ABSTRACT for CMTC

REGIONAL CARBON SEQUESTRATION PARTNERSHIP WATER WORKING GROUP WHITE PAPER ON THE NEXUS OF WATER AND CARBON CAPTURE AND STORAGE

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Carbon capture and storage (CCS) are promising technologies that have the potential to drastically reduce anthropogenic carbon dioxide (CO_2) emissions into the atmosphere. The U.S. Department of Energy National Energy Technology Laboratory has established the Regional Carbon Sequestration Partnership (RCSP) Program, the goal of which is to develop the infrastructure, regulations, and technology for large-scale CCS from a regional perspective. In order to investigate the relationship between water and CCS, members of the RCSPs have formed the Water Working Group (WWG). This white paper, produced by the WWG, summarizes the influence CCS is expected to have on water issues and the influence of water issues on CCS.

Water is of utmost importance in every step of the CCS process, from the industrial sources where CO_2 is generated to long after the CO_2 is injected into the ground. Water is relied upon heavily for cooling, especially in power generation facilities, but is also needed for other processes, such as boiler operation and during the regeneration of solvents used during CO_2 capture. Each technique for capture and compression may require water for cooling the additional equipment and for makeup water in the various processes. Currently, a majority of the water used by power plants is provided by surface water and groundwater resources that face competition from agricultural and municipal uses across the United States. The additional water load required for CCS may be problematic or require other solutions in water-stressed areas. New technological developments in capture and compression technologies also promise to reduce the impact of these technologies on increasing water demand.

CO_2 may be stored through injection into three primary types of formations: saline formations, depleting/depleted oil and gas reservoirs, and unminable coal seams. CO_2 injected into saline formations (as well as oil and gas reservoirs and unminable coal seams) permeates the rock and occupies a portion of the pore spaces while at the same time undergoing physical, solubility, and mineral trapping. It also rapidly dissolves into formation water forming carbonic acid (H_2CO_3), reducing the overall pH of the formation fluid. While there is potential for negative impacts to engineered materials and the storage formation itself as a result of these geochemical interactions, their impact can be largely mitigated through proper engineering design. Furthermore, the end product of these reactions is the near-permanent storage of CO_2 through mineral trapping mechanisms. The potential also exists for injected gases or formation fluids to migrate out of storage formations during CCS operations, most likely along pathways introduced during the drilling and completion process. Risks of fluid migration can be greatly reduced or nearly eliminated through proper adherence to a variety of best practices being developed as part of the RSCP Program.

A process referred to as CCS water extraction, which involves intentionally removing formation water from a storage formation, is one potential method of improving CCS operations by increasing storage capacity, managing storage reservoir pressure, and/or controlling free-phase CO_2 movement. In addition, extracted water may have applications for beneficial use, which could be capitalized upon by CCS operators. It is important to note that formation water often coexists with oil and gas in the subsurface, and large amounts are typically produced from oil and gas pools everyday as a result of normal oil and gas operations.

When the quality of extracted water is such that surface reuse is advantageous, it may be part of the overall CCS strategy to intentionally extract water. CO_2 storage in deep saline formations does not require the extraction of formation water, although there may be circumstances where the extraction of water is beneficial to the overall CO_2 storage strategy. The simplest management option for extracted water is to minimize extraction, but if extraction of water is necessary, subsurface reinjection is the most direct disposal option. Reinjection activities are regulated through the Underground Injection Control (UIC) Program, which provides rules and guidelines for determining where extracted waters may be reinjected and controls on the construction and operation of the reinjection wells. In conjunction with state and local regulators, UIC's regulations protect underground sources of drinking water from unintentional contamination. Beneficial use of CCS extracted water may also be a cost-reducing or even energy-offsetting option and should be considered on a case-by-case basis. Potential for reuse will be determined primarily by the quality of the CCS extracted water and local water demand.

A variety of treatment processes exist that are applicable to extracted water, notably reverse osmosis, ion exchange, thermal desalinization mechanical vapor recompression, and innovative treatment technologies such as freeze–thaw/evaporation and constructed wetland treatment. The utility of these and other processes will vary, depending on the quality of the extracted water input and the required quality of the treated water output, as the costs are highly dependent on the application.

Industry experience with produced water management can serve as a guide for understanding the challenges which may be encountered with managing extracted water.

Produced water can have salinity concentrations that exceed 300,000-ppm total dissolved solids (TDS), much higher than the average TDS concentrations of seawater, which is approximately 35,000 ppm. Common dissolved constituents in produced water include salts, hydrocarbons, and dissolved organics. Produced water can have an adverse effect on surface and groundwater resources, so care is required in its handling and disposal. The majority of produced water is either reinjected into the formation from which it was produced or into another deep saline formation. Water produced from oil fields may also be reused (recycled) in other oil production activities, such as secondary oil recovery (waterflood), water alternating gas, or hydrofracturing treatments. Such recycling is not uncommon in oil fields located in regions of the country where there is limited access to additional water resources.

A broad range of potential extracted water applications exist for beneficial use, from nearby oil field operations to treatment and use for supplemental drinking water. Oil field applications include use for waterflooding and hydraulic fracturing. A variety of industrial processes may benefit from the use of CCS extracted waters, such as use in power plant cooling, wood and pulp production, textile and tannery processes, chemical production, and cement production. Extracted water may also have applications for geothermal power generation, as recent technological advances have lowered the minimum required temperature of geothermal fluids. Agriculture and livestock production may also benefit from the availability of extracted water, particularly in arid regions, as the water quality requirements of crops and livestock are typically less than those for human consumption. Finally, CCS extracted water may also be of such quality (with or without treatment) that it may be utilized for artificial recharge of aquifers that provide drinking water or to protect such aquifers from saltwater intrusion.