


International Collaboration on Large Scale Saline Injection

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June 2016

U.S. DEPARTMENT OF ENERGY | Fossil Energy

Background

- 2013 CSLF Ministerial Meeting charged Policy Group to "identify and prioritize a focused set of collaborative actions where the CSLF could add the greatest near-term value"
- CSLF well-positioned to facilitate discussions on global collaboration efforts for large-scale CCS projects, whether as new green field projects or adding additional functionality and value to existing or planned commercial projects
- CSLF Policy Group in June 2015 approved initiative to coordinate development of CCS projects dedicated to testing large-scale CO_2 storage in saline formations
- Important factor was focus of most ongoing large-scale CCS projects on use of captured CO_2 for EOR
- Storing CO_2 in deep saline formations may ultimately be most important CCS option for achieving major CO_2 emissions mitigation

Initiative Timing

Initial scope of effort was divided into two phases:

- Phase I developed preliminary list of candidate projects evaluated against initial selection criteria, which was discussed at October 2014 Policy Group Meeting
- Phase II focused on the development of:
  - Further information (e.g. geology, CO_2 supply, governance structures, potential CSLF member support) on a limited group of projects identified by the Policy Group
  - Project selection recommendations were presented at June 2015 Policy Group Meeting
  - Initiated "Large-Scale Saline Storage Project Network" at end of 2015, following approval at November 2015 CSLF Ministerial

Large-Scale Saline Storage Project Network

- Announced at 2015 CSLF Ministerial Meeting in Riyadh, Saudi Arabia
- Builds on success of "CO_2 Capture Test Center Network"
- This Network serves two purposes:
  1. Facilitate collaborative testing of advanced technologies at large-scale saline storage sites
  2. Form global network of large-scale injection sites to share best practices, operational experience, and key learnings

Large-Scale Saline Storage Project Network

- As first step, US Department of Energy (DOE) collaborated to identify opportunities to field test advanced technologies at Shell's Quest CCS Project in Alberta, Canada.
- DOE and Shell are collaborating in field tests to validate advanced monitoring, verification, and accounting (MVA) technologies for underground storage of CO_2
- DOE and Shell will test novel fiber optic sensors and improved monitoring devices that can lower operating costs to measure and verify integrity of CO_2 storage sites
- Collaboration provides model for future efforts

New Phase III Initiative Timing

- Large-scale carbon storage projects in saline formations, such as the Shell Quest Project, are critically important in global, commercial deployment of CCS
- CSLF can help facilitate real-world testing of promising technologies, such as MVA technologies, as projects stand up and technologies continue to develop.
- As more large-scale saline storage projects are developed and deployed throughout the world, they are encouraged to join and participate in this network.
- Phase III will focus on identifying more potential projects to add to the Large-Scale Saline Storage Project Network, by developing a preliminary list of candidate projects and collaborative topics for discussion at June 2016 Policy Group Meeting.

Project Selection Criteria

To determine the best initial candidates, Large-Scale Integrated Projects (LSIP) data base published by the Global CCS Institute (GCCSI) was screened to identify projects:

- That can achieve low-cost capture of sizeable amounts of CO_2 in a relatively near-term timeframe
- With varied geology that could accommodate different country interests
- Where project management and operators are amenable to discussing hosting an international consortium at the site and development of a governance structure

Applying the Selection Criteria

- Two most restrictive criteria are amount of CO_2 captured and near-term timeframe, and the following projects most closely adhere to criteria and are in “operate” or “execute” project lifecycle stage

Project Lifecycle Stage	Project Name	State / District	Country	Volume CO_2 (mtpa)	Operation Date	Capture Type
Operate	Sleipner CO_2 Storage Project	North Sea	Norway	0.9	1996	Pre-combustion capture (natural gas processing)
Operate	Snøhvit CO_2 Storage Project	Barents Sea	Norway	0.7	2008	Pre-combustion capture (natural gas processing)
Operate	Quest	Alberta	Canada	1.08	2015	Industrial Separation
Execute	Illinois Industrial Carbon Capture and Storage Project	Illinois	United States	1.0	2016	Industrial Separation
Execute	Gorgon Carbon Dioxide Injection Project	Western Australia	Australia	3.4-4.0	2017 (GCCSI estimate)	Pre-combustion capture (natural gas processing)

Applying the Selection Criteria

- The following projects most closely adhere to criteria and are in the "define," "identify," "evaluate," or "injection suspended" project lifecycle stage

Project Lifecycle Stage	Project Name	State / District	Country	Volume CO_2 (mtpa)	Operation Date	Capture Type
Define	Rotterdam Opslag en Afvang Demonstratieproject (ROAD)	North Sea	Netherlands	1.1	2019-2020	Post-combustion capture (power generation)
Identify	China Resources Power (Haifeng) Integrated Carbon Capture and Sequestration Demonstration Project	South China Sea	China	1.0	2019	Pre-combustion capture (power generation)
Evaluate	Don Valley Power Project	North Sea	United Kingdom	1.5	2020	Pre-combustion capture (gasification)
Evaluate	Korea-CCS 1	Offshore Korea	South Korea	1.0	2020	Post-combustion capture (power generation)
Evaluate	Caledonia Clean Energy Project	North Sea	United Kingdom	3.8	2022	Pre-combustion capture (gasification)
Evaluate	Korea-CCS 2	Offshore Korea	South Korea	1.0	2023	Under evaluation (power generation)
Evaluate	South West Hub	Western Australia	Australia	2.5	2025	Industrial Separation (fertiliser production)
Evaluate	CarbonNet Project	Victoria	Australia	1.0 - 5.0	2020's	Under evaluation
Evaluate	Teesside Collective Project	North Sea	United Kingdom	2.8	2020's	Various
Operate	In Salah CO_2 Storage	Krechba	Algeria	0.0 (injection suspended)	2004	Pre-combustion capture (natural gas processing)

