the ENERGY lab

PROJECT FACTS

Carbon Storage – Geologic Storage Simulation

Training Graduate and Undergraduate Students in Simulation and Risk Assessment for Carbon Sequestration

Background

Fundamental and applied research on carbon capture, utilization and storage (CCUS) technologies is necessary in preparation for future commercial deployment. These technologies offer great potential for mitigating carbon dioxide (CO_2) emissions into the atmosphere without adversely influencing energy use or hindering economic growth.

Deploying these technologies in commercial-scale applications requires a significantly expanded workforce trained in various CCUS technical and non-technical disciplines that are currently under-represented in the United States. Education and training activities are needed to develop a future generation of geologists, scientists, and engineers who possess the skills required for implementing and deploying CCUS technologies.

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL), through funding provided by the American Recovery and Reinvestment Act (ARRA) of 2009, manages 43 projects that received more than $12.7 million in funding. The focus of these projects has been to conduct geologic storage training and support fundamental research projects for graduate and undergraduate students throughout the United States. These projects include such critical topics as simulation and risk assessment; monitoring, verification, and accounting (MVA); geological related analytical tools; methods to interpret geophysical models; well completion and integrity for long-term CO_2 storage; and CO_2 capture.

Project Description

NETL is partnering with the Colorado School of Mines to conduct research and training in the area of "Simulation and Risk Assessment" associated with geologic carbon storage (GCS) to advance state-of-the-art CCUS science. CCUS simulation and risk assessment is used to develop advanced numerical simulation models of the subsurface to forecast CO_2 behavior and transport; optimize site operational practices; ensure site safety; and refine site monitoring, verification, and accounting efforts. Results can be integrated to provide an assessment of site technical and programmatic risks. As the simulation models are refined with new data, the uncertainty surrounding the identified risks decreases, thereby providing a more reliable risk assessment.

This laboratory project focuses on the risks associated with potential leakage of injected CO_2 and the pore-scale geochemical process associated with injectivity of CO_2, such as

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PROJECT DURATION

Start Date
12/01/2009

End Date
11/30/2012

COST

Total Project Value
$414,948

DOE/Non-DOE Share
$299,997 / $114,951

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

mineral reactivity and multiphase flow. Model simulations identify high and low risk leakage scenarios by linking (Figure 1):

- Heterogeneous subsurface flow and contaminant transport.
- Possible capture in one or more downgradient receptors (wells).
- Water delivery system to many different households.
- Potential household exposure and health risk via multiple pathways.

Laboratory experiments focus on the geochemical processes that occur as CO_2 is injected into saline reservoir storage targets. These processes include decreases in pH, changes in ionic strength, and changes in permeability and porosity of the reservoir and caprock. A quantitative model is being developed to better understand fundamental processes and lead to a more robust conceptual model and tools useful for design and risk mitigation of CCUS projects.

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 goal of this project is to train graduate and undergraduate students and advance the science in two critical areas of risk assessment:

- Multi-process, reservoir-scale characterization and model simulation of health risks associated with leakage into overlying aquifers.
- Pore-scale geochemical processes in CO_2 storage related to injectivity and storage, including mineral reactivity and multiphase fluid reactions, needed to assess the likelihood of a successful carbon storage effort.

This research effort is contributing to understanding the processes that lead to successful CO_2 injection into and storage permanence into the injection zone.

Accomplishments

- As of March 2012, two students had accumulated 6,132 training-related hours under the program.
- The project team has completed a list of EPA regulated byproducts of reaction between aquifer materials and CO_2 and any toxic byproduct information
- The project team also completed determination of rate parameters of important geochemical reactions between minerals, CO_2, and water brine from bench scale experiments.

Benefits

Overall the project is making a vital contribution to the scientific, technical, and institutional knowledge necessary to establish frameworks for the development of commercial-scale CCUS technologies that ensures injected CO_2 remains in the injection zone. Results from this project are leading to better informed risk assessments associated with geologic carbon storage and advancing the scientific understanding of hydrogeochemical processes at multiple scales. The benefits to the DOE include advancing technological options to reduce greenhouse gas emissions and, in turn, to address climate-change mitigation; enabling two university professors to develop sustainable research programs in CCUS science; enabling one post-doctoral research scientist to begin a career in CCUS science; and producing two highly trained graduate scientists/engineers. Furthermore, it is providing introductory classroom training to approximately 50 graduate and undergraduate students who will gain a firm grasp of the principles related to GCS.

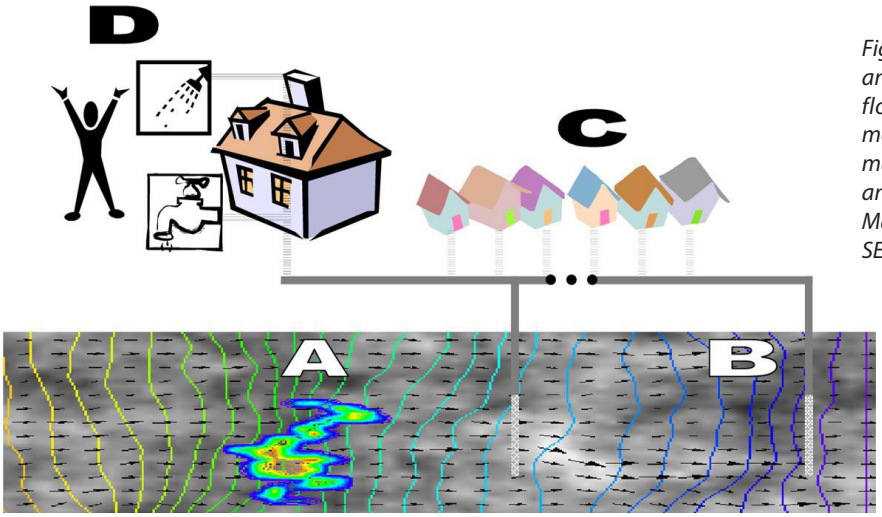

Figure 1. Risk assessment model will link (A) CO_2 leakage and dissolution of metals; (B) heterogeneous subsurface flow and transport of metals; (C) capture in one or more down gradient wells; (D) water delivery system to many different households; and (E) household exposure and health risk to varying individuals. (Modified from Maxwell et al. WRR34 (4),1998; Maxwell and Kastenberg, SERRA13 (1-2), 1999).