Developing a carbon storage resource assessment methodology for offshore saline reservoirs

Steve Galer[1,2], Corinne Disenhof[1,3], Emily Cameron[1,3], Mackenzie Mark-Moser[1,2], Burt Thomas[1,3], Jennifer Bauer[1], Kelly Rose[1]

[1] US Department of Energy, National Energy Technology Laboratory, Albany, Oregon
[2] US Department of Energy, National Energy Technology Laboratory, ORISE, Albany, Oregon
[3] US Department of Energy, National Energy Technology Laboratory, AECOM, Albany, Oregon

Abstract

Carbon capture and storage (CCS) in the subsurface is rapidly becoming a viable option for reducing carbon emissions. USDOE's current CCS assessment efforts have been focused onshore using a volumetric approach. However, due to the vast resource potential in deep saline formations offshore, CCS in this environment is gaining more attention. Upon extensive literature review, we have identified significant differences between offshore and onshore systems that must be addressed in a resource assessment methodology. These differences include geomechanics of unconsolidated marine sediments, chemistry and flow of subsurface waters, and logistics and economics of offshore operations. Our literature review also reveals unconventional trapping opportunities offshore, such as basalt trapping, gravitational trapping, and hydrate storage. Accounting for these differences using a ranking system and prospectivity analysis will provide stakeholders and investigators with a methodology to accurately assess offshore carbon storage resources. Specifically, NETL's geospatial and geoanalytical tools tailored to offshore carbon storage estimation are powerful options for addressing these offshore considerations. Further, offshore data assimilation from a variety of sources performed at NETL can also aid in developing offshore-specific efficiency factors that help refine resource estimates in data-poor regions.

Project Goal: Year 1

Develop an offshore CO_2 storage assessment methodology leveraging DOE: NETL's existing volumetric onshore approach while addressing key differences in offshore deep saline formations.

U.S. Deep Saline Formations (DSF)

Saline Formations onshore and offshore. Potential offshore resources exist in the Gulf of Mexico, offshore Alaska, Pacific shelf, and Atlantic shelf.

Approach

- Complete extensive literature analysis and synthesis to describe offshore environments and identify key factors affecting CO_2 storage resources there.
- Leverage DOE:NETL-developed volumetric approach and efficiency factors to calculate high-level site screening estimates (Goodman et al., 2011).
- Refine high-level estimates and reduce uncertainty in data-poor regions by incorporating geospatial analysis addressing key factors not included in the volumetric approach (Next Steps).

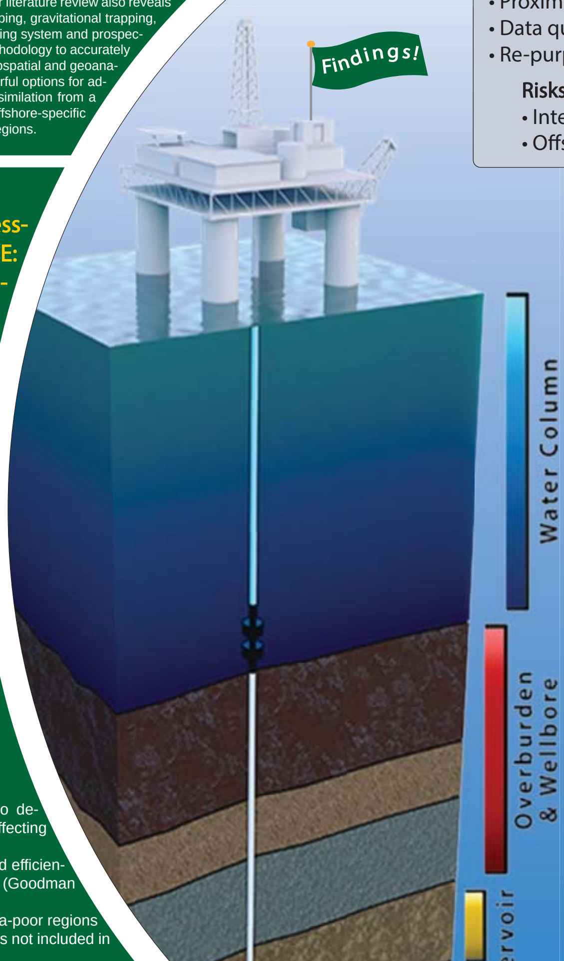
$$G_{st} = A\, h\, \varphi\, \rho_{CO_2}\, E$$

