IEAGHG INVESTIGATION OF EXTRACTION OF FORMATION WATER FROM CO_2 STORAGE

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The Energy & Environmental Research Center has conducted an analysis of formation water extraction from carbon dioxide (CO_2) storage reservoirs under joint sponsorship from the IEA Greenhouse Gas (IEAGHG) R&D Programme and the U.S. Department of Energy. The concept of extracting saline waters from reservoirs has been proposed as a means of managing storage formation pressures, increasing reservoir storage capacity, controlling CO_2 plumes, and controlling migration of displaced formation water. The practice may also provide water that can be put to a beneficial use such as geothermal energy recovery from high-temperature extracted waters or the supply of potable water where treatment can be performed at reasonable cost.

The current state of knowledge on the potential impacts of water extraction on CO_2 storage capacity and plume migration is somewhat limited. Site-specific geological and project design factors can all impact the benefits derived from water extraction. Formation water characteristics will influence the potential for beneficial use of the water. In order to address these issues on a global basis, the project was designed to investigate water extraction under a wide variety of conditions.

The work included a survey of geological and water quality conditions of deep saline aquifers (DSAs); selection of four case study sites representing a wide range of these geologic and water quality conditions; and a study of the impacts of formation water extraction on CO_2 storage and the potential for the beneficial use of extracted water at these sites. The four case study sites were the Ketzin site in Germany; the Zama Field in Canada; the Gorgon project area in Australia; and the Teapot Dome Field in the United States. Reservoir-scale dynamic simulations were conducted to investigate the impact that formation water extraction could have on storage capacity and reservoir management and to determine effective water extraction rates for those purposes. Simulations included control studies with no water extraction, water extraction designed to increase storage capacity, and water extraction designed to manage reservoir pressure and the direction of plume migration.

The results from the simulation studies show that the increase in CO_2 storage capacity achieved through the use of water extraction varies greatly based on site conditions. Additional benefits of water extraction in reservoir management included reduction of maximum reservoir pressures and plume management. In general, higher water extraction rates were required in order to provide better pressure and plume management. This led to higher ratios of water extraction to CO_2 storage when plume and pressure management were used as primary drivers than cases designed to maximize the increase in storage capacity.

Surface dissolution, which has been proposed as a potentially useful option because it eliminates the generation of a buoyant plume, was analyzed using equilibrium chemistry modeling and by performing reservoir simulations for the Ketzin and Teapot Dome sites. The results reveal that surface dissolution would require removal (and reinjection) of very large volumes of water while providing only a small fraction of the CO_2 storage capacity that can be achieved through injection of supercritical CO_2. In addition, there are technical and economic challenges associated with performing surface dissolution under the temperature and pressure conditions required to keep the CO_2 in solution while also controlling corrosion and scaling. These two findings significantly limit this practice as a reasonable alternative to injection of pure-phase CO_2.

The potential for beneficial use of the extracted water was also investigated. The cost of treating extracted water having the range of water quality known to be present in DSAs was estimated for reverse osmosis, brine concentrators, and brine crystallizers. Most beneficial uses require water of significantly greater quality than is likely to be present in extracted water, meaning that desalination will be required. In most cases, the cost of desalination will be too high to make this a viable option, and it should be expected that the extracted water will be disposed of through deep well injection.

If the water salinity is low enough and the water is being extracted from an inland site, it is possible for the cost of desalination to be reasonable. Desalination for coastal and offshore site extracted water is unlikely to be cost-effective because seawater desalination would likely be selected over extracted-water desalination, especially if transportation costs are considered. Seawater availability is much more certain but low-salinity extracted water may be considered as a substitute in special situations.

There do not appear to be any regulatory barriers to the extraction of brine as a pressure maintenance technique for carbon capture utilization and storage (CCUS) projects in any of the jurisdictions reviewed. While regulations are not in place to specifically deal with brine extraction related to CCS projects, disposal of brine solutions has occurred all over the world. Brines and other fluids associated with the production of oil and gas operations have been injected into wells in a variety of geological settings. Regulatory authorities and industry have developed best management practices and regulatory processes that have allowed for safe injection disposal. These practices and regulations should be applicable to extracted-water operations as well.

Formation water extraction from CO_2 storage reservoirs is applicable for increasing storage capacity, reservoir pressure management, and plume control. Analysis of the resulting water quality and quantity, available treatment technologies, and potential transportation costs reveals there is likely to be limited potential for the beneficial use of extracted water from CCS facilities. Ideal circumstances of relatively high quality reservoir water and highly stressed or limited regional water resources will need to coexist before beneficial use of extract water may be considered. Additional work classifying the water quality of potential DSA storage targets is necessary before these conclusions can be revisited.