Oil & Natural Gas Technology

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Research and Development Concerning Coalbed Natural Gas

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EXECUTIVE SUMMARY

The Powder River Basin in northeastern Wyoming is one of the most active areas of coalbed natural gas (CBNG) development in the western United States. This resource provides clean energy but raises environmental concerns. Primary among these is the disposal of water that is co-produced with the gas during depressurization of the coal seam.

Beginning with a few producing wells in Wyoming's Powder River Basin (PRB) in 1987, CBNG well numbers in this area increased to over 13,600 in 2004, with projected growth to 20,900 producing wells in the PRB by 2010. CBNG development is continuing apace since 2004, and CBNG is now being produced or evaluated in four other Wyoming coal basins in addition to the PRB, with roughly 3500-4000 new CBNG wells permitted statewide each year since 2004. This is clearly a very valuable source of clean fuel for the nation, and for Wyoming the economic benefits are substantial. For instance, in 2003 alone the total value of Wyoming CBNG production was about $1.5 billion, with tax and royalty income of about $90 million to counties, $140 million to the state, and $27 million to the federal government.

In Wyoming, cumulative CBNG water production from 1987 through December 2004 was just over 380,000 acre-feet (2.9 billion barrels), while producing almost 1.5 trillion cubic feet (tcf) of CBNG gas statewide. Annual Wyoming CBNG water production in 2003 was 74,457 acre-feet (577 million barrels). Total production of CBNG water across all Wyoming coal fields could total roughly 7 million acre-feet (55.5 billion barrels), if all of the recoverable CBNG in the projected reserves of 31.7 tcf were produced over the coming decades.

Pumping water from coals to produce CBNG has been designated a beneficial water use by the Wyoming State Engineer's Office (SEO), though recently the SEO has limited this beneficial use designation by requiring a certain gas/water production ratio. In the eastern part of the PRB where CBNG water is generally of good quality, most of it is discharged to surface drainages or to soil (for irrigation). CBNG water quality generally declines when moving from the Cheyenne River drainage northwestward to the Belle Fourche, Little Powder, and Powder River drainages and in the central and western part of the PRB, most CBNG water goes to evaporation-infiltration ponds or is discharged directly to surface drainages. Concerns center on the salinity of the water, usually measured as total dissolved solids (TDS), or electrical conductivity (EC) and sodium adsorption ratio (SAR). Other management options currently in use include injection, managed irrigation (with additives to mitigate the effects of high salinity), atomization, and treatment by reverse osmosis or ion exchange. A key water quality issue is the cumulative effect of numerous CBNG water discharges on the overall water quality of basin streams. This leads to one of the most contentious issues in CBNG development in Wyoming's PRB: Montana's concern about the potential downstream effects of water quality degradation on rivers flowing north into Montana.

Many of the benefits and costs associated with CBNG development have been debated, but dealing with CBNG water quantity and quality arguably has been the most difficult of all the issues. Given the importance of these issues for continued development of CBNG resources in Wyoming and elsewhere, the DOE-NETL funded project presented here focuses on CBNG co-produced water management.

The research was organized around nine separate, but interrelated, technical project tasks and one administrative task (Task 1). The nine technical project tasks were pursued by separate research teams at the University of Wyoming, but all nine tasks were coordinated to the extent possible in order to maximize information gained about CBNG co-produced waters. In addition to project management in Task 1, the key research tasks included: (2) estimating groundwater recharge rates in the PRB; (3) groundwater contamination of trace elements from CBNG disposal ponds; (4) use of environmental tracers in assessing water quality changes in ground and surface water systems; (5) development of a software toolbox to assess CBNG water treatment technologies; (6) potential value of CBNG water for enhanced oil recovery using low salinity waterflood; (7) evaluation of natural zeolites for low cost CBNG water treatment; (8) evaluation of aquatic toxicity testing methods required by regulatory agencies on some CBNG water discharges; (9) use of remote sensing to evaluate CBNG water discharges as habitat for West Nile Virus transmitting mosquitoes; and (10) a summary of lessons learned from historic CBNG management in Wyoming.

Some of the most important conclusions drawn from the research in this project include the following (see individual task reports for additional key research conclusions):

- Investigators estimated that recovery times for PRB groundwater levels from CBNG water production may be as much as 10 times longer than BLM's 2003 EIS estimate of ~30 years – the new estimate is based on researcher's analysis using the Surface Water Assessment Tool (SWAT) to calculate recharge rates and uncertainty levels (Task 2).
- Stable isotopes of carbon show excellent potential for tracing CBNG production water, with a signal that is easily distinguished from natural surface waters – this method allowed investigators to identify CBNG contributions to Wyoming surface waters, but also led to their conclusion that Powder River samples from Montana are little affected or unaffected by CBNG production upstream even during low flow conditions (Task 4).
- The CBNG treatment toolbox software developed in Task 5 allows cost comparison estimates for 5 demineralization technologies, showing that treatment costs may range from $0.036/bbl to $0.190/bbl depending on technology and local conditions – overall the Toolbox results indicate that treatment cost is directly impacted by the amount of sodium removed regardless of technology used (Task 5).
- Injection of CBNG water in Tensleep Formation cores resulted in significantly improved oil recovery following injection of high salinity formation water, supporting a conclusion that, depending on the proximity of CBNG wells and targeted oil reservoirs, use of CBNG water can improve oil recovery in waterflood applications (Task 6).
- Wyoming zeolites modified with calcium additions had a much higher CBNG water treatment potential for removal of sodium than natural Ca-zeolites from New Mexico and Idaho, and Task 7 experiments led investigators to estimate Wyoming zeolite material costs at $0.05/bbl to $0.10/bbl of treated CBNG water (Task 7).
- Chemical constituents in Beaver Creek, Wyoming, CBNG discharge water did not cause acute toxicity to 11- to 15-d-old fathead minnows either in in-stream or lab toxicity tests, and field observations of aquatic plants and animals suggested no overt adverse effects from CBNG effluent discharged to Beaver Creek during 2006-07 study periods (Task 8).
- Ammonification of organic nitrogen in CBNG effluents can occur during transport of unpreserved effluent samples, thus potentially biasing Whole Effluent Toxicity tests by increasing ammonia concentrations by the time the samples arrive at the lab (Task 8).