalbed-methane>). According to the EIA (2017, p. 8, 11; last updated March 7, 2017), “Geoscience Australia estimated total proved plus probable commercial reserves at 114 Tcf (62% conventional natural gas, 38% coal bed methane (CBM), and less than 1% tight gas) as of 2014.” “CBM resources, equivalent to about 43 Tcf, are primarily located in the northeastern Queensland Province in the Bowen Basin and the Surat Basin. Geoscience Australia anticipates the resource distribution of natural gas will shift from the offshore traditional gas production to CBM or other sources in the next few decades because key CBM developers are aggressively exploring and drilling in several areas.” “Commercial production from CBM, which began in 1996, rose to 424 Bcf in 2015, 50% higher than in 2014. This production increase corresponds with the commencement of the country’s first CBM-to-LNG export terminals in Queensland over the past two years”.

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> (accessed April 3, 2019).

Stark and Smith (2017) indicated the Walloon CSG play in the Bowen-Surat Basin (discovered in 2009) has gas resources of 503 million barrels of oil equivalent (MMBOE) while the Walloon CSG play in the Kumbarilla Ridge Basin (discovered in 2001) has gas resources of 535 MMBOE.

Mallants et al. (2018) reported >8,000 CSG wells as of 2016 with >18,000 CSG wells planned over the next 10 years in the Bowen and Surat basins of Queensland, Australia.

An interactive map of coal seam gas wells in New South Wales is available at <https://www.resourcesandgeoscience.nsw.gov.au/landholders-and-community/coal-seam-gas/facts-maps-links/map-of-csg-wells>.

Salmachi et al. (2019) discussed a study on the deep and ultradeep (4,700-12,000 ft) coal seams of the Cooper Basin.

China. Stark and Smith (2017) indicated the Taiyuan CBM play in the Qinshui Basin (discovered in 2007) has gas resources of 717 MMBOE.

In 2018, the CBM production in China was 7.26 billion m³ (bcm) with a growth of 5.8%, of which the production in December alone was 0.64 billion m³ (<https://www.chyxx.com/shuju/201901/711710.html>). In the first two months of 2019, the CBM production in China was 1.34 billion m³ with a growth of 11.9%, as reported by the China Coal Bed Methane Industry Market Research Report (<http://www.chinabqao.com/chanliang/291659.html>). Shanxi province has the most CBM production of 0.95 billion m³ in the first two months of 2019 with a growth of 8.7%. According to news from Shanxi Energy Bureau, Shanxi province is planning to introduce a new pattern of development and utilization in CBM industry in 2019, and accelerate the construction of a national unconventional natural gas support base (<http://www.camining.org/kuangyezixun/show.php?itemid=32064>). Shanxi province is estimated to have a CBM production of 12.9 billion m³ in 2019. Shanxi province will focus on promoting the development of coalbed methane in the Mabi Block and Liulin Block, and will accelerate the construction of the coalbed methane industrialization base in the Qinshui Basin and the eastern margin of the Ordos Basin. At the same time, the plans are to actively promote coalbed methane extraction in abandoned coal mines, encourage multi-gas mining, and achieve rapid increase in coal-bed methane production.

By 2020, China will build 2 to 3 coalbed methane industrialization bases, and the CBM production is estimated to be 24 billion m³. CMM in China is available at EPA (2019a). The China country analysis brief is available at EIA (2015; last updated May 14, 2015). A review of current status, challenges and opportunities in China’s coalbed methane development is available from Li et al. (2018) and Tao et al. (2019).

Canada. Canada contains diverse CBM resources, which are concentrated chiefly in the Carboniferous strata in the intermontaine basins of the Canadian Maritime Provinces, Mesozoic-Cenozoic strata in intermontaine basins of British Columbia, and in Cretaceous strata of the Western Canada Sedimentary Basin of the Cordilleran foreland in Alberta. The vast majority of the resource and reserve base are in Alberta, where the Alberta Geological Survey estimates original gas in place (OGIP) on the order of 500 Tcf. The bulk of the production comes from the Horseshoe Canyon play, where OGIP is estimated to be 179 Tcf. Development is active in a variety of Cretaceous coal-bearing formations, and the deeper Mannville coal seams have OGIP estimated at 321 Tcf. Early production operations focused on vertical wells completed in multiple coal seams, particularly in the Horseshoe Canyon Formation. Expansion of the industry between 2005 and 2007 was buoyed by the advent of lateral and multilateral drilling in single seams, which facilitated development of lower permeability coal seams in the Mannville Group.

Remaining reserves in Alberta are estimated to be about 2 Tcf according to the Alberta Energy Regulator, indicating that, although development is widespread, potential exists for a major expansion of the industry given a favorable economic climate. Development activity, however, has decreased significantly in recent years in response to low natural gas prices. According to the International Energy Agency, Canadian coalbed methane production peaked at 8.9 Bcm (315 Bcf) in 2010. Production was 7.2 Bcm (254 Bcf) in 2014, and the annual rate of decline has increased from 3.7% in 2011 to 6.8% in 2014. More recent production data are unavailable, and the economic climate remains challenging for the development of new coalbed methane reserves in Canada.

General information on CBM in Alberta is available from the Alberta Energy Regulator (2015) and Alberta Geological Survey (2018).

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).

Recent articles on India CBM include the following: Chatterjee and Paul (2013), Kumar et al. (2018), Mohanty et al. (2018), Naveen et al. (2018), and Shah and Totlani (2014).

Russia. Information on prospects for CBM production in Russia is at <http://www.gazprom.com/about/production/extraction/metan/> (accessed April 3, 2019). CMM in Russia is available at EPA (2019b).

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(<http://www.aer.ca/documents/sts/ST98/ST98-2015.pdf>)

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- EIA, 2017, Country analysis brief: Australia: U.S. Energy Information Administration, 24 p. <https://www.eia.gov/beta/international/analysis.cfm?iso=AUS>
- EIA, 2018a, U.S. crude oil and natural gas proved reserves, Year-end 2017: U.S. Energy Information Administration, 48 p. <http://www.eia.gov/naturalgas/crudeoilreserves/index.cfm>
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Coalbed Methane Calendar

- April 17, 2019: North American Coalbed Methane Forum Conference, Southpointe, PA. <http://www.nacbmforum.com/conference.html>
- September 3-6, 2019: International Pittsburgh Coal Conference, Pittsburgh, PA. <https://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 Survey 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/>

CBM assessment in the Powder River Basin Province

(<https://pubs.er.usgs.gov/publication/ds69C>)

CBM assessment in Alaska (<https://pubs.er.usgs.gov/publication/ds69S>)

CBM resources of the Appalachian Basin

(<https://www.sciencedirect.com/science/article/pii/S0166516209002080?via%3Dihub>)

(<https://pubs.er.usgs.gov/publication/pp1708>)

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>

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:

<https://www.alberta.ca/coalbed-methane.aspx>

Alberta Geological Survey CBM:

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

British Columbia CBM potential:

https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-gas-oil/petroleum-geoscience/oil-gas-reports/og_report2003-3.pdf

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:

<https://www.resourcesandgeoscience.nsw.gov.au/landholders-and-community/coal-seam-gas>

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

<https://www.resourcesandgeoscience.nsw.gov.au/landholders-and-community/coal-seam-gas/facts-maps-links/videos>

Education/Information

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

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: <https://www.aplng.com.au/topics/coal-seam-gas.html>