Phase II Field Demonstration at Plant Smith Generating Station: Assessment of Opportunities for Optimal Reservoir Pressure Control, Plume Management and Produced Water Strategies

DE-FE0026140

Robert C. Trautz
Electric Power Research Institute

U.S. Department of Energy
National Energy Technology Laboratory
Mastering the Subsurface Through Technology Innovation, Partnerships and Collaboration: Carbon Storage and Oil and Natural Gas Technologies Review Meeting
August 1-3, 2017
Presentation Outline

- Technical Status
  - Permitting
  - Design
  - Planning
- Accomplishments to Date
- Lessons Learned
- Synergy Opportunities
- Project Summary
- Appendix
Technical Status
Phase I Site Screening and Down Selection Resulted in Selection of Plant Smith

- Evaluated existing geologic, geophysical and hydrologic data in the vicinity of each site, including
  - Well records, logs, core data, regional structural and stratigraphic studies and subsurface production/injection data
- Examined existing surface infrastructure at each plant
- Gaged plant commitment to hosting the BEST project
- Selected Plant Smith

Plant Bowen, Euharlee GA
Plant Daniel, Escatawpa MS
Plant Gorgas, near Parrish AL
Plant Miller, near West Jefferson AL
Kemper Co Energy Facility, MS
Plant Smith Overview

- Multiple confining units
- Thick, permeable saline aquifers
  - Eocene Series (870-2,360)
  - Tuscaloosa Group (4,920-7,050 ft)
  - Represent significant CO₂ storage targets in the southeast US
- Large Gulf Power Co. waste water injection project under construction (infrastructure)
- Water injection pressures will be managed as a proxy for CO₂ injection (~500k-1,000 gal/day)

No CO₂ injection will take place
Phase II Will Demonstrate Effectiveness of Passive and Active Pressure Management

- Passive pressure relief in conjunction with active pumping can reduce pressure buildup, pumping costs and extraction volume
- Existing “pressure relief well” and “new” extraction well will be used to validate passive and active pressure management strategies
- Test effectiveness of LBNL adaptive optimization methods and tools to manage overall reservoir system response using uncertain formation parameters

Pressure relief well reduces extraction volume by 40%
Permitting

- Florida Department of Environmental Protection (FDEP) has primacy over Class I non-hazardous waste wells
- State has rigorous UIC standards to protect water resources
  - Well construction (casing/tubing diameters & thickness, cement thickness, materials of use)
  - Temporary monitoring wells to evaluate potential impacts during drilling
  - Permanent monitor well to evaluate potential impact from injection
  - Construction standards are being applied to BEST project’s extraction well

BEST submitted a minor modification to Gulf Power’s existing well permit
Experimental Design

- Further refinement of the adaptive optimization algorithm
- 18-month injection at 1,090 m$^3$/d (200 gal/min) into two layers of the Lower Tuscaloosa creates radially extensive pressure plume
- Simulation of optimum extraction rates for test design, pump capacity and permitting
  - Sensitivity study to determine optimum range of pumping rates based on uncertainty in permeability (+/-20%, +/-50% variation around base case)
  - Optimized to prevent pressure buildup >0.3 Mpa on a hypothetical faults

Optimized extraction rates range from 4-12% of injection
Well Field Infrastructure Design

- Developed detailed technical specifications for:
  - Well pads
  - Extraction well
  - Injection well including four casin/tubing options
  - Flowline
  - Submersible pump
  - Power requirements

- Plant Smith site visit and pre-bid meeting with perspective drillers
  - Four drilling firms attended
  - Only two Florida-based firms responded with bids
  - Large disparity between prices

![Diagram showing infrastructure layout](image-url)
Water Treatment User Facility Design

- Preliminary design provides different water qualities for testing by DOE researchers and commercial water treatment vendors
  - High salinity (166,000 mg/L TDS) Tuscaloosa water only
  - Low salinity fresh or waste water (30-1,000 mg/L TDS) from Plant Smith
  - Intermediate salinity (30-166,000 mg/L TDS) by mixing in a blending tank

Flow diagram showing major components of the EPRI water treatment user facility
Accomplishments to Date

✓ Permitting
  – Submitted minor modification to existing permit (May 2017)
  – Responded to FDEP request for information (July 2017)
  – Permit approval pending (August 2017??)

