SUPPORT SB 218
GEOLOGIC SEQUESTRATION STANDARDS FOR CARBON DIOXIDE

WHAT IS GEOLOGIC SEQUESTRATION OF CARBON DIOXIDE (CO2)?

It is the storage of CO2 in a geologic formation through the injection of CO2 into an underground formation that has the capability to contain it securely over a long period of time.[1] It is poised to become the key technology option for greenhouse gas emissions abatement.[2]

For well-selected, designed and managed geological storage sites, the vast majority of the CO2 will gradually be immobilized by various trapping mechanisms and, in that case, could be retained for up to millions of years.[3]

WHY REQUIRE STANDARDS?

"Conservation, renewable energy, and improvements in the efficiency of power plants, automobiles, appliances, etc. are important first steps in any GHG (greenhouse gas) emissions mitigation efforts. But those approaches cannot deliver the level of emissions reduction needed to stabilize the concentration of GHGs in the atmosphere…."[4]

Injection Hazards:

• Fractured formations, fault and seismic activity – these could provide an avenue for CO2 leakage. Pressure build-up caused by CO2 injection could trigger small seismic events.[5]
• Portland cement caps can deteriorate when exposed to carbonic acid, which can form when CO2 interacts with saline formations. Wells and plugs must use acid-resistant calcium phosphate cements.[6]
• Abandoned oil and gas wells that were not sealed to today's standards could provide an avenue for CO2 leakage.[7]
• A sudden and large release of CO2 would pose immediate dangers to human life and health, if there were exposure to concentrations of CO2 greater than 7-10% by volume of air.[8]
• Impacts of elevated CO2 concentrations in the shallow subsurface could include lethal effects on plants and subsoil animals and the contamination of groundwater.[9]
• Environmental impacts could be major if large brine volumes with mobilized toxic metals and organics migrated into potable groundwater.[10]

WHERE WOULD CO2 BE PUT?

Ideal Site - Porous briny sandstone that can absorb CO2:
"…storage in saline (brine, salty water) aquifers. These offer the greatest potential of any type of geological storage site in terms of volume. Injected to depths of over 800 meters, CO2 enters a liquid-like "supercritical" state allowing condensed storage. Naturally more buoyant than salt water, it must be kept down by thick layers of impermeable caprock above the storage formation. Over time it may dissolve and sink in the water, or partially react with rock and mineralize. Crude estimates show that globally saline aquifers could accommodate 50-200 times the amount of fossil fuel emissions predicted in the coming 50 years."[11]

"There could be a much larger potential for geologic storage in saline formations...technical storage capacity in coal beds is much smaller..."

The U.S. Department of Energy's List of Potential Locations[12]:

- **Oil and Gas Bearing Formations.** An oil or gas formation is a formation of porous rock that has held crude oil or natural gas (both of which are buoyant underground like CO2) over geologic timeframes. Advantage: 1. has a demonstrated seal, and 2. injected CO2 can enable the production of oil and gas resources.
- **Saline Formations.** A saline formation is a formation of porous rock that is overlain by one or more impermeable rock formations and thus has the potential to trap injected CO2. Advantage: 1. large aggregate CO2 storage capacity, and 2. low number of existing well penetrations compared to oil and gas formations.
- **Basalts**. Basalts are formations of solidified lava. They generally have low porosity; the CO2 storage mechanism of interest in a basalt formation is mineralization of CO2 with silicates.
- **Deep Coal Seams.** CO2 injected into a coal bed becomes absorbed onto the coal's surface and is sequestered. Most coals contain absorbed methane, but will preferentially absorb CO2.
- **Oil or Gas Rich Shales.** Shale, the most common type of sedimentary rock, is characterized by thin horizontal layers of rock with very low permeability in the vertical direction. Many shales contain 1-2% organic material, and the hydrocarbon material provides an adsorption mechanism for CO2 storage, similar to CO2 storage in coal seams.

WHAT STANDARDS WILL BE DEVELOPED?

