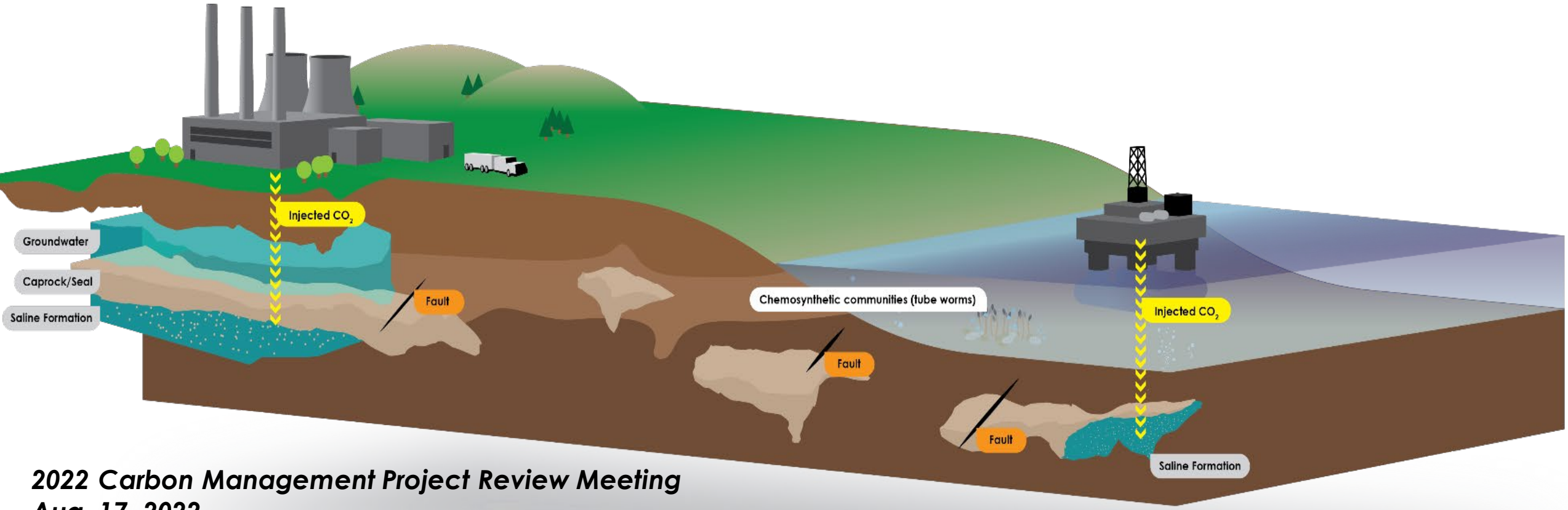
Offshore CO_2 Saline Storage Methodology and Calculator

Solutions for Today | Options for Tomorrow

NATIONAL ENERGY TECHNOLOGY LABORATORY

Lucy Romeo
NETL Support Contractor



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Technical Background

Research Problem and Resolution

Problem:

- The *validated*, volumetric **DOE CS method** (Goodman et al., 2016) for calculating resource potential is ***identical* for onshore and offshore systems**

