the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Multi-Object Optimization Approaches for the Design of Carbon Geological Sequestration Systems

Background

Increased attention is being placed on research into technologies that capture and store carbon dioxide (CO_2). Carbon capture and storage (CCS) technologies offer great potential for reducing CO_2 emissions and, in turn, mitigating global climate change without adversely influencing energy use or hindering economic growth.

Deploying these technologies in commercial-scale applications requires a significantly expanded workforce trained in various CCS specialties 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 CCS technologies.

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) has selected 43 projects to receive more than $12.7 million in funding, the majority of which is provided by the American Recovery and Reinvestment Act (ARRA) of 2009, to conduct geologic sequestration training and support fundamental research projects for graduate and undergraduate students throughout the United States. These projects will 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 Colorado State University (CSU) to conduct research and training to advance science in the area of simulation and risk assessment associated with CCS. Simulation and risk assessment for CCS, as defined by NETL, is the development of advanced simulation models of the subsurface, and the integration of the results of those models into a risk assessment that includes both technical and social risks. As the simulation models are refined with new data, the uncertainty surrounding the identified risks decreases, thereby providing more accurate risk assessment.

The project will provide training opportunities for two graduate students. Their efforts will be geared towards formulating and implementing an integrated, simulation-optimization framework to provide rigorous scientific support for the design of CCS systems to maximize the carbon storage volume, while minimizing the total cost associated with CCS projects and the risk of potential CO_2 leakage from deep geologic

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PARTNERS

None

PROJECT DURATION

Start Date
12/01/2009

End Date
11/30/2012

COST

Total Project Value
$299,960

DOE/Non-DOE Share
$299,960/$0

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

formations for any given site. This framework will, in turn, provide a tool that can be used to assist in the planning and operation of CO2 injection systems at a given geological site through the identification of optimal siting, development, and operation of injection wells.

Potential safety concerns will be addressed quantitatively by calculating the unlikely risk of upward leakage of CO_2 from the injected formations as one the objectives that should be minimized in the optimization problem. This risk is strictly connected to the uncertainty in site characterization, which increases as the carbon plume migrates to geologic regions where the sealing properties of cap rock formations are unknown. The potential risk of CO_2 leakage is consequently larger for increasing carbon injection volumes, which will tend to occupy larger portions of the injected formation. An example of this trade off is provided in Figure 1.

The scientific scope of the proposed study will rely on a combination of subsurface flow simulation models and optimization algorithms. The framework will rely on geophysical investigation data sets, data assimilation, and modeling techniques. The site investigation methods will include a combination of seismic surveys and borehole well logs, which will be used to characterize the lithology of the candidate formations for CCS, along with the spatial variations in porosity, density, and permeability. A multi-phase flow model will be used to estimate the expected intensity and the risk of possible CO_2 leakage for any given injection scheme, based on the uncertain geological parameter distribution.

Goals/Objectives

The objective of the project is to provide training opportunities for graduate students in the formulation and implementation of an integrated simulation-optimization framework to provide scientific support for the design of CCS systems. Specifically, the project's research will maximize the amount of carbon storage and minimize associated costs and potential CO_2 leakage for any given site. This represents the first attempt towards applying mathematical optimization to support geologic CO_2 sequestration planning.

Benefits

Overall the project will make a vital contribution to the scientific, technical, and institutional knowledge necessary to establish frameworks for the development of commercial-scale CCS. Further, the project will contribute to the advancement of methodologies for developing integrated modeling and monitoring of CCS systems at any given site by utilizing available geologic data.

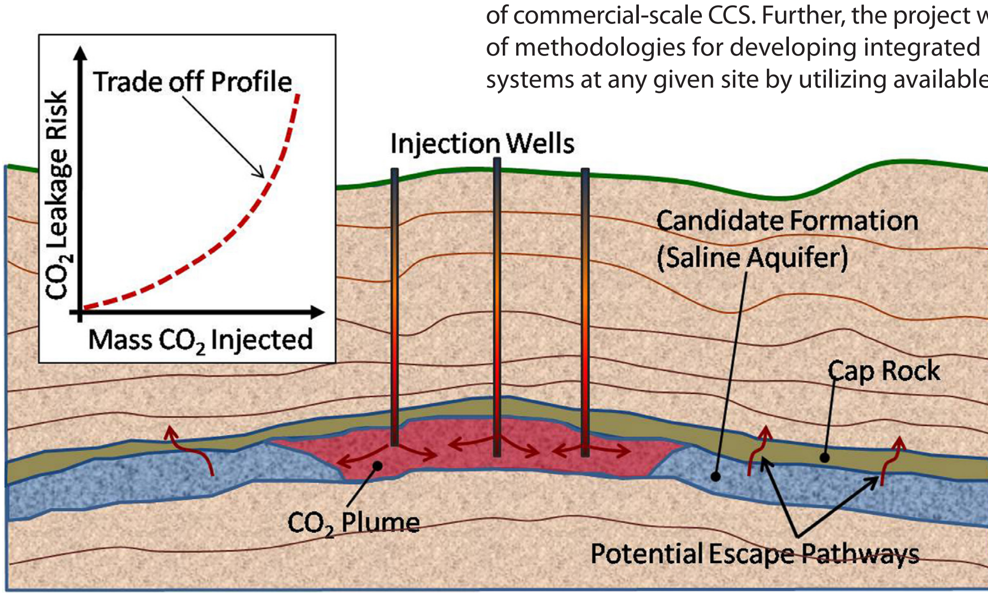

FIGURE 1: Example of Trade-off between the mass of CO_2 injected in a hypothetical saline aquifer and the risk of carbon upward leakage.