✓ Experimental Design
  – Scoped extraction rates to select submersible pump size

✓ Well field infrastructure design
  – Developed design and technical specifications for infrastructure
  – Selected qualified Florida certified driller

✓ Water treatment user facility design
  – Preliminary design and costs completed
  – Vendor requirements are needed before completing design
Lessons Learned

- Project cost drivers
  - Each state has unique UIC regulatory requirements and guidelines that can impact well construction and project costs
  - Florida drilling market for waste-water injection wells is not very competitive as shown by the large disparity in bids ($6.9M vs. $11.0M)
  - Cost of small diameter extraction well drilled to 5,400 ft with 5-inch production casing is $2.8M. Much higher than expected!!!!

Project anticipated high injection well costs but not for the extraction well
Synergy Opportunities

- EPRI and EERC are developing water treatment user facilities to test and validate water desalination technologies.
- EERC and EPRI jointly developed a technology screening questionnaire and selection criteria for hosting the water treatment technologies at the BEST project sites.
- The BEST projects plan on holding annual or semi-annual meetings:
  - Tech transfer and cross-fertilization of approaches and ideas
  - Provide project updates, technology transfer, lessons learned and experiences
Project Summary and Next Steps

- **Summary**
  - Budget Period (BP) 2 is nearing completion
  - Permit modification submitted and pending regulatory approval
  - Final well field infrastructure design is nearly complete
  - Preliminary design and costs were developed for the water treatment user facility (input from users/vendors is still needed)
  - Continuing application for BP3 submitted

- **BP3 (2017-2019) plans include:**
  - Installation of the well field infrastructure
  - Final design and installation of the water treatment user facility
  - Equipment commissioning
  - 2-3 months of injection followed by 15-16 months of injection and extraction

- **BP4 (2019-2020) plans include:**
  - Site restoration
  - Final reporting
Together…Shaping the Future of Electricity
Appendix
Benefit to the Program

- **Program Goals**
  - Develop cost effective pressure control, plume management and produced water strategies that can be used to improve reservoir storage efficiency and capacity, and demonstrate safe, reliable containment of CO₂ in deep geologic formations with CO₂ permanence of 99% or better.

- **Benefit Statement**
  The project will...
  - Use optimization methods and smart search algorithms coupled with reservoir models and advanced well completion and monitoring technologies to develop strategies that allocate flow and control pressure in the subsurface.
  - Address the technical, economic and logistical challenges that CO₂ storage operators will face when implementing a pressure control and plume management program at a power station and increase our knowledge of potential storage opportunities in the southeast region of the U.S.
  - Contribute to the development cost effective pressure control, plume management and produced water strategies that can be used to improve reservoir storage efficiency and capacity, and demonstrate safe, reliable containment of CO₂ in deep geologic formations with CO₂ permanence of 99% or better.
  - And the operational experiences of fielding a water management project at a power station can be incorporated into DOE best practice manuals, if appropriate.
Objective: Develop cost effective pressure control, plume management and produced water strategies for: 1) Managing subsurface pressure; 2) Validating treatment technologies for high salinity brines.

