the ENERGY lab

PROJECT FACTS

Carbon Storage

Tagging Carbon Dioxide to Enable Quantitative Inventories of Geological Carbon Storage

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 three-year project—performed by faculty and researchers from Columbia University—will develop an injection system for tagging CO_2 with carbon 14 (^{14}C) at an atmospheric level (1 part per trillion) and measuring the radioactivity in collected samples. Such tagging of injected CO_2 will lead to quantitative monitoring of CO_2 and make it possible to accurately inventory geologically stored carbon. The systems will be tested in the laboratory and at the CarbFix demonstration project in Iceland, where CO_2 is injected into a permeable basalt formation at 1,970 feet in depth. Once the technology is proven, adoption of this system will provide a quantitative methodology to verify the amount of CO_2 stored, thereby increasing confidence in 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 zone(s); (3) improving efficiency of storage operations; and (4) developing Best Practices Manuals (BPMs).

The overall goal of this project is to generate a CO_2 accounting and verification technology that helps foster public trust in the safety and permanence of CO_2 storage

CONTACTS

John Litynski
Carbon Storage Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4922
john.litynski@netl.doe.gov

Karen Kluger
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-6667
karen.kluger@netl.doe.gov

Klaus S. Lackner
Principal Investigator
Earth and Environmental Engineering
Columbia University
918 SW Mudd, MC 4711
500 West 120th Street
New York, NY 10027-6902
212-854-0304
kslackner@ei.columbia.edu kl2010@columbia.edu

PARTNER

None

PROJECT DURATION

Start Date	End Date
10/01/2009	12/31/12

COST

Total Project Value
$2,183,480

DOE/Non-DOE Share
$1,711,680 / $471,800

PROJECT NUMBER

DE-FE0001535

U.S. DEPARTMENT OF ENERGY

(Figure 1). A direct method of quantitative accounting is to tag the injected high-flow stream of injected CO_2 with a tracer of ^{14}C at a concentration similar to the natural ^{14}C level in the atmosphere. Because fossil fuels (from which CO_2 is generated through combustion for the purpose of energy production) and geologic formations at depth contain negligible amounts of ^{14}C, this tracer is an extremely sensitive and likely effective, tag for human injected carbon. This goal will help evaluate and demonstrate CO_2 storage permanence. Specific project tasks and objectives toward the overall goal of this project include:

1. Design of the ^{14}C tagging microcartridge injection systems and filling stations for tracer injection: This effort includes designing and fabricating microcartridge systems that can hold either dissolved or pure compressed tracer gas (SF_6 and $^{14}CO_2$). These microcartridges will be designed to inject tracer gases at the 1 part per trillion (ppt) levels. Accompanying filling stations will also be designed and fabricated.

2. Laboratory-scale evaluation of injection systems: Designing and constructing a high-pressure flow system for mixing. At the Lamont-Doherty radioisotope laboratory, test the injection systems, first with SF_6 and later with $^{14}CO_2$, to demonstrate the controlled tracer injection (1 ppt) into water, liquid CO_2, or supercritical CO_2 (flow rate of 1 kg/s).

3. Development of $^{14}CO_2$ detection system: Develop an improved ^{14}C detection system. Current monitoring equipment for ^{14}C activity is designed for other applications, but can be streamlined and improved for project purposes.

4. Field tests of developed $^{14}CO_2$ tagging systems: The CarbFix demonstration project in Iceland offers an excellent opportunity to test the tagging system, with measurements to be verified by conventional ^{14}C detection methods.

5. Hazard and environmental analyses: Perform a life cycle analysis of the full ^{14}C cycle in the proposed MVA protocol, addressing pertinent hazard and environmental concerns in order to ensure the safety of this MVA method.

