

EMD Coalbed Methane Committee
2016 EMD Annual Leadership Meeting Report
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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 of natural gas from coal beds in the United States continued to decline in 2014 while reserves increased. CBM is still an important resource globally. Research on CBM remains active, however, as indicated by the 67 technical papers published in 2015. These references have been added to the 82-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.

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, 2015a). CBM production declined to 1.404 Tcf in 2014 (EIA, 2015a; the next report release date is November 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). 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.

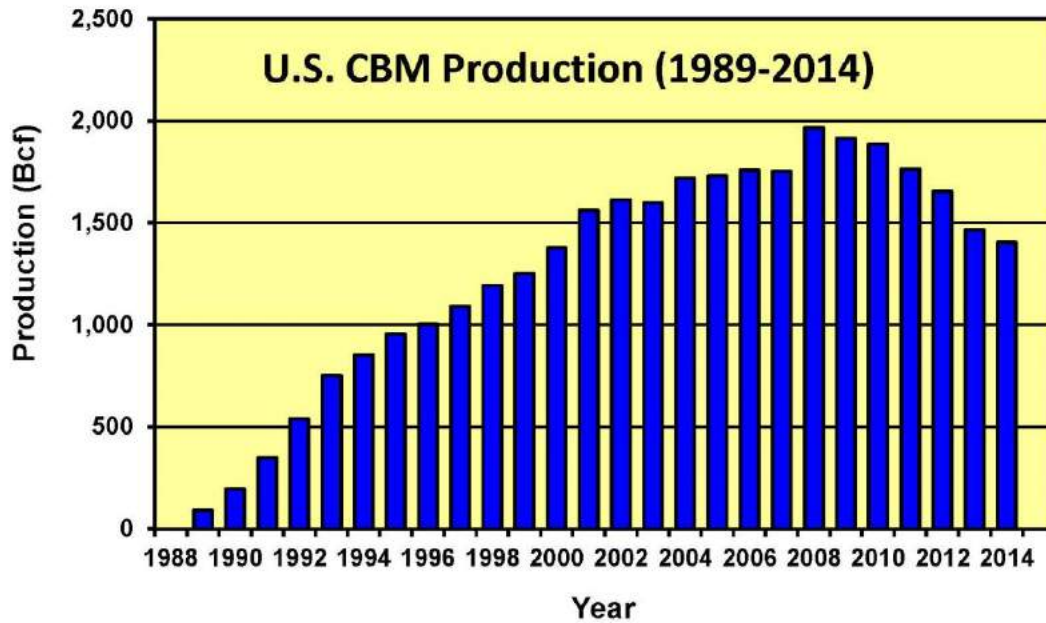


Figure 1. United States CBM production (1989–2014; compiled from EIA).

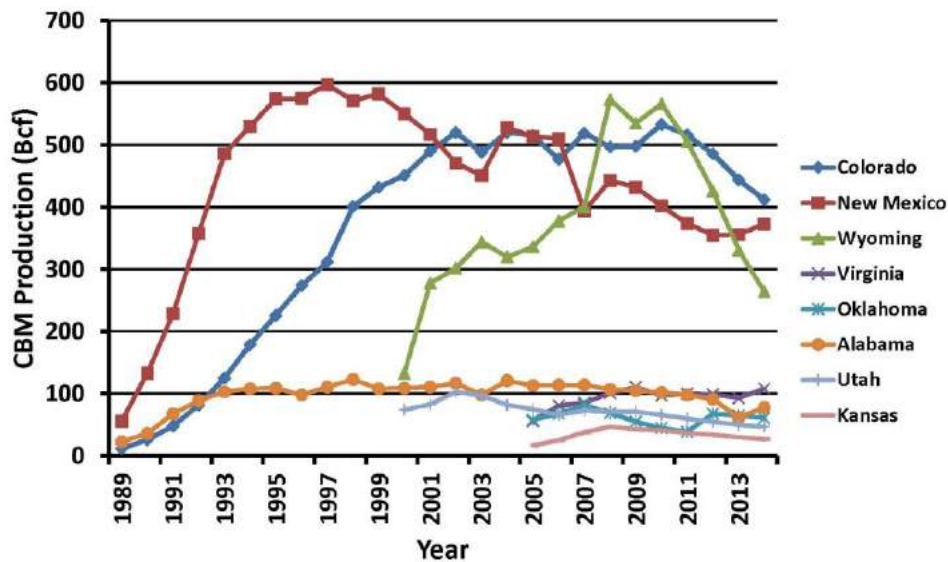


Figure 2. Annual CBM production of the top 8 U.S. states during 2014 (1989–2014; compiled from EIA, 2015a).