Pressure management practices are needed to avoid risks identified in white boxes. Brine extraction is a possible remedy for reducing or mitigating risk requiring further research.
# Phase I Project Schedule

<table>
<thead>
<tr>
<th>Description</th>
<th>Start Date</th>
<th>End Date</th>
<th>Dur. Mos.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task 1.0 Project Management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revise Project Management plan</td>
<td>9/1/2015</td>
<td>11/30/2015</td>
<td>3</td>
</tr>
<tr>
<td>NEPA approval</td>
<td>9/1/2015</td>
<td>10/31/2015</td>
<td>2</td>
</tr>
<tr>
<td>Project management</td>
<td>9/1/2015</td>
<td>8/31/2016</td>
<td>Ongoing</td>
</tr>
<tr>
<td><strong>Task 2.0 Site Screening and Down-Selection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 - Regional and Local Data Availability</td>
<td>9/1/2015</td>
<td>10/31/2015</td>
<td>2</td>
</tr>
<tr>
<td>2.2 - Site Ranking and Selection</td>
<td>11/1/2015</td>
<td>4/30/2016</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Task 3.0 Produced Water Life Cycle Analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 - Define Finish Water Specifications</td>
<td>9/1/2015</td>
<td>2/28/2015</td>
<td>3.5</td>
</tr>
<tr>
<td>3.2 - Produced Water Extraction Scenario Development</td>
<td>10/1/2015</td>
<td>1/31/2016</td>
<td>4</td>
</tr>
<tr>
<td>3.3 - Water Treatment Technology Screening</td>
<td>1/31/2016</td>
<td>3/31/2016</td>
<td>3</td>
</tr>
<tr>
<td>3.4 - Transportation Infrastructure</td>
<td>2/1/2016</td>
<td>3/31/2016</td>
<td>1</td>
</tr>
<tr>
<td>3.5 - Integrated Economic Analysis</td>
<td>4/1/2016</td>
<td>6/30/2016</td>
<td>3</td>
</tr>
<tr>
<td><strong>Task 4.0 Pressure Control and Optimization Strategy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1 - Static Geologic Model Development</td>
<td>11/1/2015</td>
<td>12/31/2016</td>
<td>2</td>
</tr>
<tr>
<td>4.2 - Reservoir and Geomechanical Predictions</td>
<td>11/1/2016</td>
<td>2/29/2016</td>
<td>4</td>
</tr>
<tr>
<td>4.3 - Development and Optimization of Pressure Management Strategies</td>
<td>1/1/2016</td>
<td>3/31/2016</td>
<td>3</td>
</tr>
<tr>
<td>4.4 - Predicting Detectability of Reservoir Response for MVA Planning</td>
<td>3/1/2016</td>
<td>3/31/2016</td>
<td>1</td>
</tr>
<tr>
<td>4.5 - Advanced Well Technology Feasibility Analysis</td>
<td>2/15/2016</td>
<td>3/31/2016</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Task 5.0 Advanced MVA Program</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1 - Injection Monitoring and Optimization</td>
<td>3/1/2016</td>
<td>4/30/2016</td>
<td>2</td>
</tr>
<tr>
<td>5.2 - Far-Field Monitoring Program</td>
<td>3/1/2016</td>
<td>4/30/2016</td>
<td>2</td>
</tr>
<tr>
<td><strong>Task 6.0 Develop Phase II Field Demonstration Work Plan, Cost &amp; Schedule</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1 - Site Characterization Plan</td>
<td>4/1/2016</td>
<td>4/30/2016</td>
<td>1</td>
</tr>
<tr>
<td>6.2 - Drilling Plan</td>
<td>4/1/2016</td>
<td>4/30/2016</td>
<td>1</td>
</tr>
<tr>
<td>6.3 - Testing, Monitoring &amp; Sampling Plan</td>
<td>4/1/2016</td>
<td>5/31/2016</td>
<td>2</td>
</tr>
<tr>
<td>6.4 - Surface Infrastructure &amp; Implementation Plan</td>
<td>4/1/2016</td>
<td>5/31/2016</td>
<td>2</td>
</tr>
<tr>
<td>6.5 - Field Demonstration Cost and Schedule</td>
<td>5/1/2016</td>
<td>5/31/2016</td>
<td>1</td>
</tr>
</tbody>
</table>
Bibliography

- None