EMD Coal Committee Mid-Year Report

William A. Ambrose, Chair

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Vice-Chairs:

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Committee Activities

The calendar of coal-related events and conferences for 2013 and 2014 has been posted on the EMD Coal Committee website.

The coal-commodity article in "Unconventional Energy Resources: 2013 Review", edited by Peter D. Warwick and Paul Hackley, will be released for publication in Natural Resources Research in 2013 or early 2014. The article is a brief summary of (1) world coal prediction and consumption, (2) U.S. coal consumption and production, and (3) U.S. coal regulatory issues and clean coal, with current examples in Texas. The 2013 EMD Mid-Year coal commodity report is an expanded version of the NRR article.

EMD is also a sponsor, along with The Society for Organic Petrology (TSOP), of the second edition of the Atlas of Coal Geology which was released in May 2013 as AAPG Datapages Discovery Series No. 17. The editors (Alexander R. Papp, James C. Hower, and Douglas C. Peters) present a comprehensive collection of images on the geology of coal and facets of the coal resource utilization industry. Volumes 1 and 2 emphasize coal geology and coal petrology, respectively. Both volumes are on the same disc. The CD-ROM is available for sale at the AAPG online book store; see http://store.aapg.org/detail.aspx?id=1212.

EMD is a sponsor for 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 is now 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.

Coal Commodity Report

Executive Summary

Coal continues to be an important component of the world's energy supply and is second only to oil in terms of the world's energy mix. Total world coal production was ~8.4 billion short tons (bst), or ~7.7 billion metric tons in 2012. China leads the world in coal production, having produced ~3.8 bst (billion short tons [~3.5 billion metric tons]) in 2012, more than three times than the U.S., and more than the U.S, India, Australia, and Indonesia combined.

Although U.S. coal production for exports is strong, coal's share of the country's overall energy production is declining because of expanded natural gas production and increasingly strict federal regulations. Market conditions and environmental regulations will contribute to 59 to 77 GW (gigawatts) of coal plant retirements by 2016. Currently, the U.S. maintains 316,000 MW (megawatts) of coal-fired generation, representing ~30% of the nation's total electricity generation fleet.

Clean coal with economic incentives from EOR (enhanced oil recovery) is a method of potentially generating electric power and being compliant with strict regulations. However, a variety of technical and economic challenges remain for clean-coal to be economically viable. 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. Two planned clean-coal projects in Texas (NRG Parish and TCEP Summit Plants) are examples of clean coal technology linked to EOR.

World Coal Production and Consumption

World coal production and consumption continues at high levels and is a significant part of the world's energy mix. Total world coal production was ~8.4 billion short tons (bst), or ~7.7 billion metric tons in 2012 (Energy Information Administration, 2013a). Coal is second only to oil as the world's top energy source. More than 1,400,000 megawatts (MW), or >1,400 gigawatts (GW) of electricity could be supplied from the ~1,200 new proposed coal-fired power plants worldwide (MIT Technology Review, 2011). China produced 45% of the world's coal in 2012, more than three times than the U.S., and more than the U.S, India, Australia, and Indonesia combined (Enerdata, 2013) (Fig. 1).

Figure 1 Global coal and lignite production in 2012, with top-ten producing countries. From Enerdata, 2013).

According to a statistical review of world energy by British Petroleum (2013), the United States and Russia lead the world in coal reserves, each possessing >5 trillion BTU (British Thermal Units)-equivalent of coal reserves. China and Australia occupy the second tier of coal reserves, each with >3 trillion BTU-equivalent reserves, whereas third-tier nations with lesser coal reserves include India, Kazakhstan, The Union of South Africa, Turkey, Poland, German, Brazil, Canada, the Czech Republic, Pakistan, and Indonesia.

