Case Study of Risk Considerations for Transitioning a CO_2-EOR Field to Dedicated CO_2-storage

Guoxiang Liu[1], Mohamed Mehana[2], Christine Doughty[3], Robert Dilmore[1], Brian Strazisar[1], Gregory Lackey[1]

[1]U.S. Department of Energy, National Energy Technology Laboratory, Pittsburgh, PA, 15236; [2]Los Alamos National Laboratory, Los Alamos, NM, [3]Lawrence Berkeley National Laboratory, Berkeley, CA

National Risk Assessment Partnership

Motivation and Objectives

The objective of this study is to develop and demonstrate a workflow to quantitatively assess the evolution of potential leakage risk when transitioning CO_2 flood enhanced oil recovery (CO_2-EOR) to a phase of increased storage and to consider the implications of that assessment for stakeholder decision making (whether the site can justify continued operation within the bounds of Class II permit or otherwise). Work presented herein is part of a larger effort under the National Risk Assessment Partnership (NRAP) that includes:

- ❑ Develop a conceptual & numerical simulation workflow that enables risk assessment of the transition of existing Class II CO2-EOR injection wells to Class VI for dedicated CO2 storage.
- ❑ Conduct numerical simulation of a realistic and practical CO2-EOR field site transitioning especially the risk considerations.
- ❑ Explore influence of scenario responses reservoir that can support stakeholder decision makings for Class II to Class VI transition.
- ❑ Develop and test a prototype reduced-order model to forecast CO_2, brine, and hydrocarbon leakage through wells.

Model and Scenario Description

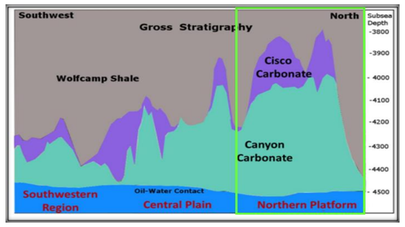
To explore this workflow, we referred a previously-published model of a mature and actively operated history and generalized it for case study. The model used as the basis for these simulations is modified from well developed previously by Han and colleagues (2010) and, as such, is considered to be credible. Model and simulations of operational scenarios are not, however, explicitly representative of a real site.

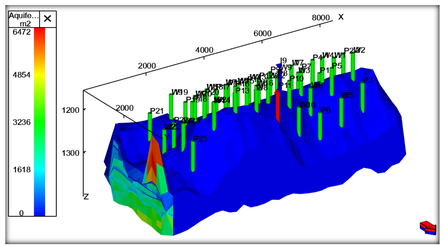
Model characteristics:

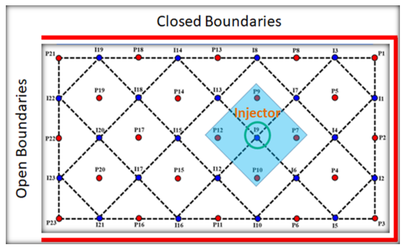
- Bounded on three sides and above and below the targeted interval with no-flow boundaries; one lateral boundary is treated as open with a Carter-Tracy boundary condition
- Depth: 1830 to 2280 meters
- Range of interval thickness: 150 to 250 meters
- Range of permeability and porosity: 10 to 1980 mD and 0.02 (2%) to 0.18 (18%)

The site has seen production through a period of primary hydrocarbon production, subsequent secondary (water flood) recovery, and a period of tertiary water-alternating-gas CO_2-EOR that continues until the initiation of a new operational paradigm (simulation year 2025, as described in the next panel). EOR was carried out using a typical 40-acre five spot pattern of injection/production wells.

A thick sequence of the Wolfcampian shale, overlaying the Cisco and Canyon formations, constitutes a natural top and lateral seal for the reservoir (Isdiken, 2013). The Cisco and Canyon deposition gets narrow and drops below the regional oil-water contact towards its east and west extents.







Operational Scenario Description

	Injection Cases	Reservoir Conditions	Boundary Conditions (BCs)	Injection Period (Yrs)	Post-Injection Period (Yrs)	Notes
Scenario 1	Bussiness-as-usual injection rate	Hydrocarbon reservoir	One side open	30	50	Reported on the poster Liu, 2023
Scenario 2	Dedicated CO_2 injection (1 MT/year)	Hydrocarbon reservoir	One side open			Comparison Scenarios 2 & 4
Scenario 3	Dedicated CO_2 injection (1 MT/year)	Hydrocarbon reservoir	All sides open			Comparison BCs
Scenario 4	Dedicated CO_2 injection (1 MT/year)	Saline reservoir	One side open			Comparison Scenarios 2 & 4
Scenario 5	Dedicated CO_2 injection (1 MT/year)	Saline reservoir	All sides open			Comparison BCs

Preliminary Simulation Results & Remarks

Based on the scenarios and outcomes, critical pressure based on the equation recommended from EPA was calculated and applied for the Area of Review (AOR) assessment based on the hydrocarbon and saline reservoirs (scenarios 2 & 4). Moreover, model domain and boundary condition impacts were also analyzed to assess a few risk considerations for the class II to class VI well transition.

