

Coal to Liquids Water Usage

Prepared by Sonja Nowakowski for November 8 ETIC meeting

Background

Over the last two years, coal-to-liquids (CTL) development has been the subject of much discussion in Montana. In response, the 2007-08 Energy and Telecommunications Interim Committee requested background information as well as a panel discussion about potential water usage at CTL developments. The information included in this report analyzes the varying water usage estimates currently available. The report does not include an analysis of potential water sources for proposed CTL operations in Montana. A panel discussion hosted by the ETIC on November 8, 2007 included Paul Cartwright, Department of Environmental Quality; Chuck Kerr, president Great Northern Properties; and Chuck Magraw, Natural Resources Defense Council. Information provided by the panelists is available on the ETIC Website.

Brief history of coal-to-liquids

Coal-to-liquids operations are not new technology. The original Fischer-Tropsch process was developed by German researchers. Gasified coal or natural gas was used to produce paraffin wax that was then refined into diesel, naphtha, and liquid petroleum gases, including propane and butane. Fischer-Tropsch diesel is ultra-clean and contains almost none of the impurities found in petroleum diesel. During World War II, Germany used Fischer-Tropsch to fuel its war machines with diesel after allied forces cut off petroleum imports. More than 90% of Germany's aviation gasoline and half its total petroleum during World War II came from synthetic fuel plants.¹

During South Africa's isolation under apartheid, Fischer-Tropsch also was further developed. Sasol, a South African company, has produced 1.5 billion barrels of synthetic fuel from about 800 million tons of coal since 1955. Sasol continues to supply about 29% of South Africa's fuel needs from coal.²

While the technology for producing synthetic fuels from coal or natural gas has been around for decades, it was not profitable when oil prices were below \$30 per barrel. The Department of Energy estimates that the first coal to fuel plants in the U.S. can be built and operate competitively with oil-derived fuel plants, when oil prices are around \$50 to \$55 per barrel of oil.³

¹ http://www.fe.doe.gov/aboutus/history/syntheticfuels_history.html

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http://www.oilvoice.com/Sasol_Produces_15_Billion_Barrels_of_Synthetic_Fuel_From_Coa/4383.htm

³ "Squeezing clean fuels from U.S. coal," Lowell Miller, director of the Office of Sequestration, Hydrogen and Clean Coal Fuels, U.S. DOE, July 2007.

Coal-to-liquids in Montana

Most recently Montana's Congressional delegation announced discussions with top U.S. Air Force officials interested in building a plant at Malmstrom Air Force Base in Great Falls that would convert coal into liquid fuels. Rep. Denny Rehberg, R-Mont., has introduced legislation to have 10 pilot coal-to-liquids plants on military bases across the country. Previous energy legislation, however, has not included incentives for coal-to-liquid facilities. Rehberg also has said the legislation will include provisions for research on the environmental impacts of using coal for synthetic fuel.

In October 2006 Gov. Brian Schweitzer announced Montana would be home to one of the nation's first coal-to-liquid fuel facilities -- a \$1.3 billion project. DKRW Advanced Fuels, Arch Minerals and Bull Mountain Cos. released plans to develop the plant at the Bull Mountain mine 14 miles south of Roundup. The state is not a partner in the project. DKRW and Arch Minerals also are the principal developers of a CTL facility planned in Medicine Bow, Wyoming. DKRW has developed wind and natural gas projects around the world, and Arch Minerals is a U.S. coal company.

In recent months the project has encountered some setbacks. An appeal challenging the facility's air quality permit was upheld. A Department of Environmental hearing examiner ruled that the state improperly extended the company's permit after it had expired. Bull Mountain LLC also has struggled with financing and early investors, according to published reports.⁴

The proposed Roundup plant could produce up to 300 megawatts of electricity using Integrated Gas Combined Cycle technology (IGCC). The plant also would be fitted with technology to capture carbon dioxide that would be stored underground. In preliminary information on the plant, the carbon would be sequestered and used in certain Montana oil fields. The gasification process also would remove most of the mercury, sulfur and particulate matter from the coal.⁵ At the Roundup plant an estimated 22,000 barrels per day of synfuel would be produced.

Some reports show that at CTL plants, lifecycle greenhouse gas emissions, commonly referred to as "mine to wheel" are about twice as high as petroleum alternatives.⁶ Rentech, Inc., a developer

⁴ "Anticipated coal-to-liquids plant hits another setback," by Matthew Brown, Associated Press, July 17, 2007.

⁵ "Governor and Companies Announce Agreement to Build CTL Facility in Montana," Governor Brian Schweitzer News Release, October 2, 2006.

