Carbon Sequestration Leadership Forum

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TECHNICAL GROUP

Updated CSLF Gaps Analysis Summary

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UPDATED CSLF GAPS ANALYSIS SUMMARY

Note by the Secretariat

Background

At the March 2010 Technical Group meeting in Pau, France, a comprehensive plan was developed for analyzing carbon capture and storage (CCS) projects in relation to technology gaps, both for projects that have already been recognized by the CSLF and for projects that could be proposed for recognition. To that end, a Gaps Analysis Summary on the thirty CSLF-recognized projects was prepared using input from the CSLF-recognized projects and analysis by the Projects Interaction and Review Team (PIRT). The Summary was used to identify technology gaps that are not currently addressed by any of the CSLF-recognized projects.

This paper updates the original 2010 Gaps Analysis Summary with the inclusion of three projects recognized by the CSLF in October 2010 and two projects that have been nominated for CSLF recognition.

Action Requested

The Technical Group is requested to review the Updated Gaps Analysis Summary.

CSLF Gaps Analysis Summary
Prepared by CSLF Secretariat

At the March 2010 Technical Group meeting, a comprehensive plan was developed for analyzing carbon capture and storage (CCS) projects in relation to technology gaps, both for projects that have already been recognized by the CSLF and for projects that could be proposed for recognition. To that end, a preliminary version of a gaps analysis matrix "report card" on the thirty CSLF-recognized projects was prepared by the Secretariat, using information developed by the PIRT, to help identify which technology gaps these projects address. This matrix could also be used to help identify new projects that would address any remaining gaps.

In order to provide an opportunity for project managers to verify the accuracy of the matrix, the CSLF Secretariat prepared and sent out an individual gap analysis worksheet based on the matrix to each of the active and completed CSLF-recognized projects. Information was received from 15 projects and corrections provided in these responses were incorporated into the matrix. Additionally, information on three projects recognized by the CSLF in October 2010 has also been incorporated into the matrix.

The updated gaps analysis matrix identifies the following two gaps as not currently addressed:

STORAGE

Storage Options

- A world-wide digital CO_2 storage atlas

Unmineable Coal Seams

- Worldwide storage capacity in unmineable coal seams

In addition, there are several other gaps that are addressed by only a single project.

The following pages present the updated technology gaps analysis matrix

Responses were received from the following active and completed CSLF-recognized Projects:

Project #	Project Name
1	Alberta Enhanced Coal-Bed Methane Recovery Project (*project completed*)
2	CANMET Energy Technology Center R&D Oxyfuel Combustion for CO_2 Capture
3	CASTOR (*project completed*)
4	CCS Bełchatów Project
5	CCS Northern Netherlands
6	CCS Rotterdam
7	China Coalbed Methane Technology / CO_2 Sequestration Project (*project completed*)
9	CO2CRC Otway Project
10	CO_2 Field Lab Project
11	CO_2 GeoNet
13	CO_2 SINK (*project completed*)
16	Dynamis (*project completed*)
19	Fort Nelson Carbon Capture and Storage Project
23	Heartland Area Redwater Project
28	Regional Carbon Sequestration Partnerships
30	SECARB Early Test at Cranfield Project
31	Zama Acid Gas EOR, CO_2 Sequestration, and Management Project
32	ZeroGen Project

Gaps information was developed by the PIRT for the following CSLF-recognized projects:

Project #	Project Name
8	CO_2 Capture Project (Phase 2) (*project completed*)
12	CO_2 Separation from Pressurized Gas Stream
14	CO_2STORE (*project completed*)
15	Demonstration of an Oxyfuel Combustion System
17	ENCAP (*project completed*)
20	Frio Project (*project completed*)
21	Geologic CO_2 Storage Assurance at In Salah, Algeria
24	IEA GHG Weyburn-Midale CO_2 Monitoring and Storage Project
25	ITC CO_2 Capture with Chemical Solvents
26	Lacq CO_2 Capture and Storage Project
29	Regional Opportunities for CO_2 Capture and Storage in China (*project completed*)

The following projects nominated for CSLF recognition have also been included in the gaps analysis matrix:

Project #	Project Name
N1	Wandoan Project
N2	Zero Emission Porto Tolle (ZEPT) Project

Gaps information has not yet been obtained from the following CSLF-recognized projects:

