Wabash CarbonSAFE

DE-FE0031626

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U.S. Department of Energy National Energy Technology Laboratory **Carbon Storage Project Review Meeting** September 8-11 2020

Program Overview

- Funding

- Federal Share: \$11,440,875
- Non-Federal Share \$8,110,652
- Total: \$19,551,527
- Overall Project Performance Dates
 - BP1 (February 1, 2019 July 31, 2020)
 - BP2 (August 1, 2020 May 31, 2021)
- Overall Project Objectives
 - Assess the feasibility of developing a commercial-scale geological storage complex at WVR ammonia facility near Terre Haute IN, that could store up to 50 million tonnes of industrially-sourced CO₂.

Illinois State Geological SurveyPRAIRIE RESEARCH INSTITUTE

Wabash CarbonSAFE (Tasks/Partners)

- Task 1.0 Project Management and Planning
- Task 2.0 Risk Assessment and Monitoring
- Task 3.0 National Risk Assessment Partnership (NRAP) Screening
- Task 4.0 Stakeholder Engagement and Public Outreach
- Task 5.0 Business and Economic Development Assessment
- Task 6.0 Permitting and Compliance
- Task 7.0 Subsurface Characterization
- Task 8.0 Drilling and Well Testing
- Task 9.0 Storage Complex Modeling
- Task 10.0 Infrastructure Development
- Task 11.0 Storage Complex Development Planning



Illinois State Geological Survey prairie research institute

















Technology Section (Site Selection & Benefits)



Technology Section (Prior Site Characterization)

Mt. Simon Sandstone at Wabash



Nearest deep well(s) to Wabash:

75mi NW: lower Mt. Simon, zone of high porosity
22mi N: upper Mt. Simon only, disposal
25mi SE: upper Mt. Simon
50mi S: lower Mt. Simon, deeper and lower porosity

Data collection necessary, characterization Fill data gaps, expand storage resource



Technical Approach/Project Scope

Project milestones

Task		Milestone	Planned	Completion	Verification Method
	D		Completion		
1.0/1.1	A	Project Kickoff Meeting	04/01/19	03/21/19	Attend Meeting, Presentation File
1.0/1.2	В	Revised Project Management Plan	03/29/19	03/27/19	File provided to DOE
1.0/1.4	С	Finalized Communication Plan	06/02/19	03/27/19	File provided to DOE
2.0/2.1	D	Risk Assessment Summary	4/30/21		Summary in quarterly reports
3.0/3.1	E	NRAP Assessment Report	3/31/21		File provided to DOE
5.0/5.1	F	Business and Financial Case Study	3/31/21		File provided to DOE
6.0/6.2	G	Obtain Stratigraphic Well Drilling Permit	10/31/19	11/12/19	Summary in quarterly reports
7.0/7.1	Н	Pre-Drilling Site Assessment	07/31/19	11/27/19	File provided to DOE
7.0/7.4	I	Regional 2D Seismic Survey	10/31/19	08/21/19	Summary in quarterly reports
7.0/7.5	J	Deliver Integrated Data for Modeling	2/28/21		Data provided
8.0/8.2	К	Stratigraphic Test Well Completed	5/31/20	02/07/20	Summary in quarterly reports
9.0/9.4	L	Report on Modeling	3/31/21		Summary in quarterly reports
10.0/10.1	M	CO2 Source Assessment	1/31/21		File provided to DOE
11.0/11.1	N	Detailed Characterization Plan	05/31/21		File provided to DOE

Technical Approach/Project Scope

Significant project risks and mitigation strategies

Table 3: Project Risks and	d Mitigation St	trategies	
Description of Risk	Probability	Impact	Mitigation and Response Strategies
Technical Risks:			
Unsuitable geology	Low	High	Select secondary storage sites
			 Select multiple storage reservoirs
Lack of data	Med	Med	 Develop data acquisition strategy
Delays or difficulty	Med	High	 Conduct Drill On Paper exercises
when drilling well			• Monitor drilling activities daily
Non-technical Risks:			
Negative stakeholder	Med	Med-High	Develop comprehensive
response		e	stakeholder engagement strategy
Lack of policy support	Med	Med-High	• Continue to interface with decision-makers
Resource Risks			
CO ₂ source not available	Low	High	 Identify additional sources
			 Develop network of potential sources
Lack of team skills to	Low	Med	• Continue to build team capacity
populate CCS Team			• Grow team over time
Unable to achieve	Med	High	• Continue to seek new funding sources
financial support to			• Seek additional partners to contribute support
progress project			
Management risks			
Key personnel loss	Low	Med	 Maintain back-up and depth in team
			 Maintain proper project management practices
Project cost over runs	Med	High	Drilling well represents largest
		Ũ	risk, monitor costs and
			performance daily

Progress and Current Status Data acquisition

Recent significant accomplishments:

- Wabash #1 permit (6+ months); spud 11/29/19
- TD 8,739 ft on 02/07/2020
- Cored 245 ft (2 seals + target reservoir) + RSWC
- Full suite of geophysical logs
- Two DSTs prior to cased-hole well testing



Progress and Current Status Geological Characterization

Seal: Eau Claire Fm

Eau

Upper

Mt.Simon

Middle

Lower Mt.Simon

Rasalt

Mt.Simon

Claire

- 905 ft thick @ 5,322 ft MD
- 66 ft core, few RSWC

Mt. Simon Sandstone

- 2,238 ft thick @ 6,277 ft MD
- Lower porosity than IBDP wells

Reservoir Target: Lower Mt. Simon – 'Arkosic zone'

- ~260 ft thick, 119 ft cored @ 7,900-8,019'
- Routine, CT scan, thin section, petrography
- Cored section: log poros avg 12.7%

Primary porosity; minor secondary

- partial feldspar dissolution

- quartz cements, low connectivity Zircons: some dates older than IBDP

- other sediment source/direction
- fine grain size, distal sediments



Thin Section. 7750 ft MD (Mt. Simon Sandstone).



Progress and Current Status Geological Characterization



Rotary sidewall core plug from 8530 ft MD. Unidentified basalt.



After 20 feet...



Thin Section. 8530 ft MD (basalt).



Rotary sidewall core plug from 8690 ft MD. Possible Precambrian sediments.

Surprise! Sediments beneath the basalt...

- Fast drilling; 8,650-8,720 ft log porosity avg 11.9%
- Secondary porosity via anhydrite cement partial dissol.
- Incomplete thickness 204 ft
- Tentative correlation with Precambrian Middle Run Fm. (aka 'Sandstone Below Basalt')



Thin Section. 8690 ft MD ('PC' sediments).

Progress and Current Status Geological Characterization

- Interpretation still underway
- No faults seem to be offsetting the Eau Claire Fm seal



Progress and Current Status Static Model Development

Static model: Data from:

22 x 22 mi, 740 layers, >2.6 million grid cells Core analyses, log suite, DSTs, and well tests



Wabash 3-D porosity model

Two DSTs immediately after drilling to calibrate perm:

- 7,696-8,120 (424 ft) and 6,710-6,912 (202 ft)
- single-digit millidarcy averages
- higher permeability in localized intervals

Core and RSWC analyses corroborate lower perm values

Mt.S Log porosity \rightarrow transform function \rightarrow perm. curves Non-unique results: Core-matching and DST-matching curves



Progress and Current Status Dynamic Modeling

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Preliminary simulations

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Heterogenous Nexus model

- Run numerous model scenarios (30 yrs): vary zones, vert & horiz well, by perm case
- Assess injection rates, plume dimension, max injection pressure
- In parallel, develop STOMP model for NRAP Open-IAM input
- Initial simulations informed selection of zones for cased-hole well testing program

Progress and Current Status Well Testing



Pressure Fall-Off and Step Rate Testing:

- Potosi Dolomite (Knox Gp.) selected from prior knowledge Vuggy porosity in several zones Test interval 4,505 ft to 4,525 ft Potosi results: 3-4 darcys over short interval
- Lower Mt. Simon (2) relatively higher poros/perm zones Resolve Core- vs DST-matching perm transforms 7192-7202 (between DSTs) 7976-7996 (containing DST1)
- 'PC' sandstone: 8661-8671, 8681-8691 (20 ft)

Results to be incorporated into next-generation modeling

Progress and Current Status Challenges and Integration

Challenges:

- Mt. Simon: lower porosity and perms than seen westward in IL Basin
 - 'PC' sandstone: what is reservoir potential, how widespread?
 - Evaluation of stacked saline storage w/ Potosi Dolomite...
 - commercial interests, how to best develop site?

Regional Integration:

SimCCS

- Source/sink expansion modeling
- Site data $\leftarrow \rightarrow$ Regional information

Synergies:

CarbonSAFE IL Storage Corridor **MRCI** Regional Initiative



Summary Key Findings and Future Plans

Significant accomplishments:

- Completion of BP1 milestones and data acquisition tasks
- Data analysis, geological characterization
- Preliminary dynamic simulations

Key findings to date:

- Lower Mt. Simon reservoir quality is not as good as westward in IL Basin
- Potosi Dolomite (Knox Gp.): secondary reservoir, stacked saline storage potential
- 'Precambrian' sediments below Mt. Simon Sandstone...
- Wabash #1 well information: insights into IL Basin evolution, distribution/character of Mt. Simon Sandstone

BP2 plans:

- Finish model updates, geological characterization
- Complete ongoing tasks started in BP1:
 - Risk analysis, NRAP Toolkit Assessment
 - Regional source/transport, SimCCS, business environment
 - Industry-led outreach and permitting needs



Thank You!



