Coal consumption from several countries has dramatically increased in the past 50 years. Indonesia saw an increase of >33,000% during this time, whereas consumption from China, South Korea, Mexico, and Taiwan has increased between ~1,300 to 1,540% (MIT Technology Review, 2011). Coal consumption increases in Turkey, India, and Brazil range from ~700 to 790% in the past 50 years. China consumed 3.8 billion short tons (3.45 billion metric tons) of coal in 2011, nearly half the world's total consumption (Sweet, 2013). This increased consumption is partly driven by more than a threefold increase in electricity generation in China since 2000. Global demand for coal has grown by about 2.9 billion short tons (2.6 billion metric tons) since 2000, with 82% of the total demand in China.

U.S. Coal Production and Consumption

U.S. coal production in 2012 was ~1.0 bst (~0.9 billion metric tons), down from 2010 and 2011 levels (Energy Information Administration, 2013b). Coal production in the first and second quarters of 2013 was slightly less than 0.5 bst (Energy Information Administration, 2013b) (Fig. 2).

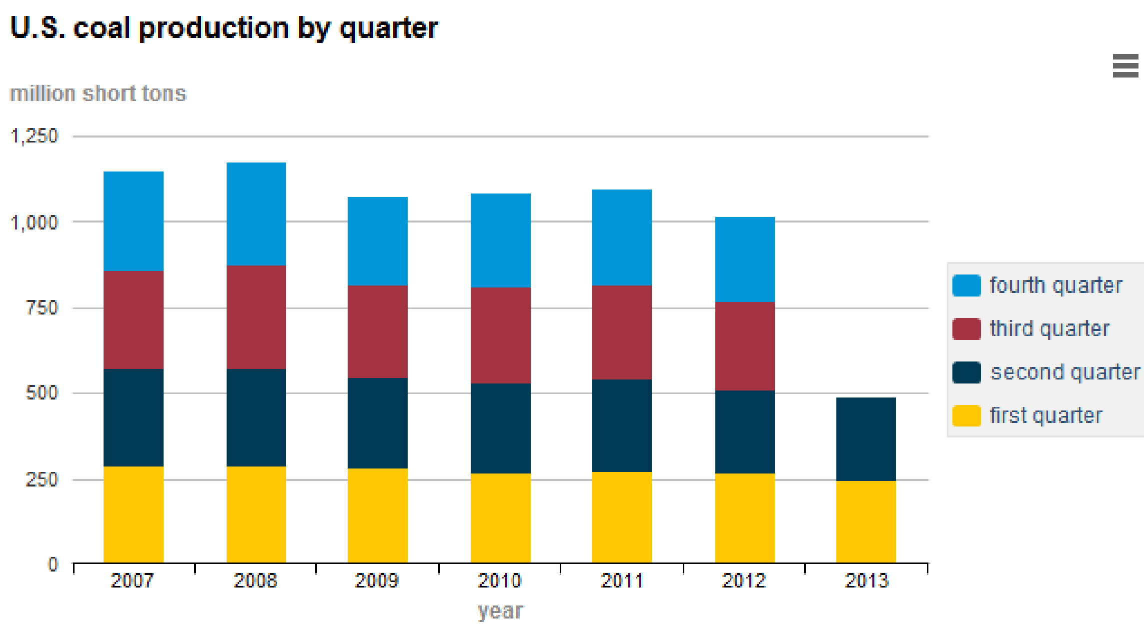

Figure 2. U.S. coal production by quarter, 2007 to the first two quarters of 2013. From Energy Information Administration, 2013b).

Although U.S. coal production for exports continues to be strong, coal's share of the country's overall energy production is declining, mainly owing to expanded natural gas production (Humphries and Sherlock, 2013). Lower demand for coal in U.S. markets is projected from a combination of factors that include increasingly strict federal regulations, lower natural gas prices, and coal-plant retirements. Elliott and others (2011) and Reuters (2012), based on data from NERC (2011), estimate that market conditions and environmental regulations will contribute to 59 to 77 GW of coal plant retirements by 2016 (Fig. 3). Greatest loss of coal-fired electricity generation is projected to be in the southeastern U.S., with 27 to 30 GW of plant retirements, followed by the northeastern U.S. (18 to 26 GW).

