EMD Coal Committee Mid-Year Report

William A. Ambrose, Chair

November 9, 2011

Vice-Chairs:

Dr. John S. Mead (Vice-Chair: University), Southern Illinois University, Carbondale, Ill.

Susan J. Tewalt (Vice-Chair: Government), U.S. Geological Survey, Reston, Va.

Committee Activities

The EMD Coal Committee in 2011 appointed two Vice-Chairs, (1) Dr. John S. Mead (jmead@siu.edu), Director of the Coal Research Center at Southern Illinois University, as the University Vice Chair, and (2) Susan J. Tewalt (stewalt@usgs.gov), geologist and NCRDS State Coops Technical Officer at USGS, who is serving as the Government Vice Chair.

The AAPG-OSU (Oklahoma State University) Committee approved funding for a GIS project for Wilcox lignite in the Texas Gulf Coast. Eighteen of 23 Wilcox maps have already been converted from CAD to GIS by the OSU cartography lab. The EMD Coal Committee appreciates the efforts and dedication from Sam Limerick for proposing and championing the project.

A manuscript for coal has been written for inclusion in the 2011 review of unconventional energy resources to be published by NRR (Natural Resources Research), edited by Peter D. Warwick. Topics summarized by the article on coal include (1) world and U. S. consumption and production, (2) clean coal, (3) underground coal gasification, and (4) coal-to-liquids technology. Expanded details on each of these topics can be accessed on the EMD members-only web site at: http://emd.aapg.org/members_only/annual2011/Coal_EMDAR2011.pdf.

EMD is a sponsor for the soon-to-be released Gulf Coast coal report: Geologic Assessment of Coal in the Gulf of Mexico Coastal Plain, U.S.A., edited By Peter D. Warwick, Alexander K. Karlsen, Matthew Merrill, and Brett J. Valentine: AAPG Discovery Series No. 14, AAPG Studies in Geology No. 62. The CD-ROM will soon be available via the AAPG book store. The GIS supporting files can be downloaded for free via AAPG Datapages open-file portal:
http://www.datapages.com/Services/GISUDRIL/OpenFiles/GulfCoastCoalAssessment.aspx

The list of references for the EMD Coal Committee has been updated and posted on the committee website. Updating of the 2012 calendar is underway. Many thanks to Brian Cardott for updating these references and to Janet Brister for posting these references, which can be accessed via:
http://emd.aapg.org/members_only/coal/index.cfm

Coal Commodity Report

This mid-year coal commodity report focuses primarily on U. S. coal production, consumption, regulatory issues, and clean coal with some aspects of world coal production. Information on coal gasification and coal-to-liquids (CTL) can be accessed on the EMD members-only web site at: http://emd.aapg.org/members_only/annual2011/Coal_EMDAR2011.pdf.

World Coal Production and Consumption

Coal accounts for 27% of total energy use worldwide (Energy Information Administration, 2011a). Estimated worldwide coal production in 2010 exceeded 7 billion short tons (bst), or 130.4 quadrillion Btu, where 1 bst is equivalent to ~18.8 quadrillion Btu (National Petroleum Council, 2011). Non-OECD (Organisation for Economic Cooperation and Development) Asia led the world in coal production (72.8 quadrillion Btu [~3.9 bst]) in 2007, of which China produced 55.3 quadrillion Btu (~2.9 bst). In contrast, 2007 coal production in OECD North America represented only 25.3 quadrillion Btu (~1.3 bst), of which coal production in the United States was 23.5 quadrillion Btu (~1.2 bst). World coal production is estimated to rise to ~207 quadrillion Btu (~11 bst) by 2035 to meet expected increasing demand (Energy Information Administration, 2011a). Approximately 64% of international coal consumption in 2008-2009 was used for generation of electricity, whereas 33% was sold for industrial use (primarily steel manufacture). The remainder was primarily for consumers in residential and commercial sectors. Although most steel-producing countries reduced their steel production >10% from 2008 to 2009, China, India, and Iran saw increases.

U.S. Coal Production and Consumption

Monthly U. S. coal production from January to August, 2011 has been ranging from 85 to 95 mst (million short tons), comparable to that of the same time periods in 2009 and 2010 (Fig. 1).

However, the Energy Information Administration predicts a decline in coal consumption in the electric sector in 2012, with 944.4 mst consumed, down from a previous forecast of 966.5 mst (Noh, 2011). The primary reason for this projected decline is the expectation that more electricity generation will come from natural gas, with a 3.5% increase compared to <1% increase from coal.

