WESTCARB Annual Business Meeting

Geologic Characterization and CO_2 Storage Capacity

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Seattle, WA
November 27, 2007

The Challenge and a Caveat

- "The methodologies… are designed to *integrate results of data* completed by the seven RCSPs for three types of geological formations: saline formations, unmineable coal seams, and hydrocarbon (oil and gas) reservoirs. These methodologies are *developed to be consistent across North America for a wide range of data*."
- "This assessment is a *high-level overview* and is *not intended as a substitute for site-specific assessment and testing*."

All quotations in this presentation are from:
Capacity and Fairways Subgroup, Geologic Working Group, U.S. Department of Energy Regional Carbon Sequestration Partnerships. October 2007. Methodology for Development of Geologic Storage Estimates for Carbon Dioxide. U.S. Department of Energy National Energy Technology Laboratory.

Emphasis added

CO_2 Storage Resource vs. CO_2 Storage Capacity

- "A CO_2 storage resource estimate includes all estimates of geologic storage reflecting physical and chemical constraints or limitations, but *does not reflect current or projected economic constraints, regulations, or well and/or surface facility operations*."
- "Carbon dioxide storage capacity is the *highest degree of certainty of capacity with present economic and regulatory considerations included*."

Emphasis added

CO_2 Storage Calculation: Reporting

- "Polygons enclosing each area assessed with an attached database file (.dbf) are the preferred method of reporting."
- "Data that support the calculated volumes (for example, thickness, depths, and porosity maps and grids, and any intermediate calculations such as per-unit or per-grid cell capacity) are noted and archived by each RCSP."
- For Atlas II, "each RCSP is providing a list of assumptions and calculation criteria that are used in their Region…. The criteria outlined in this document are considered the default settings; if RCSPs opt to use other criteria, these must be explicitly stated along with the rationale."

Atlas II: "Areas with Potential for CO_2 Storage"

- The oil and gas reservoir and coal seam maps will show reservoirs or formations:
  - with CO_2 storage potential that have had some degree of assessment
  - with no CO_2 storage potential
  - that have been identified but not yet assessed for CO_2 storage potential.
- The saline formations map will illustrate areas with
  - no sedimentary rock
  - sedimentary rock not suitable for CO_2 storage
  - sedimentary rock that have not yet been assessed for CO_2 storage
  - sedimentary rock with CO_2 storage potential that have had some degree of assessment

Saline Formations: Screening Criteria

- "Saline formation… is defined as a porous and permeable body of rock [sandstone or carbonate]containing water with total dissolved solids (TDS) greater than 10,000 parts per million (ppm), which can store large volumes of CO_2."
- "Saline formations assessed for storage are restricted to those where the following basic criteria for the storage are met:
  1. "pressure and temperature conditions in the saline formation are adequate to keep the CO_2 in dense phase (liquid or supercritical),
  2. "a suitable seal is present to limit vertical flow of the CO_2 to the surface (caprock), and
  3. "salinity in the saline formation is such that injection is acceptable under provisions of the Underground Injection Control (UIC) Program." (e.g., >10,000 ppm)
- Caprock must be shale, anhydrite, and/or evaporite

Saline Formations: Capacity Calculation

$$G_{CO2} = A\ h_g\ \phi_{tot}\ \rho\ E$$

Parameter	Units*	Description
G_{CO2}	M	Mass estimate of saline formation CO_2 storage resource.
A	L^2	Geographical area that defines the basin or region being assessed for CO_2 storage resource calculation.
h_g	L	Gross thickness of saline formations for which CO_2 storage is assessed within the basin or region defined by A.
ϕ_{tot}	L^3/L^3	Average porosity of entire saline formation over thickness h_g or total porosity of saline formations within each geologic unit's gross thickness divided by h_g.
ρ	M/L^3	Density of CO_2 evaluated at pressure and temperature that represents storage conditions anticipated for a specific geologic unit averaged over h_g.
E	L^3/L^3	CO_2 Storage Efficiency Factor that reflects a fraction of the total pore volume that is filled by CO_2.

* L is length; M is mass

- A storage efficiency factor (E) is applied to this formula to reflect the accessible volume to injected CO_2. Monte Carlo simulations estimated a range of E between 1 and 4% of the bulk volume of saline formations for a 15 to 85% confidence range.

Oil and Gas Reservoirs: Screening Criteria

- Salinity > 10,000 ppm
- No minimum (or maximum) cutoff
- No seal requirement (presence of hydrocarbons evidence enough of seal presence/integrity)
- No distinction about the maturity of the field
- Storage estimates reported at the field level

Oil and Gas Reservoirs: Capacity Calculation (volumetrics-based method)

$$G_{CO2} = A\ h_n\ \emptyset_e\ (1-S_w) B\ \emptyset\ E$$

Parameter	Units*	Description
G_{CO2}	M	Mass estimate of hydrocarbon formation CO_2 storage resource.
A	L^2	Area that defines the oil or gas formation that is being assessed for CO_2 storage resource calculation.
h_g	L	Hydrocarbon column height in the formation.
ϕ_e	L^3/L^3	Average porosity over net thickness h_n or effective porosity of formation divided by h_n.
S_w	L^3/L^3	Average water saturation within the total area (A) and net thickness (h_n).
B	L^3/L^3	Formation volume factor; converts standard oil or gas volume to subsurface volume (at formation pressure and temperature).
ρ	M/L^3	Density of CO_2 evaluated at pressure and temperature that represents storage conditions in the formation averaged over h_n.
E	L^3/L^3	CO_2 storage efficiency factor that reflects a fraction of the total pore volume from which oil and/or gas has been produced and that can be filled by CO_2.

* L is length; M is mass

Unmineable Coal Seams: Screening Criteria

- Permeability cutoff of <1 md used to determine maximum depth
- Suggestion: minimum depth dictated by a water quality standard (> 10,000 ppm TDS)
- Unmineability is determined by today's technology and economics
- Storage estimates reported at the geological basin level

Unmineable Coal Seams: Capacity Calculation

$$G_{CO2} = A\ h\ C\ \rho\ E$$

Parameter	Units*	Description
G_{CO2}	M	Mass estimate of CO_2 storage resource of one or more coal beds.
A	L^2	Geographical area that outlines the coal basin or region for CO_2 storage resource calculation.
h_g	L	Gross thickness of coal seam(s) for which CO_2 storage is assessed within the basin or region defined by A.
C	L^3/L^3	Concentration of CO_2 standard volume per unit of coal volume (Langmuir or alternative); assumes 100% CO_2 saturated coal conditions; if on dry-ash-free (daf) basis, A and h must be corrected for daf.
ρ	M/L^3	Standard density of CO_2.
E	L^3/L^3	CO_2 Storage Efficiency Factor that reflects a fraction of the total coal bulk volume that is contacted by CO_2.

* L is length; M is mass

- GIS approach with a minimum grid cell size of 10 km x 10 km
- A storage efficiency factor (E) is applied to this formula to reflect the accessible volume to injected CO_2. Monte Carlo simulations estimated a range of E between 28 and 40%; these values provide a 15 to 85% confidence range.