

Systems Engineering and Analysis Projects for Task 10.0 of the Carbon Storage FWP

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Mastering the Subsurface Through Technology Innovation, Partnerships and Collaboration:
Carbon Storage and Oil and Natural Gas Technologies Review Meeting

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Presentation Outline

- Technical status
- Accomplishments to date
- Synergy opportunities
- Project summary: next steps

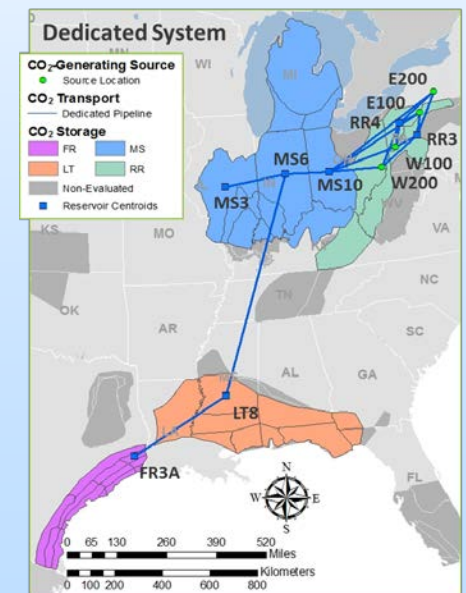
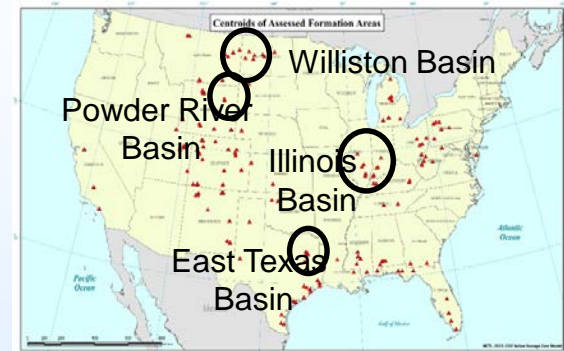
Technical Status

- This Task consists of five separate projects involving the development and application of performance and cost models for CO₂ saline storage and CO₂ enhanced oil recovery (EOR)
 - Onshore saline storage of CO₂
 - Offshore saline storage of CO₂
 - Onshore storage of CO₂ using CO₂ EOR with application to the residual oil zone (ROZ)
 - Life cycle analysis for CO₂ storage
 - Market analysis of saline storage and CO₂ EOR

Technical Status

Onshore saline storage of CO₂

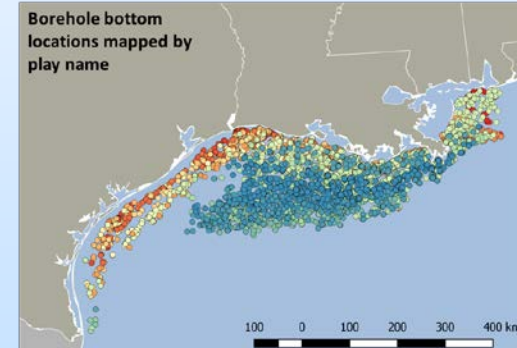
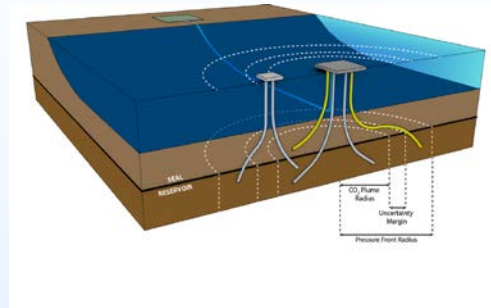
- Updated the FE/NETL CO₂ Saline Storage Cost Model and revised the FE/NETL CO₂ Transport Cost Model
 - Models will be posted to NETL website
- Updated QGESS Report: Carbon Dioxide Transport and Storage Costs in NETL Studies
 - Provides cost of transport and storage in four basins
- Performed an analysis of CO₂ transport options
 - Examined sources in northeast with storage options in Appalachia, Midwest and Southeast
 - Examined costs of dedicated pipelines versus trunk-lines with short connecting pipelines



Technical Status

Offshore saline storage of CO₂

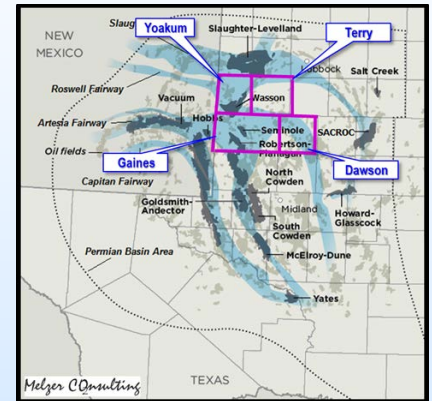
- Developed the Offshore FE/NETL CO₂ Saline Storage Cost Model
 - Model applicable to shallow water of the Gulf of Mexico (660 ft)
 - Model will be posted to NETL website
- Developing geologic database
 - Utilizing extensive data from BOEM
 - BOEM data summaries focus on sands with oil or gas
 - Need to account for all sand that could be used to store CO₂
 - » Sands without hydrocarbons are much thicker



