the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Lawrence Livermore National Laboratory – Advancing the State of Geologic Sequestration Technologies towards Commercialization

Background

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) is helping to develop carbon capture and storage (CCS) technologies to capture, separate, and store carbon dioxide (CO_2) in order to reduce green-house gas emissions without adversely influencing energy use or hindering economic growth. Carbon sequestration technologies capture and store CO_2 by injecting and permanently storing it in underground geologic formations.

NETL is working to advance geologic carbon sequestration technology by funding research projects that aim to accelerate deployment and remove barriers to commercial-scale carbon sequestration. Lawrence Livermore National Laboratory (LLNL), one of DOE's national laboratories for science and engineering research, is working in conjunction with several other national laboratories, industry partners, and universities on a series of individual tasks aimed at advancing the state-of-the-science of geologic sequestration by conducting research studies on key topics critical to the success of geologic sequestration. Research areas include sequestration monitoring for risk assessment, brine production and beneficial use, pathways through natural systems, groundwater impacts, collaboration with international CCS efforts, and systems modeling for risk assessment.

LLNL and its partners will perform collaborative and coordinated research to enhance the nation's capabilities for science-based risk assessment for geologic carbon sequestration. This project combines fundamental geological sequestration research and commercial-scale international programs with risk and hazard management projects to address key issues affecting commercial-scale carbon storage.

Project Description

Lawrence Livermore National Laboratory is working to advance the existing state of geological sequestration technologies by collaborating with several other national laboratories, industrial partners, and universities to complete a series of five distinct

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PARTNERS

British Petroleum
Lawrence Berkeley National Laboratory
Los Alamos National Laboratory
Pacific Northwest National Laboratory
Sonatrach
Statoil Hydro
West Virginia University

PROJECT DURATION

Start Date	End Date
10/01/2009	09/30/2011

COST

Total Project Value
$6,900,000

DOE/Non-DOE Share
$5,900,000 / $1,000,000

and unique tasks. Each task is focused on advancing a critical component needed for successful geologic storage of CO_2. A detailed description of each task is listed below:

- **National Risk Assessment Program Collaboration Research:** LLNL is working with NETL, Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), and Pacific Northwest National Laboratory (PNNL) to perform collaborative and coordinated research to enhance the nation's capabilities for science-based risk assessment for geologic carbon sequestration. Research tasks are focused on monitoring for risk assessment, well integrity, pathways through natural systems, groundwater impacts, and systems modeling for risk assessment. Ensuring that geologic CO_2 storage is safe and effective will require site-specific quantitative risk assessment, which combines performance assessment of a storage site (i.e., prediction of the fate and impact of the stored CO_2) with an assessment of potential consequences of concern (e.g., environmental, health, economic).

- **Fresh Water Generation from Storage Formation Pressured Carbon Storage:** The Fresh Water Generation task establishes the potential for using brine pressurized by CCS injection operations in saline formations as the feedstock for desalination and water treatment technologies, including nanofiltration and reverse osmosis. This method uses the energy required to inject CO_2 into the subsurface to provide all or part of the inlet pressure for the desalination system. This process improves sequestration by providing additional storage space (capacity) in the reservoir, as well as providing low-cost fresh water to offset costs or operational water needs. It also reduces operational risks by relieving long-term pressure growth in the formation.

- **Injection and Reservoir Hazard Management - The Role of Injection-Induced Mechanical Deformation and Geochemical Alteration at In Salah CO_2 Storage Project:** The In Salah project provides an opportunity to study key physical and chemical processes in operational deployment of geological carbon sequestration from natural gas production in eight fields in the Algerian Central Sahara. In Salah has been successful at minimizing the associated environmental footprint by capturing and storing excess CO_2 extracted from natural gas production streams. The objectives of the research are to study two components relevant to storage effectiveness and operational success at In Salah: (1) reactive chemistry of the brine-CO_2-reservoir-caprock-wellbore system, and (2) the geomechanical effects of large-scale injection on crustal deformation and fault leakage hazards. Results from this work will enhance predictive capability of field performance, provide a new basis for interpretation of geophysical monitoring at In Salah, and provide additional information relevant to the creation of geological sequestration standards.

- **Carbon Sequestration Support to Collaborative Efforts in China:** LLNL will work in collaboration with NETL and West Virginia University to provide technical support for a potential CCS project for Shenhua Direct Coal Liquefaction (DLC). The work includes assessment and identification of CCS potential within the Ordos Basin, an estimate of the fate of stored CO_2 using reactive transport simulators and geologic models based on available literature, and consideration of monitoring and verification needs and potential technologies. LLNL will also contribute to topical reports requested by DOE and Shenhua DLC.

- **Snøhvit CO_2 Storage Project - Understanding the role of injection-induced mechanical deformation and directed sea-floor monitoring:** The Snøhvit project is the first petroleum production plant to be located in the Barents Sea. At the onshore liquefied natural gas plant, CO_2 is separated from the production stream to make the product suitable for compression and export. Separated CO_2 is then sequestered below Snøhvit at rates up to 700,000 tons of CO_2 per year. Large-scale commercial CO_2 injections face several new technical challenges in development and operations, including pressure build-up caused by the large-volume CO_2 injection and associated stress issues. This stress can lead to potential leakage pathways. Another issue is the operational challenge of monitoring the sea-floor. Many common surface detection methods for detecting CO_2 fluxes will not work in the deep sea environment or be deployed easily and economically. This creates challenges for the appropriate stewardship and environmental protection of large projects as required by important stakeholders and international maritime agreements. LLNL will study two components relevant to storage effectiveness and operational success: (1) the geomechanical effects of injection on rock deformation and fault leakage hazards, and (2) guidance on developing a monitoring program focused on possible migration of CO_2 and brines to the seafloor. Results from this work will enhance the predictive capability of field performance models, provide a new basis for interpretation of geophysical and operational data at Snøhvit, and provide support for the creation of appropriate regulations and monitoring schemes for sub-sea geological storage of CO_2.

