the ENERGY lab

PROJECT FACTS

Carbon Storage

Basin-Scale Leakage Risks from Geologic Carbon Sequestration: Impact on Carbon Capture and Storage Energy Market Competitiveness

Background

Through its core research and development program administered by the National Energy Technology Laboratory (NETL), the U.S. Department of Energy (DOE) emphasizes monitoring, verification, and accounting (MVA), as well as computer simulation and risk assessment, of possible carbon dioxide (CO_2) leakage at CO_2 geologic storage sites. MVA efforts focus on the development and deployment of technologies that can provide an accurate accounting of stored CO_2, with a high level of confidence that the CO_2 will remain stored underground permanently. Effective application of these MVA technologies will ensure the safety of geologic storage projects with respect to both human health and the environment, and can provide the basis for establishing carbon credit trading markets for geologically storing CO_2. Computer simulation can be used to estimate CO_2 plume and pressure movement within the storage formation as well as aid in determining safe operational parameters; results from computer simulations can be used to refine and update a given site's MVA plan. Risk assessment research focuses on identifying and quantifying potential risks to humans and the environment associated with geologic storage of CO_2, and helping to ensure that these risks remain low.

Project Description

This three-year project—performed by Princeton University in partnership with Brookhaven National Laboratory and the University of Minnesota—is developing a framework to examine geologic storage investment decisions in light of uncertainty in CO_2 leakage risks, potential subsurface liability, and the associated losses in carbon credits, should they be created. The project team is using this framework to quantify damages that derive from interferences with competing subsurface resources; identify regulatory, and liability management alternatives; and determine the role of geochemical reactions in affecting the probability of CO_2 leakage through alteration of the integrity of caprocks and well cements. The geographic focus of the project is based on the States that are part of DOE's Midwest Regional Carbon Sequestration Partnership (MRCSP). The research is focused on investigating injection scenarios in the Michigan sedimentary basin, including the Bass Island Dolomite Formation and the Mt. Simon sandstone.

Widespread commercial carbon capture, utilization, and storage (CCUS) will occur only if the technology is economically competitive, politically feasible, and aligned with the DOE performance goal of 99 percent CO_2 storage permanence with a 10 percent or less energy cost premium. The greatest uncertainty for a geologic storage project lies with the costs and liabilities from imperfect performance, in which some of the CO_2 stored in deep geologic formations leaks out. This leakage translates into the loss of carbon mitigation credit, as well as potential interference with other subsurface resources, such

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PROJECT DURATION

Start Date	End Date
10/01/2009	09/30/2012

COST

Total Project Value
$1,849,296

DOE/Non-DOE Share
$1,349,297 / $499,999

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as hydrocarbons or potable water. In order for geologic storage to be successful, therefore, potential CO_2 leakage rates must be projected with a high level of certainty, translated directly into costs and liabilities, and evaluated at each site, formation, and basin within the context of the entire energy economy and competing subsurface land uses. These are the challenges that this project is formulated to address.

Goals/Objectives

The primary objective of the DOE's Carbon Storage Program is to develop technologies to safely and permanently store CO_2 and reduce Greenhouse Gas (GHG) emissions without adversely affecting energy use or hindering economic growth. The Programmatic goals of Carbon Storage research are: (1) estimating CO_2 storage capacity in geologic formations; (2) demonstrating that 99 percent of injected CO_2 remains in the injection zone(s); (3) improving efficiency of storage operations; and (4) developing Best Practices Manuals (BPMs). The overall project goal is to develop capabilities that can link the energy market competitiveness of geologic storage with the potential liabilities and economic losses from CO_2 leakage. This goal will help to improve and demonstrate the need for efficient storage operations. The project team is developing a framework to quantify leakage risk in probabilistic terms, and combine it with a basin-scale model of competing subsurface land uses. Model output is being used to evaluate market competitiveness of alternative geologic storage options and to assess implications of different regulatory and legal frameworks.