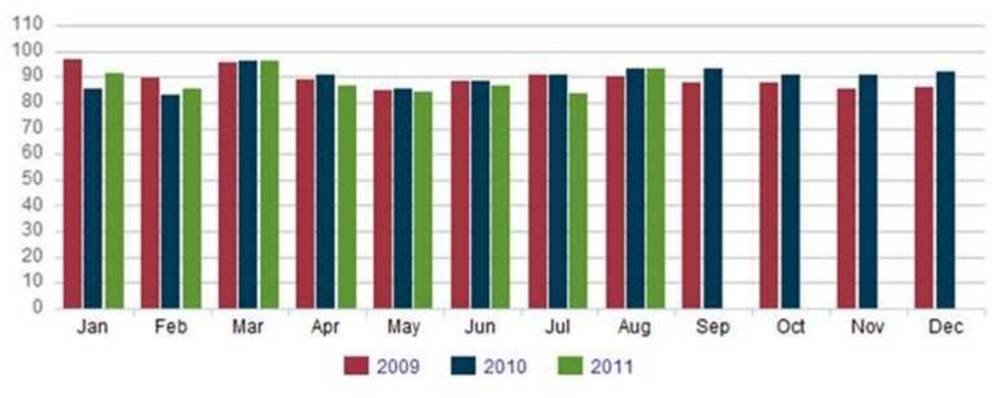

Figure 1. Monthly U. S. coal production in 2009, 2010, and from January to August, 2011. Units are mst. Modified from Energy Information Administration (2011b).

Although coal has traditionally provided ~50% of U.S. electricity generation, it has recently declined by ~4%, owing to a variety of factors that include increased use of cheaper natural gas for power generation, decrease in demand owing to the recent recession, delays in commissioning new proposed coal-fired power plants, and new strict regulatory requirements from EPA (Environmental Protection Agency). In contrast, electric-generation capacity from natural gas has increased from 18 to 21% and DOE (U. S. Department of Energy) estimates that 90% of new power plants built in the next 20 years will be fired with natural gas. Approximately 300 gigawatts (GW) or 281,557 billion Btu of electrical capacity in the U.S. was provided by coal from ~1,500 generating facilities in 2009 (Energy Information Administration, 2011c).

Estimates for U. S. coal prices have also been revised, with cost increases attributed primarily to transportation costs (Noh, 2011). EIA reports that average delivered coal prices to the electric power sector have increased over a ten-year period by 6.7% per year. Delivery costs to the power sector averaged \$2.26/MMBtu (million British Thermal Units) in 2010 and approximately \$2.38/MMBtu in 2011. Between 2008 and 2014 a potential recovery in coal production is projected to be offset by low natural gas prices and increased electricity generation from renewables. However, beginning with 2014, coal production should grow at an average annual rate of 1.1 percent through 2035, with increases in coal use for electricity generation and synfuels production (Energy Information Administration, 2011d).

U.S. coal production fell from 1,171.8 to 1,074.9 mst between 2008 and 2009, the largest one-year decline since 1949 (Energy Information Administration, 2009). Likewise, coal consumption in the electric sector declined by 10.3%, whereas coking coal consumption decreased by 30.6%. These declines resulted in record high coal stocks of 233.0 mst at the end of 2009 (Energy Information Administration, 2009). The western U. S. coal region continues to lead the U.S. in coal production, accounting for ~585 mst in 2009 (Table 1). Wyoming was the highest-producing coal-mining state. West Virginia in the Appalachian Basin experienced the greatest tonnage decline in the region in 2009, dropping by 20.7 mst to 137.1 mst (Table 1).

Coal-Producing Region and State	**2008 Production (mst)**	**2009 Production (mst)**
Appalachian Total	**390.2**	**341.4**
Alabama	20.6	18.8
Kentucky, Eastern	90.3	74.7
Maryland	2.9	2.3
Ohio	26.3	27.5
Pennsylvania	65.4	58.0
Tennessee	2.3	2.0
Virginia	24.7	21.0
West Virginia	157.8	137.1
Interior Total	**146.6**	**145.8**
Arkansas	0.1	0.0
Illinois	32.9	33.7
Indiana	35.9	35.7
Kansas	0.2	0.2
Kentucky, Western	30.1	32.6
Louisiana	3.8	3.7
Mississippi	2.8	3.4
Missouri	0.2	0.5
Oklahoma	1.5	1.0
Texas	39.0	35.1
Western Total	**633.6**	**585.0**
Alaska	1.5	1.9
Arizona	8.0	7.5
Colorado	32.0	28.3
Montana	44.8	39.5
New Mexico	25.6	25.1
North Dakota	29.6	29.9
Utah	24.4	21.7
Wyoming	467.6	431.1
Refuse Recovery	**1.4**	**2.7**
U.S. Total	**1,171.8**	**1,075.0**

Table 1. U.S. Coal production by region and state, 2008-2009. Modified from Energy Information Administration (2009).

