MEMORANDUM

DATE: April 5, 2012

TO: Stephen M. Testa, President, AAPG Energy Minerals Division

FROM: Jack C. Pashin, Government Representative,
Coalbed Methane Committee

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. Last year's AAPG Annual Convention and Exposition featured a poster session on coalbed methane development, which was held on Monday. An oral session featuring several presentations on coalbed methane and clean coal technology was chaired by Bill Ambrose and Peter Warwick on Tuesday afternoon and included some spirited discussion of coalbed methane development and geologic carbon storage. The coalbed methane related program is limited at this year's meeting in Long Beach, although presentations on environmental impacts, coal-seam CO_2 storage, and seismic characterization of coalbed methane reservoirs are scattered through the convention program.

One of the goals of the EMD Coalbed Methane Committee for 2012 is to expand our membership and to start compiling more international data from a variety of sources and to monitor international CBM activities more closely. The chairmanship of the coalbed methane committee is currently open, and the search for a new chair continues. The industry and academic positions on the committee are also vacant at this time and will hopefully be filled soon as well. AAPG has collected information from the membership about their commodity interests and their desire to take an active role in committee activities, which is aiding the search for new committee members.

Coalbed Methane Activity:

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 San Juan, Powder River, Black Warrior, Raton, Central Appalachian, 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, and 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 pilot tests for CO_2 storage and CO_2-enhanced coalbed methane recovery in coal. Injection has been completed in the Illinois, San Juan, Appalachian, Williston, and Black Warrior basins. A major pilot being conducted by CONSOL is in progress, and DOE has funded a new pilot program in the Appalachian basin of Virginia.

The Energy Information Administration has not released new coalbed methane production and reserve numbers, and so data are only available through the end of 2009. Annual coalbed methane production in 2009 was 1,914 Bcf and was nearly level with 2008 coalbed methane production (1,966 Bcf) (Figure 1; Table 1). Coalbed Methane reserves decreased from 20,798 Bcf in 2008 to 18,578 Bcf in 2009 representing a decrease of 2,220 Bcf or (10.7%) (Figure 2; Table 2). Coalbed methane represented 9.3 percent of 2009 dry-gas production and 6.8 percent of proved dry-gas reserves in the US. Interestingly, coalbed methane production is holding steady as a proportion of US gas production but is declining significantly in terms of proved dry gas reserves. This decline appears to be related to the booking of major shale gas reserves during 2009, which is significantly changing US gas markets (fig. 3).

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. At least 2,267 coalbed methane wells have been drilled to date in southwestern Virginia and production has increased from 105 Bcf in 2008 to 111 Bcf in 2009 (Table 1). West Virginia had more 290 coalbed methane wells and coalbed methane production of 31 Bcf as of the end of 2009. The number of wells in Pennsylvania is undetermined, but production increased from 11 Bcf in 2008 to 16 Bcf in 2009. The advent of pinnate horizontal drilling has resulted in a significant expansion of the coalbed methane industry in the Appalachian basin by providing access to large volumes of gas in low-permeability coal seams. There were more than 4,800 coalbed methane wells operating in Alabama with cumulative production of 2.2 Tcf and annual production of 105 Bcf in 2009.

The mid-continent region, consisting of the Cherokee, Forest City, Arkoma, and Illinois Basins has recently been one of the more active regions in the U.S., but production and reserves appear to be declining. Exploration in the Cherokee basin in Oklahoma and Kansas has spread northward to include the southern part of the Forest City Basin. The Arkoma Basin continues to produce CBM and there are multiple prospects being developed in this basin. As in the Appalachian Basin, 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 from 47 Bcf in 2008 to 43 Bcf in 2009, whereas production decreased in Oklahoma from 69 Bcf in 2008 to 55 Bcf in 2008 (a 20.3% decrease).

Infill drilling of Fruitland CBM wells in the San Juan Basin (Colorado and New Mexico) has decreased markedly in 2009 due to the recession. To minimize the environmental impact of infill drilling, operators are drilling deviated wells into Fruitland coal from the existing well pads. Environmental groups continue to express concern about gas seeps along the margins of the San Juan Basin in the Fruitland outcrop belt. 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 over 67% of total U.S. CBM production. In 2009, CBM production in Colorado held steady at 498 Bcf (vs. 497 in 2008), and production in New Mexico declined slightly from 443 to 432 Bcf.

There were 3,500 fewer producing wells in the Powder River Basin in 2009 compared to 2008. The production high in 2008 was attributed to: (a) "Big George" production that has been on for many years but is finally lowered the hydrostatic pressure enough to yield major gas production, and (b) the likelihood that many of the wells shut in in 2009 were not big producers. Another positive statistic for the basin is the lowest water to gas ratio since the play became commercial, 1.02 barrels of water per MCF. In December 2009, the EPA raised concerns about the discharge of CBM-produced water in the PRB, claiming that Wyoming‘s surface discharge program does not meet Clean Water Act or Wyoming‘s own agricultural protection standards. As a result a number of water discharge permit applications with the Wyoming Department of Environmental Quality were put on hold. The Wyoming DEQ and State Engineer's offices have had to refine their oversight of coalbed methane water management. In Wyoming, 2009 CBM production totaled 535 Bcf, whereas only 12 Bcf was produced in Montana.