The overall focus of the LLNL research is to insure that geologic CO_2 storage is safe, effective, and will be a commercially viable solution to reduce greenhouse gas emissions. This requires site specific studies which combine performance

assessment of a storage site with an assessment of potential consequences of concern (e.g., environmental, health, economic). DOE's Carbon Sequestration Program involves components ranging from applied laboratory research through pilot scale (the Core R&D Program) to Demonstration and Deployment (e.g., the Regional Carbon Sequestration Partnerships, international engagement, and other commercial opportunities). For geologic sequestration technology to be cost effective and commercially viable, risk assessment methodologies must be developed, tested, and validated.

Goals/Objectives

The project goal is to gain knowledge of key technologies and processes critical to geologic sequestration of CO_2 through field investigations and supporting experimental and simulation studies at existing sequestration projects.

Project objectives are:

- Reduce the risk of large scale demonstration projects
- Improve scientific exploration and strengthen a working relationship in CCS between China and the U.S
- Investigate project risk assessment and treatment systems for produced formation water
- Investigate monitoring tools for effective sub-sea geologic storage projects
- Explore CO_2 plume formation, migration, and geomechanical responses
- Participate in international carbon capture sequestration projects

Benefits

The expected project impacts and benefits are to provide fundamental research and application technologies leading to commercial-scale deployment and to make contributions to and gain insight from international CCS efforts. This research addresses specific technical issues raised during ongoing field projects; leverages and coordinates experiences, resources, and capabilities of the national laboratories as applied to CCS; and reduce the overall risk of large demonstration projects. Most importantly, the work provides a scientific basis for both understanding important scientific concepts critical to the success of CCS and risk assessments for demonstration projects leading toward commercial-scale deployment.

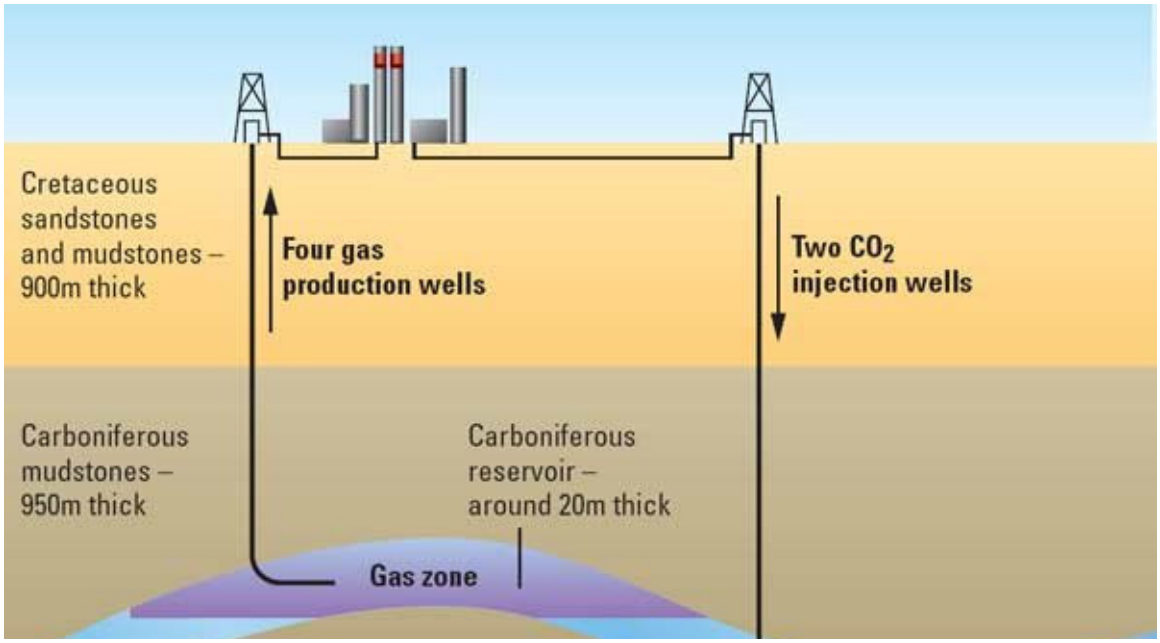

Figure 1: Schematic of operations at the In Salah CO_2 Storage Project, Algeria. Natural gas is extracted from a gas zone formation and CO_2 is separated. The separated CO_2 is then injected into the water leg of the carboniferous reservoir. Image from www.insalahco2.com

Figure 2: The liquefied natural gas plant at Melkøya, Norway (pictured) captures carbon dioxide from the production stream in sub-sea wells in the Barents Sea. CO_2 is separated and transported through a dedicated pipeline back to the sub-sea reservoir as part of the Snøhvit Project.