Technical Status

Storage of CO₂ using CO₂ EOR and application of CO₂ EOR to the ROZ

- Updated the FE/NETL CO₂ Prophet Model
 - Model was too efficient at extracting oil
- Developing FE/NETL Onshore CO₂ EOR Cost Model
- Developed geologic databases for ROZ oil fields in 12 counties in Permian Basin
 - San Andres and Grayburg formations
- Developed Python interface to apply each model to oil fields in database
 - Output used to generate cost-supply curves

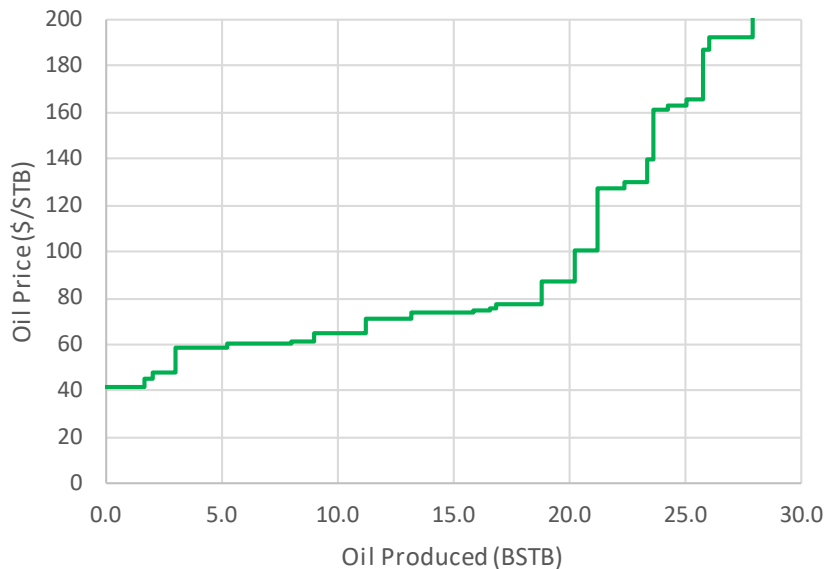


Residual Oil Zone Fairways in the Permian Basin. Four of the twelve counties of the ROZ study outlined.

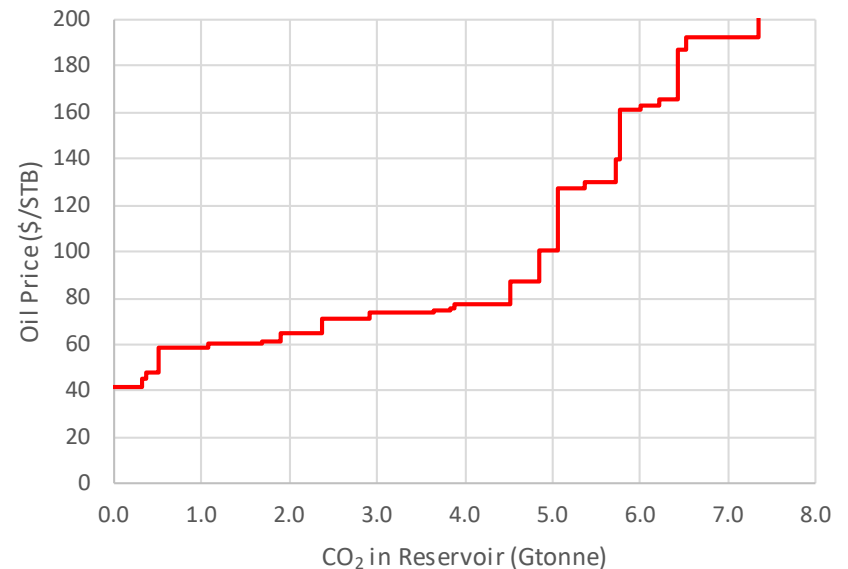
Technical Status

Storage of CO₂ using CO₂ EOR and application of CO₂ EOR to the ROZ

Cumulative Oil Produced



Cumulative CO₂ in Reservoir



Oil produced and CO₂ in reservoir within selected ROZ fairway locations as a function of oil price
Output is for illustrative purposes and should not be cited

Technical Status

Life cycle analysis for CO₂ storage

- Incorporating the FE/NETL CO₂ Prophet Model and FE/NETL Onshore CO₂ EOR Cost Model into CO₂ EOR Life Cycle Model
 - Calculates greenhouse gas emissions
- Performing Life Cycle Inventory expansion for CO₂ saline storage and CO₂ EOR models
 - Will allow for holistic environmental assessment of these technologies
- Performing life cycle analyses of CO₂ enhanced methane recovery applied to conventional and unconventional natural gas reservoirs and coal beds



