the ENERGY lab

PROJECT FACTS

Carbon Storage – MVA

# In-Situ MVA of $CO_2$ Sequestration Using Smart Field Technology

## 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 $CO_2$.

The new technology is based on the concept of "smart fields," which is rapidly gaining support and popularity in the oil and gas industry. Smart fields integrate digital information technology with the latest monitoring techniques to provide continuous knowledge and control of reservoir operations and processes. Under this concept, hundreds of millions of dollars have been invested to successfully develop highly sensitive PDGs that are capable of operating in harsh environments for long periods. The PDGs collect and transmit high-frequency data streams in real time to remote control centers to be analyzed and used for reservoir management.

The project team will use the pattern recognition power of state-of-the-art Artificial Intelligence and Data Mining (AI&DM) technology to develop a methodology, residing in a computer program, to recognize patterns from simulated realistic pressure data acquired from PDGs located within the reservoir model (Figure 1). This software will be capable of, but not limited to, locating point sources within a reservoir from which $CO_2$ is leaking based on changes in pressure data. The methodology will autonomously cleanse and summarize raw data collected from in-situ pressure gauges, to prepare the data for processing and analysis. Upon completion, the methodology will be validated by its ability to accurately identify the location of simulated leakage points in a model of an existing heterogeneous reservoir. Once the approximate location of potential $CO_2$ leakage is identified, the information will be communicated via e-mails, text messages, or other means to those performing "at" or "near" surface monitoring locations for more precise detection and analysis.

The main objective of this project is to develop the next generation of intelligent software that is able to take maximum advantage of the data collected by PDGs to continuously and autonomously monitor and verify $CO_2$ storage in geologic formations as part of the effort to assure $CO_2$ storage permanence in the subsurface. Further, the project team will investigate the feasibility of using this technology to monitor the growth and advancement of the $CO_2$ plume during the injection process.

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## PARTNERS

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## PROJECT DURATION

| **Start Date** | **End Date** |
|---|---|
| 10/01/2009 | 09/30/2013 |

## COST

**Total Project Value**
$1,681,125

**DOE/Non-DOE Share**
$1,344,617 / $336,508

## PROJECT NUMBER

DE-FE0001163



U.S. DEPARTMENT OF ENERGY

## Accomplishments

To date, researchers have selected two sites (one in Mattoon, Illinois and a second in Citronelle, Alabama) to be used as models in the development of the software. The following provides summaries of the accomplishments to date for each site:

- **Mattoon, IL Site**

– Surrogate Reservoir Models (SRM) were constructed and datasets were generated. The SRMs were built with the purpose of pressure and water saturation prediction with a reasonable accuracy as well as to predict the $CO_2$ mole fraction in the reservoir.

– The dataset was divided into two sets due to the pressure and rate turbulence at the beginning. The first data set was generated in the time interval of the first to the seventh month while the time scale for the second dataset was the first to the seventh year. The first to seventh month dataset results showed a maximum error of ~6.5% for the water saturation and pressure. The first to seventh year dataset results showed a maximum error of ~3.4% for the water saturation and ~3.8 % error for the pressure case.

- **Citronelle, AL Site**

– Heterogeneous porosity and permeability maps were generated for the model using values interpreted from resistivity and induction logs. Two different porosity values were interpreted based on true resistivity and induction logs for 51 simulation layers in 48 wells. Nine different models were built based on multiple geological realizations obtained from the two different porosity distribution and four porosity-permeability correlations.

– Simulations were performed in order to generate data streams from the flow model. This was done by modeling an array of slim holes in the reservoir where Permanent Downhole Pressure Gauges (PDPG) might be installed. Then simulated carbon dioxide leakage data recoded during the simulation runs were collected. A method was developed for distorting the data from the pressure readings to emulate background noise inherent to field measurements using techniques such as including random pressure spikes and adding random white noise. Data cleansing routines were incorporated as a data pre-processing step for the high resolution data. These routines had the ability to remove outliers and reduce white noise using mathematical techniques such as moving average.

– A study on leakage modeling and simulating in the reservoir was performed. A Leakage Detection System (LDS) was developed using pressure data received in high frequency streams from simulated Permanent Down-hole Gauges (PDG). A set of simulation runs were completed that provided simulated pressure behavior in the observations wells with respect to leakage rates and locations.

## 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.

Successful performance of this project will improve the understanding of factors affecting $CO_2$ storage permenence and capacity, and increase confidence that $CO_2$ placed in geologic formations is accurately tracked and that any leakage is detected and quickly treated. Results of the project are expected to be broadly applicable to a variety of geologic storage technologies and projects seeking to model potential $CO_2$ leakage from geologic formations.

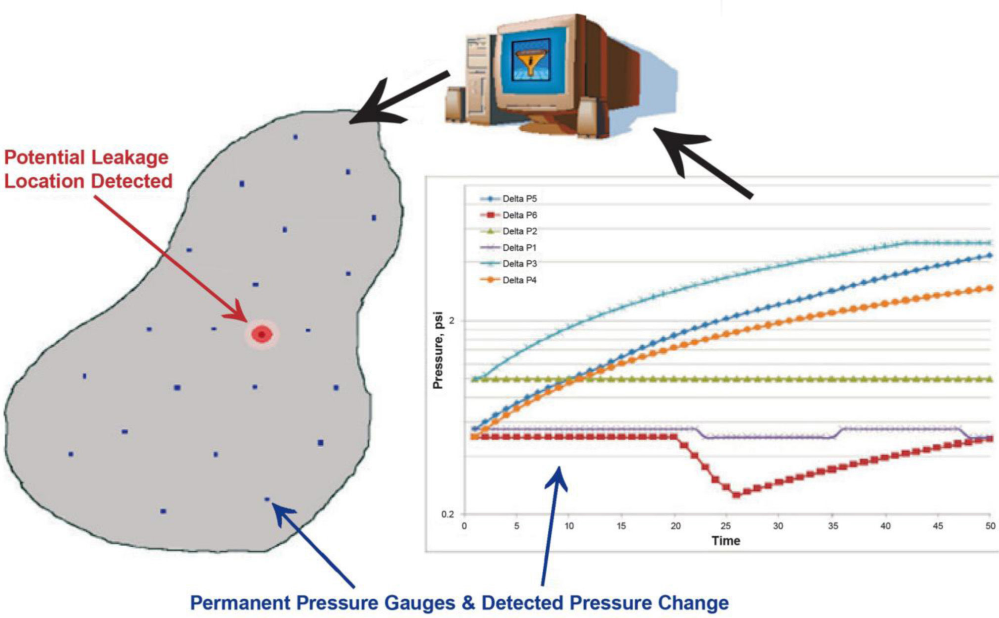


*Figure 1: By performing intelligent pattern recognition on pressure changes as a function of time, the new technology will be able to approximate the location and amount of $CO_2$ leakage in a geologic storage project. In the above plot (right), the changes in pressure (Δp) that have been detected by different PDGs are shown in different colors. The new technology will analyze and interpret these changes in real time and provide an approximate location of the potential leakages as shown on the left.*