CO_2 Capture Project Phase 2: Storage Monitoring and Verification Program

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CO_2 Capture Project

The SMV Team

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Review CCP1-SMV

30+ Studies from R&D organizations and consultants from the US, EU, Norway and Australia addressing issues in storage:

1) Integrity of geologic and engineered systems
2) Optimization of processes and economic offsets
3) Monitoring of performance and leakage
4) Risk assessment of containment systems

Major findings include:

- Containment of geologic systems is predictable using 3D stratigraphic structural models and fluid history analysis
- CO_2 geo-storage compares favourably with natural & industrial analogs
- Well integrity is a concern but mitigating factors and engineering solutions exist
- Economic efficiencies and offsets are available for capture purity, pipeline transportation and enhanced recovery
- Cost-effective monitoring technologies from multiple vantage points are available or under development but testing is needed
- Suitable probabilistic and deterministic risk assessment protocols have been developed but need to be benchmarked, simplified and tested

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CCP2-SMV Program

Major Objectives
- Address issues arising from CCP1-SMV and other JIP work
- Move from R&D to deployment-ready
- Testing of CCP technologies and protocols

Projects
- Well Integrity
- Certification Framework
- Operational Parameters
  - Coupled Geochemical / Geomechanical Simulation
  - Efficiency and HSE Limits
- Monitoring
  - Direct Remote Sensing of CO_2 & Methane
  - Novel Geophysical Concepts
  - Well-based *In Situ* detection
- Pilots & Demos

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Well Integrity

SMV is developing a well "autopsy" and "prognosis" study for use on a decommissioned well that has been CO_2-exposed for 2-3 decades. Scoping is in progress.

- Well selection based on design, production history and logging assessment
- Extensive sampling / analysis of solids and fluids to assess current state
- Experiment on well materials to infer reaction kinetics
- History model developed for alteration over time
- Forward simulation to predict well stability over extended time
- Identification of engineering solutions to vulnerabilities in well design and materials with insight into intervention and remediation efforts

The well integrity study will provide quantitative information on well stability during the operational phase and a realistic prognosis for long term stability. Insight into well design and materials and options for remediation, intervention and de-commissioning will provide appropriate regulatory criteria.

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Certification Framework

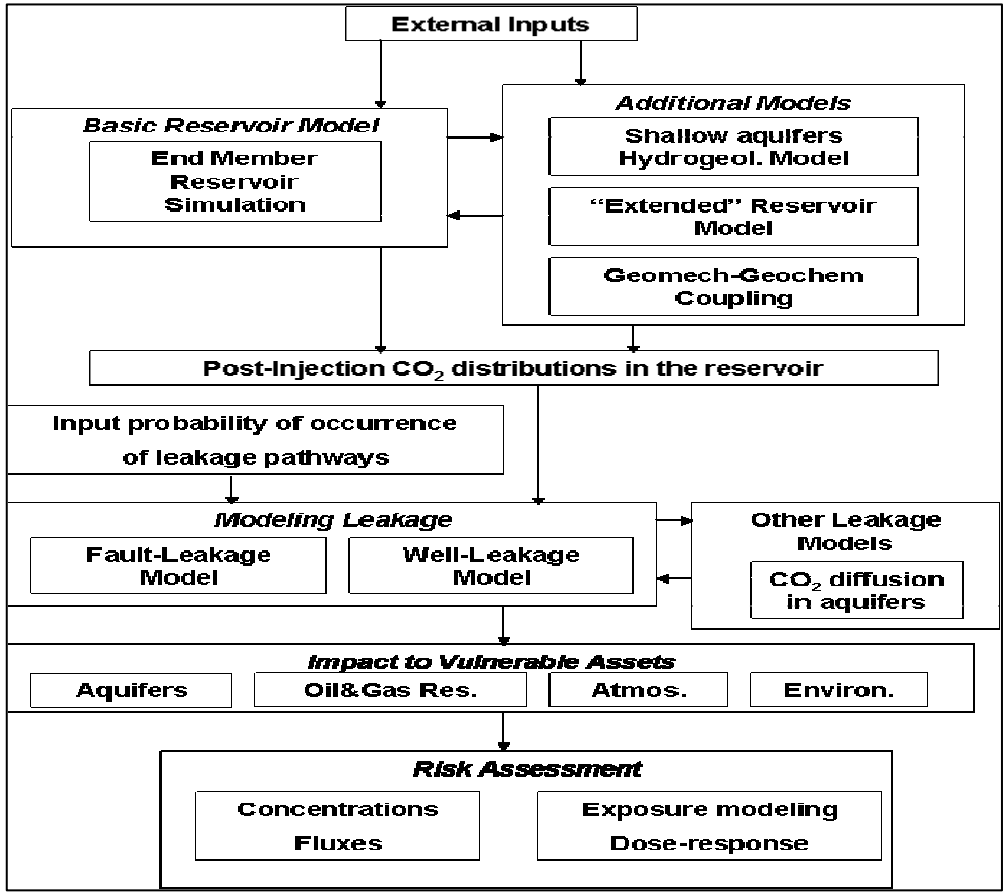
SMV recognized the need for a simple, transparent and systematic process for storage site assessment, including risk assessment. Proposal by Lawrence Berkeley NL and the University of Texas nearing completion.