Western coal production, bolstered from large reserves in the Powder River Basin, is projected to increase greatly to 2035 (Fig. 2). In contrast, coal production in the Interior U. S. is projected to increase slightly from 2.9 quadrillion Btu (145.8 mst) in 2009 to 3.5 quadrillion Btu (176.0 mst) in 2035. Production from this region is from large reserves of mid- and high-sulfur bituminous coal in Illinois, Indiana, and western Kentucky. However, coal production in the Appalachian region will decline substantially, owing to depleted, higher cost reserves of Central Appalachia being supplanted by cheaper coal from other U. S. regions.

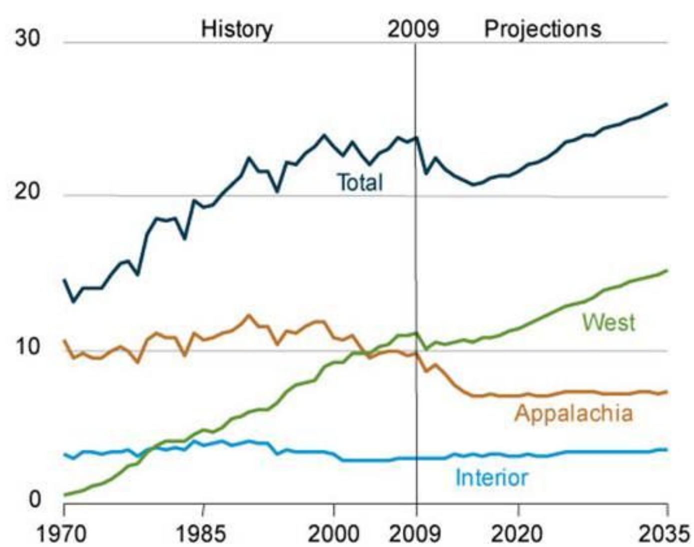

Figure 2. U. S. coal production by region projected to 2035. Units are quadrillion Btu. Modified from Energy Information Administration (2011d).

Several factors are assumed to affect future U.S. coal production, including different assumptions about the costs of producing and transporting coal, future economic growth, prices of other energy commodities such as oil and natural gas, and regulations on greenhouse gas emissions

(Fig. 3). For example, higher oil prices could spur the demand for coal synfuels, which could justify an expansion in CTL technology, resulting in as much as 1.6 MMbbl/d (million barrels per day) of synfuels by 2035. The average mine mouth price in the reference case for U.S. coal displays little variability, rising to only \$1.73/MMBtu in 2035 (Figs. 3 and 4). These minor changes in coal prices are the result of several factors, including a shift in production from high-cost coal in the Appalachian region to low-cost coal in the Interior and Western regions. Recent increases in the average price of Appalachian coal, from \$1.27/MMBtu in 2000 to \$2.56/MMBtu in 2009, in part reflect declining mining productivity.

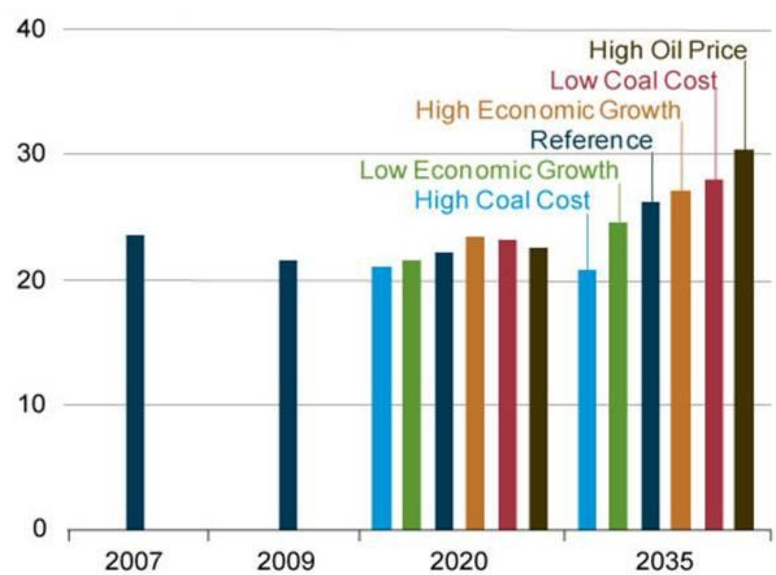

Figure 3. Six scenarios for future U. S. coal production. Units are quadrillion Btu. Modified from Energy Information Administration (2011d).