Accomplishments

- Design of the $^{14}CO_2$ tagging injection (cartridge) system(s) has been completed. The selected design for the tagging injection system is a solution-based tracer injection system using a syringe pump system, accompanied with a filling station; fabrication has been completed.
- Design of the filling station for the injection system has been completed.
- Optimization of the cartridge was completed through the construction and testing of multiple designs.
- The technical approach for the $^{14}CO_2$ detector to measure relative concentrations of ^{14}C has been revised from using a scintillation counter to using a detector based on laser spectroscopy. The prototype design of the proposed system has been determined and fabrication completed; lab testing is in progress.

Benefits

It will be necessary to improve existing monitoring technologies, develop novel systems, and protocols to satisfy regulations to track the fate of subsurface CO_2 and quantify any emissions from reservoirs. The Carbon Storage Program is sponsoring the development of technologies and protocols by 2020 that are broadly applicable in different geologic storage classes and have sufficient accuracy to account for greater than 99 percent of all injected CO_2. If necessary, the tools will support project developers to help quantify emissions from carbon capture, utilization, and storage (CCUS) projects in the unlikely event that CO_2 migrates out of the injection zone. Finally, coupled with our increased understanding of these systems and reservoir models, MVA tools will help in the development of one of DOE's goals to quantify storage capacity within ± 30 percent accuracy.

The development of a quantitative inventory tool using ^{14}C for tagging geologic storage of CO_2 is expected to result in a true inventory of human injected and stored CO_2 in geologic reservoirs. In combination with conventional monitoring technologies, it will significantly improve the overall resolution of monitoring CO_2 storage operations and will contribute to verification of leakage at the surface. If the CO_2 tagging technology is successful, it will provide another tool that can validate that the carbon dioxide has been effectively stored in the geologic formation, thereby helping to increase confidence in geologic storage.

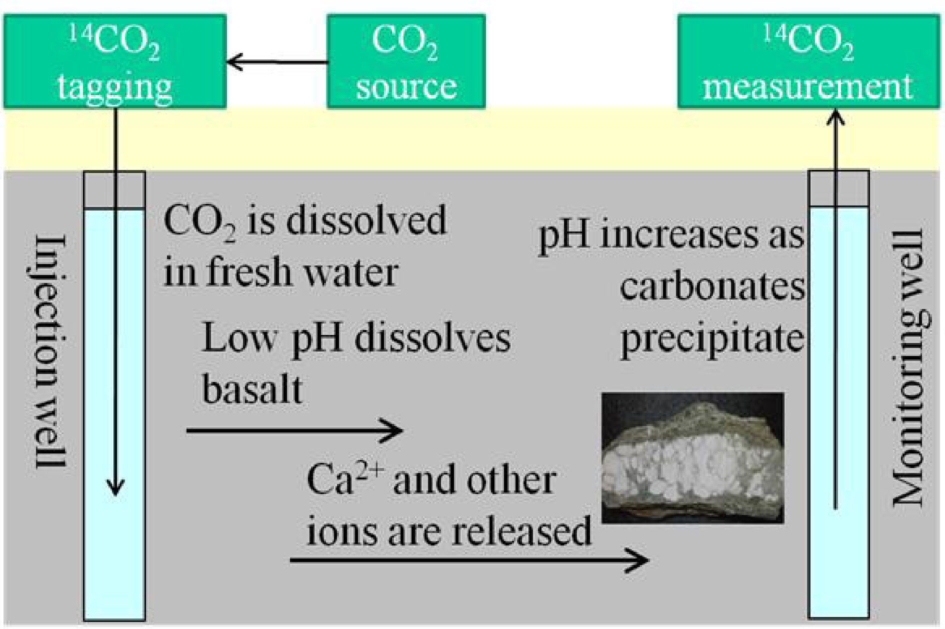

Figure 1 - The diagram illustrates the conceptual model for the CO_2 tagging and storage demonstration site. "Dead" CO_2 is tagged with atmospheric concentrations of $^{14}CO_2$ before mixing with water and underground injection. The low pH dissolves basalt in the rock, which then precipitates out as carbonate. The $^{14}CO_2$ content of samples from the monitoring well is used to determine the extent of incorporation of CO_2 in the carbonate.