Technical Status

Market analysis of saline storage and CO₂ EOR

- Project examines influence of Carbon Storage Program's projects on the macroeconomy
- Utilizes EIA's National Energy Modeling System (NEMS)
 - NEMS is used to forecast energy economy of US
 - NEMS is used for reports to government stakeholders (e.g., Congress) to assess prospective government policies
- Modifying NEMS Modules
 - Updated CTUS model in NEMS with results from updated FE/NETL CO₂ Saline Storage Cost Model
 - Incorporating results from FE/NETL CO₂ Prophet Model into CO₂ EOR portion of Oil and Gas Supply Module (OGSM) in NEMS
 - Reviewing cost assumptions for CO₂ EOR in OGSM

Accomplishments to Date

- Updated onshore FE/NETL CO₂ Saline Storage Cost Model
- Developed Offshore FE/NETL CO₂ Saline Storage Cost Model
- Updated FE/NETL CO₂ Prophet Model and developing FE/NETL Onshore CO₂ EOR Cost Model
- Developed geologic databases for ROZ fields in Permian Basin
- Incorporating models or outputs from models into Life Cycle Analysis models for CO₂ saline storage and CO₂ EOR
- Incorporating reduced order versions of models in NEMS
- Performed analyses with updated FE/NETL CO₂ Saline Storage Cost Model
- Shared the updated FE/NETL CO₂ Prophet Model with USGS for their effort evaluating CO₂ EOR in US

Synergy Opportunities

- Significant interaction and sharing of models between participants in this Task
- Geologic database for onshore FE/NETL CO₂ Saline Storage Cost Model based on NATCARB data and RCSP reports
- BOEM data provided by Geology & Geospatial Analysis Team with continuing interactions with this team
- Projects funded by Carbon Storage Program that characterize storage in Gulf of Mexico
- Tools developed by NRAP could provide useful input for the FE/NETL CO₂ Saline Storage Cost Model for site-specific analyses
- Continued interactions with USGS could enhance the FE/NETL CO₂ Prophet Model
- SEA individuals have been successful in the past in getting EIA to include NETL products in NEMS (CTUS model)

Project Summary

- Next steps
 - Estimate cost of storing CO₂ in a variety of offshore saline formations
 - Estimate the potential to produce oil and store CO₂ by applying CO₂ EOR to the ROZ in the Permian Basin and conventional oil fields in EIA oil field database
 - Update the life cycle analysis of greenhouse gas emissions using CO₂ EOR with updated models
 - Estimate the potential for CO₂ capture and storage with CO₂ EOR at the national level with updated version of OGSM in NEMS
 - Develop FE/NETL Offshore CO₂ EOR Cost Model

Questions?

- Thank you.

Appendix

Benefits to the Program

- The models developed and analyses performed in this Task are intended to assist NETL management in their management of the Carbon Storage Program
 - Identify costs associated with different approaches to storing large masses of CO₂ in the subsurface
 - Identify key cost drivers for carbon storage that might be affected (lowered) by R&D
 - Assess the potential benefits that successfully executed R&D can have on the economy of the US

Participants

- SEA project managers
 - Tim Grant, David Morgan, Don Remson & Chris Nichols
- SEA management
 - Kristin Gerdes, Peter Balash and Chuck Zelek
- NETL site support contractors:
 - KeyLogic: Derek Vikara, Chung Yan Shih, Allison Guinan, ShangMin Lin, Anna Wendt, Arun Iyengar, Tim Carr
 - Advanced Resources International: Vello Kruuskraa, Matt Wallace, Michael Godec
 - OnLocation: Less Goudarzi, Francis Wood, Niko Kydes
 - The CETER Group: Nick Azzolina

Bibliography

Presentations and Papers

2017 Carbon Capture, Utilization & Storage Conference – Chicago, Illinois, April 10-13, 2017

- Estimation of CO₂ Storage Coefficients from CO₂ Enhanced Oil Recovery Using the FE/NETL CO₂ Prophet Model Calibrated to Field Data
- A Four-County Appraisal of the San Andres Residual Oil Zone (ROZ) “Fairway” of the Permian Basin

9th Trondheim Conference on CO₂ Capture, Transport and Storage – Trondheim, Norway, June 12-14, 2017

- Comparative Analysis of Transport and Storage Options from a CO₂-Generating Source Perspective
- A paper will be submitted for publication either in The International Journal of Greenhouse Gas Control or conference proceedings.

AAPG Eastern Section meeting – Morgantown, West Virginia, September 24-27, 2017

- Comparative Analysis of Transport and Storage Options from a CO₂-Generating Source Perspective (Submitted)