# Deep Controlled Source Electro-Magnetic Sensing: A Cost Effective, Long-Term Tool for Sequestration Monitoring

**Award Number: DE-FE0012266**

## Project Summary:

The goal of this project was to develop and test a robust sensor array for long-term monitoring of carbon dioxide ($CO_2$) inventories in deep geologic formations using a controlled source electromagnetic method (CSEM) to measure the electrical properties of $CO_2$ reservoirs. The method was designed to provide cost-effective, permanent, autonomous data collection assuring a much higher temporal data density than can be achieved with other methods. The system used a borehole-based vertical-electric-dipole source placed at reservoir depths in the formation. The signals were received on the surface using an array of stations each capable of measuring electric and magnetic fields.

**Prime Performer:**
*Multi Phase Technologies, LLC*

**Principal Investigator:**
*Dr. Doug LaBrecque*

**Project Duration:**
*10/1/2013 – 12/31/2016*

**Performer Location:**
*Sparks, Nevada*

**Field Sites:**
*Ketzin Storage Pilot Site, Germany*

**Program:**
*Carbon Transport & Storage*

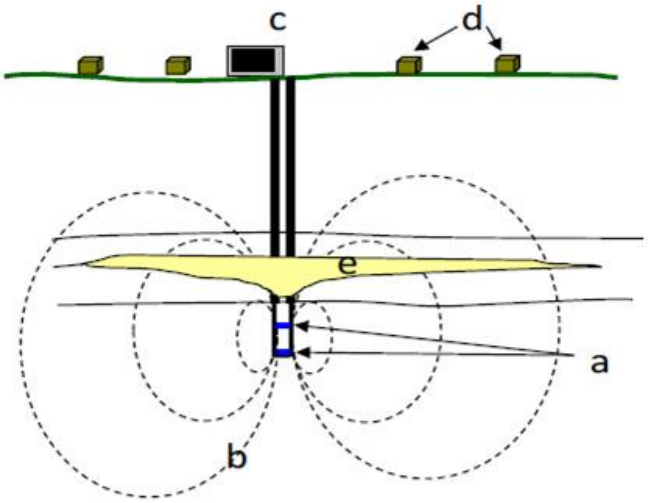


**Figure 1. Overview of the proposed CSEM configuration showing (a) the borehole electrodes; (b) electric field/ current flow lines; (c) transmitter/current source; (d) mobile surface electric and magnetic field receivers; and (e) the $CO_2$ reservoir.**

## Project Outcomes:

This project developed and field-tested a new sensor array for long-term CSEM monitoring application (Figure 1). The field set-up at the Ketzin site focused on the high-density surface array to minimize the effects of nearby gas pipelines. However, the pipelines along with the high traffic in the area, nearby electric railway, and wind and/or solar farms all had an effect on the signal-to-noise ratio. Overall, the research showed an increase in resistivity of the $CO_2$ plume from the Phase II field campaign to the Phase III field campaign. This appeared to be counterintuitive to the brine solution injection between the field tests because the brine solution should have created a decrease in resistivity of the $CO_2$ plume surrounding the injection well. Additional modeling and analysis provided the same conclusion that there is an increase in resistivity between the Phase II and Phase III data. However, both the CSEM and cross borehole electrical resistance tomography showed intermittent decreases in resistivity along the borehole, which may indicate the injection of the brine solution in the reservoir. Further research is needed to resolve signal-to-noise issues and to validate results obtained by the field testing.

## Presentations, Papers, and Publications

**Final Report:** Deep Controlled Source Electro-Magnetic Sensing: A Cost Effective, Long-Term Tool for Sequestration Monitoring (May 2015) Douglas LaBrecque, Russel D. Brigham, Conny Schmidt-Hattenburger, Evan Um, Peter Petrov, Thomas Daley