Northern Great Plains Water Consortium

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Water Use Fact Sheet

Water Use in Carbon Capture and Storage Activities

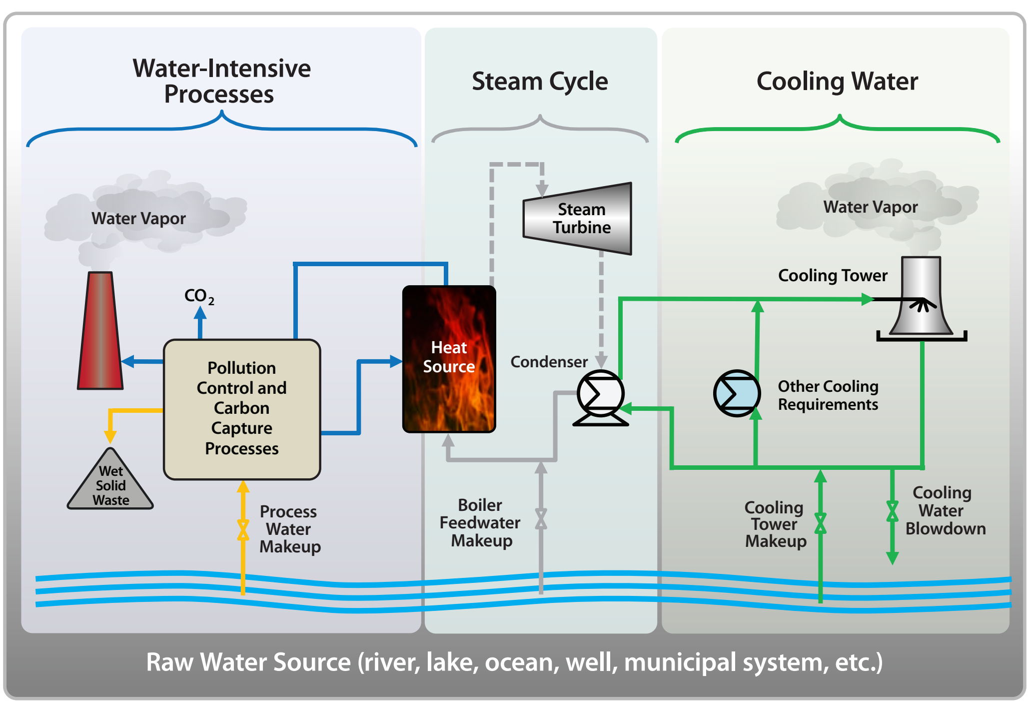
Carbon capture and storage (CCS) is an approach to greenhouse gas (GHG) management that offers the potential to significantly reduce anthropogenic (human-made) carbon dioxide (CO_2) emissions into the atmosphere. The first step in CCS is capture of the CO_2 at its source. The CO_2 is then dried, compressed, and transported (usually by pipeline) to a secure geologic formation where it is permanently stored. Nearly 40% of the CO_2 emitted in the United States comes from the electricity-generating sector, making power plants among the likely first adopters of CCS. Besides posing technical challenges with respect to application of carbon capture to power plant flue gas, the water requirements for both power generation and CCS must be met. The additional water utilization from carbon capture will be of critical importance when the viability of employing CCS at power plants is determined, especially in arid regions.

The Energy & Environmental Research Center (EERC) is developing a partnership between the U.S. Department of Energy (DOE) and key energy-producing entities in the northern Great Plains to address issues related to water availability, reducing freshwater use, and minimizing the impacts of facility and industry operations on water quality. The partnership is called the Northern Great Plains Water Consortium (NGPWC).

Water Associated with CO_2 Capture at a Power Plant

A power plant that captures its CO_2 will consume more water than a facility that simply vents the CO_2 to the atmosphere. Some of the water is needed by the additional gas cleanup required by most capture processes. Some is needed for the cooling and process water requirements associated with the capture, dehydration, or compression processes. Still more is needed by any additional generation facilities installed to replace the power required to operate the capture plant and the compressors.

