Subsurface Technology Overview

Larry Myer
WESTCARB Technical Director (Retired)
Lawrence Berkeley Laboratory
lrmyer@lbl.gov

California Carbon Capture and Storage Review Panel

Sacramento, CA
April 22, 2010
Outline

- Some fundamentals
- Technology experience
- Managing CCS risks
- California geologic storage opportunities
- Technologies for site characterization, project design, and monitoring
- Summary
Primary Storage Options for CO₂

- Oil and gas reservoirs
  - Storage with enhanced oil recovery (EOR), enhanced gas recovery (EGR)
  - Storage only
- Saline formations
  - Storage only
- Deep, unminable coal beds (not an option for California)
  - Storage with enhanced coal bed methane (ECBM) recovery

(Source: NETL)
Geologic Storage Mechanisms

- Physical/structural trapping
- Dissolution
- Phase trapping
- Mineralization
- Surface adsorption

Typical geological structures ideal for trapping CO₂ (Source: W Gunter, ARC)
Geologic Storage Is Already Under Way Using Petroleum Industry Technology

- Statoil injects 1 million metric tons per year at Sleipner under the North Sea
- BP injects 1 million metric tons per year at In Salah in Algeria
- EnCana EOR project with CO₂ storage in the Weyburn field
Geologic Storage Projects have Multiple Risks

- **Geologic risks**
  - Leaky seals, faults
  - Brine intrusion
  - Induced seismicity

- **Operational risks**
  - Operational safety hazards
  - Leaky wells, old and new
  - Overpressurization
  - Surface equipment failure

- **Project financial risks**
  - Unexpected conditions
  - Cost overruns
  - Price of carbon

- **Legal and regulatory risks** (particularly large for early projects)
  - Pore space ownership unclear
  - Regulatory jurisdiction unclear
  - Long-term liability undefined

- **External risks**
  - Public opposition
  - Policy shifts
IPCC Has Provided Scientific Consensus That Geologic Risks Are Manageable

“With appropriate site selection informed by available subsurface information, a monitoring program to detect problems, a regulatory system, and the appropriate use of remediation methods to stop or control CO₂ releases if they arise, the local health, safety, and environment risks of geological storage would be comparable to risks of current activities such as natural gas storage, EOR, and deep underground disposal of acid gas.” IPCC, 2005

Crystal Geyser, Utah – the result of a well drilled into CO₂ bearing artesian formation
(Source: Julio Friedmann, LLNL)
Managing Risk

- Risk assessment program
  - Identify risks
  - Identify risk reduction actions
- Project management plan
  - Contracts/legal agreements
- Comprehensive site safety plan
- Careful site characterization
  - Old wells
  - Subsurface geology
- Careful well construction and injection
- Prediction of plume behavior
- Comprehensive monitoring program
  - Operational EH&S
  - Assurance monitoring
  - Storage security monitoring
- Mitigation plan
- Public outreach program
- Plan for post-injection site stewardship
California CO₂ Emissions by Sector and Major Source Type

(Source: U.S. EPA)
California Geology Provides a Major CO$_2$ Storage Resource

California Saline Formation Resource Estimate
Techniques for Site Characterization and Project Design Are In Place

Geologic models incorporate data from seismic reflection surveys and wells
(Source: S Hovorka, TBEG)

Reservoir simulations show CO$_2$ extent and immobilization over time
(Source: C Doughty, LBNL)
A Large Portfolio of Techniques Is Available for Monitoring Geologic Storage Projects

- Geophysics: seismic, electrical, gravity
- Well logging
- Hydrologic pressure and tracer measurements
- Geochemical sampling
- Remote sensing
- CO₂ sensors
- Surface measurements

Seismic reflection cross-section before injection and after 2.3, 5.0, and 6.8 Mt CO₂ injected at Sleipner (Arts, et al 2008)
Two CCS Projects Are Currently in the Permitting Stage in California

- Hydrogen Energy International commercial demonstration
  - IGCC with capture of ~2M tons CO₂ per year
  - CO₂ used for EOR
- Shell/WESTCARB small-scale injection project
  - Inject about 6000 tons into a deep saline formation; monitor
  - Assess sequestration potential of western Sacramento Valley
Summary

- Technological knowledge base for geologic CO$_2$ storage is extensive; successful projects are already underway
- Risks have been identified and are manageable
- California has a large geologic CO$_2$ storage resource
- Early projects provide important knowledge base for regional CCS implementation