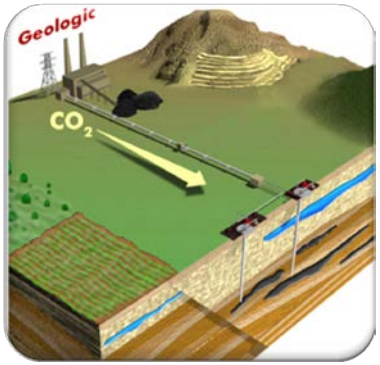


International Cooperation on Large Scale Saline Injection

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Background

- The CSLF is well-positioned to facilitate discussions on global collaboration efforts for large scale CCS projects, whether as new green field projects or by adding additional functionality and value to existing or planned commercial projects.
- Currently most of the large scale CCS projects are in the US and Canada. For a variety of economic and risk-related reasons, CO_2 captured at these CCS projects is used mainly for EOR.
  - For example, EOR produces an important income stream in the absence of a carbon price, and in the US EOR sites have existing, well established permit regimes in place allowing CO_2 injection and avoiding potential CO_2 storage (Class VI) well permitting challenges.
- As a result, technology progress associated with storage in deep saline formations will be limited even though significant emission reductions from major nations will eventually require CO_2 storage in such formations.
- In response to this, the CSLF Policy Group at the November 2013 CSLF Ministerial approved an initiative to coordinate development of a CCS project dedicated to testing large-scale CO_2 storage in saline formations. The US and China are the lead countries for this initiative.

Initiative Timing

The scope of this overall effort is divided into two phases:

- Phase I will develop a preliminary list of candidate projects evaluated against initial selection criteria for discussion at the October 2014 Policy Group meeting.
- Phase II will develop:
  - 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 for presentation at the Spring 2015 Policy Group meeting with the goal of initiating at least one project in the 2nd half of 2015 following approval at the Ministerial.

Project Selection Criteria

Six criteria were initially considered:

1. Able to store over **one million tons of CO_2 per year** in a **saline formation**.
2. Focus on **nearer-term opportunities**, i.e., exist or be close to "shovel-ready," and amenable to rapid permitting, construction, and operation.
3. Offer **multiple injection opportunities** via alternative injection zones with different properties and challenges, thus providing opportunities to compare approaches to subsurface characterization, plume modeling and tracking, mobility control, etc.
4. Have access to an **abundant source of CO_2 at a low cost** and committed supply, ideally at a location with access to a potential saline aquifer storage project.
5. Have project **management/operator willing to consider hosting an international consortium** focused on advancing the state-of-the-art for CO_2 storage in saline aquifers, and have a governance structure capable of carrying this out.
6. Exist in a location where **local public consultation has already taken place or is well underway,** or where the considerations associated with public consultation may not be as involved (e.g., at an offshore location).

Applying the Selection Criteria

- The primary source of data for developing the list of candidate projects is the Large-Scale Integrated Projects (LSIP) data base published by the Global CCS Institute (GCCSI).
- LSIPs are projects which involve the capture, transport and storage of CO_2 at a scale of not less than 800,000 tonnes of CO_2 annually for a coal-based power plant; and not less than 400,000 tonnes of CO_2 annually for other emission-intensive industrial facilities (including natural gas-based power generation).
- The GCCSI defines its projects to be in one of five phases. From initial consideration to actual operation these categories are: Identify, Evaluate, Define, Execute and Operate. A final investment decision is made on a project at the end of the define phase, moving it into the execute phase.
- This analysis focuses on projects at or beyond the Define stage – others are not sufficiently mature for consideration at this time.
- Application of individual criteria follows.

Criterion 1: Able to store over one million tons of CO_2 per year in a saline formation

Project Lifecycle Stage	Project Name	State / District	Country	Volume CO_2 (mtpa)	Operation Date	Capture Type
Operate	In Salah CO_2 Storage	Wilaya de Ouargla	ALGERIA	0	2004	Pre-combustion capture (natural gas processing)
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)
Execute	Gorgon Carbon Dioxide Injection Project	Western Australia	AUSTRALIA	3.4-4.0	2016	Pre-combustion capture (natural gas processing)
Execute	Illinois Industrial Carbon Capture and Storage Project	Illinois	UNITED STATES	1	2015	Industrial Separation
Execute	Quest	Alberta	CANADA	1.08	2015	Industrial Separation
Define	Don Valley Power Project	South Yorkshire	UNITED KINGDOM	5	2019	Pre-combustion capture (gasification)
Define	FutureGen 2.0 Project	Illinois	UNITED STATES	1.1	2017	Oxy-fuel combustion capture
Define	Rotterdam Opslag en Afvang Demonstratieproject (ROAD)	Zuid-Holland	NETHERLANDS	1.1	2017	Post-combustion capture
Define	Spectra Energy's Fort Nelson CCS Project	British Columbia	CANADA	2.2	2018	Pre-combustion capture (natural gas processing)
Define	White Rose CCS Project	North Yorkshire	UNITED KINGDOM	2.0	2018-2019	Oxy-fuel combustion capture
Define	Peterhead CCS Project	Aberdeenshire	UNITED KINGDOM	1	2019	Post-combustion capture