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. Exploration and development activity continues in western Canada, where the Horseshoe Canyon coals host a major coalbed methane play. However, depressed natural gas prices are slowing Canadian development. Horizontal drilling is playing an increasingly important role in the development of low-permeability coal seams in western Canada. Exploration and development efforts are intensifying 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. The most likely outcome is that only 2 or 3 LNG plants will be developed. Major potential exists in the Gondwanan coal basins of India, and development of fields and pipeline infrastructure is underway. The absence of regional pipelines to market and large populations in exploration fairways have hindered CBM development in India.

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 the past year to explore for coalbed methane in the structurally complex European coal basins of western Europe, including Germany.

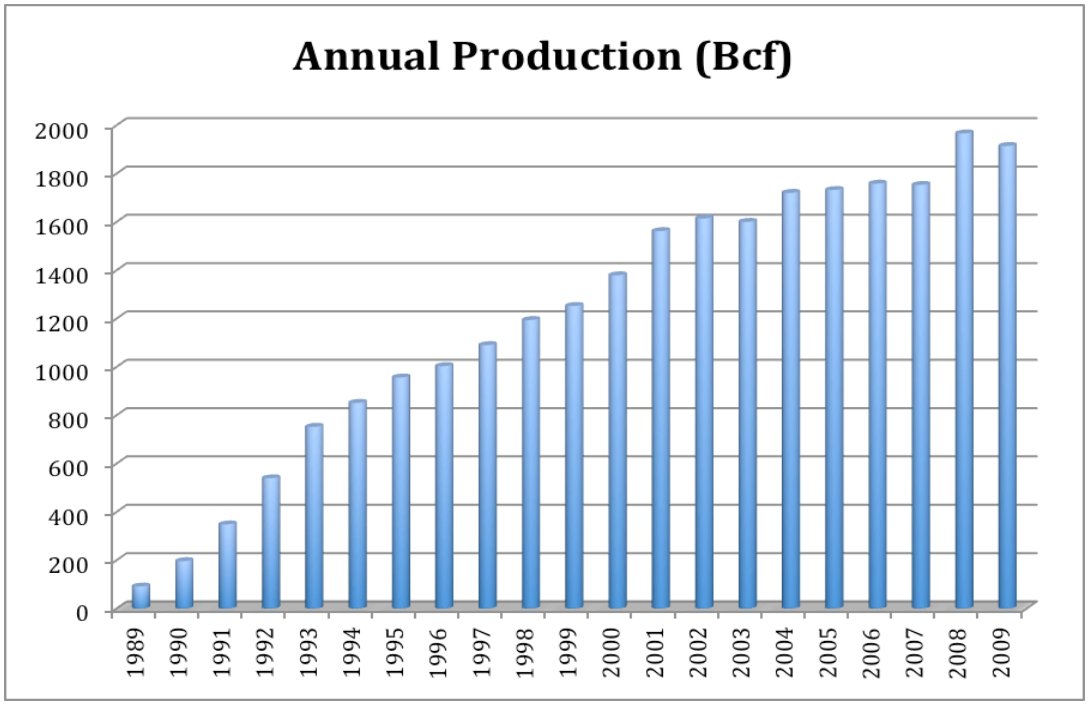

Figure 1. Historic U.S. coalbed methane production 1989-2009. Data from the Energy Information Administration (EIA).