1. Modeling
2. Monitoring
3. Mitigation
4. Verification
5. Reporting and recordkeeping
6. Bonding
7. Restoration of surface lands
8. Fees to pay for the program
9. Enforcement procedures

WHAT IS...
Modeling, Monitoring, Mitigation, and Verification (MM&V)?*

Monitoring and Verification are defined as the capability to measure the amount of CO_2 stored at a specific sequestration site, monitor the site for leaks or other deterioration of storage integrity over time, and to verify that the CO_2 is stored in a way that is permanent and not harmful to the host ecosystem.

- **Modeling**. Modeling is simulating the forces that influence the behavior of CO_2 in a geologic formation. A model is an important tool needed to prove, with a high degree of confidence, that injected CO_2 will remain securely stored before injection is allowed to commence. The behavior of injected CO_2 is a complex phenomena. It involves the flow of CO_2 through heterogeneous rock; forces acting upon the flowing CO_2, including buoyancy, dissolution, capillary trapping, and chemical reactions; and the impact of the CO_2 plume and increased pressure on the formation cap rock. A model serves as a nexus of understanding and captures the interaction of different forces. The boundary of a robust CO_2 storage model is not limited to the target formation, but also includes paths that fugitive CO_2 may travel up to the surface.
- **Plume tracking**. Plume tracking is the ability to "see" the injected CO_2 and its behavior. Seismic is a key technology in this area. Supercritical CO_2 is more compressible than saline water and sound waves travel through it at a different velocity. Thus free CO_2 in a saline formation leaves a bright seismic signature, as seen at the Weyburn and Frio field tests. Observation wells are another important source of information for plume tracking.
- **Leak detection.** CO_2 leak detection systems will serve as a backstop for modeling and plume tracking. The first challenge for leak detection is the need to cover large areas. The CO_2 plume from an injection of 1 million tons of CO_2 per year in a deep saline formation for twenty years could be spread over a horizontal area of 15 square miles or more. The second challenge is to separate CO_2 leaks from varying fluxes of natural CO_2 respiration.

There are important interconnections among these three areas. For example, data from plume tracking enables validation of reservoir models. On the other hand, a robust reservoir model enables operators to better interpret data from plume tracking. Also, models and plume tracking help focus leak detection efforts on high-risk areas.

Mitigation is the capability to respond to CO_2 leakage or ecological damage in the unlikely event that it should occur. If CO_2 leakage occurs, steps can be taken to arrest the flow of CO_2 and mitigate the negative impacts. Examples include lowering the pressure within the CO_2 storage formation to reduce the driving force for CO_2 flow and possibly reverse faulting or fracturing; forming a "pressure plug" by increasing the pressure in the formation into which CO_2 is leaking; intercepting the CO_2 leakage path; or plugging the region where leakage is occurring with low permeability materials using, for example, "controlled mineral carbonation" or "controlled formation of biofilms."

* "Carbon Sequestration Technology Roadmap and Program Plan – 2006." U.S. Department of Energy, National Energy Technology Laboratory. 2006

[1] "Carbon Sequestration Technology Roadmap and Program Plan – 2006." U.S. Department of Energy, National Energy Technology Laboratory. 2006, page 21.
[2] Ibid, page 2.
[3] "IPCC Special Report on Carbon Dioxide Capture and Storage, Summary for Policy Makers," Intergovernmental Panel on Climate Change, 2005, p. 14.
[4] "Carbon Sequestration Technology Roadmap and Program Plan – 2006." page 5.
[5] "IPCC Special Report on Carbon Dioxide Capture and Storage", p. 13
[6] "Carbon Sequestration Technology Roadmap and Program Plan, 2006," pages 23 and 24.
[7] Ibid, p. 21.
[8] "IPCC Special Report on Carbon Dioxide Capture and Storage", p. 12
[9] Ibid, p. 13
[10] "Gas-water-rock interactions in Frio Formations following CO2 injection: Implications for the storage of greenhouse gases in sedimentary basins", *Geology*: Vol. 34, No. 7, pp. 577-580
[11] "Verification Yearbook 2003", Chapter II, Monitoring and verification of geological and ocean carbon dioxide disposal. Jason Anderson.
[12] "Carbon Sequestration Technology Roadmap and Program Plan, 2006," p. 24.