Project #	Project Name
18	European CO_2 Technology Center Mongstad
22	Gorgon CO_2 Injection Project
27	Quest CCS Project

CSLF Gaps Analysis Checklist
CAPTURE TECHNOLOGIES

Post-Combustion Capture	**Project #s**	**Total # of Projects**
Optimise capture systems	**2, 3, 4, 6, 16, 25, N2**	7
Improved solvent systems	**3, 4, 6, 25, N2**	5
Power plant concepts to integrate CO_2 capture	**3, 4, 5, 6, 16, 8, 25, N2**	8
CO_2 capture pilot plant	**3, 5, 6, 16, 28, 25, N2**	7
Fully integrated demonstration plant	**4, 6, 16, 25, N2**	5
Develop better solvents	**3, 6, 25, N2**	4
Optimise capture process systems to reduce power stations energy loss and environmental impact	**2, 3, 6, 16, 25, N2**	6
Advance organic / inorganic non-precipitation absorption systems	**2, 4**	2
Identify advantages and limitations of precipitating systems (e.g., carbonates)	**4**	1
Develop better understanding of the assessment of environmental impacts of capture technologies	**2, N2**	2
Pre-Combustion Capture	**Project #s**	**Total # of Projects**
Hydrogen-rich turbines	**6, 16, 32, 17, N1**	5
Improved air separation processes	**2, 16, 17**	3
Improved water-gas shift	**16, 32, 8**	3
Improved H_2/CO_2 separation	**2, 6, 16, 32, 8**	5
Power plant concepts to integrate CO_2 capture	**6, 16, 32, 8, 17**	5
Polygeneration optimization	**6, 16, 8**	3
Advance integration and optimization of components for power station applications	**16, 32, N1**	3
Coal and liquid petroleum gasification, natural gas reformer, syngas cooler	**6, 16, 32**	3
Improve CO_2 separation and capture technologies	**2, 6, 16, 32, 8**	5
Develop high efficiency and low emission H2 gas turbines	**16, 32, 17**	3
Fully integrated demonstration plant	**6, 16, 32**	3

CSLF Gaps Analysis Checklist
CAPTURE TECHNOLOGIES

Oxyfuel Combustion	**Project #s**	**Total # of Projects**
Boiler design	**2, 8, 15, 17**	4
Improved air separation processes	**2, 17**	2
Oxy-fuel gas turbines	**2, 15, 17**	3
Combustion science	**2, 15, 17**	3
Power plant concepts to integrate CO_2 capture	**2, 15, 17, 26**	4
CO_2 capture pilot plant	**2, 15, 17, 26**	4
Fully integrated demonstration plant	**2, 17, 26**	3
High temperature turbines	**2, 17**	2
CO_2/N_2 separation technology for industrial processes	**8**	1
Research into material selections	**2, 8**	2
Cryogenic air separation	**2**	1
Industrial Applications	**Project #s**	**Total # of Projects**
Capture from non-power industrial processes	**3, 6, 19, 28, 8, 21**	6
Emerging and new concepts for CO_2 capture	**Project #s**	**Total # of Projects**
Research into Post-combustion carbonate looping cycles	**8**	1
Research into Gas separation membranes and adsorption processes for CO_2	**2, 3, 6, 16, 8, 12, 25**	7
Research into Ion-transport membranes for O_2 separation	**16, 8**	2
Research into Chemical looping	**2, 8, 17**	3
Generation Efficiency	**Project #s**	**Total # of Projects**
Support initiatives to improve efficiency of electricity generation plant	**2, 16, 32, 8, 15, 17, 26**	7
Develop high efficiency gas turbines and support new cycle concepts	**2, 32, 8**	3
Develop alternative power generation processes that have the potential to produce improved economics when paired with absorption capture	**2, 16, 32, 15**	4

