INTRODUCTION
The Energy & Environmental Research Center (EERC) at the University of North Dakota conducted a prefeasibility study for a commercial-scale carbon dioxide (CO2) geologic storage complex in western Nebraska, USA. Regional geologic models were built for two potential storage complexes: the Cretaceous Cloverly Formation (Dakota Group) and Perman Cedar Hills Formation. Dynamic flow simulation was conducted to assess the feasibility of storing 50 million tonnes (Mt) of CO2 over 25 years in a portion of the Cloverly Formation in Nebraska. Given the high degree of uncertainty in the geologic heterogeneity of the sandstone, three probability distributions of formation properties (optimal [P90], average [P50], and conservative [P10]) were considered for numerical simulations.

A modified U.S. Department of Energy (DOE) method of calculating CO2 storage potential in saline formations was used for the regional Cloverly model (Peck and others, 2014). This method applies different Esaline values to total porosity estimates based on known factors incorporated into a model: net area, net thickness, and net porosity (Figure 2). To estimate the size of a 50 Mt CO2 plume based on the volumetric-storage potential, a moving window algorithm was used (Figure 3).

Based on the information obtained from the sensitivity analysis (Figure 6), CO2 injection at an optimum WHP was investigated to inform infrastructure design and associated economic study. Two different tubing sizes (3.5- and 4.5-inch diameters) were selected to investigate the required maximum WHP. A higher wellhead temperature of 90°F was used in this investigation to determine an optimum WHP for CO2 injection. Table 1 gives the simulated WHP values for wellhead temperature of 90°F was used in this investigation to determine an optimum WHP for CO2 injection. Two different tubing sizes (3.5- and 4.5-inch size of a 50-Mt CO2 model: net area, net thickness, and net porosity (Figure 2). To estimate the

VOLUMETRIC STORAGE POTENTIAL

Figure 2. Regional volumetric CO2 storage potential for the Cloverly Formation (P50 known net area and net thickness, Esaline, summed vertically. Dot represents the Grand Island Gentleman Station. Grid square denotes simulation model area.

CO2 AND PRESSURE PLUMES

The simulation results indicate that two, four, and 14 injection wells will be potentially required for the respective P90, P50, and P10 models to store 50 Mt of CO2 over a time period of 25 years (Figure 4). The extent of the pressure plume was extensively large in all three models because the high shale content in the model does not allow pressure to dissipate uniformly, resulting in directional and larger pressure plumes (Figure 5).

WELLHEAD PRESSURE SENSITIVITY

The CO2 plume per well grew by 1 mile to approximately 4.0 miles at the end of the 100-year postinjection simulation period. To demonstrate how small the pressure plume became during the postinjection period, the remaining pressure buildup (maximum value of 350 psi) at the end of 40 years of postinjection is shown in Figure 7 compared to the pressure plume at the end of the 25-year injection period shown in Figure 5 (the middle image, P50 model).

REFERENCES

GEOLOGIC MODEL

The Cloverly regional model was populated with lithofacies and geostatistical porosity and permeability to determine total pore volume (net area × net thickness × distributed porosity). The Cloverly simulation model (Figure 1) was clipped from the Cloverly regional model. Petrophysical data were calculated based on legacy core data. The major and minor influence ranges of the geostatistical Cloverly models were determined from the literature for fluvial channel sands (IEA Greenhouse Gas R&D Programme, 2009).

Figure 1. Porosity distributions (in plan view) for CO2 injection for P90, P50, and P10 models (from left to right). The injection wells are labeled “DK” (Dakota).

Figure 3. Simulation model volumetric CO2 storage potential estimate for the Cloverly Formation (50 km2 square in Perkins County). The color of each grid cell represents the amount of storage potential within a square window centered on that cell.

Figure 4. Simulated CO2 plumes (in plan view) for the P90, P50, and P10 models: from left to right at the end of 25-year CO2 injection operation. CO2 per unit Area + CO2 saturation + Pressure + Thickness. The CO2 plume diameters measure approximately 3.5, 3, and 2 miles around each injection well, respectively.

Figure 5. Simulated pressure plumes (in plan view) for the P90, P50, and P10 models: from left to right at the end of a simulated 25-year CO2 injection operation. The lower limit in pressure scale is bounded by the pressure threshold value of 134 psi. The pressure plume diameters measure approximately 20x20, 21x21, and 22x22 miles, respectively.

Figure 7. The postinjection CO2 plume (in plan view) after 100 years of postinjection simulation period. To demonstrate how small the pressure plume became during the postinjection period, the remaining pressure buildup (maximum value of 350 psi) at the end of 40 years of postinjection is shown in Figure 7 compared to the pressure plume at the end of the 25-year injection period shown in Figure 5 (the middle image, P50 model).

Figure 6. Relative effect of well parameters on WHP.

Table 1. Simulated Maximum WHP with Different Tubing Sizes.

POSTINJECTION

The CO2 plume per well grew by 1 mile to approximately 4.0 miles at the end of the 100-year postinjection simulation period.