MEMORANDUM

DATE: March 12, 2014

TO: Jeremy Boak, President, AAPG Energy Minerals Division

FROM: Jeffrey R. Levine, Chair EMD Coalbed Methane Committee, and
Jack C. Pashin, Academic Representative

SUBJECT: Coalbed Methane Commodity Report

EMD Coalbed Methane Activities:

Coalbed methane continues to be a topic of interest to the membership of AAPG and EMD, although the level of engagement has certainly declined, as attention has shifted to other of unconventional gas. Last year's (2013) AAPG Annual Convention and Exposition in Pittsburgh featured an oral presentation on produced water and five poster presentations covering a range of topics from resource evaluation to stable isotopes in coalbed methane reservoirs. This year's (2014) conference in Houston features a field trip on unconventional petroleum systems in Colorado that includes CBM reservoirs of the Piceance Basin and is led by Stephen Sonnenberg and Jeremy Boak. Presentations in the technical program include a poster on seismic inversion in CBM reservoirs, an oral presentation on in-situ stress in coal of the Surat Basin in Australia, and a presentation on Drunkards Wash Field in Utah.

EMD CBM Committee Leadership. Jeff Levine has stepped in to fill chairmanship of the Coalbed Methane Committee. Jack Pashin serves as Academic Representative, and the Government and Industry positions are currently open. We plan to fill these openings soon. Any current EMD members interested in filling these roles should contact the Jeff Levine at Jeffrey.Levine@BakerHughes.com.

USA National Perspective:

The U.S. remains the world leader in coalbed gas exploration, booked reserves, and production. Currently, there is commercial coalbed gas production or exploration in approximately 12 U.S. basins and several basins in Canada, although activity has slowed substantially in response to low gas prices. The major producing areas are the Powder River, San Juan, Black Warrior, Central Appalachian, Raton, and Uinta (Ferron and Book Cliffs) basins. Other U.S. areas with significant exploration or production are the Cherokee, Arkoma, Illinois, Hanna, Gulf Coast, and Greater Green River basins. Exploration continues in all major U.S. basins. The principal environmental issue confronting development is water disposal.

Production operations are maturing in U.S. coalbed methane basins, and the U.S. Department of Energy (DOE) has sponsored a series of studies on produced water management and CO_2-enhanced coalbed methane recovery. Of major interest is a new pilot program that is being led by Virginia Tech in the Appalachian basin of Virginia, which is scheduled to begin injection of up to 20,000 tons of CO_2 into multiple coal seams to determine the viability of enhanced recovery and geologic storage. Injection is slated to begin this summer.

The Energy Information Administration has released coalbed methane production and reserve numbers through the end of 2011. Annual coalbed methane production in 2011 was 1,763 Bcf, decreasing by 6.5 percent from the previous year, and representing a 10.3% decrease from the peak of 1,966 Bcf in 2008 (Figure 1; Table 1). Although production operations continue, few new wells are being drilled, and reserves are not being replenished, which proportionally decreases the market value of the companies holding those reserves. Reserves of 16.8 TCF at the end of 2011 represent a decrease of 4.1% from 2010, and a 23% drop from the peak value of 21.9 TCF in 2007 (Figure 2; Table 2).

When calculated as a proportion of US gas production coalbed methane production is projected to continue to decline slowly, indicative of the very slow decline rates of mature CBM fields, as contrasted with the much larger projected proportional decline in Tight Gas and Non-Associated Onshore gas (fig. 3). In 2011, coalbed methane still represented 7.3 percent of 2011 dry-gas production in 2011 and 5.0 percent of proved dry-gas reserves in the US. Based upon its continuing presence in domestic energy markets, we can anticipate that there will be sustained, even if substantially diminished, interest in geological issues related to CBM.

Regional CBM Activity:

Most of the coalbed methane activity in the eastern U.S. is focused on the Appalachian Basin of Southwestern Virginia and the Black Warrior Basin of Alabama, with several companies actively developing joint CBM and CMM projects. In southwestern Virginia, production has increased slightly from 97 Bcf in 2010 to 100 Bcf in 2011 (Table 1). West Virginia saw a production increase from 17 to 18 Bcf over the same time period. In Pennsylvania, production decreased from 3 to 4 Bcf. In Alabama, production declined slightly, with 102 Bcf being produced in 2010 and 98 Bcf being produced in 2011.