LSIP Saline Storage Projects

Criterion 2: Focus on near-term opportunities

Project Lifecycle Stage	Project Name	State / District	Country	Volume CO_2 (mtpa)	Operation Date	Capture Type
Operate	In Salah CO_2 Storage	Wilaya de Ouargla	ALGERIA	0	2004	Pre-combustion capture (natural gas processing)
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)
Execute	Gorgon Carbon Dioxide Injection Project	Western Australia	AUSTRALIA	3.4-4.0	2016	Pre-combustion capture (natural gas processing)
Execute	Illinois Industrial Carbon Capture and Storage Project	Illinois	UNITED STATES	1	2015	Industrial Separation
Execute	Quest	Alberta	CANADA	1.08	2015	Industrial Separation
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Define	FutureGen 2.0 Project	Illinois	UNITED STATES	1.1	2017	Oxy-fuel combustion capture
Define	Rotterdam Opslag en Afvang Demonstratieproject (ROAD)	Zuid-Holland	NETHERLANDS	1.1	2017	Post-combustion capture
Define	Spectra Energy's Fort Nelson CCS Project	British Columbia	CANADA	2.2	2018	Pre-combustion capture (natural gas processing)
Define	White Rose CCS Project	North Yorkshire	UNITED KINGDOM	2.0	2018-2019	Oxy-fuel combustion capture
Define	Peterhead CCS Project	Aberdeenshire	UNITED KINGDOM	1	2019	Post-combustion capture

LSIP Saline Storage Projects

Criterion 3: Offer multiple injection opportunities

- Having the capability to investigate alternative injection zones could provide results applicable to a larger portion of the global saline resource.
- Some candidates already well-characterized but further analysis needed to facilitate comparisons.
- Doing this right could require significant effort, so decision made to defer until Policy Group reduces number of candidates.

Criterion 4: Provide abundant, low-cost CO_2

- All projects in the LSIP data base are reasonably close to a large source of CO_2, but "abundant" would imply that CO_2 could be diverted from the current project or additional CO_2 made available.
- In terms of cost of supply, of the 7 most desirable LSIPs shown earlier targeting saline storage, 5 produce relatively "high purity" CO_2 streams (from natural gas processing, hydrogen production) and thus have relatively low capture cost .
- Sleipner, Gorgon and Snohvit separate CO_2 from a natural gas production stream and inject it into a saline reservoir for storage, which is essentially disposal. This process is covered by the cost of operations and an income stream from CO_2 sales is not essential. However, diverting CO_2 for experimentation in an offshore environment could be expensive.
- The cost and commitment of potential supply for candidate projects will require further assessment.

Criterion 5: Management willingness to host test facility and governance challenges

- The project host, potential project partners, and those performing specific R&D activities at the site will have many details to agree upon with regard to activities at the facility.
  - New wells will likely be drilled and require permitting.
  - New injection, at a different location, may begin in the current reservoir utilized by the host.
  - New reservoirs may need to be characterized and utilized for injection testing.
  - New surface facilities will be required and separate MVA operations conducted over the same territory occupied by the host.
- A government governance structure will also be required to:
  - Establish a framework encouraging responsible operation and investment.
  - Balance stability and predictability with flexibility and adaptability to new scientific information.
  - Provide ease of implementation for both regulators and industry.
  - Ensure that the Test Facility commits to providing non-IPR data and materials to facilitate knowledge sharing, and publishes openly to the public non-IPR information and materials generated during implementation of the project.

