EMD Coal Committee

EMD Coal Committee Mid-Year Commodity Report

Focus Topics: Clean Coal, Coal Gasification, and Coal-to-Liquids

William A. Ambrose, P.G., Chair

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Committee Activities

Introduction

Much recent activity in the field of coal resources and power generation from coal is currently focusing on clean-coal technology. Issues regarding coal gasification and coal-to-liquids are also being discussed, although much of the current funding emphasis is on clean-coal technology. New research institutions and governmental agencies, including the U.S. Department of Energy (DOE), the International Energy Agency, are conducting research in clean-coal, coal gasification, FutureGen-type power-generating facilities, as well as sequestration and industrial application of gasification by-products.

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. A common combustion process in clean-coal systems is called integrated gasification combined cycle (IGCC), a more efficient and less-polluting alternative to simple pulverization and burning of coal.

The National Energy Policy Development Group (NEPDG) report states that from 2007 to 2030, 139 gigawatts (GW) of new coal-based generating capacity is projected to be added to the overall

US electrical-generation base. This will involve an increased reliance on coal, resulting in a 78% increase of coal use. DOE is seeking to invest ~$1.3 Billion to commercialize carbon capture and storage technology and is soliciting applications for the restructured FutureGen program. In June, 2008 DOE issued a Funding Opportunity Announcement (FOA) to invest in Integrated Gasification Combined Cycle (IGCC) or other clean-coal power plants with capture and storage (CCS) technology. DOE anticipates that $290 million will be available for funding of selected projects through FY 2009 and an additional $1.01 billion is expected to be available later.

Despite recent projections of increased reliance on coal for electricity in the US, only ~47% currently comes from coal, down from 50% in 2005. In contrast, electricity from natural gas has increased from 18 to 21% and DOE estimates that 90% of new power plants built in the next 20 years will be fired with natural gas. The Obama administration is seeking to increase the role of clean coal in electric-power generation. A recent announcement on August 5 was to revive a scaled-back version of the federal government's previous efforts on CCS within the FutureGen project that had selected Mattoon, Illinois as the site for an experimental clean-coal facility. Rather than moving forward with the site, DOE announced it would use $1 billion in stimulus funding to retrofit an old oil-burning power plant ~140 miles west of Mattoon in Meredosia, Illinois.

Source:

http://news.nationalgeographic.com/news/2010/08/100813-energy-lighting-fire-clean-coal/

Texas

Several U. S. states, including Texas, have a wide variety of geologically defined areas that could be potentially targeted for new clean-coal facilities. These areas can be 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 potential for enhanced oil recovery (EOR). In addition, a variety of infrastructure factors such as pipelines for delivery of CO_2 to subsurface sinks and delivery of coal-produced hydrogen to refineries, make it feasible to also target numerous areas outside coal and lignite basins. In a recent paper by Ambrose et al. (2010), areas in Texas with favorably co-located geologic 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, particularly the Permian Basin where a new clean-coal facility is being planned, also have clean-coal potential because of existing CO_2 pipelines and proximity to EOR fields that can economically sustain new clean-coal facilities.

Source:

Ambrose, W. A., Breton, C., Hovorka, S. D., Duncan, I. J., Gülen, G., Holtz, M. H., and Núñez-López, V., 2010, Geologic and infrastructure factors for delineating areas for clean coal: examples in Texas, USA: Environmental Earth Science: DOI 10.1007/s12665-010-0720-2.

In early March, 2010, DOE announced that it awarded a cooperative agreement to Summit Texas Clean Energy LLC to design, build and demonstrate a coal-gasification plant near Odessa, Texas. The project was selected during the third-round phase of DOE's Clean Coal Power Initiative, a collaborative program between government and industry. The new coal-gasification plant is

designed to provide electricity for >165,000 homes. Approximately 90% of the CO_2 produced from the plant will be captured and transported using existing CO_2 pipelines to Permian Basin oilfields for enhanced oil recovery (EOR). Funding will be provided by the DOE's Office of Fossil Energy and the National Energy Technology Laboratory (NETL). The estimated total cost for the project is $1.73 billion. The DOE share will be $350 million (~20% of the total cost).