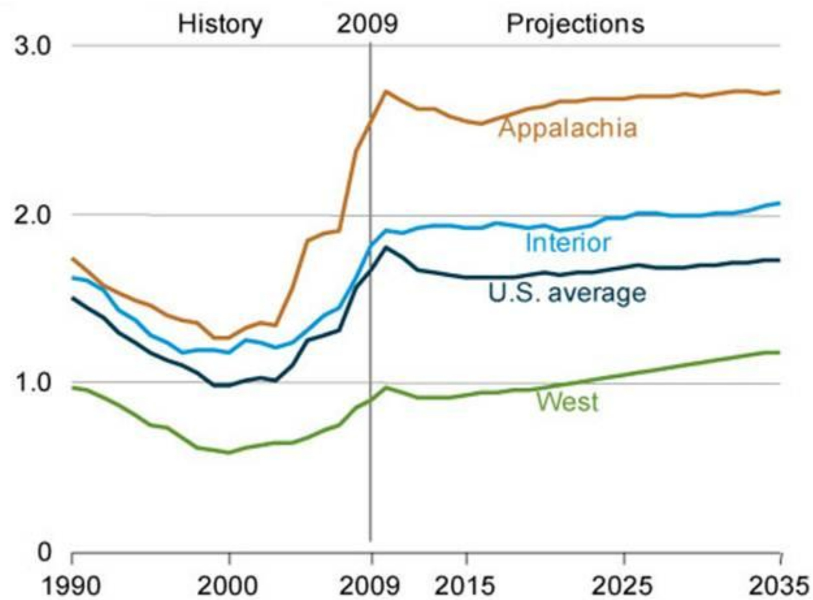

Figure 4. Average mine mouth price in U. S. regions. Units are 2009 dollars per million Btu. Modified from Energy Information Administration (2011d).

Coal-Emissions Regulatory Issues

Recently announced new EPA regulations on air quality that take effect on January 1, 2012 are already impacting electricity generation from coal. According to ERCOT (Electric Reliability Council of Texas), as much as 1.3 GW (gigawatts) of electrical power from coal-fired power plants in the state will be taken offline in January 2012, owing to insufficient time to comply with these regulations (Brown, 2011; ERCOT, 2011). The new EPA rule requires Texas and 26 other states to reduce emissions that produce smog and soot in downwind states. Under previous EPA guidelines, Texas power plants were required to address only summertime smog-forming pollution. However, EPA in July, 2011 announced new sulfur dioxide emission guidelines. The only way Luminant, the largest power producer in Texas, can comply is by reducing generating capacity by 1.3 GW, possibly resulting in rolling blackouts in summer, 2012.

Regulatory and End-Use Impacts on U. S. Coal Consumption

Investments in greenhouse-gas technologies, as well as CTL plants and integrated coal gasification and combined cycle plants (IGCC) without carbon capture and storage (CCS), will have a negative impact on U. S. coal consumption (Fig. 5). Without implementation of greenhouse-gas technologies, coal use for both electricity generation and synfuels production is 3.5 quadrillion Btu higher than in the Reference case. Moreover, 48 GW of new coal-fired generating capacity would be brought online after 2009, as compared with 26 GW otherwise.