⁶ "Coal to Liquids, Climate Change, and Energy Security," by Jeff Logan and John Venezia, World Resource Institute, May 2007.

of coal-to-liquids and gas-to-liquids technologies, shows that Fischer-Tropsch diesel fuel has lower regulated emissions than conventional low-sulfur diesel fuel. In addition, with sequestration, fuels from the Rentech Process have lower carbon dioxide emissions on a wellhead to wheels basis than petroleum based fuels, according to Rentech. Carbon capture and sequestration as well as the use of biomass at a synfuel operation can mitigate emissions. The coal+biomass-to-liquids facilities could cut life-cycle emissions of carbon dioxide by 20 percent compared to conventional petroleum processes, according to some.⁷

Water usage

There are varying estimates of water usage at CTL facilities. However, there is a general consensus that CTL facilities use substantial amounts of water. "Substantial" is defined differently depending on a number of factors, including technology, type of coal, and facility elevation.

The Governor's Office in June 2007 prepared a report examining the coal conversion and water use issue. Based on that report, estimates of water use could vary from 1 to 1.5 barrels of water per barrel of product at a zero-discharge, air cooled plant to 5 to 7 barrels of water per barrel of product at a plant with water cooling and less use of waste heat. The report notes that "compared to most electricity generating plants, CTL plants will require significantly less water per million Btu of product." The report is included in **Appendix A**.

Sasol, a world leader in producing liquid fuels from coal and natural gas using the Fischer Tropsch Process, notes that it is a significant user and producer of water. Its plants are located in water short regions, and through necessity, Sasol has become a leader in effluent reuse and reuse technology. In a 2006 report, Sasol noted that it decreased total water usage by 2%. A graphic of its water use and effluent in million cubic meters, which was part of Sasol's 2006 environmental performance report, is included in **Appendix B**.

Headwaters Incorporated, the largest provider of technology and chemical reagents to the coal-based synthetic fuels business, has provided a CTL profile for a facility that produces 40,000 barrels per day to use 36,000 acre-feet per year of make-up water.

The Department of Energy's National Energy Technology Laboratory also completed an analysis of water use at CTL facilities. The report outlines three major requirements for water: process water, boiler feed water, and cooling water. Process water is used in the liquefaction process and often plays a part in chemical reactions. Boiler feed water is used to produce steam, and much of it is recovered and returned to the boiler. Cooling is typically done using circulating water. Cooling water loss is often the most significant factor. In the 1990s, Bechtel, an engineering, construction, and project management company, analyzed various coal liquefaction schemes for

⁷Department of Energy's National Energy Technology Laboratory, Feasibility study for Coal+Biomass-Liquids Facility, August 2007.

the DOE, finding that eastern coal used about 7.3 gallons of water/gallon Fischer Tropsch liquid and western coal used about 5.0 gallons of water/gallon of Fischer Tropsch liquid. "The amount of water required to operate a coal liquefaction plant is impacted by many variables, including the design of the liquefaction unit, the type of gasifier used to provide the syngas or hydrogen, the coal properties, and the average ambient temperature and humidity."⁸

The DOE report concludes that two issues in the placement of a coal-to-liquids plant are (1) availability of water and (2) the environmental concerns related to water discharge after use. Last year, the National Energy Technology Laboratory initiated a design study for a 50,000 bbl/day CTL plant in the Illinois Basin. A technical evaluation will include a full water balance. The report also notes, "before coal liquefaction can make a significant contribution to meeting the demand for liquid fuels, it will be necessary to ensure that sufficient water resources are available at proposed plant sites."⁹

Federal and state efforts

During the May 2007 Special Session, H.B.3 was approved. The bill includes tax incentives for coal-to-liquids operations and pipelines that transport synthetic fuels.

On the federal level, the Senate recently defeated two coal-to-liquids measures, one by Sen. Jon Tester, D-Mont., and the other similar to legislation promoted by the late Sen. Craig Thomas, R-Wyo. The Tester amendment to the energy bill on the Senate floor would have provided up to \$200 million in grant money and \$10 billion in direct loans for coal gasification projects. The projects would have been required to have annual lifecycle greenhouse gas emissions at least 20 percent lower than conventional plants' emissions and to have captured and stored at least 75% of the carbon dioxide that would otherwise be released to the atmosphere. The amendment was voted down 33-61. Several coal-to-liquid pieces of Legislation remain before Congress.

⁸ "Emerging Issues for Fossil Energy and Water," NETL, June 2006.

⁹ Ibid

MEMO

June 5, 2007

TO: Evan Barrett
Eric Stern
Mike Volesky

FROM: Paul Cartwright

RE: Coal conversion and water use

Conclusion: Coal-to-liquid (CTL) facilities will use substantial amounts of water, on the same order of magnitude as other energy, agricultural and urban uses. Compared to most electricity generating plants, CTL plants will require significantly less water per million Btu (MMBtu) of product.

Discussion:

The amount of water used by a coal conversion facility depends on conversion technology, cooling technology, type of coal, elevation of the facility and climate at the facility.

In a CTL plant, some of the water is used as a source of hydrogen for the product and some is used for cooling and other processes. Estimates of energy balances of hypothetical CTL plants suggest that water use could vary from 1-1.5 barrel of water per barrel of product for a zero-discharge air-cooled plant to 5-7 bbl water for barrel of product for a plant with water cooling and less use of waste heat for process heat or cogeneration. These estimates assumed 2 barrels of product per ton of sub-bituminous coal (9,000 Btu/lb).

