the ENERGY lab

PROJECT FACTS

Carbon Storage

Development of a Software Framework for System-Level Carbon Sequestration Risk Assessment

Description

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 GoldSim Technology Group LLC in partnership with Los Alamos National Laboratory (LANL)—is developing an integrated system level risk analysis approach for CO_2 capture and geologic storage, based on dynamic, probabilistic simulation. Project success is achieved through adapting and significantly extending an existing highly-regarded and widely-used probabilistic simulation framework (GoldSim) that was originally developed for long-term safety analyses of nuclear waste disposal. Software modifications will provide better support for intensive numerical computations and manipulation of large multidimensional arrays. These adaptations will result in a robust and flexible tool that can be readily integrated with advanced subsurface flow codes and MVA technologies.

GoldSim has been adapted to a wide range of engineering applications, from water resource management to project management to mission risk analysis. In its present form, the software framework has been successfully used by LANL and the Lawrence Berkeley National Laboratory to develop system-level performance assessment models for CO_2 risk assessments (Figure 1). Although they take a system-level approach, both of these efforts have focused primarily on the technical risks associated with geologic storage, namely, the injection of CO_2 into the subsurface, its potential migration within and escape from the storage reservoir (e.g., via well bores or faults), and, ultimately, its release into the atmosphere, fresh water aquifers, and other accessible environments.

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PARTNERS

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PROJECT DURATION

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

COST

Total Project Value
$1,143,689

DOE/Non-DOE Share
$865,228 / $278,461

PROJECT NUMBER

DE-FE0001164

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U.S. DEPARTMENT OF ENERGY

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 provide a powerful and flexible framework that allows system designers and/or regulators to build comprehensive, system-level risk assessments that incorporate and couple all important aspects of CO_2 capture and geologic storage projects (technical, financial, and programmatic). This goal will improve and demonstrate the need for advancing the efficiency of CO_2 storage operations.

Accomplishments

- GoldSim completed the task of expanding the maximum size of arrays that can be manipulated, allowing the software to more realistically represent subsurface CO_2 migration processes. An additional modification added a macro code capability which allows the program to perform iterative calculations, complex array manipulations, and other highly customized calculations which previously had to be done using an external programming element. A new version of the GoldSim program 10.5 was released having these capabilities.
- In order to help planners compare alternative designs for a sequestration system a scenario analysis capability was added to the software. This capability allows side-by-side comparison of results, including probabilistic results, for multiple alternatives. Design, development, testing and documentation of this feature have been completed. Only the integration of the graphical results remains to be completed.
- A requirements analysis and design document for programmatic risk has been developed. To better support simulation of entire disposal programs GoldSim has completed development of enhanced user controls for project date/time management and the user interface for managing Monte Carlo simulations, categorizing, and charting them. Because disposal projects are complex and there is little experience with them they will likely be controversial, so a new Decision Analysis element is being added to allow multiple stakeholders to evaluate alternative project approaches. The Decision Analysis element (based on Multiattribute utility analysis) is nearing completion and is undergoing preliminary testing.
- Sequestration projects require the capture, storage, transmission and injection of large amounts of CO_2. GoldSim has developed network simulation capabilities to support more realistic simulation of the operation of such systems. Uncertainties about capital and operating costs, injection rates and capacities, potential injection-site failures, and availability and reliability of network equipment can be calculated in order to optimize network design. These new network-simulation capabilities are currently being evaluated by LANL.

Benefits

As carbon capture, storage, and utilization (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.

This technology is likely to benefit a wide range of end users, including project developers, regulators, scientists, insurers, and policy makers. They will use the technology to build comprehensive, system-level risk assessments that realistically incorporate and couple all important aspects of a CO_2 storage system (technical, financial, and programmatic) and could ultimately be used to understand the effectiveness of such systems. Having a single tool that all stakeholders can access, that is of high enough quality that they can actually use it, will improve confidence in risk assessment methodologies and lend greater transparency to CO_2 storage projects.

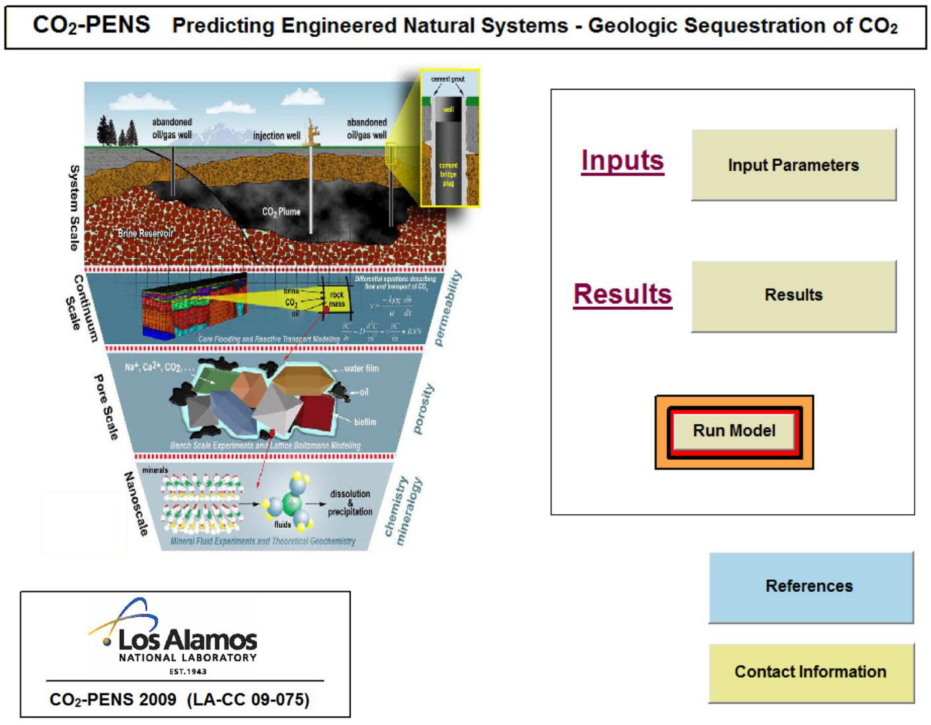

Figure 1 - LANL's CO_2-PENS Model is built on the GoldSim platform.