



SPE 110650

Eliminating Buoyant Migration of Sequestered CO₂ Through Surface Dissolution: Implementation Costs and Technical Challenges

McMillan Burton and Steven L. Bryant, SPE, University of Texas at Austin

Copyright 2007, Society of Petroleum Engineers

This paper was prepared for presentation at the 2007 SPE Annual Technical Conference and Exhibition held in Anaheim, California, U.S.A., 11–14 November 2007.

This paper was selected for presentation by an SPE Program Committee following review of information contained in an abstract submitted by the author(s). Contents of the paper, as presented, have not been reviewed by the Society of Petroleum Engineers and are subject to correction by the author(s). The material, as presented, does not necessarily reflect any position of the Society of Petroleum Engineers, its officers, or members. Papers presented at SPE meetings are subject to publication review by Editorial Committees of the Society of Petroleum Engineers. Electronic reproduction, distribution, or storage of any part of this paper for commercial purposes without the written consent of the Society of Petroleum Engineers is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of where and by whom the paper was presented. Write Librarian, SPE, P.O. Box 833836, Richardson, Texas 75083-3836 U.S.A., fax 01-972-952-9435.

Abstract

Sequestration of CO₂ in geologic formations will be part of any substantive campaign to mitigate greenhouse gas emissions. The risk of leakage from the target formation must be weighed against economic feasibilities for this technology to gain stakeholder acceptance. The standard approach to large-scale geologic sequestration assumes that CO₂ will be injected as a bulk phase into a saline aquifer. In this case, the primary driver for leakage is the buoyancy of CO₂ under typical deep reservoir conditions (depths > 2600 ft or 800 m). Investigating alternative approaches that utilize inherently safe trapping mechanisms can help to characterize the price of reducing the risk of leakage.

In this paper, we investigate a process in which CO₂ is dissolved in brine prior to injection into deep subsurface formations. The CO₂-laden brine is slightly denser than brine containing no CO₂, so ensuring the complete dissolution of all CO₂ into brine at the surface prior to injection will eliminate the risk of buoyancy-driven leakage. We examine the feasibility of dissolving CO₂ at surface facilities and injection of the saturated brine. To estimate the costs of this process, we determine the capital costs for the additional facilities and compare them the capital costs for injecting bulk phase CO₂. We also estimate the power requirements to determine the additional operating costs. The additional capital and operating costs can be regarded as the price of this form of risk reduction.

Comparing this alternative to the standard, we find that an additional power consumption of 3% to 8% of the power plant capacity will be required and the capital costs will increase by 34% to 44%. Brine is required at rates of millions of barrels per day, and in most applications this would be lifted from the target aquifer. The bulk volume of the aquifer is on the order of a hundred million acre-ft for reasonable power plant sizes (250MW to 1000MW) and for reasonable injection periods

(30-50 years). Although this alternative results in higher costs, surface dissolution may be attractive where the costs of monitoring or insuring against buoyancy-driven CO₂ leakage exceed these additional costs.

Introduction

The prototypical implementation of carbon capture and sequestration on existing power generation plants involves separation of CO₂ from the flue gas followed by compression for injection into a brine-filled formation for geologic storage (see Fig.1). Future power generation may rely on advanced combustion schemes that eliminate the flue gas separation step, but compression and injection of the CO₂ stream will still be required for greenhouse gas mitigation. In either case, the CO₂ phase will be less dense than brine at conditions in the geologic formation. Many studies suggest buoyant bulk phase CO₂ can be stored in the subsurface formations by a combination of dissolution into the brine, capillary trapping, and structural trapping.¹⁻² Similarly, some studies suggest co-injection of brine and CO₂ could improve the pore scale mixing and dissolution near the injection site.³ Geologic uncertainties, such as the extent and conductivity of faults and seals, as well as human-introduced uncertainty, such as location and conductivity of well penetrations, pose important risk to structurally trapped CO₂.⁴

This study estimates the operating and capital costs of preparing CO₂-dense brine in surface facilities and compares them to the costs of the standard approach of injection. The comparison considers only the case of retrofitting capture technology on an existing coal-fired power plant. The approach can be readily extended to anticipated power generation plants which do not require separation. Our original motivation was to determine whether the major contributions to power consumption for a surface dissolution scheme would be prohibitively large. Thus the present analysis neglects several issues, such as the consequences of geochemical reactions or energy required for efficient mixing and dissolution.

We apply these results in a simple case study of a well documented brine aquifer, the Mt. Simon formation in central Illinois. The case study illustrates how the information presented in this paper can be used. We also discuss the technical challenges and future research needs.