FACT SHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Midwest Regional Carbon Sequestration Partnership (MRCSP)

NETL Cooperative Agreement DE-FC26-05NT42589

DOE/NETL Project Manager: Lynn Brickett,
Lynn.Brickett@NETL.DOE.GOV

Submitted by Battelle

November 2007

Cincinnati Arch Geologic Test, East Bend Power Plant	
Principal Investigator	Dave Ball, Battelle (614-424-4901; balld@battelle.org)
Test Location	Duke Energy East Bend Plant, Rabbit Hash, Kentucky
Amount and Source of CO_2	1000-3000 metric tons Source = Trucked in from a commercial source (TBD) or possibly from Babcock and Wilcox oxy-coal combustion system in SE Ohio.
Field Test Partners (Primary Sponsors)	Duke Energy
	Kentucky Geological Survey and Indiana Geological Survey

Summary of Field Test Site and Operations:
The site location is in Boone County, Kentucky, along the Ohio River near Rabbit Hash, Kentucky. The test site is located at the Duke Energy East Bend facility, a 650 MW coal-burning power plant (Figure 1). The plant is located on 1,800 acres on the floodplain along a bend in the Ohio River, with terrain becoming hilly away from the Ohio River Valley. The plant is an industrial setting, with various generating buildings, coal staging areas, and other facilities. The site is located on an active plant which is providing property access for the field work and other support that should aid in completing the project. The area is moderately developed with a large amount of land available for field work. This site represents a fairly typical setting for the Cincinnati Arch which is considered a significant feature for CO_2 storage in the region. As such, information gathered at this site would be useful over much of the MRCSP region.

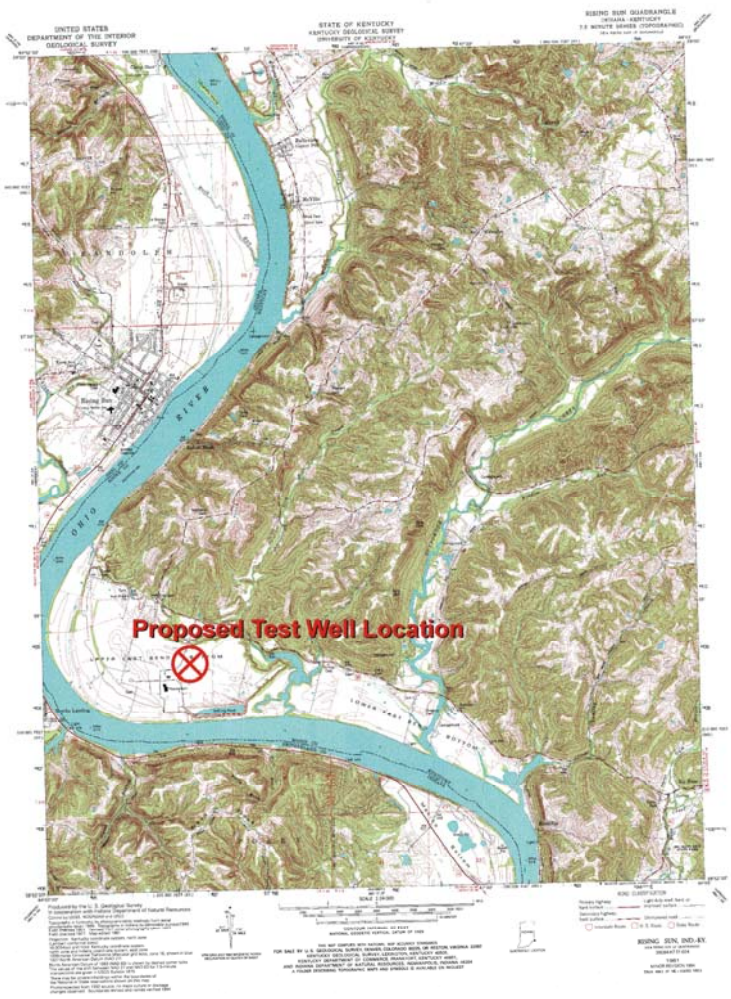


Figure 1. Site location map

The site is situated along the Cincinnati Arch, a regional geologic structure in which sedimentary rocks form an arch between the Appalachian and Illinois basins. Like most of the MRCSP region, thick sequences of sedimentary rock overlie Precambrian age basement rock at the site. The objective at this site is injection into a deep regional saline formation. The site is representative of the geology of a large part of the MRCSP region. Thus, this test site is exemplary of current or potential future power plants in the region.

