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Best Practices for CO_2 Geologic Storage in the PCOR Partnership Region

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Summary

The Plains CO_2 Reduction (PCOR) Partnership, as part of the Regional Carbon Sequestration Partnerships (RCSP) Initiative run by the U.S. Department of Energy (DOE), aims to foster the deployment of carbon capture and storage (CCS) across a large area of the northern United States and Canada. Using an adaptive management approach (AMA) to the assessment of carbon dioxide (CO_2) geologic storage (hereinafter referred to as "storage"), the PCOR Partnership has demonstrated that secure storage can be achieved in association with CO_2 enhanced oil recovery (EOR) operations. Multiple storage-monitoring techniques successfully tested by the PCOR Partneship include casing-conveyed downhole sensors, pulsed-neutron logs (PNLs), 4-D seismic surveys, and shallow environment sampling. These techniques are also applicable to dedicated storage scenarios such as the use of deep saline aquifers. This work has culminated in the publication of a series of best practice manuals (BPMs) for storage.

Introduction

CCS is widely regarded as an essential technology component of plans to curb greenhouse gas (GHG) emissions and mitigate risks associated with climate change.[1] Since the mid-2000s, the RCSP Initiative run by DOE and its National Energy Technology Laboratory (NETL) has been one of the leading international research efforts focused on proving the security and effectiveness of storage to support the widespread deployment of CCS.

The PCOR Partnership, one of seven regional partnerships within the RCSP Initiative, is managed by the Energy & Environmental Research Center (EERC) in Grand Forks, North Dakota. The aim of the PCOR Partnership is to foster the deployment of CCS in a large region of central North America covering nine U.S. states and four Canadian provinces (Figure 1).

The PCOR Partnership covers a region with outstanding potential for CCS deployment, combining significant storage resources, fossil fuel reserves, and major point source emissions of CO_2 from power generation and industry. Three of the operational CO_2 capture projects defined as "large scale" by the Global CCS Institute[2]—the Great Plains Synfuel Plant (North Dakota), the Boundary Dam Project (Saskatchewan), and the Quest Project (Alberta)—are located in the PCOR Partnership region. In addition, two further U.S. projects—the Lost Cabin Gas Plant and the Shute Creek Gas-Processing

Facility—are located in close proximity to the region and supply CO_2 to the Bell Creek oil field (within the PCOR Partnership Region in southeastern Montana) for CO_2 EOR.

Figure 1. The PCOR Partnership region.[3]

Storage Demonstration Projects

Storage can be broadly divided into two types: dedicated storage, where mitigation of GHG emissions is the primary purpose of underground injection, and associated storage, where GHG mitigation is a secondary aspect of injection operations, typically at EOR sites. Within the PCOR Partnership region, dedicated storage as part of large-scale CCS is being undertaken at the Quest and Aquistore projects. Associated storage resulting from CO_2 EOR operations has been monitored and studied by the IEA Greenhouse Gas R&D Programme (IEAGHG) Weyburn–Midale CO_2 Monitoring and Storage Project[4] and, more recently, by the PCOR Partnership at the Bell Creek oil field, operated by Denbury Onshore LLC.

The PCOR Partnership has applied an AMA (Figure 2) to the main components of storage assessment at Bell Creek: site characterization; technical risk assessment; modeling and simulation; and monitoring, verification, and accounting (MVA). The application of adaptive management enables an iterative approach to be adopted for storage assessment, with each assessment component informing parallel

activities over the course of a project, for example, use of MVA data to refine predictive modeling efforts. Ultimately, the AMA fosters the development of an integrated storage assessment.[5,6]

