Exploration for Carbon Dioxide Storage Potential in the Midwestern USA

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Kentucky Sequestration Consortium
December 7, 2007, Lexington Kentucky
Battelle’s operation of major energy labs provides insights into energy challenges

- Pacific Northwest
- Idaho
- Columbus
- Brookhaven
- Lawrence Livermore
- National Renewable Energy Lab
- Oak Ridge
- NBACC
- BEST Center

$4.0 billion R&D volume
20,000 staff
31 scientific user facilities
Battelle Plays a Key Role in Several Carbon Sequestration Initiatives

Mountaineer

Regional Reservoir Characterization “Piggyback Drilling”

FutureGen

Global Energy Technology Strategy Program (GTSP)
Mountaineer Plant, West Virginia, USA – Funded by DOE-AEP-BP-Battelle-OUCO-Schlumberger etc.

- 1300 MW pulverized coal plant with NOx and SOx control
- An area of intense power production and future expansion
- AEP has announced a major scale-up and a multi-pronged CCS deployment at this and other sites.
Site-Specific Characterization

**Essential for Safe and Effective Operations**

- **Ground level**: 9,000 feet below the surface
- **Possible storage formations**: > 2,500 ft deep
- **9,000 feet below the surface**

### Seismic Survey

- Drilling Test Well

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Mountaineer Site - Seismic Survey Demonstrated Impact of Plant Noise and Lack of Faulting
CO₂ Injectivity in the Mountaineer Area

- A number of geologic formations have been evaluated for CO₂ storage potential in the Ohio River Valley region through Mountaineer project.

CO₂ injection should also be possible in shallower sandstone and carbonate layers in the region.

- Rose Run Sandstone (~7800 feet) is a regional candidate zone in Appalachian Basin.

- A high permeability zone called the “B zone” within Copper Ridge Dolomite has been identified as a new injection zone in the region.

- Mount Simon Sandstone/Basal Sand - the most prominent reservoir in most of the Midwest.
Simulating Geologic Sequestration to support permitting, outreach, MMV, and Facility Design

**Carbonate Reservoirs**

- **Multiple Injectors**
- **Stochastic Simulations**
- **Water, CO2, Salt**

**Carbonate Reservoirs**

- Time = 6.000000E+00, y
- Gas Saturation
  - 0.81
  - 0.71
  - 0.61
  - 0.51
  - 0.41
  - 0.31
  - 0.21
  - 0.11
  - 0.01

**CO2 Injection**

- Total CO2
- Supercritical CO2
- Dissolved CO2

**CO2 Tracer**

- Radial Distance From Well (ft)
- True Depth Below Ground Surface (ft)

**Realization 26**

- Realization 27
- Realization 28
- Realization 29
- Realization 30
- Realization 31
- Realization 32
- Realization 33
- Realization 34
- Realization 35
- Realization 36
Mountaineer CO₂ Storage Assessment Project - A Unique Public Private Collaboration

- Since 2002, a number of organizations and experts have contributed financially (>7M) and technically in evaluating geologic sequestration feasibility at the Mountaineer Plant:
  - Battelle Memorial Institute – Lead performer and co-sponsor
  - DOE/NETL – Primary financial support
  - AEP – Host site and co-sponsor
  - Ohio Coal Development Office
  - BP
  - Schlumberger
  - Ohio Geological Survey
  - Regional Geologists
  - Stanford’s GCEP Program
  - CO₂ Capture and handling Companies
  - Regional Oil and Gas Companies
  - CRIEPI (Japan)
  - Midwestern Regional Carbon Sequestration Partnership (MRCSP)
The MRCSP’s mission is to be the premier resource for sequestration knowledge in its region

- One in Four Americans
- 1/5 of U.S. Electricity - ¾ From Coal
- ~830 Million Tons of CO₂/year
- ~340 Large Point Sources of CO₂

Phase I

- Developing a Regional Model of the Economics of Sequestration

Phase II

- Implementation
  - Geological
  - Terrestrial

Reaching Out To and Educating Stakeholders

Terrestrial:
- Potential for 20% annual offset for large point sources

Geologic:
- 100s of years of capacity for large point sources in deep saline alone

www.mrcsp.org
MRCSP Region’s Vast Geological Storage Potential is Well Positioned Relative to Sources