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).

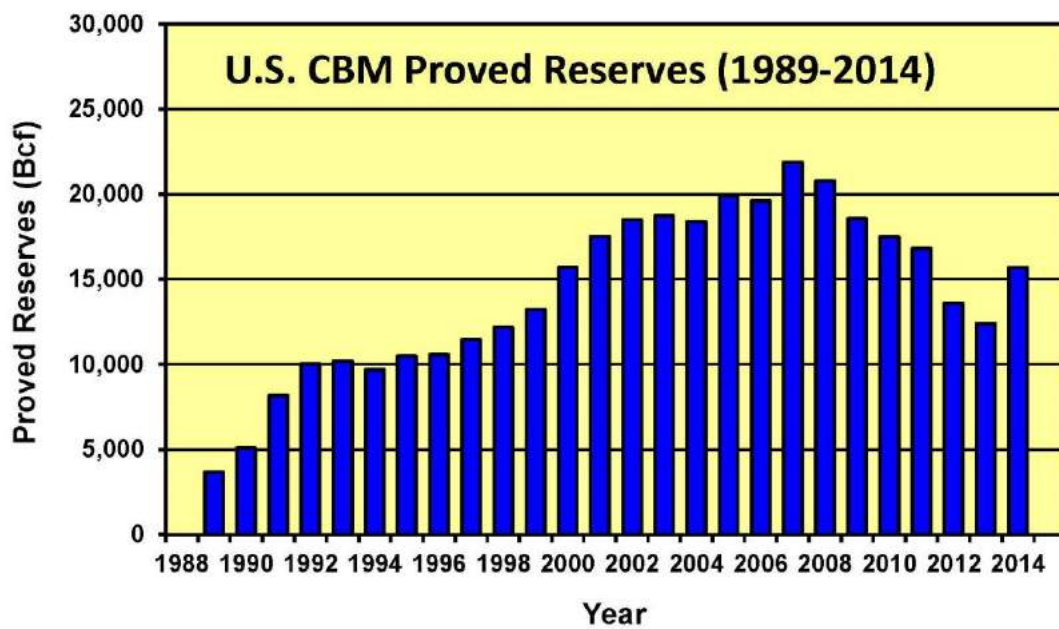


Figure 3. United States CBM proved reserves (1989-2014; compiled from EIA).

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).

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 November 8, 2015 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

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 584 Bcf in 2014. 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).

A recent review on development of CBM Industry in China was provided by Qin Yong and Ye Jianping (2015). In brief they report that:

- 1) Total CBM resources in China are estimated at 38.61 trillion m³, of which respectively 31%, 28%, 28%, and 13% comes from the eastern, central, western, and southern parts of China. About 85% of these resources occur in nine basins including Ordos, Jungar, and Qinshui.
- 2) China has total proven CBM reserves of 845.4 billion cubic meters, including two CBM fields with reserves of more than one hundred billion cubic meters, which provides the basis for the sustainable CBM industry in China.

- 3) Research on CBM has been carried out mainly in the Qinshui, Ordos, western Henan, western Guizhou, eastern Yunnan and Liaohai basins. The Turpan-Hami, Junggar, Liang Huai, Sichuan, Ningwu, Hailar, Erlan and Santanghu basins also received some attention. In the published work on CBM in China, papers related to geological research and CBM exploration and drainage in the Ordos and Qinshui basins have received the most attention. More than 90% of the CBM production in China was derived from these two major basins over the past ten years.

In 2015, production of CBM in China was 18 billion m³ (year-on-year growth of 5.5%), of which extraction from virgin coal was 13.6 billion m³ (year-on-year growth of 2.3%), and from coal mines was 4.4 billion m³ (year-on-year growth of 17.0%). The utilization rates were about 47.8% (<http://www.sxcoal.com/gas/4322847/articlenuw.html>, in Chinese). By the end of 2014, China had about 14,700 CBM wells mainly located in the Qinshui and Ordos basins, in which about 9,300 wells were operating with an average daily production per well of 1,050 cubic meters per day (Qin and Ye, 2015). The Fanzhuang field of South Qinshui Basin is one of the most successful areas for CBM development, where hydraulic fracturing plugging-removal technology was first used for horizontal wells (<http://www.cnki.com.cn/Article/CJFDTotal-TRQG201111003.htm>, in Chinese). Efforts are focusing on using multilateral wells to improve recovery of CBM from semi-anthracite and anthracite in the Qinshui Basin.