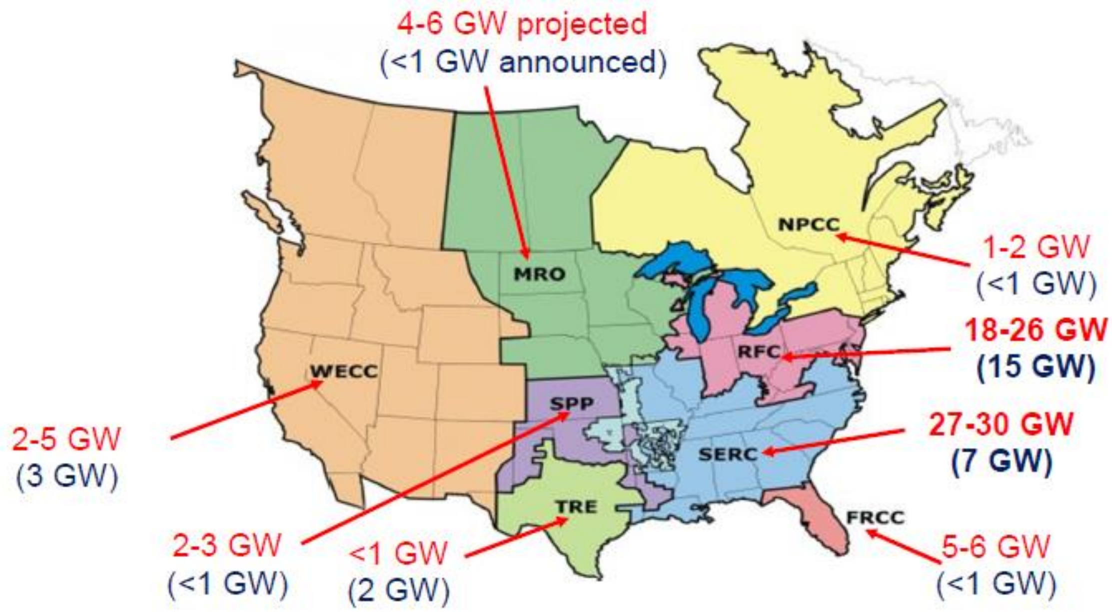

Figure 3. Distribution of anticipated U.S. coal plant retirements in terms of power-generation losses expressed in gigawatts (GW). From Elliott and others (2011) and Reuters (2012), based on data from NERC (2011). Florida Reliability Coordinating Council (FRCC); Midwest Reliability Organization (MRO); Northeast Power Coordinating Council (NPCC); ReliabilityFirst Corporation (RFC); SERC Reliability Corporation (SERC); Southwest Power Pool, RE (SPP); Texas Reliability Entity (TRE); Western Electricity Coordinating Council (WECC).

Coal production (excluding lignite) in the western U.S., dominated by Wyoming, was 193.8 million short tons (mst) in 2012 (Energy Information Administration, 2013c). Wyoming continues to be the leading coal-producing state in the first half of 2013, with 91.8 mst of production.

Europe remains the primary export market for U.S. coal, accounting for 16.4 mst in 2012 (Energy Information Administration, 2013b). Exports to Asia in 2012 were 7.0 mst, representing a 23% increase from 2007 to 2012. Exports to South America and Africa were 1.8 and 1.2 mst, respectively.

U.S. Coal Regulatory Issues and Clean Coal

The Environmental Protection Agency (EPA) is in the process of developing new greenhouse-gas regulations that may impair the construction of new coal-fired power plants in the U.S. that do not employ clean-coal technology with carbon capture and storage (CCS). EPA has announced that proposed rules for existing and modified plants will be issued in 2014, with regulations to be finalized in 2015. These regulations are to be applied to existing power plants, even though annual U.S. SO_2 emissions from coal-fired electricity plants have declined from 16 to less than 6 mst since 1990 and annual NO_x emissions have declined from 7 to 1.8 mst in the same period (Energy Information Administration, 2012a). Despite recent stricter air-emission regulations, coal will still account for up to 35% of U.S. electricity generation for another 30 years (Energy Information Agency, 2011). Currently, the U.S. maintains 316,000 MW of coal-fired generation, representing ~30% of the nation's total electricity generation fleet.