North Dakota and California

Other DOE-sponsored projects related to clean-coal technology include the Post Combustion CO_2 Capture Project with the Basin Electric Power Cooperative in Beulah, North Dakota and the Hydrogen Energy California Project: Commercial Demonstration of Advanced IGCC with Full Carbon Capture with Hydrogen Energy International LLC in Kern County, California. The $100 million Post Combustion CO_2 Capture Project, which will partner the Basin Electric Power Cooperative with Powerspan and Burns & McDonnell, will demonstrate CO_2 removal from flue gas by adding CO_2 capture and sequestration (CCS) to Basin Electric's 450-megawatt (MW) Antelope Valley Station. Ammonia-based technology will be used to capture CO_2 from Antelope Valley Station Unit 1. This will result in 90% removal of CO_2 from the treated flue gas, yielding 1,000,000 tons per year of CO_2. The ammonia-based SO_2 scrubbing system will also produce ammonium sulfate for fertilizer.

The Hydrogen Energy California Project is a joint venture owned by BP Alternative Energy and Rio Tinto, which will design, construct, and operate an integrated gasification combined cycle power plant. Blends of coal and petroleum coke, mixed with non-potable water, will be used for conversion into hydrogen and CO_2. The CO_2 will be separated from the hydrogen using the methanol-based Rectisol process. The hydrogen gas will be used to fuel a power station, and the CO_2 will be transported by pipeline to nearby oil reservoirs for EOR. The project will capture more than 2,000,000 tons per year of CO_2.

West Virginia

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 (after a late 2009 'process validation' there of employing Alstom's patented chilled ammonia process for post-combustion CO_2 capture). The project, hopefully operational in 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.

Source:
http://www.aep.com/environmental/climatechange/carboncapture/

More than 30 reports from DOE summarizing recent and ongoing clean coal demonstrations, as well as DOE post-project assessment are accessible at NETL via the following link:

http://www.netl.doe.gov/technologies/coalpower/cctc/cctdp/bibliography/program/doeassess.html

USGS

The U.S. Geological Survey (USGS) released the World Coal Quality Inventory, a provisional database on international coal chemistry containing almost 1600 analyses of coal, partings, and coal-related materials from 57 countries. Data use and caveats are addressed in a section of the Report; analytical data are presented in Excel 2003 format. It is now on-line at **http://pubs.usgs.gov/of/2010/1196/.**

Other sources:
http://fossil.energy.gov/news/techlines/2008/08023-FutureGen_FOA_Released.html

http://www.oaoa.com/news/agreement-44479-doe-gets.html
http://www.fossil.energy.gov/aboutus/fe_cleancoal_brochure_web2.pdf

http://www.netl.doe.gov/publications/press/2009/09043-DOE_Announces_CCPI_Projects.html
http://www.netl.doe.gov/publications/factsheets/project/FE0002650.pdf
http://www.netl.doe.gov/publications/factsheets/project/FE0000663.pdf

http://www.thedaonline.com/news/univ-participates-in-12-5-million-coal-research-project-1.1606211#4

Australia

Australia, the world's largest coal exporter, has announced an initiative to develop clean coal technology. The institute, funded with 100 million dollars (US$70 million), will help develop clean-coal technology. More than 80 nations, corporations and institutions have joined the Global Carbon Capture and Storage Institute, launched in January, 2009.