- Develop generic model
- Simulate CO_2 injection in model reservoir
- Screen leakage and accumulation scenarios at vulnerable assets (e.g., potable aquifers and surface water, soil zones, hydrocarbon deposits)
- Simulate impacts to vulnerable assets
- Risk assessment
- Visualization and stakeholder outreach

The application developed could comprise the frame work for screening prospects, a ”certification” protocol for regulators and a means of defining success criteria to justify field de-commissioning.

Certification Framework (cont.)

Study Work Flow



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Operational Parameters - Coupled Geochemical-Geomechanical Simulation

Short- and long-term interactions between CO_2 (and its phases) and reservoir-seal fluids and rocks is recognized as near-term operability and lifecycle containment issue. An application will be developed by the University of Bergen to provide such a tool.

- Literature variables and geomechanics code inserted into ATHENE
- Analysis of geomechanics and fractures
- Geochemical effects on porosity / permeability and geomechanics
- Test case 1 (Utsira) and test case 2 (TBD)

Coupling of geochemical and geomechanical simulations will be predictive of reservoir-seal integrity and thus guide regulatory field operational and decommissioning parameters. The application developed will become public domain once tested.

Co-Funder: Norway Klimit

Operational Parameters – Efficiency and HSE Limits

Efficient operating conditions are needed to ensure the technical and economic success of CO_2 storage projects within HSE limits. A coal seam / cap rock simulation program is underway with Sproule associates.

- Data acquisition and initial simulations
- Secondary simulations and model development
- Final simulations and optimal settings / strategies

The operational parameters study is relevant to coal but an analog study could be applied to siliciclastic reservoirs and aquifers. The results of the study may be used to regulate operational parameters and establish system "preservational" conditions necessary for secure field de-commissioning.

Co-Funder: US DOE

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Monitoring – Direct Remote Sensing of CO_2 & Methane

Development of direct aerial CO_2 and methane detection methods would be a cost-effective means of monitoring leakage from CO_2 large storage projects. Study underway at University of California – Santa Cruz.

- Site identification and characterization (e.g., open coal mine, landfill or controlled release)
- Thermal hyperspectral imaging (adaptation of existing or new technology)
- Data processing, anomaly identification and mapping

This project has high technical risk, but if successful will be useful for GHG monitoring of multiple settings

Co-Funder: US DOE

Monitoring – Novel Geophysical Concepts

Non-seismic geophysical techniques (Gravity, ElectroMagnetic) may be of sufficient resolution to monitor CO_2 flood performance and leakage. Coal-bed case study conducted by Lawrence Berkeley NL (with seam model used in Sproule Assoc. "Operational Parameters" study)

- Generation of 3D geophysical models
- Geophysical models run and simulations inverted
- Direct inversion of test data

Non-seismic monitoring methods, if proven, will be a cost-effective and environmentally benign alternative to surface seismic methods. A parallel saline aquifer case is being conducted in collaboration with the Australian CO2CRC.

Co-Funder: US DOE

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Monitoring – Well-Based *In Situ* Detection

A novel well design that allows accumulation of CO_2 in the subsurface with detection using conventional logging tools. A pressurized vessel containing water saturated sand will be injected with supercritical and vapor phase CO_2. The study is a continuation of the CCP1 2004 study conducted by Schlumberger.

