The Nexus of Water and CCS: A Regional Carbon Sequestration Partnership Perspective

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Abstract

The Regional Carbon Sequestration Partnership (RCSP) Program of the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) has formed a Water Working Group (WWG) to advance the understanding of the relationships between water management and carbon capture and storage (CCS). Recognizing that each RCSP has its own unique set of challenges related to water utilization and the implementation of CCS, the WWG is focusing on the identification and examination of the water-related issues that are common to all of the RCSPs as well as those that are specific to each region of the United States. This paper summarizes the framework that has been developed by the WWG to identify and investigate the primary issues that result from the nexus of water generation and utilization and the implementation of CCS operations.

Water is of the utmost importance in every step of the CCS process, beginning with the capture of carbon dioxide (CO_2) at industrial sources to long after the CO_2 is injected into the ground (Figure 1). Water is the predominant source of cooling at the majority of CO_2 point sources. These cooling water demands will be increased by the CCS steps that will be located at most CO_2 point sources, namely, capture and compression. Furthermore, additional water will also be needed for other capture processes, such as solvent regeneration. However, the largest impact to water use is likely to come from the parasitic load CCS operations may place on existing facilities. This additional power load will require additional cooling of some form, regardless of whether it is made up at the CO_2 point source or some other location on the grid.

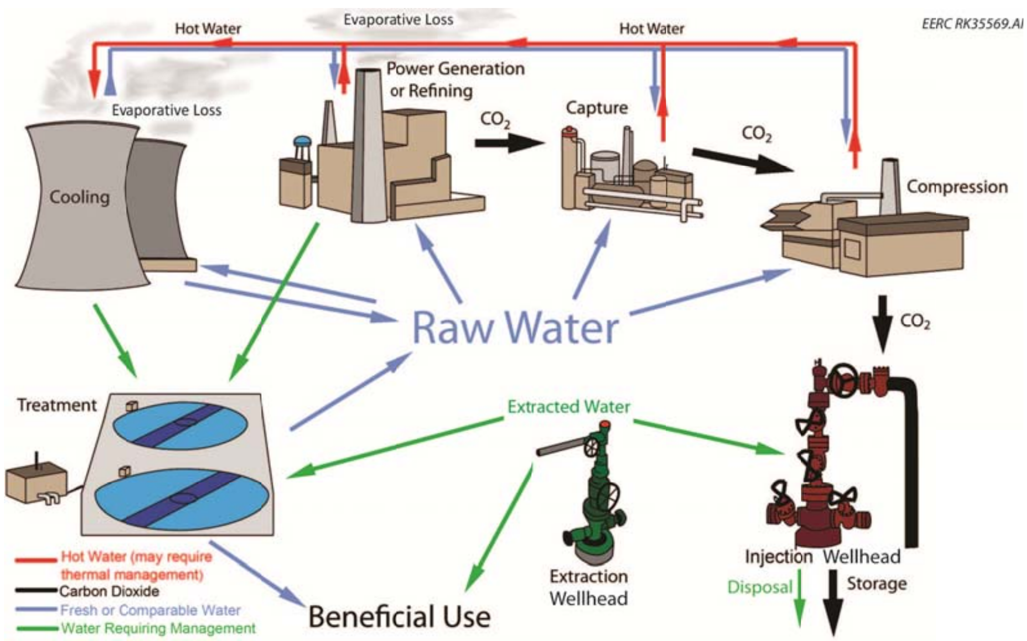

Figure 1. The primary components of water use and generation at each phase of a CCS project.

Currently, a majority of the water used by power plants is provided by surface water and groundwater resources, which face competition from agricultural and municipal uses. The additional water load imposed by CCS operations may be problematic, particularly in water-stressed areas. New developments in capture and compression technologies that hold promise to reduce the impact of CCS on water demand are currently being investigated.

Following separation, CO_2 will be transported and stored in one of three primary types of formations: saline formations, depleting/depleted oil and gas reservoirs, and unminable coal seams. CO_2 interactions with the formation water that is present in each of these storage targets will occur during the storage process. In some instances, formation water may also be removed from the subsurface. For example, when the process of CO_2 enhanced oil recovery is implemented in conjunction with CO_2 storage into depleting/depleted oil and gas reservoirs; similarly, large volumes of water will also typically be generated during enhanced coalbed methane recovery, which is likely to be the most common form of CO_2 injection and storage into coal seams.

Removal, or extraction, of formation water is not expected to be required for the majority of CO_2 storage operations that inject into saline formations. Site characterization work from the RCSPs has shown that many storage targets exist with adequate volume to hold very large quantities of CO_2 without the need for extraction of formation water. However, as noted above, when combined with enhanced hydrocarbon recovery operations, removal of formation water is often part of normal operations. Since large amounts of water are already removed from oil and gas pools on a daily basis as a result of normal oil and gas operations, industry experience with the handling of extracted water is providing invaluable insights for the development of water management strategies for CCS projects.

When the quality of formation water is such that surface reuse is advantageous, intentional extraction of the water may be part of the overall CCS project strategy. Additionally, there may be circumstances where the extraction of formation water is performed to improve the effectiveness of the CCS operations, i.e., increase the storage capacity, reduce the formation pressure, or control the movement of free-phase CO_2.

From a water management perspective, the first goal should be to minimize the quantity of water that is produced. However, if extraction of water is deemed useful to improve the effectiveness of the storage operations, subsurface reinjection is the most direct disposal option. In the United States, these reinjection activities are regulated through the Underground Injection Control Program, which provides rules and guidelines for determining where produced waters may be reinjected and the type and level of controls that are required for the construction and operation of the injection wells.

Beneficial use of CCS extracted water can also be a cost-reducing or even energy-offsetting option and should be considered on a case-by-case basis. Under this scenario, some or most of the extracted water is treated and distributed for reuse. For example, a variety of industrial processes may benefit from the use of CCS extracted waters, such as use in power plant cooling, enhanced geothermal energy production, wood and pulp production, textile and tannery processes, chemical production, cement production, and in various oilfield applications. Agriculture and livestock may also benefit from the availability of extracted water, particularly in arid regions. Finally, CCS extracted water may also be utilized for artificial recharge of aquifers that provide drinking water or to protect such aquifers from saltwater intrusion.

Water is expected to be an important factor in nearly all situations where CCS is adopted and is expected to present many challenges. The goal of DOE’s WWG is to identify and investigate creative and innovative solutions to these water management challenges. This paper describes the WWG and the water/CCS framework that is being developed. A brief review of the activities of the WWG since its inception in 2010 is also provided.

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