the ENERGY lab

PROJECT FACTS

Carbon Sequestration

The Coal-Seq III Consortium: Advancing the Science of CO_2 Sequestration in Coal Seam and Gas Shale Reservoirs

Background

Through its core research and development (R&D) 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, of possible carbon dioxide (CO_2) leakage at CO_2 geologic storage sites, along with risk assessment of those sites. As a part of these efforts, Advanced Resources International, Inc. (ARI) has been leading the Coal-Seq industry/government R&D collaborative project since 2000, with cooperating industry partners BP America, BG Group, and Sasol Petroleum International, among others. The primary goal of the project was to understand the technical/economic feasibility and application potential of carbon storage in coal seams.

Project Description

Coal-Seq Consortia I & II were widely successful in furthering an understanding of the mechanisms controlling CO_2 extended coal bed methane recovery (ECBM) as a byproduct of CO_2 storage in deep, unmineable coal seams. By studying the only long-term, multi-well ECBM projects that exist in the world today (the Allison and Tiffany units in the San Juan Basin), Coal-Seq identified numerous important sub surface reservoir mechanisms, performed laboratory research to verify and validate gas storage mechanisms in these reservoirs, developed a screening model to assess CO_2 geologic storage potential in other promising coal basins of the United States, and established a better predictive capability for such projects to promote investment in them.

Now Coal-Seq III, a new three-year consortium phase of this project is developing and testing three advanced geochemical and geomechanical modules that will increase the accuracy of simulating CO_2 behavior in coals and shales, and couple these with flow simulation (Figure 1 and 2). The project also will address coal storage factors such as coal failure and permeability enhancement, matrix swelling and shrinking, and competition with water as an adsorbed phase on coals, as well as other aspects of CO_2 geologic storage.

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

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PROJECT DURATION

Start Date	End Date
9/25/2009	12/23/1012

COST

Total Project Value
$2,139,015

DOE/Non-DOE Share
$1,000,000 / $1,139,015

PROJECT NUMBER

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zone(s); (3) improving efficiency of storage operations; and (4) developing Best Practices Manuals (BPMs). The primary project goal of Coal-Seq III is to develop a set of robust mathematical modules to accurately predict how coal and shale permeability and injectivity change with CO_2 injection. These modules will correctly account for multi-component (methane-CO_2-nitrogen-water) matrix shrinkage/ swelling; coal-weakening; competitive adsorption; bi-direction diffusion; and system pressure, volume, and temperature (PVT) behavior. Overall, Coal-Seq III will help to improve CO_2 storage operation efficiency by further understanding the dynamics of CO_2 storage in coal seams and shales.

Accomplishments

- The project team completed a trial experiment using a coal sample available from a prior Coal-Seq study. The coal was obtained from a mining operation in the San Juan basin.
- The project team has successfully compiled a database comprised of experimental vapor-liquid equilibrium (VLE) and pressure-volume-temperature (PVT) data from the literature for mixtures of CO_2 and water.
- The CO_2 gas density measurements performed earlier were used to calibrate the density meter. In particular, a weighted regression technique was used, where the weights were the expected uncertainties in gas densities. The regressions provided a weighted average absolute deviation (WAAD) of 0.5 in CO_2 densities. Further, an average absolute deviation (AAD) of 0.0001 g/cc was obtained, which correspond to an average absolute percentage deviation (% AAD) of 0.03%.
- Gas density measurements were conducted for pure methane and nitrogen to validate the density meter calibrations performed earlier with CO_2. The density meter predicted the densities of pure methane and nitrogen with WAADs of 0.8 and 0.7, respectively. This corresponds to AADs of 0.0001 g/cc (% AADs of 0.05%) for both methane and nitrogen. Thus, the density meter calibration appears capable of predicting densities of methane, nitrogen and CO_2 within their expected uncertainties, on average.
- The recently developed volume translation method for the Peng-Robinson equation of state was extended to mixtures. For this purpose, detailed thermodynamic expressions were derived and these were implemented in the computational algorithm used to perform volumetric and phase equilibrium calculations.

Benefits

As carbon capture, utilization, and storage (CCUS) capacity increases and projects become commercial beyond 2020, the importance of accurate geologic models and robust risk assessment protocols will become increasingly important to project developers, regulators, and other stakeholders. NETL's Carbon Storage Program aims to continue improvements to the models and risk assessment protocols. Specific goals within the Simulation and Risk Assessment Focus Area that will enable the Carbon Storage Program to meet current programmatic goals are to (1) validate and improve existing simulation codes which will enhance the prediction and accuracy of CO_2 movement in deep geologic formations to within ± 30 percent accuracy, (2) validate risk assessment process models using results from large-scale storage projects to develop risk assessment profiles for specific projects, and (3) develop basin-scale models to support the management of pressure, CO_2 plume, and saline plume impacts from multiple injections for long-term stewardship in major basins of the United States.

The knowledge gained from this project will benefit the energy industry by providing verifiable and valid storage mechanisms in coal reservoirs, as well as a new source of clean gas supply. The ability to take advantage of these opportunities will be facilitated by the development of valid geochemical and geomechanical predictive modules for coal seam and methane behavior under CO_2 geologic storage as described above.

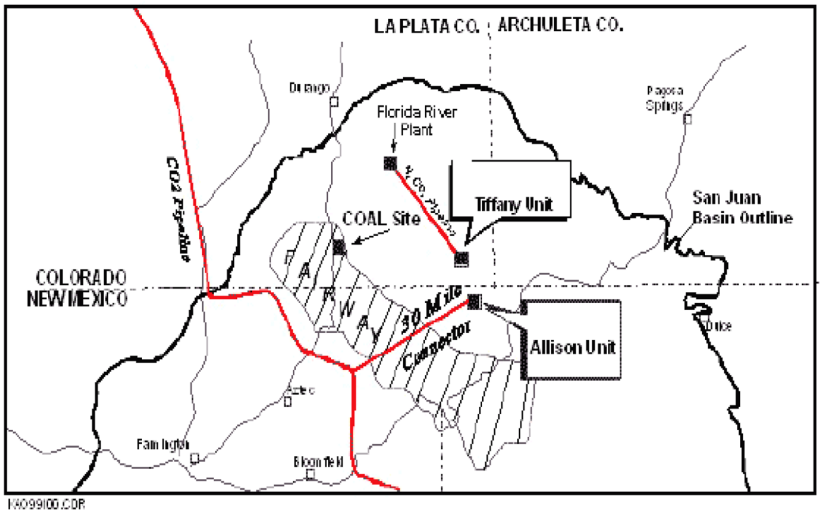

Figure 1: Location of the Tiffany and Allison units on the Colorado-New Mexico border.

Figure 2: CO_2 injector well at the Allison Unit.