The target reservoir is the Mt. Simon sandstone. This formation is an extensive sandstone rock unit that has been historically used for injection of industrial and hazardous liquid waste in the MRCSP region. This unit is expected to have a higher amount of porosity and permeability in the Arches Province, suggesting that it would be suitable for CO_2 sequestration. Geological correlations based on nearby wells indicate that the formation is 300 ft thick at a depth interval of about 3,200-3,500 ft below surface at the site (Figure 2). Precambrian-age sandstones potentially underlie the Mt. Simon sandstone. These rocks are probably too densely packed to serve as storage reservoirs, but they are not that well characterized in the region.

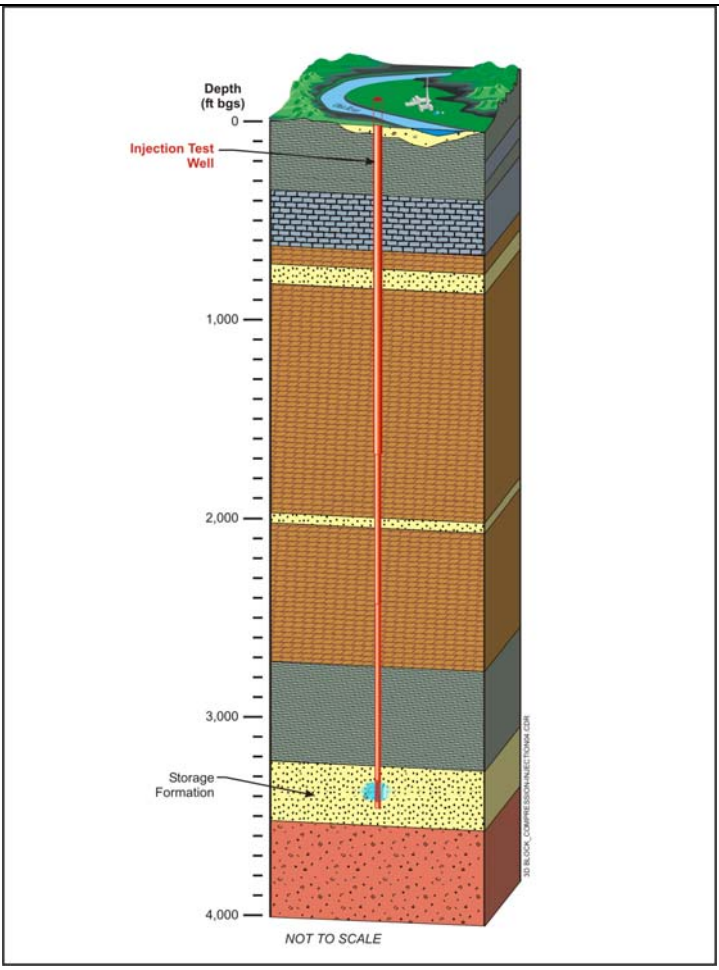


Figure 2. Conceptual diagram of CO_2 sequestration tests for East Bend site

The Eau Claire shale provides containment above Mt. Simon sandstone. This low permeability shale unit is approximately 500 ft thick and extends throughout the region. There is very little oil and gas production in the area, and it is limited to shallower rock units. No wells penetrate the Mt. Simon sandstone within 2 miles of the site. Target storage formations in the area are saturated with heavy brines (TDS > 100,000 mg/L) that have no economic value. The deepest underground drinking water source is bedrock units less than 250 ft deep, but most groundwater is obtained from the Ohio River Valley alluvium. No extensive faulting is present in the study area. Rocks dip very gently to the east at less than 40 ft/mile.

Overall, the regional geology in the area is well-characterized and generally continuous in the region. However, site specific information on the Mt. Simon sandstone is limited because there are very few deep wells in the area. While it appears fairly certain that the Mt. Simon sandstone is about 300 ft thick in the area, the permeability and porosity of the unit need to be investigated.

The overall site plan for the East Bend Site is to perform a relatively thorough characterization of the site geology and perform limited injection testing and monitoring. The Mt. Simon sandstone has been identified as the primary storage target at this site. General steps of the site plan are listed as follows:

1) Preliminary Geologic Assessment of Potential Storage Reservoirs and Caprocks − This work will involve compiling available well logs, developing geologic cross-sections, delineating target storage reservoirs, and identifying any issues related to geologic storage that may affect the project. Indiana and Kentucky Geologic Surveys will complete most of this task because they are the repository for geologic data in the region of interest.

2) Site Characterization Field Work − Based on results of the preliminary geologic assessment, a fairly

thorough site characterization field effort will be completed. Field work is proposed at the existing power plant or adjacent property. At the Cincinnati Arch Site, little test data exists on the main storage target, the Mt. Simon sandstone. Consequently, it will be necessary to perform a fairly thorough characterization effort. Drilling a new stratigraphic test at the site that may be used for injection testing is planned. Well installation will also involve rock coring, logging, and/or reservoir testing.

3) CO_2 Injection Testing and Monitoring − At this early stage, the goal at the Cincinnati Arch site is to inject up to 3,000 metric tons of CO_2 into the Mt. Simon sandstone and do more detailed monitoring of its fate in the reservoir. Well completion specifications (Figure 3) and an injection schedule are being planned. Actual test conditions, injection rates, and targets will be a function of the site conditions and budget. If feasible, CO_2 may be obtained from a Babcock and Wilcox oxy-coal combustion system in southeastern Ohio. Otherwise, CO_2 will be purchased from a commercial source.

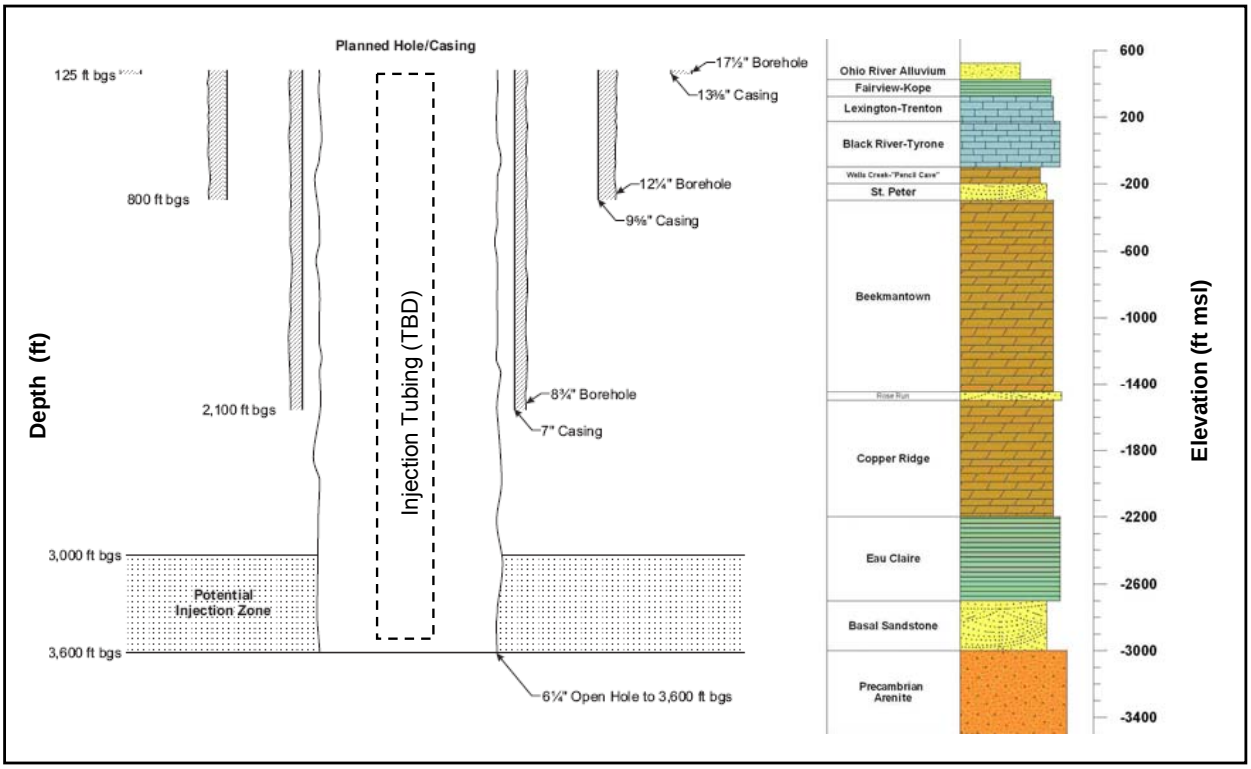


Figure 3. Geologic stratigraphic column showing estimated lithology and preliminary well design

4) Post-injection Monitoring and Site Closure − Once injection has been completed, some closure monitoring will be performed to assess the fate of the injected CO_2. A relatively small injection volume is planned at this site so venting after injection or a "push-pull" approach may be considered to eliminate the risk of CO_2 for the plant.

Currently, the preliminary geologic assessment has been completed and field work has started. A work plan will be developed prior to starting field work, including a site health and safety plan(s). No CO_2 has been injected at the East Bend site as of September 2006.

Research Objectives:

The primary research objective is to demonstrate CO_2 sequestration in the Mt. Simon sandstone, a major CO_2 sequestration target for the MRCSP region (and the United States). Since the Mt. Simon sandstone extends throughout the Midwestern United States, much of the information from this test will be useful for other portions of the MRCSP and beyond. In addition to this main objective, the tests are aimed at better understanding regional trends (i.e. permeability, porosity, geochemistry, mineralogy) in the Mt. Simon sandstone.

With regard to injection tests, the work is aimed at demonstrating CO_2 sequestration processes in older

Paleozoic rocks in the Midwest. Since the Mt. Simon sandstone is 300 ft thick at the site, tests may be able to reveal any tendency for upward migration of the CO_2 plume. In addition, it is likely that rock-water interactions may be studied at the site.

Summary of Modeling and MMV Efforts (Use the table provided for MMV):
Since no detailed site-specific data are available from the site, initial modeling has entailed simplified STOMPCO_2 simulations based on assumed hydrologic parameters and injection system specifications (i.e. 300 ft sandstone reservoir at 3200-3500 ft, 1000-3000 tons injection over 30 days, etc.) The objective of this preliminary modeling was to provide guidance on monitoring and liability issues. Initial modeling suggests little migration of CO2 from the point of injection (100's of feet). Data from a test well will be collected to support the modeling of migration before any gas is injected.

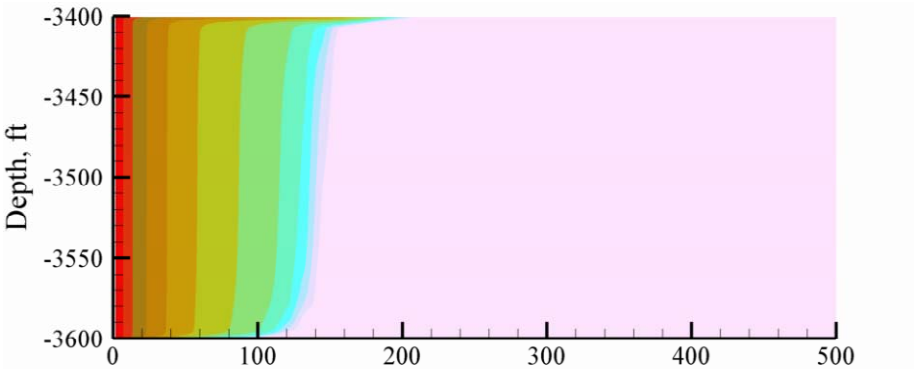


Figure 4. Preliminary STOMPCO_2 simulation showing gas saturation extent after 60-days of injection 200 tons CO_2 per day in a 200 ft thick Mt. Simon sandstone

Monitoring technologies for CO_2 sequestration were reviewed and a subset of options was selected based on the proposed injection system specifications and geologic setting. A complete monitoring plan and schedule will be determined after site characterization efforts are finished.

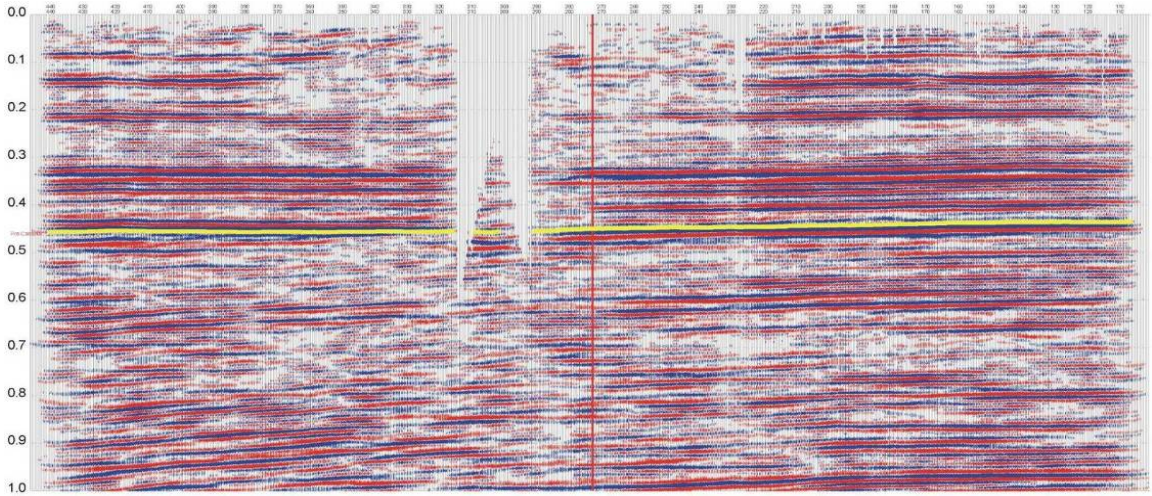
The proposed monitoring methods are given in Table 1 for the East Bend site. Since the injection interval is fairly thick, the monitoring approach may involve tracking the upward migration (if any) of the injected CO_2. Accordingly, cross-well seismic/vertical seismic profiling and wireline methods are considered the most promising for this site.

Accomplishments to Date:
Most work for the East Bend site has involved site preparation, preliminary geologic assessment, and seismic survey:

- Site preparation activities were completed including survey of the site for suitable test well location, seismic survey lines, and injection system. A test well location was selected and cleared with East Bend plant personnel.
- Stakeholder outreach groundwork was completed. This included several meetings with the Duke Energy internal project team and East Bend plant staff to inform them about the test.
- An informational letter and supporting material was sent to neighbors within a five mile radius of the plant. An open house was held at the plant in August 2006 to discuss the project and answer questions. The open house was attended by approximately 30 people. In conjunction with the open house a briefing was held with Boone County officials at their offices.
- A preliminary geologic assessment was completed by the Indiana and Kentucky Geological Survey describing the regional geologic setting, target sequestration rock formations, and other issues.
- Preliminary well construction specifications and a drilling plan were prepared for the site.
- Permitting discussions were completed with Region 4 EPA to determine Underground Injection

Control (UIC) procedures for the test well and injection tests. A permit to construct the test well was started.

- A 2D seismic survey acquisition was completed at the Cincinnati Arch East Bend site October 26-November 7. Two 5-mile transects were completed through the site with vibroseis trucks as a source and a geophone array for recording. Some delays occurred in setting up the microwave telemetry across the Ohio River because of the wide bend in the river, but the acquisition was otherwise successful. The seismic suggests that the target Mt. Simon interval is continuous through the test site with no faulting or fracturing which would affect the tests. Additional processing of the data was completed to resolve some of the deeper features. On the whole,



N-S Seismic Line from East Bend site. Yellow line shows surface of Precambrian rocks. Red vertical line is proposed well location. Note: gap in data coverage is across Ohio River.

analysis of the seismic has been completed until the test well is completed.

- Preliminary plans for site characterization and testing were completed. These plans outline the general approach to drilling a test well, geophysical logging, core sampling, brine sampling, and other testing prior to injection. Accordingly, contractors were contacted for availability and price quotes for the field work. A test well site has been tentatively selected. A work plan for the field work was developed outlining procedures and health and safety practices.

Summarize Target Sink Storage Opportunities and Benefits to the Region:

- The target sink is the Mt. Simon sandstone, a major sequestration target in the MRCSP and Midwestern U.S. Test results may be applied for much of the MRCSP region and the Midwest.
- Added value from using CO_2 from Babcock and Wilcox oxy-coal combustion system in the area of carbon capture and separation.
- Added value in performing the test at an active power plant to demonstrate CO_2 sequestration in a real-world setting.
- Added value from partnering with a major power company toward promoting carbon capture and geologic storage (CCS) in the energy industry.

Cost*:

Total Project Cost: $23,745,399

DOE Share: $17,458,272 (73.52%)

Non-Doe Share: $6,287,127 (26.48%)

(*) Costs are for overall MRCSP Phase II proje

Field Project Key Dates:

Baseline Completed: Summer 2007

Drilling Operations Begin: Late Summer 2007

Injection Operations Begin: Fall 2008

MMV Events: TBD

Table 1. Measurement Technologies Employed at Field Test Site

Measurement Technique	Measurement Parameters	Application
Water composition	CO_2, HCO_3, CO_3^{2-} Major ions Trace elements Salinity	Quantifying solubility and mineral trapping Quantifying CO_2-water-rock interactions Detecting leakage into shallow groundwater aquifers
Subsurface pressure	Formation pressure Annulus pressure Groundwater aquifer pressure	Control of formation pressure below fracture gradient Wellbore and injection tubing condition Leakage out of the storage formation
Well logs	Brine salinity Sonic velocity CO_2 saturation	Tracking CO_2 movement in and above storage formation Tracking migration of brine into shallow aquifers Calibrating seismic velocities for 3D seismic surveys
Vertical seismic profiling and crosswell seismic imaging	P and S wave velocity Reflection horizons Seismic amplitude attenuation	Detecting detailed distribution of CO_2 in the storage formation Detection leakage through faults and fractures

Source: IPCC Special Report on Carbon Dioxide Capture and Storage