Criterion 5: Management willingness …… (continued)

- Project partners should be prepared, if necessary, to discuss appropriate incentive mechanisms to get sufficient interest from existing or planned commercial projects, especially for projects in developing countries.
  - These mechanisms may include financial supports, market-based incentives and conditions conducive for investment in CCS, and technology transfer.
- Governance Models:
  - Weyburn Midale: International Agreements (PTRC Management)
  - Regional Carbon Sequestration Partnerships: (Distributed Across Country)
  - Sleipner, Shohvit, Otway: Direct International Participation by labs
- Totally Hypothetical CSLF Model:
  - CSLF organizes participating countries, funding and participant guidance
  - An in-country, 3rd party entity (e.g. similar to PTRC, Regional Partnership) works directly with the project to implement testing based in CSLF member requirements
  - Host country facilitates, champions, advises
  - Other independent entity (e.g., IEAGHG) organizes technical reviews

Criterion 6: Carry out local public consultation

- In all of the nearer-term projects public consultation has already taken place or is well underway.
- Once a short list of candidate projects is developed based on the other selection criteria, a more detailed assessment will be conducted of candidate projects to evaluate the state of public consultation with respect to the proposed project.
- Public notification is a requirement of the Class VI injection permit process in the US. It will be good policy to inform the local public of the project prior to the application for any permit required for the project. Neglected public outreach can delay if not jeopardize the success of a proposed project.

Applicability of Selection Criteria to Nearer-term Projects

- The nearer-term projects identified earlier appear to meet most of the selection criteria, although a more detailed analysis is needed to better prioritize projects.
- Some, such as Quest and the Illinois Industrial CCS project, are carrying out or planning aggressive R&D at their sites, and have already indicated an interest in discussing participation by other groups.

Non-LSIP Options

- While the GCCSI list of LSIPs provides a good opportunity to develop criteria and perspective, it is not intended to be the exclusive list to serve as the source of potential candidate projects.
- Other sites to consider may include current EOR sites with excess CO_2 and with deeper saline storage potential, sites with local low cost CO_2 capture potential and saline storage potential, or other potential project sites that have not yet made it to the Global CCS Institute database.
- Additional candidate sites may be identified as part of this CSLF process. It would be helpful if CSLF representatives could facilitate investigation of candidates in their own countries.
- As in the case for capture test centers, consideration should be given to pursuing development of a network of saline storage test centers given the potential geologic variation among countries.

Next Steps

- A decision by the Policy Group is needed as to what LSIP subset should be further pursued at this time, and whether a saline storage test **network** should be the ultimate goal.
- Prior to the next Policy group meeting:
  - Further information (e.g. injection opportunities, CO_2 supply, management interest, public consultation) will be gathered for the approved candidate project subset.
  - Any additional candidate sites should be proposed early enough to allow vetting before the meeting (do we wish to consider complete greenfield options?).
  - CSLF members will be consulted to determine interest in providing financial and in-kind support to a test center, and when support could become available.

Questions/ Discussion

Implementation Options

Multi-National Projects Examples - Models:

- Weyburn Midale Monitoring Project – International Agreements
- Regional Carbon Sequestration Partnerships – Distributed Country
- Sleipner and Snohvit – Industry/Country
- Otway saline storage project – Country / leveraged internationally

Network Oversight and Management - CSLF

3rd party peer review and technical guidance – (IEAGHG, GCCSI, others?)

Host Country(ies) Coordination – Project contracting and management

Partnerships in R&D – Leveraging international investments

Major Demonstration Projects

Recipient	Project	Location	DOE Funding	Status	Storage Type	CO_2 Seq. (Metric Tons Per Year)	Storage Start
Air Products	Steam Methane Reformer Hydrogen Production	Port Arthur, TX	$284M	Operations	EOR	~925,000	2013
Southern Company Services (Kemper)	Integrated Gasification Combined Cycle (IGCC)	Kemper County, MS	$270M	Under Construction	EOR	~3,000,000	2014
Archer Daniels Midland	Ethanol Fermentation CO_2	Decatur, IL	$141M	Under Construction	Saline	~900,000	2014
NRG Energy (Petra Nova) WA Parish	Retrofit Pulverized Coal plant	Thompson, TX	$167M	Financing	EOR	1,400,000	2016
Summit Texas Clean Energy Project	Integrated Gasification Combined Cycle Polygeneration	Penwell, TX	$450M	Financing	EOR	2,200,000	2017
Leucadia Energy, LLC	Methanol from Petcoke Gasification	Lake Charles, LA	$261M	Front End Engineering & Design	EOR	~4,500,000	2017
FutureGen 2.0	Oxycombustion Pulverized Coal Boiler Retrofit	Meredosia, IL / Morgan County, IL	$1B	Front End Engineering & Design	Saline	1,000,000	2017 (est.)
Hydrogen Energy California (HECA)	Integrated Gasification Combined Cycle Polygeneration	Kern County, CA	$408M	Front End Engineering & Design	EOR	2,570,000	2019 (est.)

Global CCS Institute definitions for status of CCS projects