Carbon capture at a power plant has not been demonstrated at full scale, which would involve capture of hundreds of thousands or even millions of tons of CO_2 each year, although carbon capture is being demonstrated on small slipstreams taken from power plant exhaust at some locations. Implementation of the capture technologies that are currently available (such as scrubbing using amines or ammonium carbonate) will necessitate increased water usage, mostly in the form of increased cooling tower load. According to DOE (Gerdes and Nichols, 2009), the addition of a CO_2 capture and compression system will increase water consumption by an estimated 90% for a subcritical pulverized coal (pc) plant, 87% for a supercritical pc plant, 76% for a natural gas combined-cycle (NGCC) plant, and 46% for an integrated gasification combined-cycle (IGCC) plant, depending on whether the gasifier is dry- or slurry-fed.



Water is consumed in many of the steps required to generate electricity and to capture CO_2 at a power plant (based on Gerdes and Nichols, 2009).

Estimated Water Consumption Relative to Net Power Production for Bituminous Coal* (from Gerdes and Nichols, 2009)

Plant Type	Without Capture + Compression	With Capture + Compression
Subcritical pc	0.52	0.99
Supercritical pc	0.45	0.84
NGCC	0.19	0.34
Dry-Fed IGCC	0.30	0.48
Slurry-Fed IGCC	0.31	0.45

*In gal per kWh. A kWh is a typical measure of electrical energy; residential electricity bills show energy usage in kWh.

Water Associated with CO_2 Transportation

Whether the transport occurs via tanker truck, railcar, or pipeline, CO_2 must be compressed prior to its transport. The large quantities that will be moved during widespread deployment of CCS will necessitate the use of pipelines. CO_2 is usually transported in a pipeline as a supercritical fluid, meaning that the CO_2 is at a high-enough pressure to behave as a liquid, i.e., pressures ranging from at least 1180 to as high as about 3000 psi. The water use associated with producing the power needed to compress the CO_2 from a power plant to such high pressures adds about 0.01 gal/kWh of energy produced by the power plant to the total water consumption during CCS (Bennett et al., 2007).

Fluor's Economine FG[SM] plant at Florida Power and Light's facility located at Bellingham, Massachusetts (Reddy et al., 2008). The Economine FG plant has a capacity of 330 tons/day of food-grade CO_2 or 300 to more than 3000 times smaller than a power plant.

Water Associated with CO_2 Injection at the Geologic Storage Site

Water can actually be produced during injection, depending upon the nature of the geologic storage site. When the CO_2 is used for enhanced oil recovery (EOR), some water is produced with the oil and is typically reinjected to assist with continued oil production. When put on the basis of the quantity of CO_2 formed during the production of 1 kWh of energy, water produced during EOR activities typically amounts to 1 gal/kWh. Similarly, water produced during CO_2 injection into unminable coal seams for coalbed methane recovery may total 0.01 to more than 1 gal/kWh, decreasing as the injection continues. Injection into saline formations or depleted oil and gas reservoirs produces water only if the CO_2 displaces brine or, in the case of the oil and gas reservoirs, water that was injected into the reservoir previously. This produced water, which may total as much as 0.5 gal/kWh, is generally of such poor quality that it is uneconomical to treat it for further use (Bennett et al., 2007). More information about the water associated with the injection of CO_2 into geologic storage sites can be found in the DOE "Regional Carbon Sequestration Partnership Water Working Group Fact Sheet."

References

Bennett, B., Ramezan, M., and Plasynski, S., 2007, Impact of carbon capture and sequestration on water demand for existing & future power plants: Presented at the 6th Annual Conference on Carbon Capture & Sequestration, Pittsburgh, Pennsylvania, May 2007.

Gerdes, K., and Nichols, C., 2009, Water requirements for existing and emerging thermoelectric plant technologies: U.S. Department of Energy National Energy Technology Laboratory Report 402/080108, Morgantown, West Virginia.

Reddy, S., Johnson, D., and Gilmartin, J., 2008, Fluor's Econamine FG Plus[SM] technology for CO_2 capture at coal-fired power plants: Presented at the Power Plant Air Pollutant Control "Mega" Symposium, Baltimore, Maryland, web.mit.edu/mitei/docs/reports/reddy-johnson-gilmartin.pdf (accessed 2010).

Are you interested in joining the NGPWC?

The EERC is actively seeking additional members to complement DOE funding and to help direct the program's efforts. The NGPWC is currently engaged in Phase II of the program, which focuses on demonstrating water minimization and beneficial reuse strategies and technologies.

The NGPWC is a partnership of key public and private water users in the northern Great Plains region. New members are welcome. To learn more, contact:

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