In generating plants, cooling is the main use of water. Different studies have estimated different rates of water use for different technologies. A key finding is that integrated gas combined cycle (IGCC) plants will use significantly less water than conventional pulverized coal (PC) plants (20-50 percent less by different estimates). This is plausible in that the steam cycle, with its cooling needs, accounts for only a portion of the electricity produced at an IGCC.

Electricity generating plants, using conventional technology, have been built with air cooling. They are not very common. The 290 MW Wyodak plant near Gillette, Wyoming, was built in 1978 and was the largest air-cooled generating plant in the US. In 2006, Basin Electric proposed building a 422 MW coal-fired, air-cooled plant in the same area. Air-cooled generating plants can require less water per MMBtu product than CTL plants.

CTL plants need large amounts of electricity, which effectively increases the amount of water embodied in the final product. The exact amount depends on the technologies used

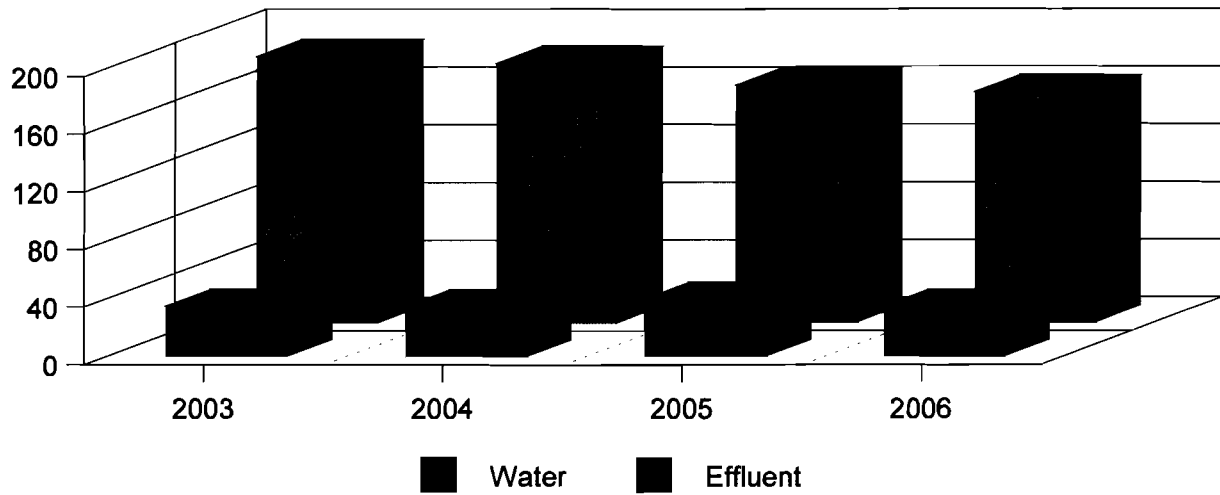
in the generating plant. By way of comparison, the water used at a conventional plant to generate electricity for Dakota Gasification equaled about one-quarter of the in-plant water consumption at DGI in 2004. However, the generating portion of a plant combining CTL and IGCC would use considerably less water than a conventional generating plant such as serves DGI.

Water consumed by actual and hypothetical uses are shown below. Consumption data are given in acre-feet per year and in million gallons (MMgal) per day.

Water consumption by actual and hypothetical uses

Name	Type of Plant	Acre-ft/yr	MMgal /day	Gal/MMBtu product	Notes
Colstrip 1-4	2094 MW PC	28,652	25.6	168	2005; 575 gal/MWh
Dakota Gasification	170 MMcf/day (winter) synthetic natural gas plant	7,494	6.7	50	2004; doesn't include water embodied in purchased electricity; doesn't assign any water consumption to co-products
CTL plant (1:1 water:product)	11,000 bbl/day	414	0.4	7	Example; assumes all water use is assigned to liquid fuel product; capacity factor =.8
CTL plant (7:1 water:product)	11,000 bbl/day	2,898	2.6	50	Example; assumes all water use is assigned to liquid fuel product; capacity factor =.8
City of Helena	27,000 people	5,872	5.2		2002-2005 average
Sugar beets	1,000 acres	1,830	1.6		Eastern Montana; optimal crop yields under efficient and scheduled irrigation (derived from NRCS est.)
Alfalfa	1,000 acres	2,000	1.8		Eastern Montana; optimal crop yields under efficient and scheduled irrigation (derived from NRCS est.)

Water use and effluent (million cubic meters)



Appendix B

Information gleaned from Sasol 2006 "Our Environmental Performance." Full report is available at

http://www.sasolsdr.investoreports.com/sasol_sr_2006/downloads/segmented/sasol_sustainable_development_report%202006_our_environmental_performance.pdf

