the ENERGY lab

PROJECT FACTS

Carbon Storage – MVA

Real-Time In-Situ CO_2 Monitoring ($RICO_2M$) Network for Sensitive Subsurface Areas in CCS

Background

The goal of the Department of Energy's (DOE) Carbon Storage Program is to develop and advance technologies to significantly improve the effectiveness of geologic carbon storage, reduce implementation costs, and prepare for widespread commercial deployment between 2025 and 2035. Research to develop these technologies will ensure safe and permanent storage of carbon dioxide (CO_2) to reduce greenhouse gas (GHG) emissions without adversely affecting energy use or hindering economic growth.

Geologic carbon storage involves securely and permanently injecting CO_2 into onshore and offshore underground formations. Current research and field studies are focused on developing a better understanding of the science and technologies needed for safe and permanent CO_2 storage in onshore and offshore storage reservoirs, which include: clastic formations, carbonate formations, unmineable coal seams, organic-rich shales, and basalt interflow zones. DOE's Storage Program is accomplishing this through: (1) developing technologies that address technical challenges and ensure the cost effectiveness of carbon storage, (2) validating technologies that ensure safe and permanent carbon storage, and (3) facilitating public, industry, and international community awareness of research and development (R&D) efforts underway related to carbon storage. These technologies will facilitate future CO_2 management for coal-based electric power generating facilities and other industrial CO_2 emitters by enabling the safe, cost-effective, permanent geologic storage and utilization of CO_2 in all storage types.

The Carbon Storage program is comprised of three primary technology areas (1) Core Storage R&D, (2) Storage Infrastructure, and (3) Strategic Program Support. These three areas work together to address significant technical challenges in order to meet program goals that support the scale-up and widespread deployment of carbon capture and storage (CCS). Within these technology areas, emerging technologies are supported through applied laboratory- and pilot-scale research. In addition, promising technology options are being validated through small- and large-scale field projects. This approach allows technologies to develop from concept through validation in the field and increases the Nation's confidence in future safe, effective, and permanent geologic CO_2 storage. The Core Storage R&D technology area is sub-divided into three research areas: (1) Geologic Storage Technologies and Simulation and Risk Assessment (GSRA); (2) Monitoring, Verification, Accounting (MVA), and Assessment; and (3) Carbon Use and Reuse. This project is part of the MVA research area, which is designed to confirm permanent onshore and offshore CO_2 storage in geologic formations through monitoring capabilities that are reliable and cost effective. Monitoring is an important aspect of CO_2 injection, because it focuses on a number of

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PROJECT DURATION

Start Date	End Date
10/01/2013	09/30/2016

COST

Total Project Value
$1,500,392

DOE/Non-DOE Share
$1,199,523 / $300,869

AWARD NUMBER

DE-FE0012706

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permanence issues. Monitoring technologies are being developed for atmospheric, near-surface, and onshore and offshore subsurface applications to ensure that injection, abandoned, and monitoring wells are structurally sound and that CO_2 will remain within the storage complex. This project, led by Intelligent Optical Systems, Inc is developing a multi-parameter monitoring system capable of covering large areas for detection of low levels of CO_2 in sensitive areas, particularly in groundwater.

Project Description

Intelligent Optical Systems (IOS) seeks to develop a real-time CO_2 detection system that will include fully distributed fiber optic sensors. The system will combine novel fiber-optic distributed sensors for detecting pH, salinity, and CO_2 with commercially available fiber optic sensors for monitoring temperature (Figure 1). The focus of this project is to produce and validate in the field a multi-parameter unit incorporating fiber-optic CO_2 sensor previously developed by IOS with the pH and salinity fibers being developed by this research effort.

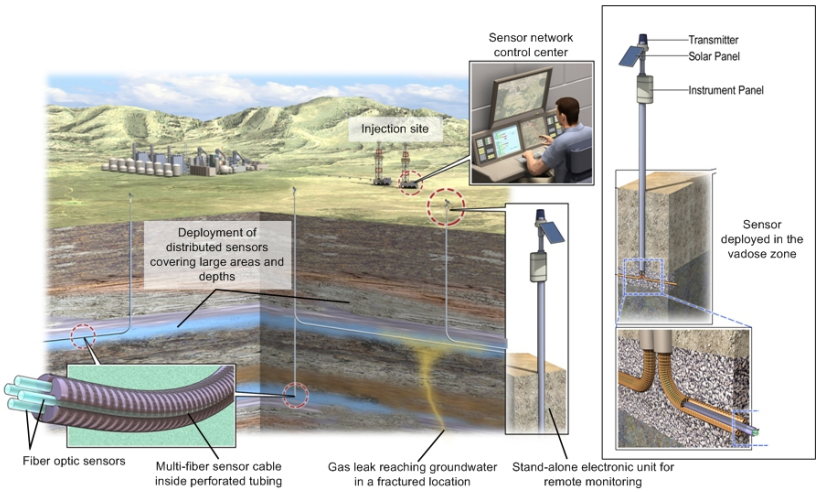

Figure 1. (Left) Depiction of the multi-parameter system incorporating CO_2, pH, salinity, temperature sensors, and $RICO_2M$ Net deployed in a highly fractured area within sources of drinking water; and (Right) depiction of the distributed sensor deployed in the vadose zone.