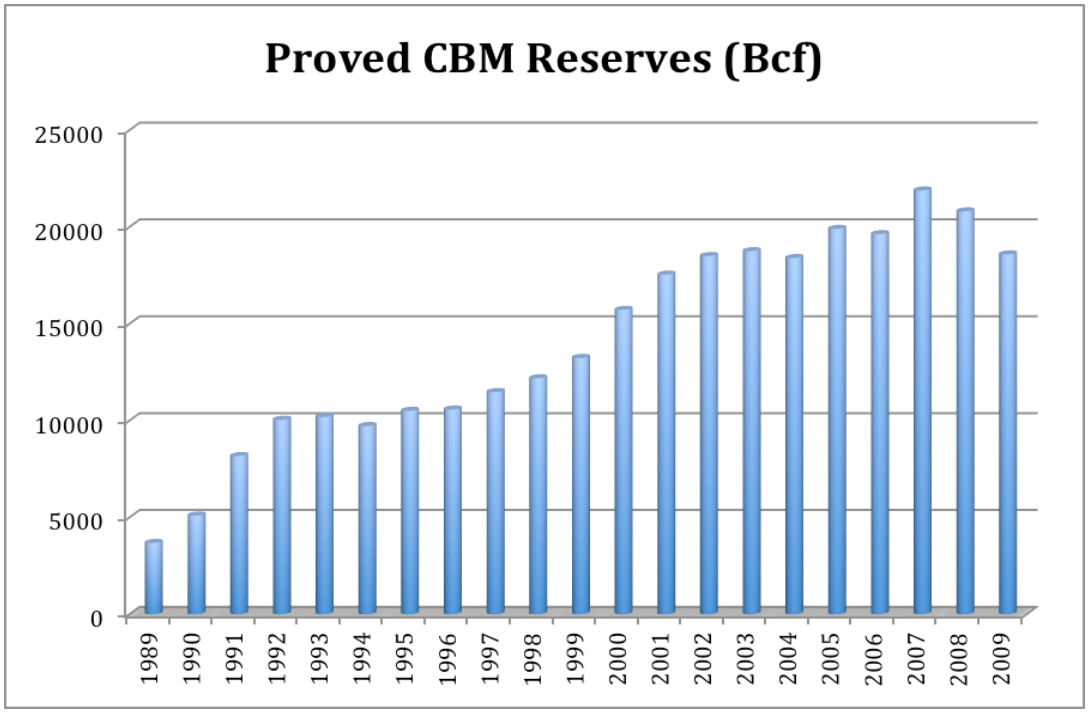

Figure 2. Historic U.S. coalbed methane reserve trends 1989 to 2009. Data from Energy Information Administration (EIA).

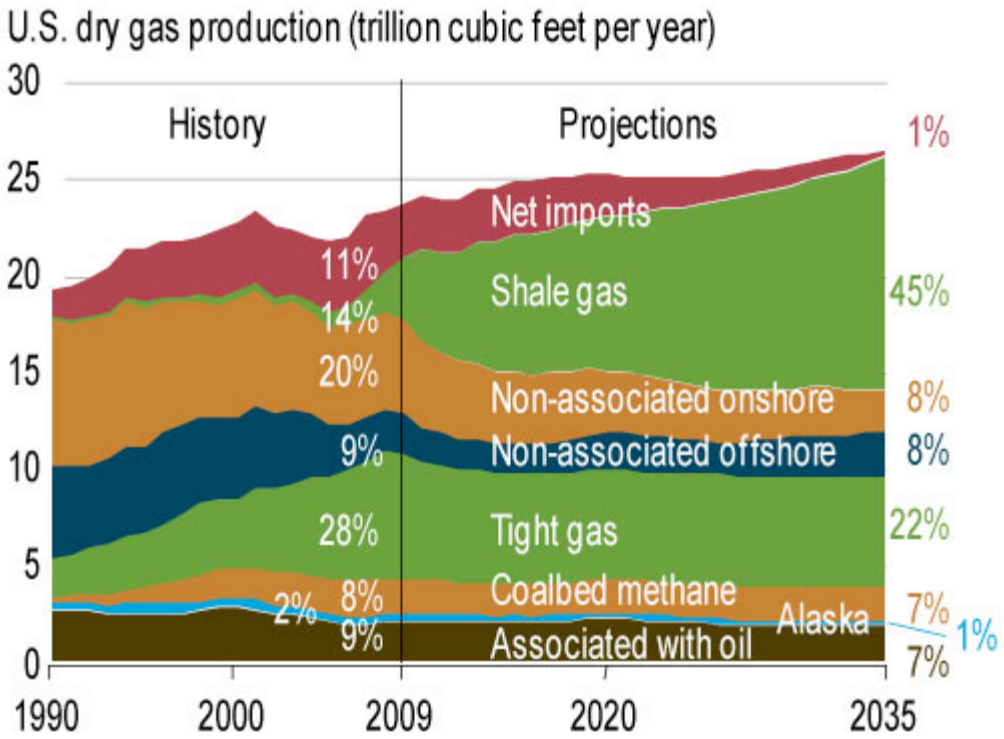

Figure 3. Sources of U.S. Natural gas production showing projected steady coalbed methane supply concurrent with major increase of shale gas supply (Source: Energy Information Administration).

Table 1. Historic U.S. coalbed methane production by year (1989-2009; Bcf). Data from the Energy Information Administration (EIA)

Year	US	AL	CO	NM	OK	UT	VA	WV	WY	Others
1989	91	23	12	56						0
1990	196	36	26	133						1
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

Table 2. Historic U.S. coalbed methane proven reserves by year (1989-2009; Bcf). Data from the Energy Information Administration (EIA)

Year	US	AL	CO	NM	OK	UT	VA	WV	WY	Others
1989	3676	537	1117	2022						0
1990	5087	1224	1320	2510						33
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