The Midcontinent region consists of the Cherokee, Forest City, Arkoma, and Illinois Basins, and production and reserves appear to be declining. Horizontal drilling is proving to be an effective development strategy, although major increases of production in recent years are now being offset by decline. Production for Kansas decreased modestly from 41 Bcf in 2010 to 37 Bcf in 2011, whereas production decreased in Oklahoma from 45 Bcf in 2010 to 39 Bcf in 2011 (a 13.3% decrease), continuing a steep decline trend that began in 2007. The principal issues

affecting CBM development in the eastern and mid-continental U.S. is competition with shale gas, which has introduced significant price pressure.

Infill drilling of Fruitland CBM wells in the San Juan Basin (Colorado and New Mexico) decreased markedly in 2009 due to recession, but activity is starting to turn around. The States of Colorado and New Mexico continue to dominate CBM production and reserves (Tables 1 and 2). Cumulative production for Colorado and New Mexico represents 50% of total U.S. CBM production. In 2011, CBM production in Colorado decreased from 533 to 516 Bcf, and production in New Mexico declined slightly from 402 to 374 Bcf. In the Powder River Basin of Wyoming, production decreased in 2010 from 566-506 Bcf, but still accounts for ~30% of U.S. CBM production.

International CBM Activity:

International activity has been on the rise, and operations in the Qinshui Basin of China remain active, thus proving the CBM potential of intensely fractured semi-anthracite and anthracite. As in the U.S., depressed natural gas prices are slowing Canadian development. Exploration and development efforts are continuing in the Bowen, Surat, and Sydney Basins of Australia, as well as the Karoo Basin of South Africa. Coalbed methane in eastern Australia is being produced from high-permeability coal seams that can contain large quantities of oil-prone organic matter, and produced gas is being considered for export into Asian LNG markets. A number of LNG plants (up to 5 or 6) are being considered in Australia so many of these companies are striving to book CBM reserves to justify the expenditure for LNG plant development as quickly as possible. Significant potential exists in the Gondwanan coal basins of India, and some fields have been developed.

Significant potential also exists in the coal basins of Europe and the Russian platform, and development in these areas is focusing mainly on coal-mine methane. Russia is continuing to promote CBM exploration and development but defining a market for the gas and predicting gas prices are problematic for future development. However, the coal basins in Russia may contain the largest CBM resources in the world so once a market for this gas, internally or internationally, is identified, then CBM exploration in Russia should increase significantly. Some significant exploration programs have been initiated within recent years to explore for coalbed methane in the structurally complex European coal basins of western Europe, including Germany.

Acknowledgements

Jeff Levine would like to acknowledge and thank outgoing chairman Jack Pashin for his substantial contribution to the preparation of the current report, as well as for his past contributions as chairman of the CBM Committee.