- Design, specifications and materials
- Vessel construction & testing at reservoir T&P
- CO_2 charging and testing of logging tools
- Optimization of fluid accumulation and detection
- Final testing with deployment recommendations

This is a unique approach to CO_2 flood performance and leakage detection that involves modest modification of standard well designs. Early detection of leakage will facilitate intervention decisions and methods.

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Monitoring – Well-Based *In Situ* Detection (Cont.)

Well-Based In Situ CO_2 Accumulation Chamber (3.5m tall; 16 tonnes when loaded)

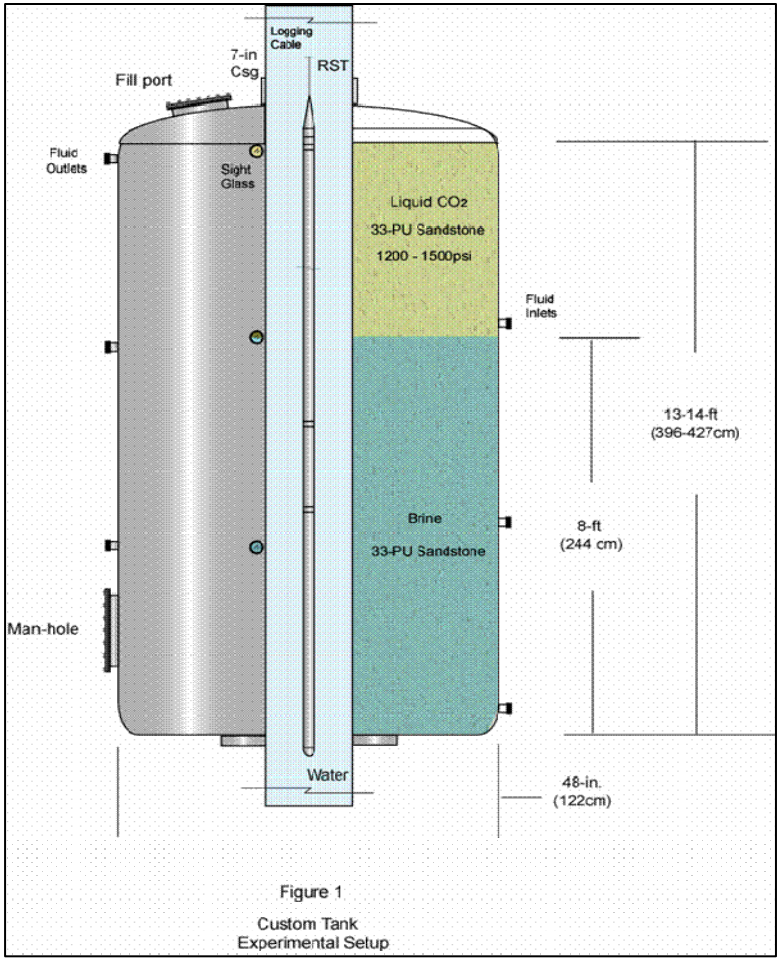

Figure 1
Custom Tank
Experimental Setup

Pilots / Demonstrations

SMV is seeking to engage in pilot / demonstration projects, operated by other organizations, that meet criteria such as:

- coverage of key issues in geological storage,
- match with CCP2 timeframe and objectives and
- opportunity to test CCP2 technologies / protocols

One or two projects from 3 geographic areas (North America, EU/Norway and South America) will be selected

An option remains to collaborate with US DOE Regional Partnership and EU consortia to access pilot project data and experience

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Summary

The CCP2-SMV Team has developed a slate of projects selected to:

- Address remaining and emerging critical issues in containment assurance, particularly wells
- Simplify models, simulations and protocols to facilitate a systematic assessment of storage sites and regulation thereof
- Continue to develop high R&D risk monitoring technologies that, if successful, will reduce costs and leave a smaller environmental footprint.

Seeking pilot / demonstration projects that address key technical issues and CCP2 objectives

The SMV team is interested in the NGO and regulatory perspective and is willing to modify project scopes to accommodate major concerns

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Thank You

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