CSLF Gaps Analysis Checklist

STORAGE TECHNOLOGIES

Injection	Project #s	Total # of Projects
Optimum well spacings and patterns	1, 4, 6, 7, 19, 28, 32, 8, 21, 24, N1, N2	12
Optimum injection parameters	1, 4, 6, 7, 9, 13, 19, 23, 28, 32, 8, 21, 24, 26, N1, N2	16
Definition of variable rock facies or rock property types for injectivity.	3, 4, 6, 7, 9, 11, 19, 23, 28, 30, 32, 8, 21, 24, 26, N1, N2	17
Sustainability of high injection rates	1, 4, 6, 7, 19, 30, 32, 8, 21, 24, N1, N2	12
Formation water compression / displacement in closed or open system	4, 6, 7, 19, 23, 28, 30, 32, 8, 21, 24, N1, N2	14
Reservoir engineering aspects	1, 6, 7, 9, 13, 19, 23, 28, 30, 32, 21, 24, N1, N2	14
Address costs associated with storage, especially drilling and establishing wells	1, 4, 6, 23, 28, 32, 8, 21, N1, N2	10
Storage Options	**Project #s**	**Total # of Projects**
Saline Aquifers – fluids/rock relationships and interactions	3, 4, 6, 9, 11, 13, 16, 19, 23, 28, 30, 32, 14, 20, 21, N1, N2	17
Coal – rock properties	1, 7, 11, 28, N1	5
EOR – lessons to be applied to other storage reservoirs	6, 11, 16, 28, 31, 24, N1	7
Depleted oil and gas fields – viability	3, 5, 6, 9, 16, 28, 21, N1	8
Basalts – proof of concept	28	1
Ultra-low permeability rocks (e.g., organic rich shales, non-conventional reservoirs) – proof of concept	7	1
A world-wide digital CO_2 storage atlas	Not Addressed	0

CSLF Gaps Analysis Checklist

STORAGE TECHNOLOGIES

Deep Saline Formations	Project #s	Total # of Projects
Consistent methodology for storage capacity estimation	4, 6, 16, 19, 28, 30, 32, N1, N2	9
Record and define existing aquifer capacity data from world-wide projects	16, N1	2
Provide a robust storage capacity classification system and informs the legal end of storage licensing procedures	19, 28, 32, 8, N1	5
Reservoir and cap rock characteristics – storage injectivity, capacity and integrity	3, 4, 6, 7, 9, 11, 13, 19, 23, 28, 30, 31, 32, 20, 21, 24, 26, N1, N2	19
Predicting spatial reservoir and cap rock characteristics with uncertainties	4, 6, 9, 11, 16, 28, 32, 21, N1, N2	10
Depleted Oil and Gas Fields	**Project #s**	**Total # of Projects**
Depleted oil and gas fields – existing wells and remediation	3, 6, 16, 19, 28, N1	6
Inventory of oil and gas fields with large storage capacity	6, 28	2
Unmineable Coal Seams	**Project #s**	**Total # of Projects**
Worldwide storage capacity in unmineable coal seams	Not Addressed	0
CO_2-coal interactions – methane displacement and permeability decreases	1, 7, 11, 28	4
Mineral Carbonation	**Project #s**	**Total # of Projects**
Enhancing mineral trapping in specific types of settings (basalt, saline aquifers, etc.)	9, 19, 28, N1	4
Impact on fluid flow, injectivity, and geomechanics	3, 9, 19, 28, 21, N1	6
Thermodynamics and kinetics of chemical and microbiological reactions	1, 3, 9, 13, N1	5
Techno-economic viability of mineral storage of CO_2	N1	1
Gaps in Uses of CO_2 (EOR and EGR)	**Project #s**	**Total # of Projects**
Validate enhanced recovery of gas (EGR) (including ECBM)	1, 3, 6, 7, 11, 28, N1	7

