the ENERGY lab

PROJECT FACTS

Carbon Storage

Comprehensive, Quantitative Risk Assessment of CO_2 Geologic Sequestration

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 four-year project performed by Headwaters Clean Carbon Services LLC and partners is developing an innovative, advanced, process-based risk assessment model to determine quantitative risks and predict impacts associated with CO_2 capture and storage. The model can be applied to field project sites that can be readily integrated with advanced simulation models and MVA technologies. The project uses a Failure Modes and Effects Analysis (FMEA) approach to convert and integrate widely accepted risk assessment approaches into a common framework that allows an in-depth, comprehensive, quantitative risk assessment that can be tailored to assess any CO_2 geologic storage site. FMEA is a proven method of identifying, analyzing, prioritizing, quantifying and mitigating risks. The results are displayed in a spreadsheet format that is easy to understand, improve, expand, or tailor to the needs of a site-specific project.

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 primary project objective is to develop and apply an innovative, advanced, process-based FMEA risk assessment model that can be readily integrated

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PARTNERS

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PROJECT DURATION

Start Date	End Date
10/1/2009	9/30/2013

COST

Total Project Value
$1,879,868

DOE/Non-DOE Share
$1,409,899/$469,969

PROJECT NUMBER

DE-FE0001112

with advanced simulation models and MVA technologies to determine quantitative risks and predict quantitative impacts at CO_2 storage project sites (Figure 1) to help meet NETL's goal of assuring storage permanence of injected CO_2 in the subsurface.

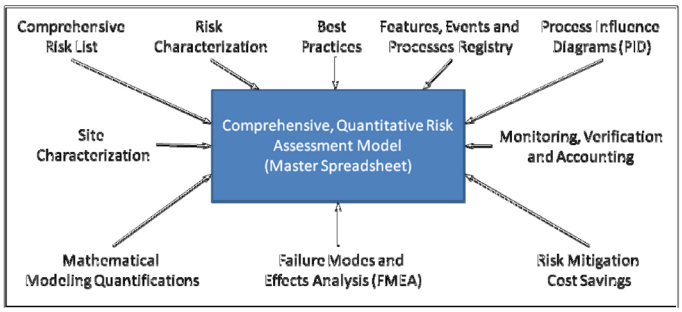

Figure 1 - Risk Assessment Model

Accomplishments

Major accomplishments to date include:

- Developed a comprehensive list of technical and programmatic risks for all aspects of CO_2 geologic storage, including CO_2 capture, pipeline transport, storage in deep saline aquifers (DSA), for use in enhanced oil recovery (EOR) and for use in enhanced coal bed methane (ECBM). These risks have been integrated into a FEPs (features, events and processes) registry, indexed and characterized in a master spreadsheet. The interaction between FEPs have been analyzed and visually displayed in separate process influence diagrams for DSA, EOR and ECBM applications. The process influence diagrams are cross-indexed with the FEPs registry.
- Developed a functioning Failure Modes and Effects Analysis (FMEA) model which is used to identify potential modes of failure, cause(s) of failure, potential failure effects, methods of detecting failure early, and possible steps to prevent or mitigate failure. The FMEA is also used to quantify and prioritize risks based on failure probability, failure severity and difficulty of failure detection. Heuristic information from best practices manuals has been incorporated into the FMEA.
- Accumulated a substantial amount of site-specific information on the SACROC site and is in the process of organizing and inputting it into the FMEA Model. Once this is done, the team will reevaluate the potential failure modes, causes, effects, and detectability and prioritize the risks relative to the probability, severity, and difficulty of detecting failure. The team is looking at what steps have been or can be taken to prevent or mitigate failures and assess the costs and cost savings involved.
- Upgraded an existing process-level model of the SACROC Northern Platform reservoir to quantify the impact of CO_2-EOR operations. The first step was to history match the CO_2-EOR operations from 1972 to 2002. Once a suitable history match is obtained, the project team will try to model several operating scenarios to quantify how much CO_2 can be stored safely and economically and how much oil can be recovered. The process-level model will generate data on reservoir surface pressures and saturation levels which will be inputted into the CO_2-PENS system-level model along with site-specific information on wellbores, faults, primary seals, secondary seals/sinks, and drinking water aquifers (Figure 2). This information will be used to estimate the likelihood and severity of CO_2 leakage and water contamination.

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 expected outcome of this project is the development of a comprehensive, quantitative CO_2 risk assessment tool that can be customized to assess site-specific projects, integrated with other CO_2 storage assessment tools, and be easily modified, improved, or expanded. This tool will be made available to regulators, scientists, engineers, bankers, project developers, operators, insurers, environmentalists, and the general public in a form that can be easily understood and used by all of the different stakeholders. The tool will help to assess CO_2 leakage risks to insure storage permanence in the subsurface.

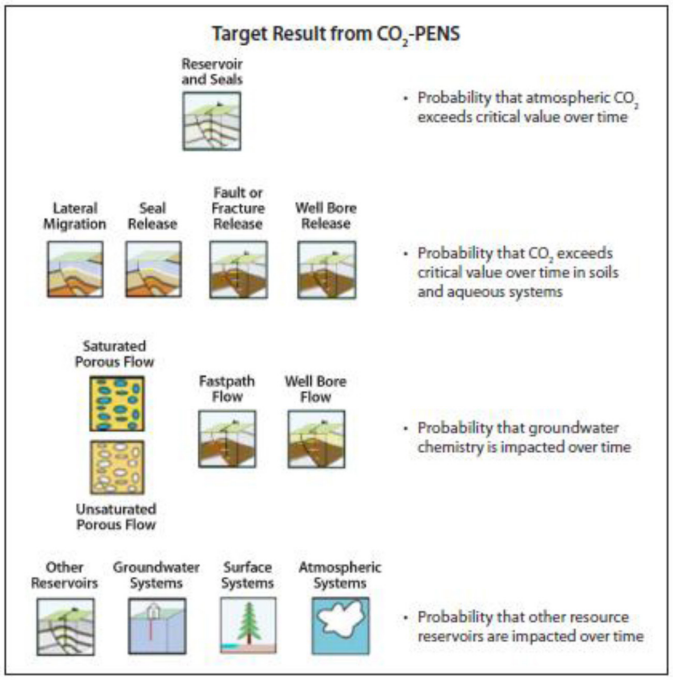

Figure 2 - Example of probabilistic risk assessment from LANL's CO_2-PENS model, which is an important aspect of a comprehensive FMEA risk assessment framework.