In the next five years, official target of CBM production is 40 billion m³ with coal mine methane production of 20 billion m³. CBM production in China will still focus on the Qinshui Basin and East Ordos Basin, and an emerging area is the southern Sichuan Basin (Mu et al., 2015).

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.

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>, 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 (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, 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. 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 4).

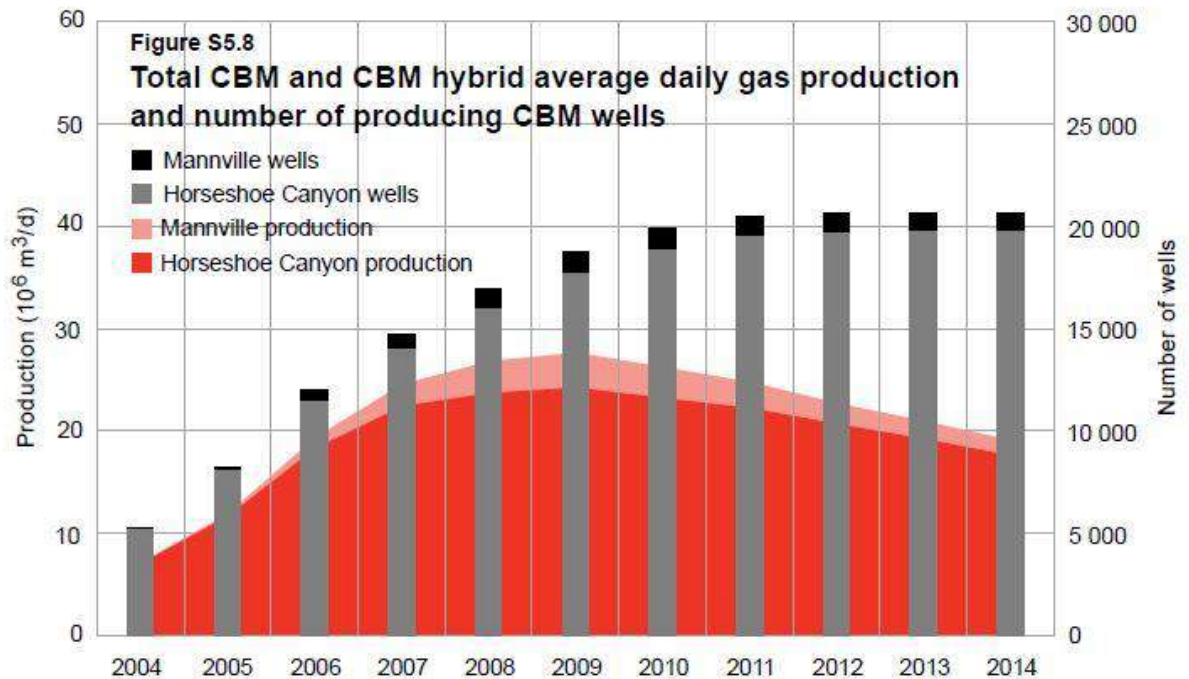


Figure 4. Canada CBM average daily gas production rates and number of producing wells from 2004–2014 (from Alberta Energy Regulator, 2015, p. 5-35).

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<http://www.eia.gov/naturalgas/crudeoilreserves/index.cfm>
- EIA, 2015b, Natural gas annual, 2014: U.S. Energy Information Administration, 206 p.
<http://www.eia.gov/naturalgas/annual/>
- EIA, 2015c, Australia country analysis brief: U.S. Energy Information Administration,
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http://www.searchanddiscovery.com/pdfz/documents/2015/80454yong/ndx_yong.pdf.html
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http://ags.aer.ca/publications/DIG_2003_0001.html
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Calendar

May 17, 2016: North American Coalbed Methane Forum 56th session in Pittsburgh, PA.
<http://www.nacbmforum.com/index.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>

Government

U.S. EPA Coalbed Methane Outreach Program: <https://www3.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

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>