Practical leakage risk assessment for CO₂ assisted enhanced oil recovery and geologic storage in Ohio’s depleted oil fields

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Abstract

CO₂ emissions from Ohio are a significant source of CO₂ in the US; currently ranked 7th nationally among states with 215 million tonnes per year of emissions. Sustaining Ohio’s current coal-based power production while transitioning to a low-emissions economy will require the state to develop and introduce strategies for carbon capture and geologic storage, possibly in conjunction with CO₂ enhanced oil recovery (CO₂-EOR). Collectively these are referred to as carbon capture, utilization, and storage (CCUS). Ohio’s oil and gas reservoirs may store between 205 and 878 million metric tonnes CO₂ [Battelle, 2016], which is 2.6 to 5.2 times the 79 million tonnes of CO₂ emitted from Ohio’s power sector in 2016 [U.S. EPA, 2017].

To date, no large-scale CCUS operations have been conducted in Ohio. This allows time to develop a focused strategy to implement CCUS by building on similar projects outside the state while tailoring to local geography, geology, and risks. As part of the strategy, a field-specific risk framework for CCUS in depleted oilfields has been created.

This presentation will describe the method used to conduct risk assessments and the results of risk assessments for potential CCUS projects at three legacy oilfields in Ohio. The fields are the East Canton Consolidated Oilfield, Morrow Consolidated Oilfield, and Gore Consolidated Oilfield with 3,483, 898, and 5992 wells, respectively. Field-scale well integrity studies have had to rely largely on historical data to assess the potential for fluid leakage related to CCUS projects. Several groups have developed methods to identify risky wells that may need to be monitored or remediated. These methods serve as analogs for determining the frequency of wellbore leakage in other fields.

Methods to assess well integrity can be qualitative, semi-quantitative, or quantitative. This study defined risk as the product of the likelihood of occurrence and the severity of occurrence of leakage (Equation 1). Where Risk and Severity of occurrence are in US dollars

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\text{Risk} = \text{Likelihood of leakage} \times \text{Severity of occurrence} \quad [\text{Equation 1}]
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The risk framework described in this study uses the bow-tie method with features, events, and processes (FEPs) to identify and assess risk posed by legacy wells. The bow-tie allows simple visualization of top risk events (hazards) stemming from threat scenarios developed using FEPs that lead to specific consequences.
This study builds on work by Duguid et al [2017], using categories of known information to develop a proxy for likelihood of leakage. Proxy categories were: Spud Date, Treatment, Well Status, Plugging and Abandonment (P&A) Date, Well Type, Plug, Surface Cement, and Primary Cement. Separate risks were developed for each well and each scenario. Because limited leakage data are available the study mapped the Ohio likelihood proxy data to the surface casing vent flow and gas migration data reported by Watson and Bachu [2009] to provide likelihood of leakage. Watson and Bachu, found that their data strongly correlated to oil price that drove the number of wells spud with time. Trends in the number of wells spud in Alberta and Ohio are similar.

As part of the assessment, leakage scenarios were developed that helped drive the risk with respect to specific subsurface horizons. The scenarios considered were:

- Low cost leakage from wellbore below an aquifer
- High cost leakage from wellbore below an aquifer
- Low cost leakage from wellbore to an aquifer
- High cost leakage from wellbore to an aquifer
- Low cost leakage from wellbore to the surface
- High cost leakage from wellbore to the surface

The low-cost storylines are based on leakage through a legacy production well. The high-cost storylines are based on wellbore leakage compounded by geographic factors including the proximity of populations and drinking water sources.

The consequence of a leakage event was estimated based on costs to businesses and property owners for each leakage scenario. Cost categories in this framework include: finding and fixing the leak, environmental remediation, CO₂ injection interruption, technical remedies for damages, and legal costs.

Using the likelihood of leakage calculated for each field and the cost of potential consequences, the risks for each field were estimated to be between $13 million to $63 million for the three fields of
interest. The use of the bow-tie method allows easy visualization and identification of barriers that can reduce the likelihood of the top event in a risk scenario. It also allows visualization of mitigation barriers to be identified for each consequence. Overall, the identification of threats, hazards, and consequences and the identification of barriers to lessen the likelihood of occurrence or minimize consequences aids in the development of a targeted CCUS strategies.

References:


