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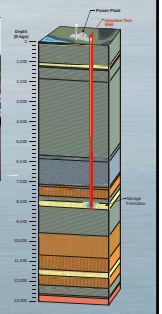

Appalachian Basin, MRCSP
R.E. Burger Geologic Field Test Site

Presented By: Neeraj Gupta, Battelle
DOE/NETL Regional Partnership Annual Meeting
December 12-13, 2007, Pittsburgh, PA

MRCSP
MIDWEST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

R.E. Burger Field Test Core Team

FirstEnergy — ***Michele Somerday, Danielle Schneider, and others***

Larry Wickstrom, Doug Mullet, Ron Riley, Ernie Slucher, Mark Baranoski

Battelle The Business of Innovation — ***Dave Ball, Neeraj Gupta, Phil Jagucki, Joel Sminchak, Danielle Meggyesy, Judith Bradbury, Bob Janosy, Jackie Gerst, Diana Bacon, Ioan Feier***

NETL — ***Lynn Brickett, Charlie Byrer***

West Virginia Geological Survey — ***Lee Avary, Eric Lewis***

Pennsylvania Geological Survey — ***John Harper, Kristin Carter***

Schlumberger — ***Dwight Peters***

CO_2 Supply System team includes EPRI (Rob Steele), PowerSpan, and Ariel Compressors

Additional Contributions by Numerous Other MRCSP Team Members

Regional Carbon Sequestration Partnerships Initiative Review Meeting
December 12-13, 2007, Pittsburgh, PA

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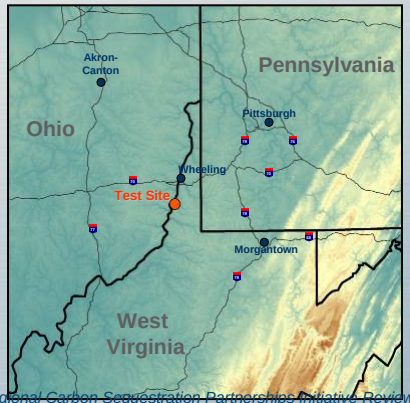
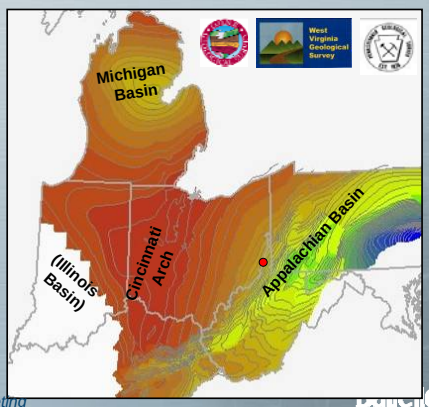
Appalachian Basin- R.E. Burger Test Site

- FirstEnergy plant outside of Shadyside, OH; across from Moundsville, WV.
- 30 miles southwest of Wheeling, West Virginia
- Near Maryland, Ohio, Pennsylvania, and West Virginia
- Site is located in the western flank of the Appalachian Basin, a major sedimentary basin in the MRCSP region.





R.E. Burger Test Site

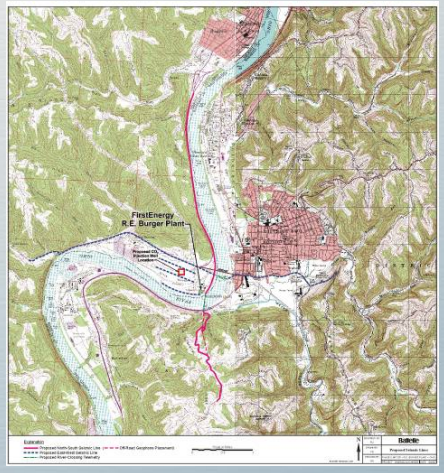
- FirstEnergy R.E. Burger Plant is host site for tests. The plant is a 413 MW coal power plant located on 100 acres on the Ohio River.
- CO_2 source = PowerSpan pilot-scale emission control system at the site.
- This provides an opportunity to test an integrated CO_2 capture, handling, and injection system.

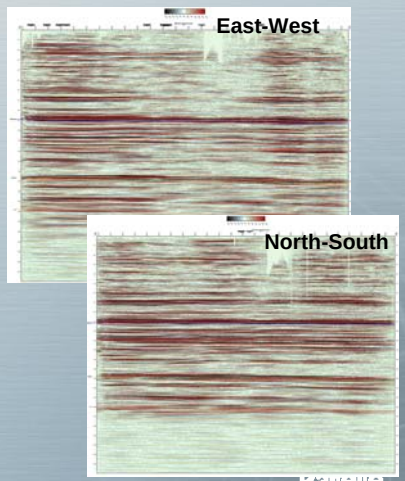
R.E. Burger Test Site: Outreach

- Summer 2006:
  - Coordinated with FirstEnergy in planning interactions and developing a series of informational materials to introduce project and describe future seismic and other activities (neighbor letter, fact sheet, briefings)
- Winter 2007:
  - Coordinated with FirstEnergy in scheduling a site visit and presentations to DOE FE management
  - Facilitated development of an educational video of well drilling by the Science Media Group at the Harvard-Smithsonian Center for Astrophysics
- Now initiating planning for an informational meeting to be held prior to publication of the Notice of Availability of the draft permit for public review by Ohio EPA

Site Characterization-Seismic Survey

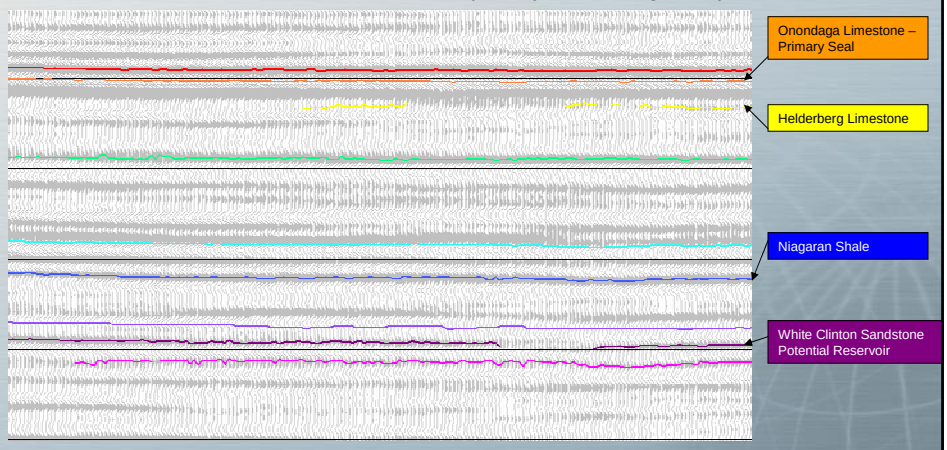
- 10-mile seismic survey completed in August 2006
- Additional 1-mile of "quasi-3D" to investigate reservoirs and 3D options





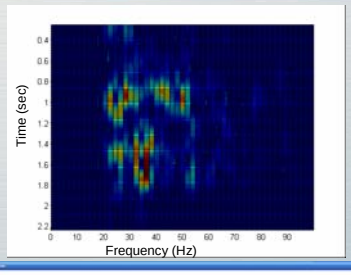
Site Characterization- Detailed Seismic Interpretation

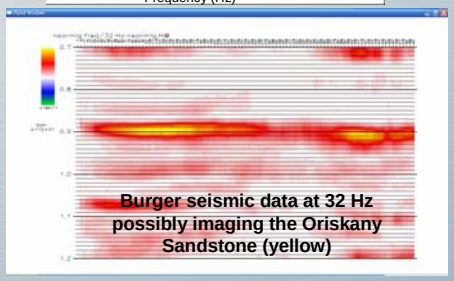
- The Oriskany Sandstone (between the Onondaga and Helderberg) is right at the resolution limit of this data
- The White Clinton is much easier to see and post injection changes may be detectable



*Initial Results

Site Characterization- Low Frequency Seismic Analysis



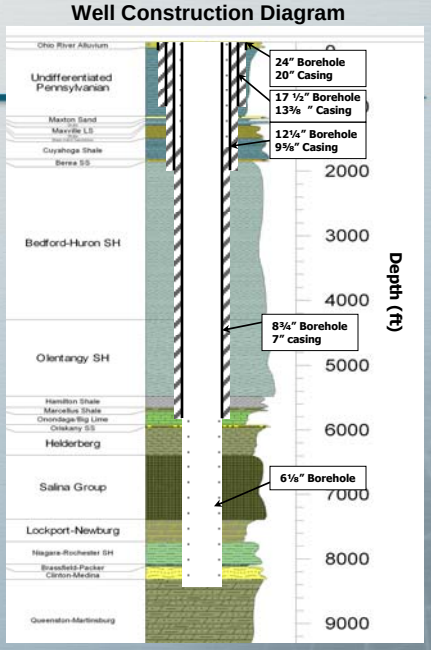


- Low frequency response of a formation is largely dictated by pore fluids
- Different formations should peak at different frequencies
- Imaging methods explored to better define sandstone injection targets

Site Characterization-Test Well Drilling

Deep Test Well Drilling in Winter 2007
Total Depth = 8,384' 2/5/07

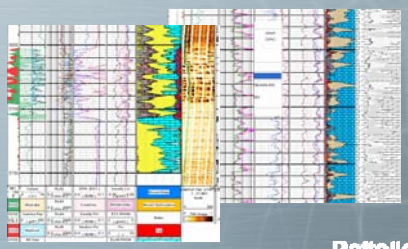
Well Construction Diagram



Site Characterization-Test Well Drilling

- Mudlogging and Wireline logging were used to characterize well.
- Sidewall coring could not be completed due to technical issues
- This will be done prior to final well completion in Winter 2008

Wireline Logging

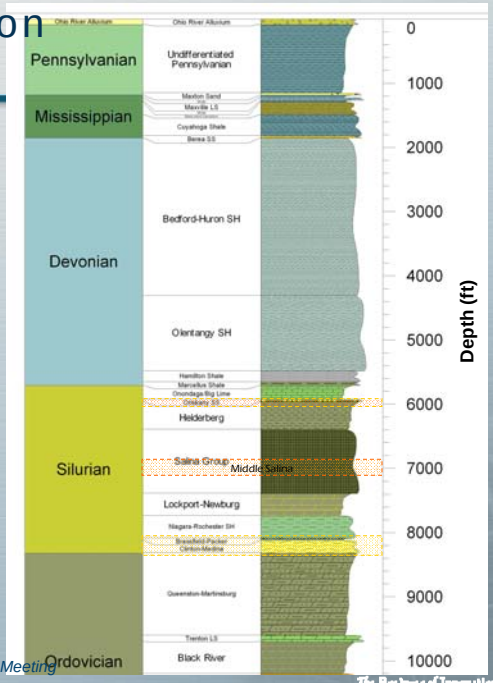


Site Characterization Results

Primary targets include Oriskany Sandstone, middle Salina carbonate unit, and Tuscarora/"Clinton" sandstone.

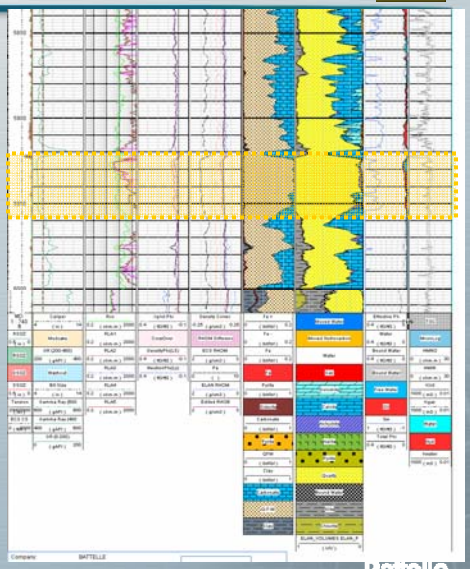
•Secondary carbonate targets Lockport-Newburg and Williamsport merit further examination

•Thick Devonian Shale section provides excellent containment.



Test Well – Potential Injection Zones

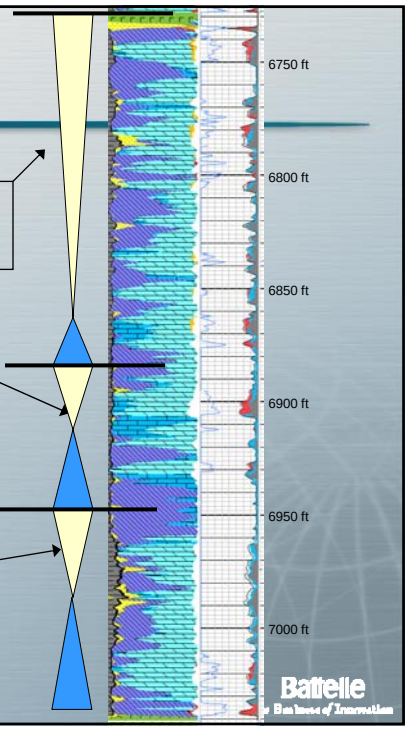
Oriskany Sandstone (5923-5953 ft)
- SS: clr, wh, tan-lt gy, modsrt, sbrnd, g-sph, cln, pred loose, occ calc
- Overall, this unit has suitable lithologic character for injection (clean sandstone).
- However, porosity and thickness appear inadequate for large-scale injection at this location
- This formation is know to be thicker towards the east of the plant location in Pennsylvania and West Virginia



Test Well – Potential Injection Zones

Middle Salina (6740-7038 ft)
- Dolomite-carbonate unit within the Salina Group.
- DOL tan-dk gybrn, vfxln, occ arg, occ salt in sample.
- Logs show zones of porosity up to 10%.
- Some short-lived gas shows encountered in this formation.
- Nicely sandwiched between salt intervals.
- Potential for injection needs to be confirmed with reservoir tests.

Salina Subgroup Sequence Stratigraphy



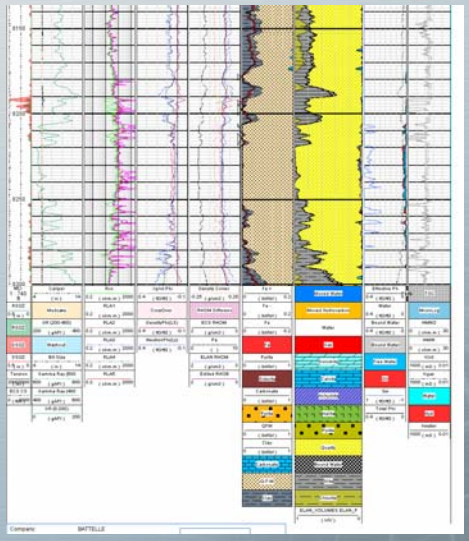
No large packages and high frequency cycles indicating very slow rise, and a moderately restrictive marine environment

Maximum flooding zone for the subgroup representing the deepest and freshest marine environment. Porosity is valid, concentrated in dolomites, and is most likely widespread.

Gradual rise in sea level creating aggradational dolomites and moderate porosity. Porosity is most likely valid.

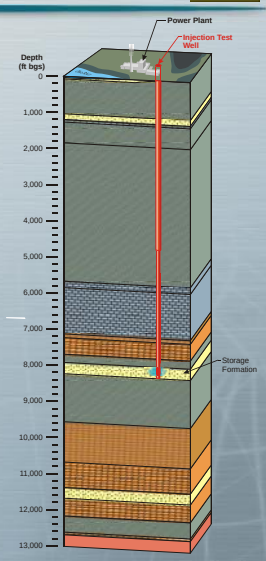
Test Well – Potential Injection Zones

Clinton-Tuscarora Sandstone (8118-8318 ft)
- SS: wh-lt gn, vfg, sbrnd, w-srt, g-sph, occ loose, cln
- Logs show porosity at 4-6% across 67 ft (8207-8274 ft) corresponding to "White Clinton."
- Overall, this unit has suitable lithologic character for injection (clean sandstone).
- However, permeability is uncertain and needs to be confirmed with sidewall cores and/or injection tests.



Conceptual Injection System

- Middle-Devonian to Middle Silurian deep saline formations primary target (Oriskany, mid-Salina, and "Clinton" sandstones).
- Exploratory approach is being developed to perform injection tests in several different targets.
- Target injection volume = 3,000 metric tons CO_2 at supercritical conditions (roughly equivalent to ~1 million gallons or 57 MMSCF) over several months.
- Injection rate ~20 metric tons/day over 6 months (based on PowerSpan delivery schedule).
- Very extensive shale and carbonate containment layers.



CO_2 Source

- CO_2 will be obtained from PowerSpan pilot-scale emission control system at the site.
- This will provide an opportunity to test an integrated CO_2 capture, handling, and injection system in this tri-state area of the Appalachian Basin.

CO_2 Injection System Design-Compression and Pipeline

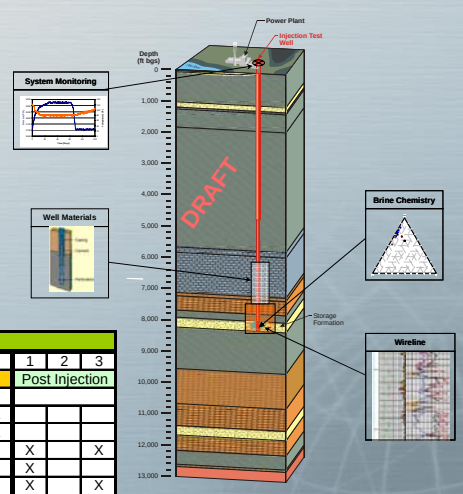
Work in progress…

CO_2 Compression-Transport Design (in Collaboration with EPRI)