CSLF Gaps Analysis Checklist
STORAGE TECHNOLOGIES

Trapping	**Project #s**	**Total # of Projects**
Understanding physical or chemical trapping mechanisms	**1, 7, 9, 11, 19, 23, 28, 30, 31, 14, 21, 24, N1, N2**	14
Migration rate	**9, 10, 11, 13, 19, 23, 28, 30, 32, 21, 24, N2**	12
Hydrodynamics	**Project #s**	**Total # of Projects**
Petroleum field development impact on hydrodynamic regime	**23, 32, 24, N1**	4
Research the impact of the quality of CO_2 (purity of CO_2) on interactions with the formation, brine, and storage behavior	**1, 6, 9, 11, 19, 23, 28, 31, 32. 14. 20, 21, N1**	13
CO_2 Properties	**Project #s**	**Total # of Projects**
Behaviour of CO_2 under different regimes of pressure, temperature and fluid mixtures	**2, 6, 9, 13, 16, 19, 28, 30, 31, 32, 20, 24, N1, N2**	14
Assessments	**Project #s**	**Total # of Projects**
Storage Capacity assessment methodologies or standards	**4, 6, 9, 11, 13, 16, 28, 32, 14, 20, 24, 26, 29, N1, N2**	15
Country wide or regional assessments of storage potential	**4, 6, 7, 16, 28, 14, 24, 29, N1**	9
Innovative methods for assessments of geological storage potential	**7, 9, 23, 28, 32, 24, 26, 29, N1**	9
Geological site characterisation, methodologies, techniques and standards	**4, 6, 7, 9, 11, 13, 19, 23, 28, 30, 32, 20, 24, 26, N1, N2**	16
Protocols for evaluation of potential sterilisation of existing resources	**32, 24, N1**	3
Develop appropriate models to predict the fate and effects of the injected CO_2 (multi-phase fluid flow, thermo-mechanical-chemical effects and feedback), including leakage	**1, 6, 9, 10, 11, 13, 19, 23, 28, 30, 32, 14, 20, 21, N1, N2**	16

CSLF Gaps Analysis Checklist

STORAGE TECHNOLOGIES

Leakage	**Project #s**	**Total # of Projects**
Flux rates of modern and ancient systems	9, 10, 11, 24, N2	5
Quantification and modeling of potential subsurface leakage impacts	6, 9, 10, 23, 28, 30, 32, 14, N1, N2	9
Existing facilities and materials	6, 10, 11, 13, 28, N2	6
Economics	**Project #s**	**Total # of Projects**
Costs of storage	4, 5, 6, 19, 28, 32, 29, N1, N2	9
Software	**Project #s**	**Total # of Projects**
Parameters for modeling fluid and rock interactions	6, 9, 11, 28, 30, 32, 20, N1, N2	8
Improvements in software for basin wide geological, reservoir engineering and hydrodynamic model	9, 11, 20, N1	4
Integration in single software system of geological, reservoir engineering and hydrodynamic aspects	1, 7, N1	3
Risk	**Project #s**	**Total # of Projects**
Risk assessment models	6, 9, 10, 11, 16, 19, 23, 28, 32, 24, N1, N2	12
Public Outreach	**Project #s**	**Total # of Projects**
Procedures and approaches for communicating the impacts of geological storage to the general public	4, 5, 6, 9, 10, 11, 13, 16, 19, 23, 28, 30, 31, 32, 20, 26, N1, N2	18

CSLF Gaps Analysis Checklist
MONITORING

General	Project #s	Total # of Projects
Assess long-term site security post-injection including verified mathematical models of storage	6, 11, 13, 16, 28, 32, 14, 20, 21, N1, N2	11
Define methods for the production and disposal of brine from saline formations as a result of CO_2 injection	28, 32, N1, N2	4
Wellbore Integrity	**Project #s**	**Total # of Projects**
Functionality and resolution of available logging tools	6, 9, 19, 28, 30, 32, 20, 21, 24, 26, N1, N2	12
Improved interpretation of cased hole logs	6, 28, 30, 32, 24, N1	6
Improved wellbore monitoring techniques	6, 9, 10, 11, 13, 19, 28, 30, 31, 32, 20, 21, 24, 26, N1	15
Physical or chemical changes to cement	6, 11, 31, 32, 21, 24, N1, N2	8
Identification of Faults and Fractures	**Project #s**	**Total # of Projects**
Use of seismic techniques	1, 4, 6, 9, 11, 13, 19, 28, 32, 14, 21, 24, 26, N1, N2	15
Use of non-seismic geophysical techniques	1, 6, 9, 11, 13, 19, 28, 32, 21, N1	10
Improved recognition and interpretation of the nature of faults and fractures	6, 9, 11, 19, 28, 32, 21, 24, N1	9
Subsurface Leaks	**Project #s**	**Total # of Projects**
Seismic, resolution	6, 9, 10, 11, 13, 28, 30, 32, 20, 21, 24, 26, N1	13
Seismic, cost reduction	6, 9, 10, 11, 32, 20, 21, N1	8
Evaluation of permanent or semi-permanent sampling points in an observation well	9, 10, 19, 28, 30, 32, 20, 21, N1	9