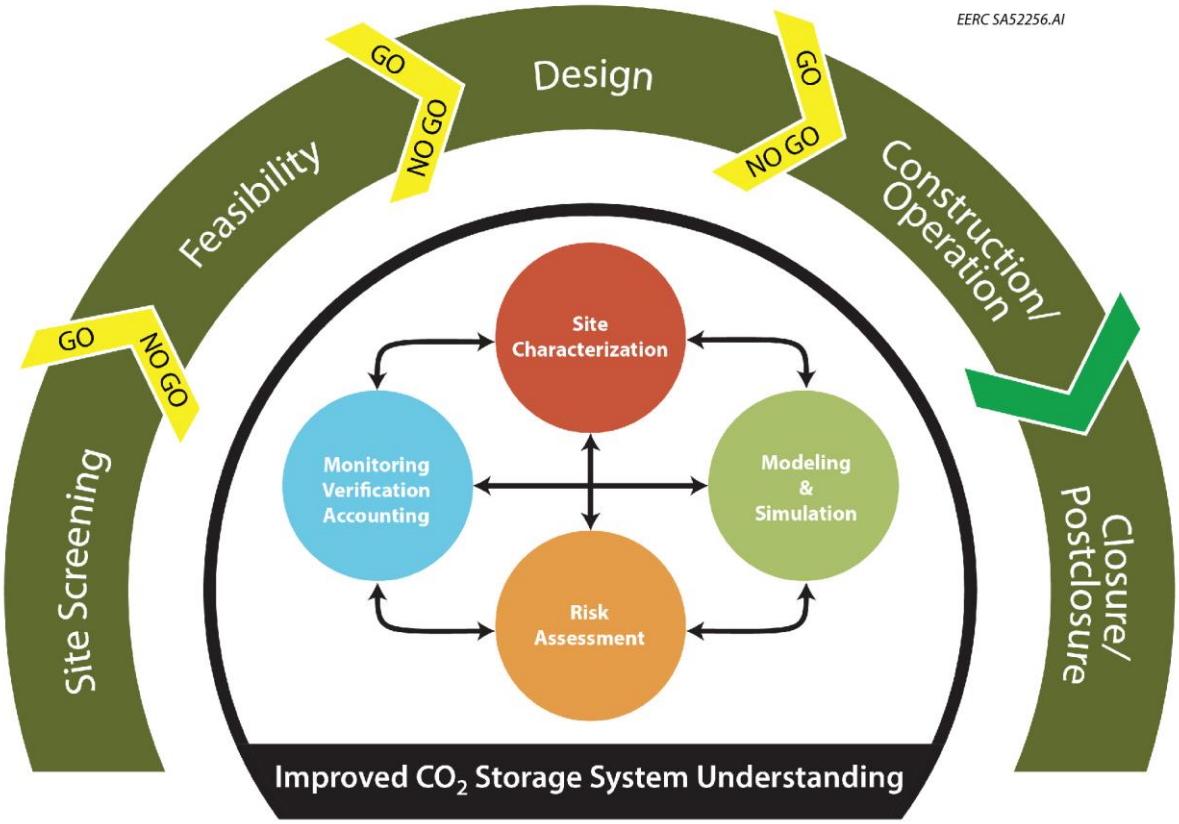

Figure 2. AMA used by the PCOR Partnership for storage assessment.[5,6]

The MVA program employed by the PCOR Partnership, in common with other storage projects, can be broadly divided between deeply focused and near-surface techniques. Deeply focused techniques are used to track the distribution and movement of injected CO_2 and check for any out-of-zone migration of CO_2 beyond the intended storage reservoir(s). Near-surface techniques include monitoring of shallow groundwater and soil gas to demonstrate the absence of impacts to sensitive environmental receptors resulting from CO_2 injection. Although the MVA program at Bell Creek has been undertaken in the context of associated storage resulting from CO_2 EOR, most of the techniques employed are equally applicable to dedicated storage scenarios such as the use of deep saline formations.

The deeply focused MVA program at Bell Creek employed by the PCOR Partnership has built on routine injection and production data collected as part of CO_2 EOR operations. Casing-conveyed downhole pressure and temperature sensors, PNLs, and 4-D seismic surveys are amongst the techniques focused on the reservoir, comprising a Lower Cretaceous-age sandstone at a depth of 1370 m. Time-lapse seismic data have provided a means of successfully tracking CO_2 distribution in the relatively thin (9- to 14-m thickness) reservoir and has enabled improved understanding of reservoir characteristics, for example, the nature of compartmentalization. PNLs have provided insights into the vertical distributions

of CO_2 in the reservoir and assurance monitoring to show that out-of-zone migration has not occurred from over 4.5 million tonnes of associated CO_2 storage.

Near-surface monitoring techniques have demonstrated the inherent variability of shallow environmental systems and the associated challenges of defining baseline characteristics. However, anomalous data due to natural processes can be readily identified as resulting from natural processes (for example, through isotopic analyses), and the data sets acquired from Bell Creek show no evidence of impacts resulting from CO_2 injection.

Conclusions

- The PCOR Partnership has successfully integrated technical data using an AMA to demonstrate secure CO_2 storage associated with EOR.
- Best practice manuals for storage based on PCOR Partnership work at Bell Creek and elsewhere are being published under the RCSP program.
- Multiple MVA techniques have been used to successfully track the presence and movement of CO_2 in the Bell Creek reservoir.
- Comprehensive MVA data have shown no evidence of out-of-zone migration or negative environmental impacts as a consequence of CO_2 injection.

Acknowledgments

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