The entire length of the optical fiber will be capable of sensing, allowing for monitoring over large areas and in wellbores to thousands of feet in depth. The resulting multi-parameter system will monitor CO_2 at low levels in multiple aqueous matrixes under wide temperature and pressure ranges. The extended structure of this fully distributed sensor system (CO_2 can be detected over multiple points within the subsurface) ensures that a slow CO_2 release can be detected before a significant release occurs (Figure 2). This is an improved approach over a single point sensor that may not be in a location to detect the initial release and might not detect the leak until significant diffusion has occurred. The timely detection of chemical changes produced by CO_2 solubilization in aquifers can yield information about the gas migration path and can also be an early-warning alarm to start remediation, especially if potable water is affected.

Objectives

Design, build, and validate—in a large-scale field test—a cost-effective Intelligent Real-time In-situ Network ($RICO_2M$ Net) to monitor geochemical parameters for highly sensitive and accurate detection of CO_2 in groundwater as part of carbon storage efforts. The system will be capable of covering large areas and detecting small changes from background concentrations in the subsurface. The two phases and specific objectives are the following:

- PHASE I: Develop a multi-parameter system for highly sensitive and accurate detection of CO_2 in groundwater.
  - Manufacture long (hundreds of meters) fiber optic sensors for monitoring pH in groundwater (measurement range from pH 4 to 10, with 0.1 pH precision).
  - Demonstrate and fabricate fiber optic sensor prototypes for salinity monitoring (measurement range from 0 to 10,000 mg/L sodium chloride).

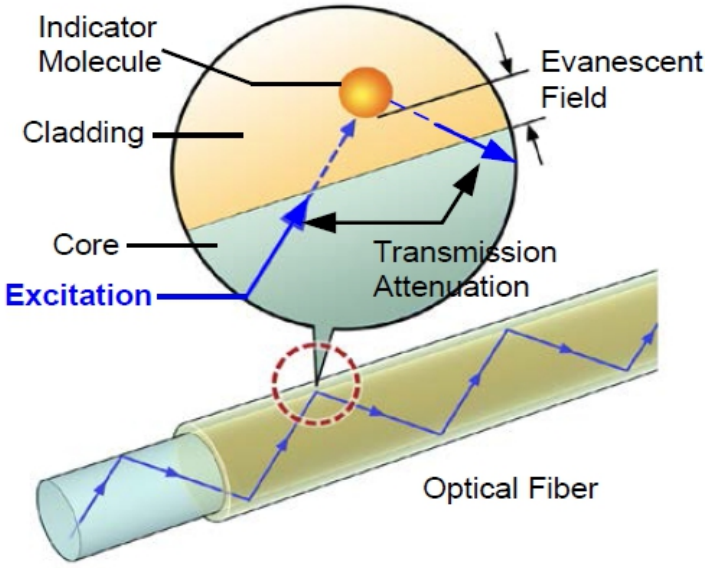

Figure 2. Fiber structure of colorimetric distributed fiber optic sensors

- Assemble a system incorporating fiber optic distributed or quasi-distributed sensors for monitoring dissolved CO_2, pH, total inorganic carbon, salinity, and temperature.
- Demonstrate CO_2 measurements in the laboratory (for drinking water and complex aqueous matrices) with high accuracy at low CO_2 concentrations (limit of detection of 0.1 mg/L of dissolved CO_2 or better, precision of 0.1 mg/L or better, and accuracy of 0.3. mg/L or better).

- PHASE II: Perform large-scale deployment of RICO$_2$M Net for highly sensitive and accurate detection of CO_2 in groundwater.
  - Design and fabricate monitoring network.
  - Deploy the multi-parameter system and perform continuous monitoring of geochemical parameters.
  - Demonstrate results from the novel multi-parameter system comparable to those of established monitoring techniques.

Accomplishments

- The project team has developed a novel distributed fiber optic sensor for the collection of pH data in the shallow subsurface. The distributed pH sensors have been validated and optimized in a simulated laboratory environment, and the sensitivity requirements for the instrument are sufficient for field deployment for further validation testing.
- The project team has completed preliminary development of a fiber optic sensor for salinity monitoring. Further validation testing in a laboratory environment is required for this instrument.
- The detailed design of the multi-parameter monitoring system has been conducted, including the development of sensor cables and electronic controller units, and fabrication of the optical and electronic modules has been initiated.

Benefits

The project is making a vital contribution to the scientific, technical, and institutional knowledge base needed to establish frameworks for the development of commercial-scale CCS. As a direct method of CO_2 detection combined with pH, salinity, temperature, and pressure monitoring, the IOS cable-based distributed sensor system will have characteristics that make it unique as a means of verifying storage permanence. The timely detection of chemical changes produced by CO_2 solubilization in aquifers can yield information about the gas migration path and also be an early-warning alarm to start remediation, especially if potable water is affected. Cost-effective and continuous protection of water resources will be critical in generating the level of confidence needed for public acceptance of carbon storage technology.