CSLF Gaps Analysis Checklist
MONITORING

Surface and Near-Surface Leaks	Project #s	Total # of Projects
Detecting CO_2 seeps into subaqueous settings	1, 9, 10, 11, 32, 14, 21, 24, N1	9
Remote sensing of CO_2 flux	1, 9, 10, 11, 28, 32, 21, 26, N1	9
Use of vegetational changes by hyperspectral surveys changes to identify gas levels in the vadose zone	9, 10, 11, 23, 28, 21	6
Improved remote sensing to identify sources of CO_2	10, 11, 20, 21, N1	5
Compile baseline surveys for measurement, monitoring and verification (MMV) activities including site-specific information on CO_2 background concentration and seismic activity	6, 9, 10, 11, 13, 19, 23, 28, 30, 32, 20, 21, 24, 26, N1, N2	16
Develop instruments capable of measuring CO_2 levels close to background and to distinguish between CO_2 from natural processes and that from storage	6, 9, 10, 13, 23, 28, 30, 24, 26, N1	10
Monitor impacts (if any) on the environment	6, 10, 11, 19, 23, 32, 20, 21, N1, N2	10
Guideline Development	**Project #s**	**Total # of Projects**
Determination of effective pre-injection surveys	6, 10, 32, 21, N1	5
Improved integration of monitoring techniques	1, 6, 7, 10, 11, 19, 23, 28, 32, 21, N1	11
Identify thresholds of leakage that can be measured	6, 10, 28, 32, 21, N1	6
Develop best practice guidelines selection, operation and closure, including risk assessment and response and remediation plans in case of leakage	3, 6, 10, 19, 28, 31, 32, 8, N1	9

CSLF Gaps Analysis Checklist
MONITORING

Gaps in Security of Geologic Storage	Project #s	Total # of Projects
Model the fate and effects of injected or leaked CO_2	1, 6, 7, 9, 10, 11, 13, 19, 23, 28, 30, 31, 32, 14, 20, 21, 24, N1	18
Develop best practice guidelines on how to characterize and monitor a site prior to, during, and after storage	3, 6, 10, 19, 28, 30, 31, 32, 8, 24, N1	11
Build tools that can be used to characterise a potential storage site	6, 28, 32, 20, 21, N1	6
Develop low cost and sensitive CO_2 monitoring technologies	6, 9, 10, 11, 28, 30, 32, 20, 21, 24, N1	11
Construct maximum impact procedures and guidelines for dealing with CO_2 leaks	10, 32, 8, N1	4
Create risk assessment tools to identify the likelihood and consequence of CO_2 leaks and inform effective decision making	6, 9, 10, 11, 19, 28, 32, 8, 21, N1	10

CSLF Gaps Analysis Checklist
TRANSPORT

General	Project #s	Total # of Projects
Cost benefit analysis and modeling of CO_2 pipeline and transport systems	**4, 6, 16, 32, 14, 26, N1**	7
Tanker transport of liquid CO_2	**6, 16, 32, N2**	4
Specifications for impurities from various processes	**2, 6, 16, 32, N2**	5
Dispersion modeling and safety analysis for incidental release of large quantities of CO_2	**6, 32, N1, N2**	4
Safety and mitigation of pipelines through urban areas	**4, 6, 16, 28**	4
Safety protocols to protect CO_2 pipelines, including response and remediation	**6, 32, N1, N2**	4
Identify regulations and standards for CO_2 transport	**4, 6, 16, 32, N1, N2**	6
Integration	**Project #s**	**Total # of Projects**
Identify reliable sources of information and data related to the design, cost, and space requirements, operation, and integration of CCS with energy facilities	**2, 6, 16, 32, N2**	5
Conduct periodic technical reviews of all aspects of recognized large-scale CCS demonstration projects and report on the "lessons learned"	**4, 6, 32, N2**	4
On a periodic basis, update the Technology Roadmap to include technology gaps identified during the technical assessment of demonstration projects	**2, 6, 10, 32**	4
Integrate with existing infrastructure	**4, 6, 16, 32, 8**	5
Cross-Cutting Issues	**Project #s**	**Total # of Projects**
Energy price issues would encourage the take-up of CCS	**6, 16, 32, 8, 21**	5