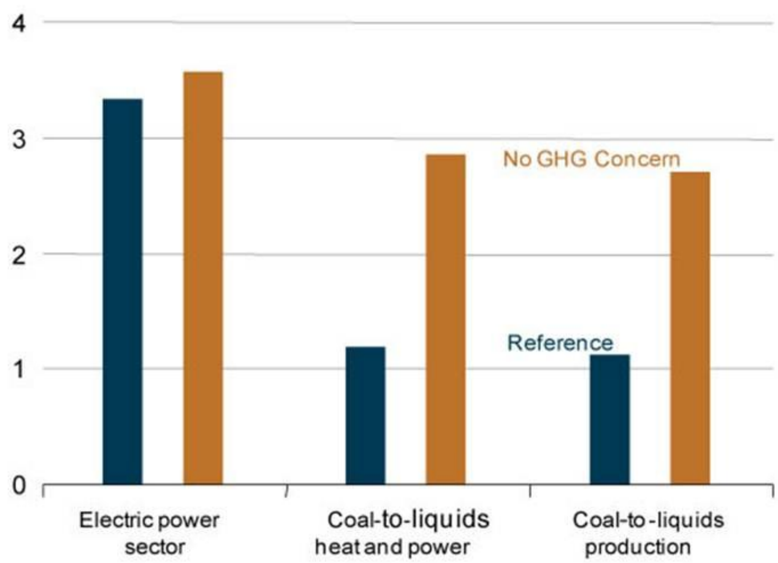

Figure 5. Changes in annual U.S. coal consumption (from 2009 to 2035) by end-use (electric power, coal-to-liquids heat and power, and coal-to-liquids production with two cases (with and without greenhouse gas (GHG) concerns. Units are quadrillion Btu. Modified from Energy Information Administration (2011d).

Clean Coal

Clean coal is coal that is stripped of minerals and other impurities and then gasified and burned in high-oxygen mixtures with capture of CO_2 and hydrogen. Factors that impact costs and the selection of optimal areas for new clean-coal sites include (1) proximity of sites to mine mouths, (2) distance of CO_2 transport via pipelines to carbon sinks, and (3) transmission losses between new power-generating facilities and user load (Mohan and others, 2008; Cohen and others, 2009; Dooley and others, 2009; Hamilton and others, 2009). Newcomer and Apt (2008) conclude that optimal sites for new clean-coal facilities should be near user electric load, owing to transmission losses exceeding costs of installing new CO_2 pipelines and fuel transport. However, economic incentives that support new clean-coal facilities should also be considered, including EOR (enhanced oil recovery) with generated CO_2 (Holtz and others, 2005; Advanced Resources International, 2006a, b; Ambrose and others, 2010). Other incentives include ECBM (enhanced coalbed methane recovery) (Reeves, 2003: McVay and others, 2009), and underground coal gasification with CCS (Roddy and Younger, 2010).

The U.S. federal government has recently been favoring initiatives to develop clean-coal technology for power plants that involve CCS. In June 2008 DOE issued a Funding Opportunity Announcement (FOA) to invest in IGCC or other clean-coal power plants with CCS technology. DOE has generated >30 reports summarizing recent and ongoing clean coal demonstrations, as well as DOE post-project assessment (NETL, 2010). The program performance goal of DOE in coal gasification is to complete research and development for advanced power systems capable of achieving 45 to 50% electrical efficiency at a capital cost of $1,000 per kilowatt (in constant 2003 dollars) or less for a coal-based plant. DOE also has a goal for the year 2015 to have ready an operating zero-emission, high-efficiency, co-production power plant that will produce hydrogen from coal. Partial oxidation of coal is a promising technology for co-production of hydrogen and electric power using IGCC technology. However, currently there are no commercial demonstrations of these joint power and hydrogen plants. (U. S. Department of Energy, 2010).

Clean-coal activity in North America is led by the Dakota Gasification Company, where ~95 million cubic feet per day of CO_2, generated by gasification of North Dakota lignite, is transported via a 205-mile (328-km) pipeline to Weyburn oil field in Saskatchewan for EOR (Chandel and Williams, 2009). Weyburn field has become the largest land-based CO_2 storage project in the world, having sequestered >12 million metric tons (Mt) (Preston and others, 2009).

In March 2010 DOE announced that it reached a cooperative agreement with Summit Texas Clean Energy LLC to design, build and demonstrate a coal-gasification plant near Odessa, Texas (Fairley, 2010). The plant is designed to provide electricity for >165,000 homes. Approximately 90% of the CO_2 (3 Mt yr^{-1}) produced from the plant will be captured and transported with existing CO_2 pipelines for EOR in nearby oil reservoirs. CO_2 sales to oil and gas operators are projected to increase plant revenues by 50%. Revenues from EOR could cover the price premium for carbon capture at the Odessa clean-coal facility, assuming an oil price of $75 per barrel (Al-Juaied and Whitmore, 2009). Funding will be provided by DOE and NETL. The estimated total cost for the project is $1.73 billion and DOE’s share will be $350 million.

DOE has awarded AEP **(**American Electric Power) funding for 50% of the cost, up to $334 million, of building a commercial-scale CCS installation at the Mountaineer plant in West Virginia. The project, to be operational by 2015, will capture and store ~1.5 million metric tons of CO_2 per year. Its goal is to remove up to 90% of the CO_2 from a 235 MWe portion of the power plant’s flue gas (American Electric Power, 2009). However, owing to uncertainties in U. S. climate policy and its current weak economy, AEP has decided to place the project on hold upon completing the initial front-end engineering and design phase of the project (Massachusetts Institute of Technology, 2011).

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