Sources:
http://www.zero-emissionplatform.eu/website/docs/GA3/ZEP%202008%20GA%20-%20Hartwell%20Australian%20insights.pdf

http://www.grist.org/article/2009-04-16-australia-coal-initiative/

The World Resources Institute is also involved in research in CO_2 capture and storage (CCS), especially in regard to coal. Information from the World Resources Institute on CCS Guidelines can be accessed at:

http://www.wri.org/project/carbon-capture-sequestration
http://pdf.wri.org/ccs_guidelines.pdf

The program performance goal of DOE in coal gasification is by 2010 to complete research and development for advanced power systems capable of achieving 45 to 50 percent electrical

efficiency at a capital cost of $1000 per kilowatt (in constant 2003 dollars) or less for a coal-based plant.

Source:
http://www.fossil.energy.gov/programs/powersystems/gasification/index.html

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 and hydrogen using IGCC technology. However, currently there are no commercial demonstrations of these joint power and hydrogen plants:

Source:
http://www.fossil.energy.gov/programs/fuels/hydrogen/Hydrogen_from_Coal_R&D.html

Coal Gasification

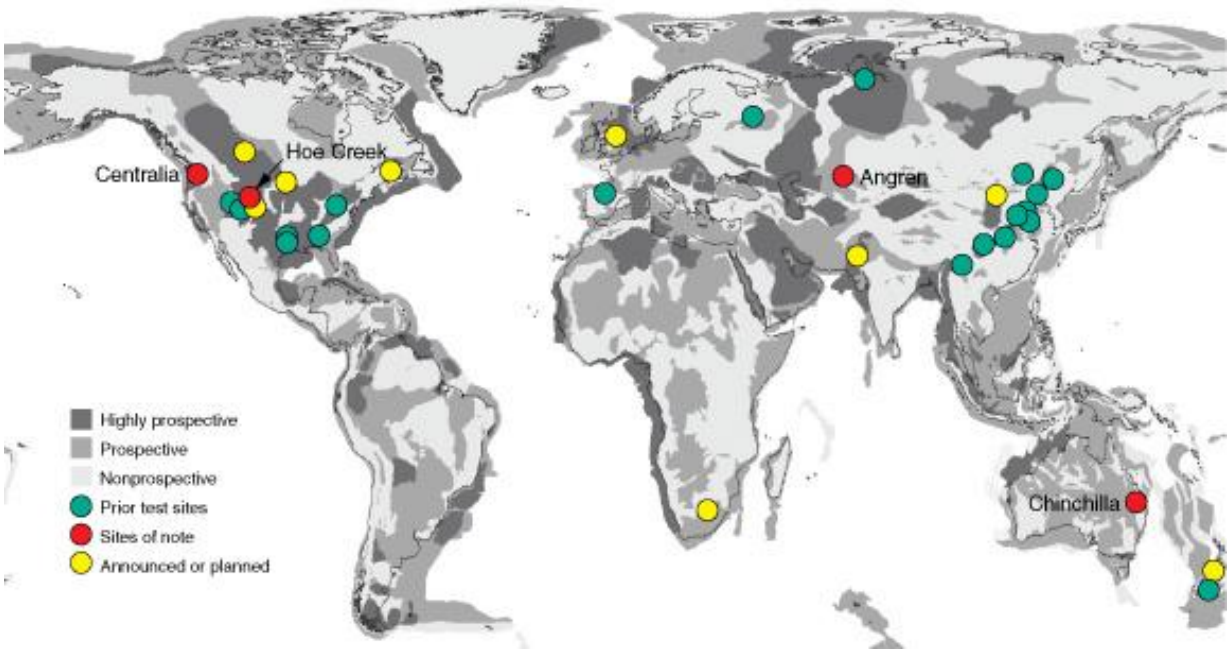
Underground Coal Gasification (UCG) consists of converting unmined subsurface coal into a gas that can be used for power generation, manufacture of hydrogen, synthetic natural gas, liquid fuels, fertilizers, or for industrial heating. According to the World Coal Institute, the fundamental UCG process calls for drilling two wells into coal seams. One well is for injection of oxidants such as combinations of water and air or water and oxygen, and the other well produces syngas created from coal combustion. Tests in Europe ~15 years ago demonstrated the feasibility of creating large cavities in coal seams for efficient combustion. This process generates large volumes of hydrogen, currently in demand as a feedstock for the chemical industry and for fuel cells.