This project is funded by the U.S. Department of Energy through the National Energy Technology Laboratory (NETL), under agreement DE-FE0031626.

Thank You!

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STORAGE STORAGE

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Appendix

These slides will not be discussed during the presentation, but are mandatory.

Organization Chart



Gantt Chart (Page 1 of 2)

Table 4: Gantt Chart		Q1			Q2		Q3				Q4		Q1			Q2				Q3			Q4			Q1			Q2	
	Jan	Feb	Mar	Apr	May			Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
Wabash CarbonSAFE																														
Task																														
- 1.0 PROJECT MANAGEMENT AND PLANNING				1	1	Y																								1
1.1 Manage all project activities, objectives, and milestones																														
A. Kick-off Meeting			-	•																										
1.2 Project Management Plan																														
B. Revised PMP			4																											
1.3 Knowledge Sharing and Best Practice Manuals																														
1.4 Communications																														
C. Communication Plan						+																								
1.5 Data Management																														
Data Management Plan		•																												
1.6 Access to Geologic Materials/Samples				1																										
- 2.0 RISK ASSESSMENT AND MONITORING		-		1		-	l																							-
2.1 Risk Assessment																														
D. Risk Assessment Summary																												4	•	
2.2 Develop Risk Mitigation Stratgey																														
2.3 Identify Risk Pathways for Storage Complex Development																														
3.0 NATIONAL RISK ASSESSMENT PARTNERSHIP (NRAP) SCREENING																														
3.1 NRAP Toolkit Assessment																														
E. NRAP Assessment Report																												,		
- 4.0 STAKEHOLDER ENGAGEMENT AND OUTREACH																														1
4.1 Conduct Stakeholder Analysis and Social Site Characterization																														
4.2 Contribute to Stakeholder Engagement and Outreach																														
5.0 BUSINESS AND ECONOMIC DEVELOPMENT ASSESSMENT				1	i		l																				_			
5.1 Business Environment Case Study																														
F. Business Environment Study																												,		<u> </u>
6.0 PERMITTING AND COMPLIANCE		_		1																										
6.1 Policy, Regulatory, Legal, and Permitting Case Study																														
6.2 Obtain necessary permits for characterization activities																														
G. Obtain Stratigraphic Well Drilling Permit											•																			
6.3 Develop UIC Permitting Plan				1																										
- 7.0 SUBSURFACE CHARACTERIZATION				1	l		l																				_			
7.1 Pre-Drilling Site Assessment				-																										
H. Complete Pre-Drilling Site Assessment								•																						<u> </u>
7.2 Assess Data Collected from Stratigraphic Well																														
7.3 Conduct Regional 2D Seismic Survey																														
I. Complete Regional 2D Seismic Survey											•																			
7.4 Integrate Well and Seismic Data into Geologic Models																														
J. Deliver Integrated Data for Modeling																														
7.5 Identify Future Data Requirements																														
8.0 DRILLING AND WELL TESTING				1																		1								
8.1 Design Well Drilling Program																														
8.2 Drill and Construct Stratigraphic Test Well																														
K. Stratigraphic Test Well Completed																		•												-
8.3 Testing and Data Collection																														-
9.0 STORAGE COMPLEX MODELING				1																										-
9.1 Development of Static Model				i																					\square			$ \rightarrow$		
9.2 Development of Dynamic Reservoir Model				1																										
9.3 Development of Geomechanical Model				1																								$ \rightarrow$		<u> </u>

Gantt Chart (Page 2 of 2)

Table 4: Gantt Chart			Q1		Q2		Q3			Q4				Q1					Q3				Q4		Q1				Q2	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
9.4 Calibrate and Test Model Outputs																														
L. Report on Modeling																												•		
- 10.0 INFRASTRUCTURE DEVELOPMENT																1				1										
10.1 CO2 Source Assessment																1														
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10.2 Infrastructure and Transportation Assessment																														
10.3 Develop Roadmap for Network and Storage Deploment																														
11 STORAGE COMPLEX DEVELOPMENT PLANNING													_												NA BOA BOA BOA BOA B					
11.1 Detailed Site Characterization Plan																														
N. Detailed Site Characterization Plan																													4	ł