- Compressor skid will be installed in an existing outdoor tent (crystallizer tent) and be supplied with CO_2 level monitoring sensors and audible and visual alerts. The compressor skid will be controlled with a Programmable Logic Controller (PLC) with a software control panel linked into the PowerSpan control room. Well head pressure will be adjustable by incorporating an adjustment valve and flow-back loop in the design.
- **Compressor type:** Ariel JGA reciprocating separable compressor
- **Compression design:** 4 stage on a 4 throw compressor.
- **Drive:** Electric motor, ~100 hp. Considering a Variable Frequency Drive (VFD).
- **Intercooling:** Gas to air heat exchanger after every compression stage. Heat exchangers are together inside an air tower driven by axial fans.
- **Drying:** Water separator at suction pipe, water separators before each compression stage, TEG (triethylene glycol) contact tower after 5th stage.
- **Inlet:** 50-150 psig
- **Outlet:** 2400 psig maximum, ~95ºF max
- **Flow rate:** 20 metric tons/day
- **Surface pipeline:**
  - Approx. 500 feet pipe from capture system 3" (3.5" OD & 3.068" ID), ASTM A106 Grade B pipe, ANSI 150# flanges. Pipe will be run through existing plant infrastructure, above ground
  - Approx 1500 feet pipe 2" (2 3/8" OD & 1.503" ID) to injection well, ASTM A106 Grade B pipe, ANSI 900# flanges. Pipe will be buried and coated for cathodic protection. There is one railroad crossing along the path.

MMV Program

- Monitoring options were reviewed and a subset of options was selected based on the proposed injection system specifications and geologic setting.
- Depth of target reservoir, injection volume, presents challenges for effective MMV methods.

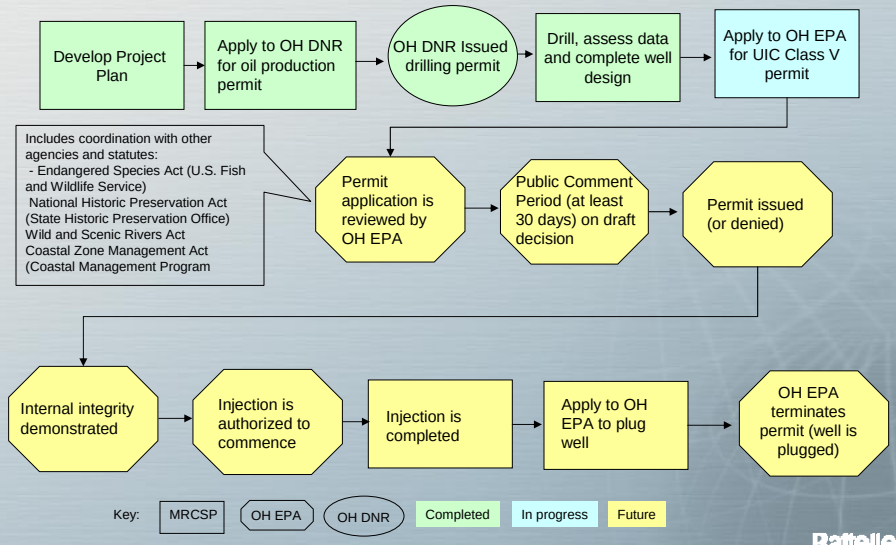


Appalachian Basin											
Time (Months)	-3	-2	-1	1	2	3	4	5	1	2	3
Phase	Pre Demo			Active Injection					Post Injection		
Injection System (PVT)				X	X	X	X	X			
Health and Safety				X	X	X	X	X			
Repeat Wireline (RST, PEX)			X			X			X		X
Reservoir Sampling			X						X		
Short-Lived Tracers					X		X		X		X

Permitting Track

- Ohio has Underground Injection Control primacy and Ohio EPA regulates Class I and Class V wells.
- A series of meetings have been held with both regulatory agencies to discuss the permitting strategy as the project progresses.
- FirstEnergy has been part of all discussions and Battelle and FirstEnergy are jointly preparing the permit documents
- A UIC *Class V Experimental Technology Injection Permit Application for Pilot Carbon Sequestration was submitted in December 2007 following review by FirstEnergy*.

Key Regulatory Steps in Ohio (R.E. Burger Pilot)



Timeline and Next Steps for the Appalachian Basin Test Site

- Complete CMR logging, Pressure Express tests, and/or sidewall coring in key intervals at the R.E. Burger FEGENCO#1 well to delineate permeability better in these rock intervals.
- Obtain UIC permit for CO_2 injection tests at the site.
- Develop injection plan for site. Given the low injection volume, a more exploratory approach may be more useful to determine injection potential across multiple units.
- Refine geological framework for CO_2 sequestration in Middle-Devonian to Middle-Silurian targets for the region.
- Continue to characterize new horizons for sequestration in the MRCSP region.