An advantage of UCG technology is low plant costs, owing to no requirements for surface gasifiers, as well as no coal-transport expenditures. UCG processes are also associated with fewer surface emissions and could be employed in conjunction with
CO_2 storage after gasification.

Recent UCG activity in four (4) example countries includes (1) China, operating ~30 projects in different phases of preparation, (2) India, which plans to employ UCG in ~350 billion tonnes of coal resources, (3) South Africa, which has been operating UCG with the Sasol and Eskom companies, and (4) Australia, which embarked on UCG in 2000 with operations by Linc Energy. Carbon Energy also successfully concluded a 100-day study in 2008.

Source:
http://www.worldcoal.org/coal/uses-of-coal/underground-coal-gasification/

Various proposed sites to test coal-gasification technologies are distributed worldwide. The underlying gray shading in the figure below shows potential areas for geologic carbon storage.



Source:
https://www.llnl.gov/str/April07/Friedmann.html

The program performance goal in the U. S. by 2010 is to complete research and development for advanced power systems that can achieve 45 to 47% electrical efficiency at a capital cost of $1,600 per kilowatt (in constant 2007 dollars) or less for a coal-based plant.

Source:
http://www.fossil.energy.gov/programs/powersystems/gasification/index.html

DOE recently received the first installment from a repayment agreement for the Liquid Phase Methanol (LPMEOH™) Process, an advanced indirect technology that uses synthesis gas to produce methanol. This process can potentially be a more-efficient, lower-cost conversion means to produce to methanol than other gas-phase technologies. A commercial- scale demonstration of the LPMEOH Process was conducted under the CCT Program with a 260-ton-per-day facility in Kingsport, Tenn. The CCT Program is a government and industry co-funded technology development program managed by NETL. It features a series of projects, including LPMEOH to demonstrate commercial viability and to generate data for technical and economic evaluation of full-scale commercial projects.

Source:

http://www.fossil.energy.gov/news/techlines/2010/10029-DOE_Receives_First_Repayment_for_L.html

Progress continues on a coal gasification program in Queensland, Australia. On August 25, Carbon Energy announced successful completion of its drilling program for UCG Panel 2. Drilling in UCG Panel 3 continues, with both the vertical-initiation well and the horizontal injection well having been completed. Once consistent gas production is established in Panel 2,

four reciprocating gas engines installed on site will be commissioned. Additional updates on the progress of the 5 MW power station and construction of Panels 2 and 3 will be provided later in 2010.

Source:
http://www.abnnewswire.net/press/en/63586/Carbon_Energy_(ASX:CNX)_Underground_Coal_Gasification_Panel_2_Drilling_Completed_At_Bloodwood_Creek.html

Laurus Energy has completed an agreement with the Cook Inlet Region Inc. (CIRI) to move forward on a plan to build an underground coal gasification plant in southern Alaska. CIRI is pursuing permits with Laurus Energy to construct an underground coal gasification facility to support a 100 MW power plant. The operation will transform coal into a synthetic gas at a depth of ≥1,800 feet. An estimated ≤3 acres per year of underground coal will be required to support the power facility, with ~90 acres to supply the plant for its expected lifetime. CIRI and Laurus are involved in planning, permitting and designing the facility. Commercial power production is projected to commence in 2014.

Source:
http://www.greentechmedia.com/articles/read/underground-coal-gasification-in-alaska-takes-a-step-forward/

New potential UCG sites in Colorado have been proposed at the lowest elevations near Holly in southeast Colorado and Loma in west-central Colorado. The Colorado Geological Survey estimates that total coal resources from eight coal regions in Colorado exceed 434 billion tons (394 billion metric tons) to a depth of 6,000 ft (1,830 m). Identified resources to a depth of 3,000 ft (915 m) are nearly 129 billion tons (117 billion metric tons). Most of this coal is not mineable owing to land-use and technological restrictions. Although most of the Cretaceous and Tertiary coal beds in Colorado are <16.5 ft (<5 m) thick, there are six locations in the Uinta, Green River, Denver, and North Park Coal Regions where there is sufficient thickness and critical depth. It is estimated that almost 12 billion tons (10.9 billion metric tons) of bituminous and sub-bituminous coal resources in Colorado with UGC potential.