$P_{i,f} = P_u + \rho_i g \cdot (z_u - z_i)$ → 176 bar (17.6 MPa/2,552 psi)

Ref: Draft Underground Injection Control (UIC) Program Guidance on Transitioning Class II Wells to Class VI Wells (epa.gov) on page 19

The calculation based on the brine density (30-years of dedicated CO_2 injection)

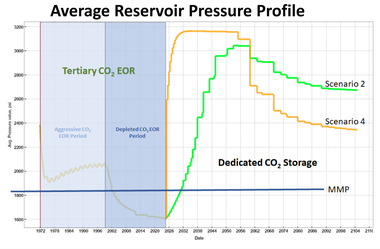
Critical pressure contour line

Ref: 1210902 (osti.gov)

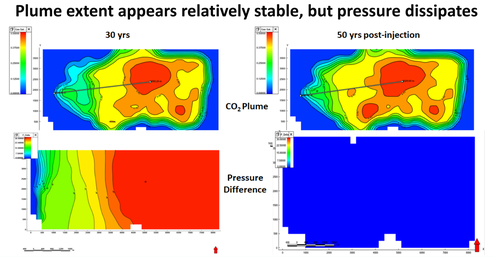
Scenario 2

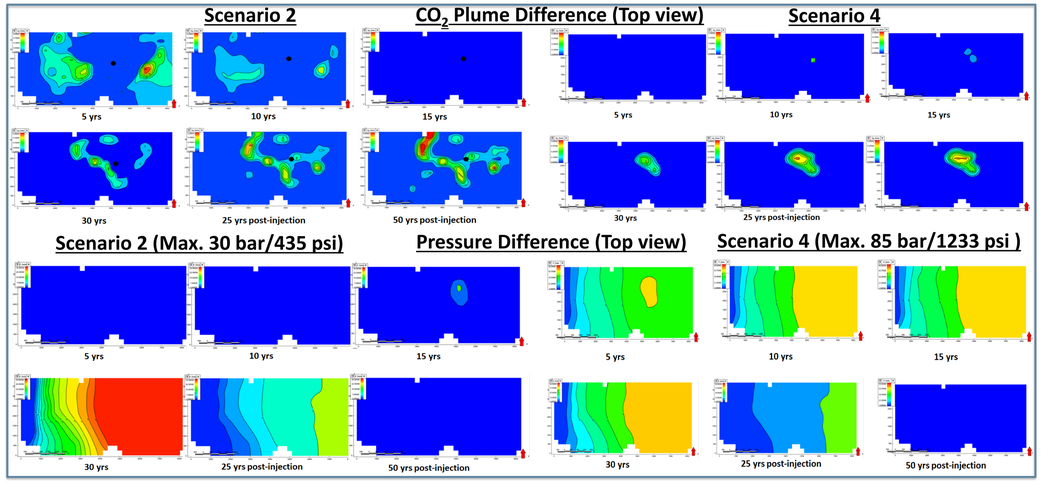
Union AOR Example (Scenario 2)

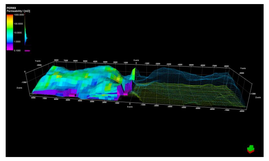
Average Reservoir Pressure Profile



Plume extent appears relatively stable, but pressure dissipates

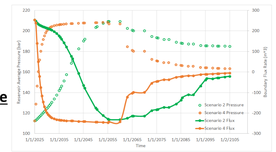






Domain Extension ⇐

Boundary Flux Profile ⇒

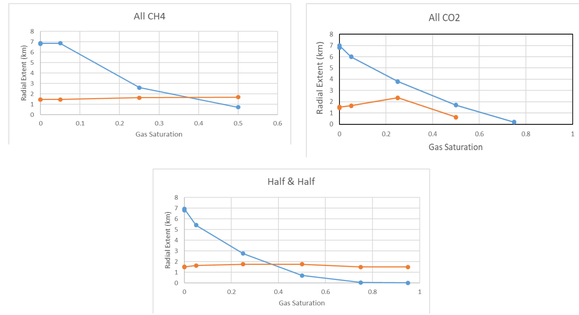


Considerations for Risk Assessment:

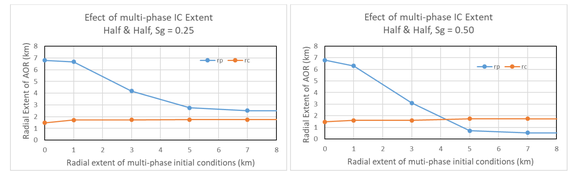
- ✓ The union of CO_2 plume and area for AOR is primary consideration based on the critical pressure calculation and mapping
- ✓ Depletion of reservoir pressure status is also primary and/or secondary consideration
- ✓ Model domain coverage may impact the AOR over all especially for the saline case as secondary consideration
- ✓ Boundary impact shows impact of the overall AOR for such structure as secondary consideration

AOR for Hydrocarbon Reservoirs

The impact of various system properties on the extent of AoR is well-established in saline aquifers. However, when GCS will be conducted in reservoirs previously used for hydrocarbon production, where oil, gas, CO_2, and water may be present, the effect of system parameters on AoR extent is not well known. We examine the physics of multi-phase, multi-component flow for GCS in reservoirs containing hydrocarbons and CO_2, and determine how the extent of the AoR depends on the system properties.



Trends in r_{pAoR} and r_{cAoR} with initial gas saturation for single-phase and two-phase initial conditions.



Trends in r_{pAoR} and r_{cAoR} with the extent of multi-phase initial conditions, for initial gas saturation 0.25 (left) and 0.50 (right).

Next Steps

- ➢ Refine reservoir simulation and expand set of operational scenarios including model domain extension, as needed
- ➢ Apply simulation results together with credible representations of well integrity to estimate potential leakage risk
- ➢ Incorporate methods developed through this study into workflows within the NRAP-Open-IAM for risk assessment of transition and Class II to Class VI decision support
- ➢ AOR ROM development and extend the model to account for the gravity effects

Disclaimer & References Cited

Reference:

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5. Isdiken, B., Integrated Geological and Petrophysical Investigation on Carbonate Rocks of the Middle Early to Late Early Canyon High Frequency Sequence in the Northern Platform Area of the SACROC Unit, Master Thesis, The University of Texas at Austin December 2013

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