Applying the Selection Criteria

- The following are examples of projects that do not adhere to large-scale criteria, yet can be considered important smaller-scale projects

Project Lifecycle Stage	Project Name	State / District	Country	Volume CO_2 (mtpa)	Operation Date	Capture Type
Operate	Aquistore	Saskatchewan	Canada	35,000 Total Tonnes (as of Jan 2016)	2014	Post-combustion capture (power generation)
Operate	Tomakomai CCS Demonstration Project	Hokkaido	Japan	0.1	2016	Hydrogen production unit

Examples of Current Ongoing R&D Collaboration: Quest Project

The Quest project has provided a number of additional research topics related to MVA technologies that can be tested at their CO_2 injection site:

- Laser-based atmospheric detection of CO_2 covering large areas, including development of both improved laser technology and software
- Radar remote sensing (Quest has collected nearly two years of calibration data)
- Stable isotope analysis to address containment and conformance monitoring at a CCS site. A number of laboratory experiments and modeling work have already been conducted.

DOE/NETL has evaluated and discussed with Quest other potential cooperative areas, including:

- Near-surface leakage MVA activities using a field-ready ^{14}C isotopic analyzer
- Compact eye-safe scanning differential adsorption LIDAR (DIAL) for spatial mapping of CO_2
- Surface and airborne monitoring technology using low cost infra-red gas analyzers
- Deep controlled source electromagnetic sensing for CO_2 plume detection and leakage based on CSEM (Controlled Source Electromagnetic Method)
- Greenhouse gas laser imaging tomography
- Real-time in-situ CO_2 monitoring (RICO2M) network for sensitive subsurface areas at storage sites
- Pressure-based inversion, data assimilation system (PIDAS) for CO_2 leakage detection
- Scalable, automated, semi-permanent seismic method to detect CO_2 plume extent during injection

Examples of Potential R&D Collaboration: Illinois Industrial CCS Project

ADM is the overall project leader, and has provided a number of research ideas that can be tested at their CO_2 injection site:

- Advances in CO_2 plume modeling, to include:
  - Improvements in surface seismic data processing that provides enhanced imaging for thin layer (pancake) plume distribution.
  - Improvements in geomechanical modeling that integrate passive seismic monitoring with pressure front and extent of plume monitoring.
  - Development of acoustic source and receiver systems (i.e., sonar) that can be used for monitoring real time changes in the site's acoustic signature.
  - Improvements in seismic monitoring approaches and technologies that allows real time seismic monitoring with enough sensitivity to pick up both P and S waves.
- Advances in reservoir monitoring, long-term CO_2 storage site monitoring and modeling approaches and technologies, especially those that can reduce the cost and time frame for storage site operational and post-operational reservoir monitoring.

Decatur Site Overview

VW#2

GM#2

CCS#2

VW1 (DAS) or receivers integrated with a new well completion.

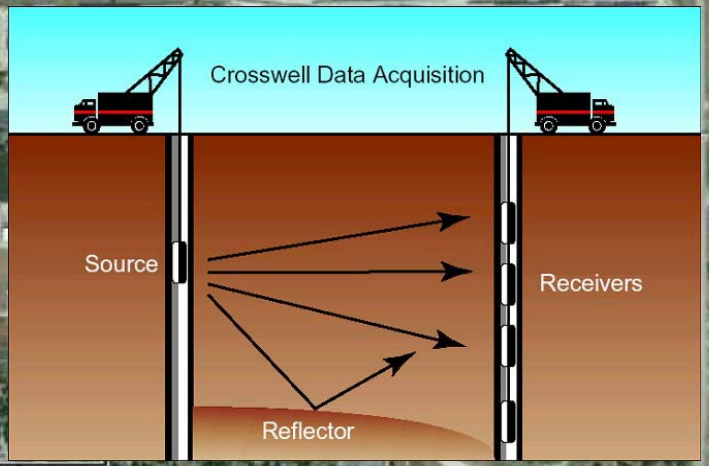
GM1 existing 30 level geophone array.

Deploy piezo electric or other type of source in CCS#1 using an automated winch and source control system.

Program the system to generate seismic sweeps at preselected depths.

Use VW1 and GM1 for cross well CASSM.

Monitoring changes in CCS#1 plume and the development of the CCS#2 plume.



CO_2 Storage Data Sharing Consortium

- To facilitate this effort, Norway-US Bilateral Storage Working Group is proposing to establish International CO_2 Storage Data Sharing Consortium.
- Main objective: To promote sharing of reference datasets from pioneering CO_2 storage projects in order to accelerate improved understanding, build capacity, reduce costs and uncertainty of CO_2 storage.
- General terms: Limited reference datasets will be offered by projects on a case-by-case basis to the worldwide research community, under terms set out in non-disclosure agreements (NDAs) principally aimed at ensuring the datasets are properly understood and acknowledged. Studies arising from use of the datasets must be checked with the data owners prior to publication and the source of the data should be appropriately acknowledged.

Next Steps

A decision by Policy Group is needed as to:

- Whether to proceed with actively seeking partners for the Illinois Industrial CCS projects as part of the Large-Scale Saline Storage Project Network (Network)
- How to handle potential additional candidate sites to be proposed to the Network, such as projects in the “define,” “evaluate,” or “identify” project lifecycle stage
- Potentially as a subset to the Network, how to handle projects that do not meet the definition of a large-scale integrated CCS projects (at least 800,000 tonnes of CO_2 annually for a coal–based power plant, or at least 400,000 tonnes of CO_2 annually for other emissions–intensive industrial facilities) but are still important potential partners
- Invite additional partners to join China and the United States in Task Force

Questions/ Discussion