Source:
http://gsa.confex.com/gsa/2010AM/finalprogram/abstract_181275.htm

South Africa has identified 160 billion tons of coal resources within the Majuba colliery in Mpumalanga with UCG potential. During the launch of its pilot plant, Eskom announced that it had begun a study of a 2,100-MW integrated gasification combined-cycle (IGCC) power station at the Majuba coalfield, using UCG technology. Eskom's first new base-load station, Medupi and Project Bravo, which will add 4,000 MW to the grid by 2015, will be coal-based.

Source:
http://www.esi-africa.com/node/8720

Other coal-gasification links:

http://en.wikipedia.org/wiki/Underground_coal_gasification
http://www.syngasrefiner.com/ucg/
http://www.ergoexergy.com/

Coal-to-Liquids (CTL)

There are two basic processes for converting coals to liquids. These are (1) direct liquefaction, which involve breaking coal down into a solvent at high temperatures and pressures, followed by treating it with hydrogen gas and a catalyst. The other process (2), indirect liquefaction, involves an initial stage of gasifying coal into an artificial syngas, and then manufacturing synthetic fuels from the syngas. With modern technology, indirect liquefaction results in clean zero-sulfur liquid fuels.

CTL fuels have many benefits, including:

- Coal is affordable and available worldwide, with countries having access to domestic coal reserves. Moreover, there is a strong international coal market. Access to these domestic potential fuels decreases reliance on oil imports and improves energy security.
- Coal liquids can be used for a variety of activities and products, including transport, cooking, power generation, and manufacture of chemicals.
- Coal-derived fuels are sulphur-free, and low in nitrogen oxides, and are low in particulate content.
- CTL fuels are ultra-clean for cooking, alleviating health risks from indoor air pollution

CTL fuel is deemed viable when the per-barrel price of oil >$45-50, owing to high front-end expenditures. For example, a 10,000 barrel-a-day plant can cost $600-700 million to construct. Moreover, the refinement process is three to four times more expensive than refining an equivalent amount of oil. When biomass is mixed with coal, the process is even more expensive, requiring oil prices above $90 per barrel to be economically viable. This estimate does not include costs of sequestrating captured CO_2, projected to increase CTL fuel prices to $5 per barrel. Introduction of carbon caps would also raise these costs, resulting in CTL production plus carbon storage at costs ranging from $1.40 to $2.20 per gallon or more by 2025.

In a recent article by Bob Milici, production of liquid fuels from coal is projected to become an important part of the hydrocarbon energy mix of the future. To achieve this, it will be necessary to economically overcome a variety of technical and environmental obstacles, including energy usage associated with production as well as impacts from CO_2 emissions. The US coal industry should be able to process a modest CTL industry, using 60 to 70 million short tons or 54 to 64 million metric tonnes of coal per annum, without premature depletion of the country's coal reserves. However, attempts to use CTL technology to replace all petroleum imports could deplete the nation's coal reserves by the end of the 21st century.

Source:
Milici, R.C., 2009, Coal-to-Liquids: Potential Impact on U.S. Coal Reserves: Natural Resources Research: DOI: 10.1007/s11053-009-9093-1.

West Virginia University is part of a consortium with different U. S. and China industries slated to receive $12.5 million over a five-year period to conduct research on clean coal and related CCS issues. The consortium is conducting research on energy-efficient buildings, storage and clean coal, which includes carbon capture.