Deep saline formations: >100,000 MMTCO$_2$

Depleted oil and gas fields ~1,400 MMTCO$_2$

Unmineable coal and shale ~350 MMTCO$_2$

Data from over 40,000 wells have been analyzed
Geologic Storage – three sites are being characterized for injection tests by MRCSP

- Michigan Basin
- Appalachian Basin
- Cincinnati Arch
Test Well Drilling at the Michigan Basin Site

- Test well drilled October 30 – November 22, 2006
Test Well Drilling

• 180 ft of full core collected.
CO₂ Storage Modeling Process
Conceptualize-characterize-Design-Monitor-Calibrate-validate

- Experience with MRCSP and other projects has demonstrated the value of site specific data from test wells.

Example - MRCSP Michigan Basin State-Charlton 30/31 Field Test Site

Preliminary Modeling Based on Regional Data

Site Drilling and Testing

Site Specific Modeling
Test Well Drilling – Permitted as Stratigraphic Test Well by State of Ohio

Surface Casing Rig

Deep Well Rig
Test Well Drilling at R.E. Burger Plant, Appalachian Basin

Deep Rig- TD = 8,384’ 2/5/07

Wireline Logging
Site Characterization - Seismic Survey at Burger Plant

- 10-mile seismic survey completed in August 2006
- Additional 1-mile of “quasi-3D” to investigate reservoirs and 3D options
Site Characterization - Detailed Seismic Interpretation

- The Oriskany Sandstone (between the Onondaga and Helderberg is right at the resolution limit of this data
- The White Clinton is much easier to see and post injection changes may be detectable

*Initial Results
Site Characterization - Low Frequency Seismic Analysis

- Low frequency response of a formation is largely dictated by pore fluids.
- Different formations should peak at different frequencies.
- Imaging methods explored to better define sandstone injection targets.

Burger seismic data at 32 Hz possibly imaging the Oriskany Sandstone (yellow).
Proposed Phase III Geologic Test Sites

Ohio Ethanol

• Primary site
  – Injection starts in early FY2010
  – Plans are to inject 1 million tons of CO₂ over a four-year period
  – Target is the Mt. Simon reservoir, the largest deep saline target in our region.

Indiana IGCC

• Optional site
  – Injection starts in FY 2012
  – Possible 2 million tons of injection over four-year injection period
  – Multiple injection zones and caprock layers
Piggy Back Program - Leveraging the Oil and Gas Exploration Industry

• Team up with oil and gas industry to collect data
• DOE gets access to existing drilling operations – saves significant cost (counts as cost share)
• Oil and gas operators get detailed wireline logs
• Data go back to build regional understanding of geology and improved capacity assessment
Regional Characterization Efforts

1. Mountaineer Well
2. Jerrell #1 Well
3. Raynor #1 Well
4. Miley #1 Well
5. Frankovitch #1 Well
6. Dager #1 Well
7. Pomarczynski 6-35 Well
8. Lee #1 Well
9. McCoy #1 Well
10. Ohio Stratigraphic Test Well
11. Hart-Feuring Well

Potential Future Opportunities

NOT TO SCALE
Objectives of Battelle’s Piggyback Drilling Project

• Identify Formations of Interest for CO₂ Storage
• Improve Geologic Framework for Deep Formations
• Determine Geologic Patterns and Regional Distribution
• Focus on Formations Deeper than 3000’
• *Generate New Data for In-Depth Reservoir Research
Approach of the Piggyback Drilling Project

• Supplement or Extend Active Exploration Projects Through:
  – Surface seismic surveys,
  – Adding a stratigraphic test tail on exploration wells
  – State-of-the-art wireline logging
  – Coring
  – Reservoir tests, brine sampling,
  – Petrographic, geochemical studies, etc.
Sequence Stratigraphy Provides Model for Prediction of Porosity and Permeability

Example from Burger well: Newly identified Salina Williamsport porosity is in dolomites associated with Maximum Flooding Zones and provides a model for distribution in time and space.

Salina Williamsport (6740-7038 ft)
- Logs show zones of porosity around 10%.
- Some short-lived gas shows
- Sandwiched between salt intervals.
- Porous dolomites above and below mappable Maximum Flooding Zone tight limestone.
Zero Lost Time Incidents – Please be safe during the site visits!
Thank you!

Drilling at Mountaineer Plant, West Virginia