

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.)