Accelergy, a company in Houston, Texas, has developed a process for converting coal into jet fuel. The company has embarked on a plan to sell jet fuel to the U.S. Air Force and has already received inquiries from China as well as commercial aircraft and engine manufacturers. In addition, biomass can also be substituted for coal for certain grades of jet fuel. The U.S. Department of Defense will be establishing standards for synthetic jet fuels in 2013.

A proposed CTL plant in Belwood, Mississippi would produce synthetic diesel and other fuels from coal and petroleum coke. The project, to be operated by Rentech, is funded by $2.75 billion state-issued bonds. Rentech has announced that several large airline companies have signed a memorandum of understanding to purchase 500,000 barrels per month of jet fuel from the proposed plant. Plans are also underway to capture a portion of the CO_2 produced by the plant and transport it via pipeline to Texas for EOR.

Plans for a CTL plant have been made for McCracken County, Kentucky. The plant, proposed by Clean Coal Power Operations of Louisville, Kentucky, would produce 40,000 barrels of synfuels per day from coal and a maximum of 300 MW electricity. A significant asset of the site is a 2-mile-deep brine-bearing formation for CO_2 sequestration. However, Carlisle County Kentucky is now receiving attention for the site of the CTL plant, owing to a more favorable tax environment.

Sources:
http://www.sourcewatch.org/index.php?title=Coal-to-Liquids
http://www.westkyjournal.com/news.php?viewStory=1568

South Africa, through its SASOL Co., has produced >700 million barrels of synthetic fuels from coal since the early 1980s. Approximately 85% of the coal consumed in South Africa is used as synfuels feedstock or to produce electricity. Efforts in CTL production in South Africa are underway, although there are CO_2-storage issues to overcome. For example, SASOL recently reported slowdowns in the Mafutha Project, a proposed 80,000-bl/d CTL project in Limpopo province. SASOL representatives have stated that the project will not progress within the originally envisaged timeline, pending clarity on a commercially viable CCS solution. China is planning a $6 billion investment in new liquefaction plants for a projected total annual production capacity of 440 million barrels of liquid fuel. A CTL facility planned for Mongolia in 2007, and based primarily on U.S.-developed technology), is producing 50,000 barrels daily of clean-burning gasoline and diesel fuel.

Source:
http://www.miningweekly.com/article/sasol-decelerates-coal-to-liquids-project-pending-carbon-capture-refinery-clarity-2010-09-13

The Society for Organic Petrology (TSOP) provides a comprehensive list of links to current activity in coal and coal-related topics. The TSOP web site can be accessed at:
http://www.tsop.org/links/links.htm

Additional links:

General review of CTL and related topics, plus listings of Coal-to-Liquids and Coal Gasification Projects in the U.S.

http://www.sourcewatch.org/index.php?title=Coal-to-Liquids

International Energy Agency: Clean Coal Technology R, D&D
http://www.iea-coal.org.uk/content/default.asp?PageId=1194
http://www.iea-coal.org.uk/site/ieacoal/reportdetails?LogDocId=81775
http://www.iea-coal.org.uk/site/ieacoal/reportdetails?LogDocId=81104

World Coal Institute: Coal gasification
http://www.worldcoal.org/pages/content/index.asp?PageID=424

Coal to liquids
International Energy Agency: Clean fuels from coal
http://www.iea-coal.org.uk/site/ieacoal/reportdetails?LogDocId=81104

World Coal Institute: Coal to liquids
http://www.worldcoal.org/pages/content/index.asp?PageID=423
http://www.worldcoal.org/coal/uses-of-coal/coal-to-liquids/

National Mining Institute: Coal to liquids
http://www.nma.org/pdf/liquid_coal_fuels_100505.pdf

AAAS: Coal to liquids
http://www.aaas.org/spp/cstc/briefs/coaltoliquid/

World Coal Institute: Hydrogen from coal
http://www.worldcoal.org/pages/content/index.asp?PageID=426

International Energy Agency: Prospects for hydrogen from coal
http://www.iea-coal.org.uk/publishor/system/component_view.asp?LogDocId=81106

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