Statistical Analysis of CO$_2$ Exposed Wells to Predict Long Term Leakage through the Development of an Integrated Neural-Genetic Algorithm

Project DE FE0009284

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U.S. Department of Energy
National Energy Technology Laboratory
Carbon Storage R&D Project Review Meeting
Developing the Technologies and Infrastructure for CCS
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Presentation Outline

• Benefit to DOE Program
• Project Overview
• Technical Status
• Accomplishments to Date
• Summary
Benefit to DOE Program

The project conducts research under DOE’s Fossil Energy Research and Development Area of Interest 1, Studies of Existing Wellbores Exposed to CO₂. The project will perform analysis of available industry and regulatory data to assess risks of well failure by various factors such as age of construction, region, construction materials, incident reports, logging and Mechanical Integrity Testing.

The computer model developed in this project will contribute to the DOE programs’ effort of ensuring 99% CO₂ storage permanence in the injection zone(s) for 1000 years and support the development of Best Practices Manual.
Project Overview

The overall **objective** of this project is the development of a novel computer model for predicting long-term leakage risks of wells exposed to CO$_2$.

The final **goal** is to deliver DOE and public a useful tool for evaluating the risk of long-term leakage of wells in future CO$_2$ sequestration projects.
Technical Status

Potential CO2 leakage paths (modified from Celia, 2004)

** PRIMARY **
1. Incomplete annular cementing job, doesn’t reach seal layer
2. Lack of cement plug or permanent packer
3. Failure of the casing by burst or collapse
4. Poor Bonding caused by Mudcake
5. Channeling in the cement
6. Primary permeability in Cement Sheath or Cement plug

** SECONDARY **
7. De-bonding due to tensile stress on Casing-cement-formation boundaries
8. Fractures in cement and formation
9. Chemical dissolution and carbonation of cement
Accomplishments to Date
The number of CO$_2$-EOR projects has increased to 123 in 2012.
- **Oyster Bayou oil field in Chambers County**
- It is in a deep (8,500 ft) reservoir with light 39° gravity oil.
The Oyster Bayou Oil Field (Frio sandstone) miscible CO₂ flood covers 3,900 acres.

It is in a deep (8,500 ft) reservoir with light 39° gravity oil.
- Denbury started injecting CO₂ for enhancing oil production in December 2010.
- In January, 2012, Denbury commenced tertiary oil production, the largest field flooded with CO₂ to-date.
- The CO₂ flood is in a moderate depth (5,700 ft) formation with 31° gravity oil.
Data Mining Area

- CO2 injection well information, including well general information, completion, cementing, well integrity information, etc.

- Plugged wells in the ¼ mile radius of CO2 injection well, and get these wells’ information including well general information, completion, cementing, plugged information, well integrity information, etc.
## Data Mining Result

<table>
<thead>
<tr>
<th>Oil Field</th>
<th>CO₂ Injection Wells</th>
<th>Plugged Wells</th>
<th>Subtotal</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Hastings</td>
<td>25</td>
<td>55</td>
<td>80</td>
</tr>
<tr>
<td>Oyster Bayou</td>
<td>56</td>
<td>372</td>
<td>428</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>81</strong></td>
<td><strong>427</strong></td>
<td><strong>508</strong></td>
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</tbody>
</table>
Summary

- Data have been collected from 508 CO2-exposed Wells in 2 GoM oil fields.

- Data set for some wells are not complete.

- Future effort will focus on collecting more data from RCT and private sectors.
Appendix

- Organization Chart
- Gantt Chart
- Bibliography
## Gantt Chart

<table>
<thead>
<tr>
<th>Year</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Team Member and Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarter</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
</tr>
<tr>
<td><strong>Task 1: Project Management and Planning</strong></td>
<td></td>
<td></td>
<td></td>
<td>Guo (PI), Nygaard (Co-PI), Duguid (Co-PI)</td>
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<tr>
<td><strong>Task 2: Data Mining</strong></td>
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<td></td>
<td>Guo (PI), Nygaard (Co-PI), Duguid (Co-PI)</td>
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<td><strong>Task 3: Statistical Analysis of Database</strong></td>
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<td>Nygaard (Co-PI)</td>
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<td><strong>Task 4: Developing Leakage Scenarios</strong></td>
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<td>Guo (PI), Nygaard (Co-PI), Duguid (Co-PI)</td>
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<td><strong>Task 5: Constructing Preliminary Neural-Genetic Algorithm</strong></td>
<td></td>
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<td>Guo (PI), Sedaghat and Li</td>
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**Task 6:** Constructing Comprehensive Neural-Genetic Algorithm

**Task 7:** Field Work Confirmation of Leakage Scenarios

**Task 8:** Field Sample Analysis

**Task 9:** Verification of Model with Field and Lab Results

**Task 10:** Risk Study, Mitigation Actions, and Standard Recommendations
1 May 2013, Project Kickoff

31 March 2014, End of Task 2
Criterion: Data collected from more than 200~500 wells?

Yes

30 June 2014, End of Task 4
Criterion: Identified 4 leakage scenarios?

No

Decision Point 2: (Major)

Contact DOE Project Manager for Advice

Yes

30 Sept 2014, End of Task 6
Criterion: Developed a comprehensive NGA model?

No

Decision Point 3: (Major)

31 March 2015, End of Task 7
Criterion: Field Work Confirmation of Leakage Scenarios?

No

Decision Point 4:

30 Sept 2015, End of Task 9
Criterion: Verification of Model with Field and Lab Results?

Yes

Complete Project

No