Accomplishments

- Development of a reactive transport-pore network model that is able to simulate precipitation and dissolution of carbonate materials has been completed.
- Developed models describing Permeability Evolution of Leakage Pathways (PELs) that predict leakage with precision and require low computational effort.
- The Semi-analytic model for estimating leakage (ELSA) model capabilities have been expanded to include leakage pathways with dynamic permeability (Figure 1). The permeability evolution will result in significantly different predictions of leakage relative to constant permeability models.
- Gathered subsurface data and built an integrated GIS model of the demonstration site (Ottowa County, MI). The project team compiled a database of more than 460,000 wells for oil and natural gas production, water production, natural gas storage, hazardous waste injection, and other subsurface uses (e.g. minerals production, brine injection).
- Developed a Leakage Impact Valuation (LIV) framework that prices actions that could be triggered by leakage, including finding and fixing the leak, addressing damages to other subsurface activities, business interruption, legal fees, environmental remediation, and obligations under climate regulation.
- Developed the Risk Interference with Subsurface CO_2 Storage (RISCS) Model. RISCS integrates the 3D GIS model with output from the ELSA model and the LIV framework. The RISCS has been applied to a base case study in Ottawa County, MI.
- Continued development of the US Market allocation (MARKAL) model to evaluate energy market risks and opportunities of carbon storage options.

Benefits

It will be necessary to improve existing monitoring technologies, develop novel systems, and protocols to satisfy regulations to track the fate of subsurface CO_2 and quantify any emissions from reservoirs. The Carbon Storage Program is sponsoring the development of technologies and protocols by 2020 that are broadly applicable in different geologic storage classes and have sufficient accuracy to account for greater than 99 percent of all injected CO_2. If necessary, the tools will support project developers to help quantify emissions from CCUS projects in the unlikely event that CO_2 migrates out of the injection zone. Finally, coupled with our increased understanding of these systems and reservoir models, MVA tools will help in the development of one of DOE's goals to quantify storage capacity within ± 30 percent accuracy.

The expected impact of this project is threefold. First, the project will reduce uncertainties in predictions of CO_2 leakage rates by quantifying the extent to which geochemical reactions can jeopardize the integrity of caprocks and well cements. Second, the project will demonstrate how CO_2 leakage and subsurface liability impact energy market competitiveness of geologic carbon storage in the Midwest. Third, the project will produce a general framework for analysis of geologic carbon storage energy marketplace competitiveness nationwide. The research will have an overall impact on improving the efficiency of storage operations for future geologic carbon storage project operators.

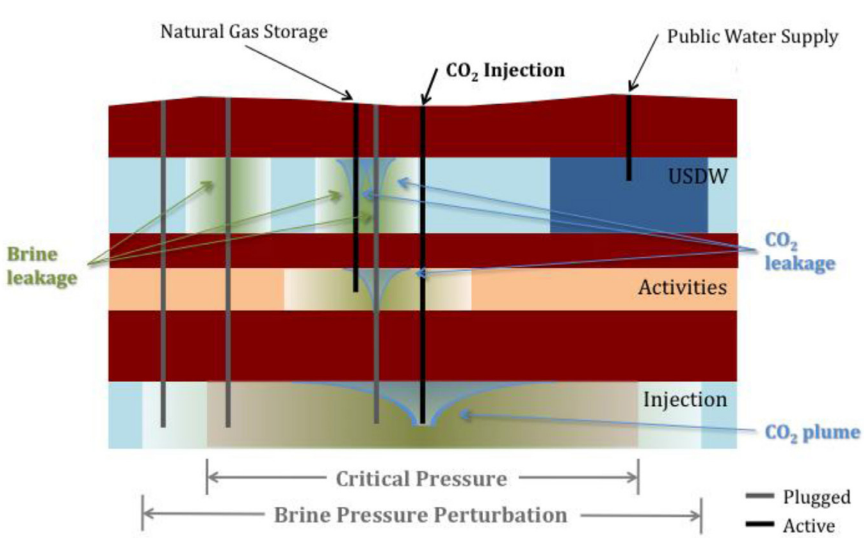

Figure 1: This figure depicts the model component of ELSA and RISCS which together estimate CO_2 leakage and brine migration as well as the risk of interference of leaked CO_2 with existing subsurface activities such as natural gas storage and underground sources of drinking water (USDW).