Where

- G_{st} = Storage resource
- A = Area
- h = Reservoir thickness
- φ = Reservoir porosity
- ρ_{CO_2} = CO_2 density at Reservoir T-P
- E = Efficiency factor

Goodman et al., 2011

Offshore Considerations



Logistics, Economics, and Infrastructure

- Infrastructure and personnel costs
- Proximity to source and transport costs
- Data quality: collection, processing, and coverage
- Re-purpose infrastructure for CO_2 storage

Risks:

- Interference with existing resource extraction efforts
- Offshore safety

Water Column:

- Influences subsurface temperature and pressure gradients

Risks:

- Ocean acidification; path to atmosphere
- Threat to fisheries and other economic resources
- Sensitive ecosystems
- Adds logistical and safety considerations

Overburden and Wellbore:

- Unconsolidated sediments weak, plastic, and potentially self healing
- Permeability
- Lithologic and depositional heterogeneity
- Faulting: density, behavior (sealing or conduit?)
- Seal quality: thickness, continuity, configuration (stacked?)

Risks:

- Leakage: Unlithified sediments, open faults, and wellbores
- Induced seismicity

Reservoir:

- Capacity: porosity, thickness, continuity, heterogeneity
- Unconsolidated/semi-consolidated storage medium
- High porosity and permeability
- Fluid chemistry and flow to/from reservoir
- Temperature and pressure conditions/gradients
- Open versus closed systems

Risks:

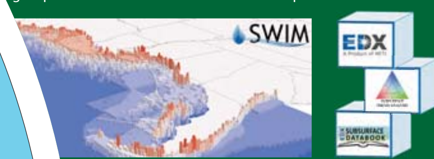
- Leakage: Unlithified sediments, open faults, and wellbores
- Overpressure

Key Takeaways

- Offshore environments offer a significant resource potential for U.S. carbon storage efforts.
- Current DOE/NETL volumetric approach is adequate for high level estimates, however, numerous offshore-specific parameters must be considered for the most certain and most meaningful assessments.

Next Steps

- Demonstrate how a **ranking system/prospectivity analysis** using NETL geospatial tools address and relate relevant parameters:



Cumulative Spatial Impact Layers (CSIL) tool: A GIS driven spatio-temporal additive model that allows the user to quantify how many variables coincide with a given grid cell or area of interest (Bauer et al., 2015).

Spatially Weighted Impact Model (SWIM) tool: Builds off of the CSIL approach, so that it not only evaluates site suitability, but also allows users to rank and compare (Bauer et al., in prep).

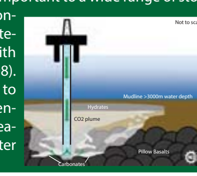
Variable Grid Method (VGM): A novel approach that leverages GIS capabilities to simultaneously visoualize and quantify spatial data trends and underlying data uncertainty (Bauer and Rose, 2015).

- **Efficiency factors** describe the percentage of the pore space that will be occupied by CO_2 around an injection well. Input variables include area, thickness, porosity, and a series of displacement parameters:

$$E_{An/At} \times E_{Hn/Hg} \times E_{\varphi e/\varphi t} \times E_A \times E_v \times E_g \times E_d$$

In FY '17, NETL will develop efficiency factors appropriate offshore, unconsolidated mediums.

- **Unconventional opportunities:** NETL's geospatial tools can be modified to incorporate parameters important to a wide range of storage targets including EOR in conventional reservoirs and unconventional strategies and targets including reaction with basic seafloor rocks (Goldberg et al., 2008). Additional parameters will be considered to assess density-stable P-T regimes where CO_2 density as hydrate or as liquid CO_2 exceeds that of seawater in shallow sediment depths below deep water columns (House et al., 2006).



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For more information on NETL's tools and offshore and CO_2 storage efforts, please visit:
https://edx.netl.doe.gov/tools
https://edx.netl.doe.gov/offshore/
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