IEAGHG Investigation of Extraction of Formation Water from CO₂ Storage

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Abstract

The Energy & Environmental Research Center has investigated the proposed practice of formation water extraction from carbon dioxide (CO₂) storage reservoirs for the purpose of enhancing CO₂ storage. This project was performed under joint sponsorship by the 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, and controlling migration of CO₂ plumes and displaced formation water. The practice may also provide water that may be put to beneficial uses, such as the supply of potable water, where treatment can be performed at a reasonable cost. This concept’s utility will depend on feasible water extraction rates, which will, in turn, depend on site-specific factors such as geologic structure, permeability, heterogeneity, and project design features (i.e., the desired CO₂ injection rate).

The impacts of formation water extraction were tested through heterogeneous geologic modeling and dynamic simulations of four case study sites. Reservoir-scale dynamic simulations were conducted to investigate the impact formation water extraction could have on storage capacity and reservoir management strategies. Storage capacity was found to increase through water extraction at all test sites, generally doubling available storage. Use of extracted water was also found to be effective for reservoir pressure management and plume control. Analysis of the resulting water quality and quantity, available treatment technologies, and potential transportation costs reveals that barriers remain for potential beneficial use of extracted water from carbon capture and storage (CCS) facilities.

Conclusions

As a tool for increasing storage capacity, formation water extraction was generally found to be effective, although each hypothetical case study site reacted differently to its implementation. The results of these four case studies illustrate the wide range of results that may be possible and that geologic and reservoir engineering factors may both have a large influence on the final results. It can also be said that if it is feasible to utilize a large number of injection and extraction wells, overall storage may be increased by a large margin, even in high-quality storage reservoirs.

With respect to treatment of extracted water, treatment and beneficial use may be feasible under certain conditions: likely a combination of high-to-moderate extracted water quality, availability of inexpensive energy, and sufficient local water demand. Of the case study sites, the best candidate for treatment and beneficial use of extracted water was the Teapot Dome site, where estimated treatment costs were comparable to that of local water supplies.

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Benefits of Multiple Injectors – Ketzin Hypothetical Case Study

Hypothetical Simulation Results

<table>
<thead>
<tr>
<th>Site</th>
<th>Variable</th>
<th>Base Case</th>
<th>Water Extraction</th>
<th>Increase (%)</th>
<th>Potential/Economical Treatment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketzin</td>
<td>Candidate Injected CO₂ (SC, tonne)</td>
<td>18,300,000</td>
<td>23,400,000</td>
<td>30%</td>
<td>Yes</td>
</tr>
<tr>
<td>Zama</td>
<td>Candidate Injected CO₂ (SC, tonne)</td>
<td>54,000</td>
<td>56,000</td>
<td>3.5%</td>
<td>Yes</td>
</tr>
<tr>
<td>Gorgon</td>
<td>Candidate Injected CO₂ (SC, tonne)</td>
<td>97,300,000</td>
<td>98,000,000</td>
<td>1.0%</td>
<td>Yes</td>
</tr>
<tr>
<td>Teapot</td>
<td>Candidate Injected CO₂ (SC, tonne)</td>
<td>3,360,000</td>
<td>11,200,000</td>
<td>33%</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Water Treatment Options

- Adsorption
- Demineralization
- Reverse Osmosis
- Membrane Technology
- Thermal Distillation
- Electrodialysis Reversal
- Compression
- Mechanical Vapor Compression
- Multistage Flash
- Multieffect Distillation
- Crystallizer

Zama Hypothetical Case Study Model

Teapot Dome Hypothetical Case Study Model

Ketzin Hypothetical Case Study Model

Gorgon Hypothetical Case Study Model