Clean coal is coal that is gasified and burned in high-oxygen mixtures, resulting in removal of hazardous substances such as arsenic, lead, cadmium, mercury, and nitrogen and sulfur dioxides, as well as 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, such as EOR (enhanced oil recovery) with generated CO_2 (Holtz and others, 2005; Advanced Resources International, 2006; Ambrose and others, 2011, 2012).

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).

Texas has several examples of new and planned clean-coal projects that illustrate how clean-coal technology can be applied to EOR. Texas, which produced 45.9 mst (~41,300 metric tons) of coal and lignite in 2011 (Energy Information Administration, 2012b), contains a wide variety of areas for clean coal. These areas are delineated by mapping spatial linkages between coal- and lignite-bearing formations, groundwater and surface-water resources, and CO_2 sinks in brine formations for long-term CO_2 storage or in mature oil fields with EOR potential. Primary regions in Texas where favorably co-located CO_2 source-sink factors related to coal and lignite trends include the Gulf Coast, the Eastern Shelf of the Permian Basin, and the Fort Worth Basin. However, areas outside coal and lignite basins also have clean-coal potential because of existing CO_2 pipelines and proximity to EOR fields that can economically sustain new clean-coal facilities.

The Texas, Louisiana, Mississippi, and Alabama part of the Gulf Coast contains an additional 4.5 billion barrels (Bbbl) of oil that could be technically produced by using miscible CO_2 flooding (Holtz and others, 2005). For example, the Texas part of the Permian Basin has the potential for technical recovery of 5.6 Bbbl and economic recovery of ~0.7 Bbbl of oil from 127 reservoirs (Advanced Resources International, 2006). Although the CO_2 pipeline infrastructure is well developed in the Permian Basin, the Texas Gulf Coast also has a great potential for clean-coal development, owing to co-located CO_2 sources and sinks such as mine-mouth electric power plants and abundant lignite resources, as well as CO_2 storage potential in EOR fields, deep, unmined low-rank coal seams (McVay and others, 2009) and thick brine formations.

Two clean-coal projects and facilities are being developed in Texas, including the NRG Parish Plant near Houston (NRG, 2013) and the TCEP Summit Plant near Odessa (TCEP, 2013). A third planned clean-coal facility near Sweetwater, Texas was recently cancelled. The NRG Parish Plant contains four main units, with up to 2,650 MW of coal-fired and 1,200 MW of gas-fired generation capacity. Its advanced burners can achieve 50 to 60% reductions in NO_x and it has a flue-gas slipstream that can capture 90% of the CO_2. Up to 1.65 Mt of CO_2 will be sequestered annually. EOR opportunities exist in the Frio Formation (Oligocene) in nearby oil fields, including West Ranch field in Jackson County (Galloway and Cheng, 1985; Galloway, 1986).

The recently cancelled Tenaska Plant near Sweetwater, Texas was to be a 2,400-acre facility to be completed in 2014. The plant, canceled because of projected cost overruns which would have made the plant uneconomic, was designed for supercritical steam generation, using dry-cooling technology. It would have had a 600 MW net capacity and coal was to be supplied from the Powder River Basin. The plant was designed to capture 85 to 90% CO_2 for EOR and additional production of 10 MMbbl/yr (million barrels) in the Permian Basin.

Operations for construction of the Summit Plant near Odessa, Texas are to begin in 2014-2015. The total project cost is projected to be ~$2.4 billion, with a $450 million contribution from DOE. The Summit Plant is designed as a 400 MW IGCC (integrated gasification combined cycle) plant with feedstock from the Powder River Basin. The plant will capture up to 90% of the CO_2, representing 3 MT/yr for Permian Basin EOR.

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