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Monetizing Leakage Risk of Geologic CO_2 Storage using Wellbore Permeability Frequency Distributions

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Carbon dioxide (CO_2) may be captured from large point sources (e.g., coal-fired power plants, oil refineries, cement manufacturers) and injected into deep sedimentary basins for storage, or sequestration, from the atmosphere. This technology—CO_2 Capture and Storage (CCS)—may be a significant component of the portfolio of technologies deployed to mitigate climate change. But injected CO_2, or the brine it displaces, may leak from the storage reservoir through a variety of natural and manmade pathways, including existing wells and wellbores. Such leakage will incur costs to a variety of stakeholders, which may affect the desirability of potential CO_2 injection locations as well as the feasibility of the CCS approach writ large. Consequently, analyzing and monetizing leakage risk is necessary to develop CCS as a viable technological option to mitigate climate change.

Risk is the product of the probability of an outcome and the impact of that outcome. Assessment of leakage risk from geologic CO_2 storage reservoirs requires an analysis of the probabilities and magnitudes of leakage, identification of the outcomes that may result from leakage, and an assessment of the expected economic costs of those outcomes. One critical uncertainty regarding the rate and magnitude of leakage is determined by the leakiness of the well leakage pathway. This leakiness is characterized by a leakage permeability for the pathway, and recent work has sought to determine frequency distributions for the leakage permeabilities of wells and wellbores. We conduct a probabilistic analysis of leakage and monetized leakage risk for CO_2 injection locations in the Michigan Sedimentary Basin (USA) using empirically derived frequency distributions for wellbore leakage permeabilities.

To conduct this probabilistic risk analysis, we apply the RISCS (Risk Interference of Subsurface CO_2 Storage) model (Bielicki et al, 2013a, 2012b) to injection into the Mt. Simon Sandstone. RISCS monetizes leakage risk by combining 3D geospatial data with fluid-flow simulations from the ELSA (Estimating Leakage Semi-Analytically) model (e.g., Celia and Nordbotten, 2006) and the Leakage Impact Valuation (LIV) method (Pollak et al, 2013; Bielicki et al, 2013). We extend RISCS to iterate ELSA semi-analytic modeling simulations by drawing values from the frequency distribution of leakage permeabilities. The iterations assign these values to existing wells in the basin, and the probabilistic risk analysis thus incorporates the uncertainty of the extent of leakage. We show that monetized leakage risk can vary significantly over tens of kilometers, and we identify "hot spots" favorable to CO_2 injection based on the monetized leakage risk for each potential location in the basin.