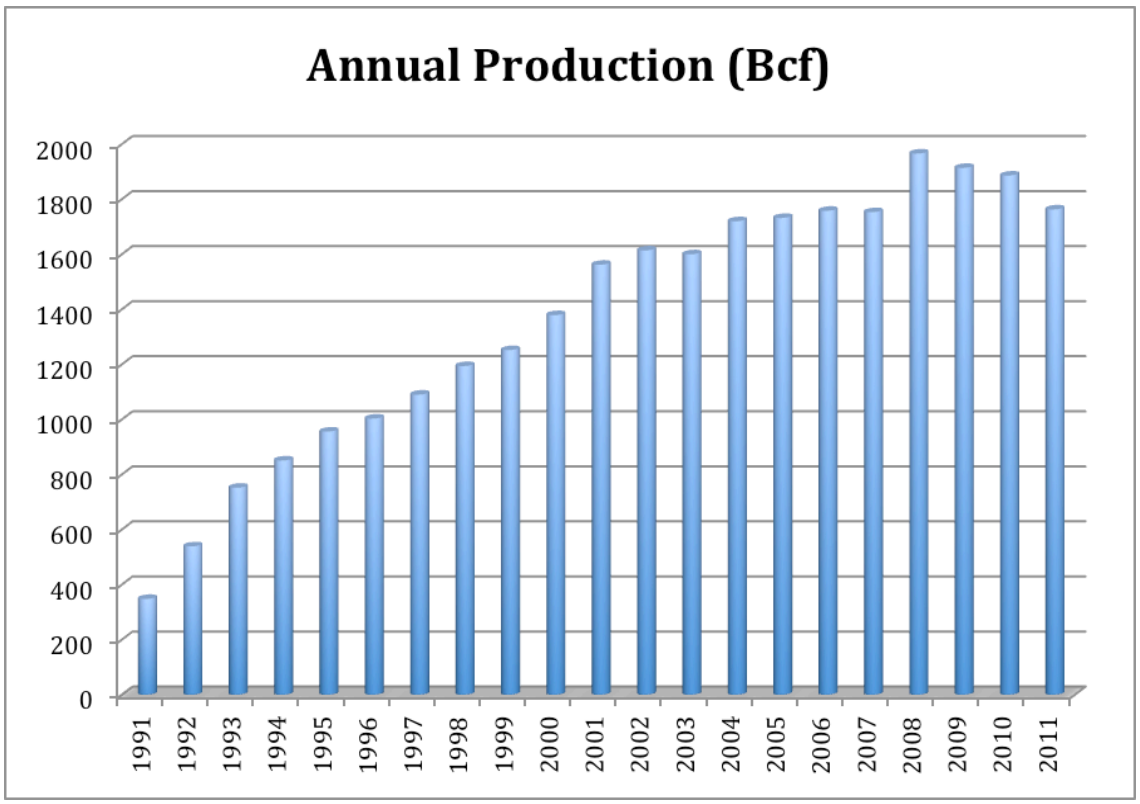

Figure 1. Historic U.S. coalbed methane production 1991-2011. Data from the Energy Information Administration (EIA). Production peaked in 2008 and has been declining every year since then. These data represent the most current available, through the end of 2011.

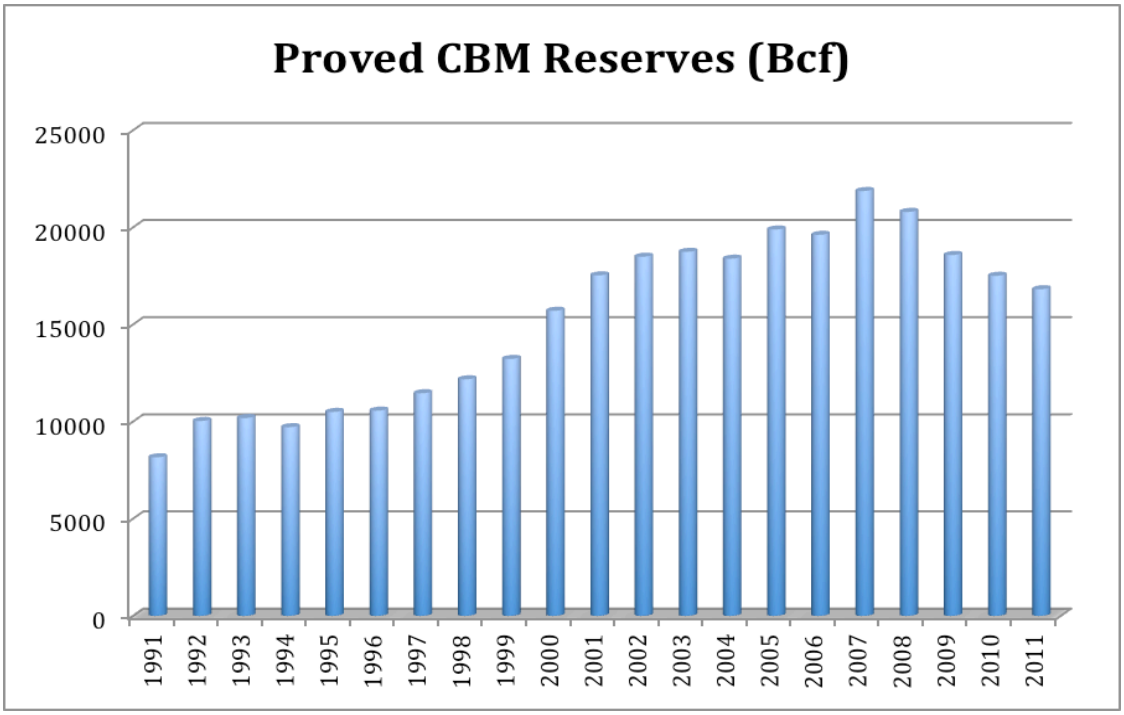

Figure 2. Historic U.S. coalbed methane reserve trends 1991 to 2011. Data from Energy Information Administration (EIA).

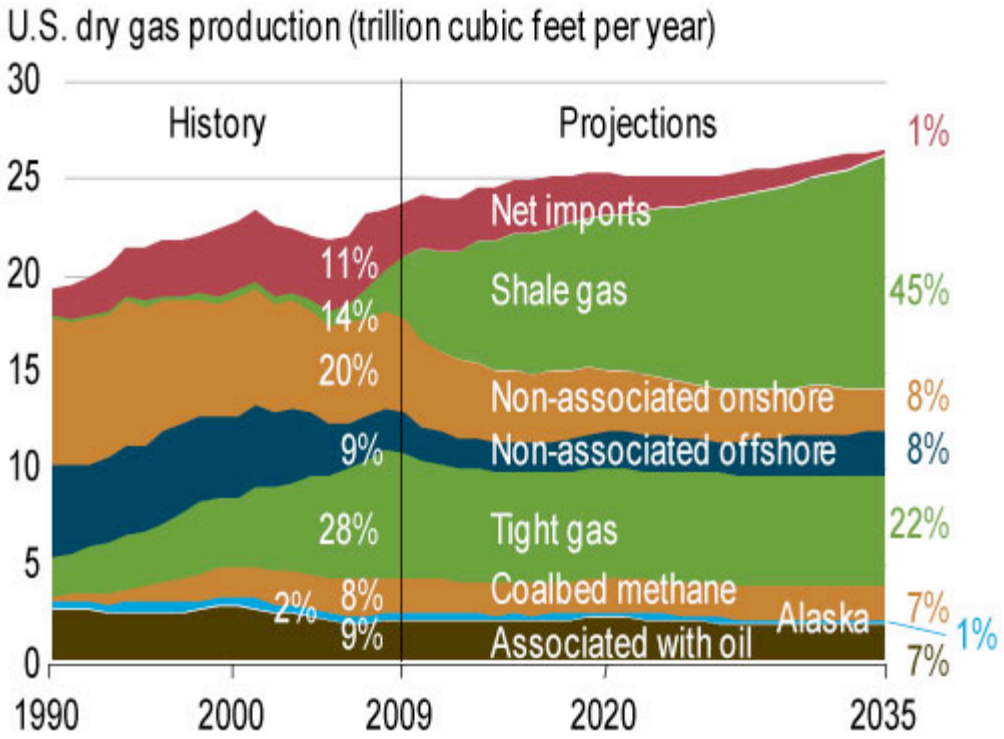

Figure 3. Sources of U.S. Natural gas production showing projected steady coalbed methane supply concurrent with major increase of shale gas supply (Source: Energy Information Administration).

Table 1. Historic U.S. coalbed methane production by year (1990-2011; Bcf). Data from the Energy Information Administration (EIA)

Year	US	AL	CO	NM	OK	UT	VA	WV	WY	Others
1991	348	68	48	229						3
1992	539	89	82	358						10
1993	752	103	125	486						38
1994	851	108	179	530						34
1995	956	109	226	574						47
1996	1003	98	274	575						56
1997	1090	111	312	597						70
1998	1194	123	401	571						99
1999	1252	108	432	582						130
2000	1379	109	451	550		74			133	62
2001	1562	111	490	517		83			278	83
2002	1614	117	520	471		103			302	101
2003	1600	98	488	451		97			344	122
2004	1720	121	520	528		82			320	149
2005	1732	113	515	514	58	75	56	30	336	35
2006	1758	114	477	510	68	66	81	18	378	46
2007	1753	114	519	394	82	73	85	25	401	60
2008	1966	107	497	443	69	71	101	28	573	77
2009	1914	105	498	432	55	71	111	31	535	76
2010	1886	102	533	402	45	69	97	17	566	58
2011	1763	98	516	374	39	60	100	18	506	52

Table 2. Historic U.S. coalbed methane proven reserves by year (1991-2011; Bcf). Data from the Energy Information Administration (EIA)

Year	US	AL	CO	NM	OK	UT	VA	WV	WY	Others
1991	8163	1714	2076	4206						167
1992	10034	1968	2716	4724						626
1993	10184	1237	3107	4775						1065
1994	9712	976	2913	4137						1686
1995	10499	972	3461	4299						1767
1996	10566	823	3711	4180						1852
1997	11462	1077	3890	4351						2144
1998	12179	1029	4211	4232						2707
1999	13229	1060	4826	4080						3263
2000	15708	1241	5617	4278		1592			1540	1440
2001	17531	1162	6252	4324		1685			2297	1811
2002	18491	1283	6691	4380		1725			2371	2041
2003	18743	1665	6473	4396		1224			2759	2226
2004	18390	1900	5787	5166		934			2085	2518
2005	19892	1773	6772	5249	568	902	1572	186	2446	424
2006	19620	2068	6344	4894	684	750	1813	194	2448	425
2007	21874	2126	7869	4169	1265	922	1948	255	2738	582
2008	20798	1727	8238	3991	511	893	1851	246	2781	560
2009	18578	1342	7348	3646	338	725	2261	220	2328	370
2010	17508	1298	6485	3532	325	718	1752	220	2683	495
2011	16817	1210	6580	3358	274	679	1623	139	2539	415