$$G_{CO2} = A_t\, h_g\, \Phi_t\, \rho\, E_{saline}$$

G_{CO2} = Amount of CO_2

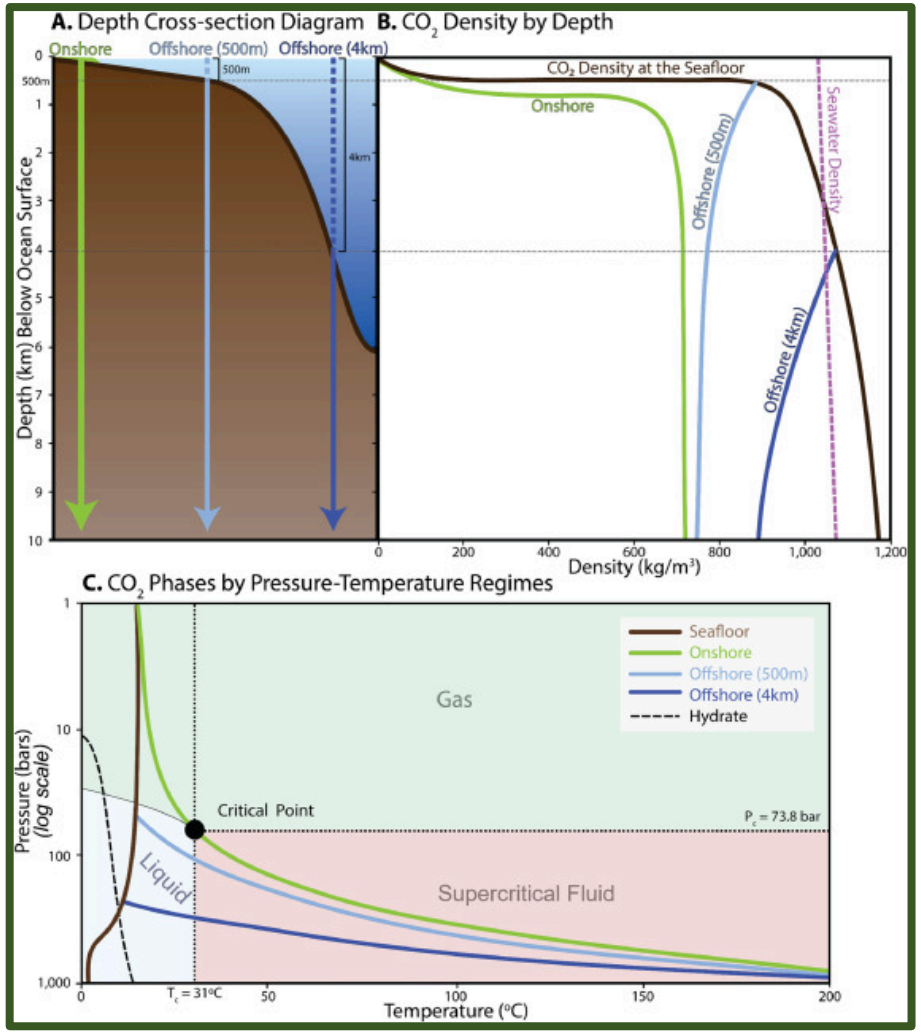
A_t = Total area

h_g = Gross height

Φ_t = Total porosity

ρ = CO_2 density at storage site

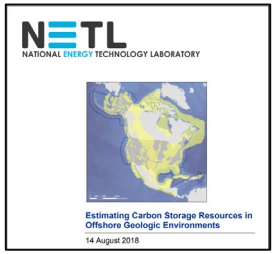
E_{saline} = Saline efficiency



Romeo et al. 2022

Offshore ≠ Onshore

- CO_2 density
- Unlithified sediments are more porous and permeable



Cameron et al. 2018

Solution:
Adapted the DOE CS method for ***offshore saline systems*** *to account for key differences.*

OCSS: Offshore CO_2 Saline Storage Methodology

Methodology supporting top-down assessments for offshore saline systems

- ***Science-based screening methodology*** *to* ***estimate saline storage potential***
- Storage estimates (**G_{CO2}**) and saline efficiency(**E_{saline}**) estimates are calculated using *all possible variable combinations*
- Produces **distributions of G_{CO2}**
- *Does not factor in time-dependent processes*

$$E_{saline} = E_A E_H E_\Phi E_d E_v$$

$$G_{CO2} = A_t h_g \Phi_t \rho E_{saline}$$

E_{saline} = Saline efficiency
E_A = Area efficiency
E_H = Height efficiency
E_Φ = Porosity efficiency
E_v = Volumetric displacement
E_d = Microscopic displacement

G_{CO2} = Amount of CO_2
A_t = Total area
h_g = Gross height
Φ_t = Total porosity
ρ = CO_2 density at storage site
E_{saline} = Saline efficiency

Romeo et al. 2022

Values Delivered:

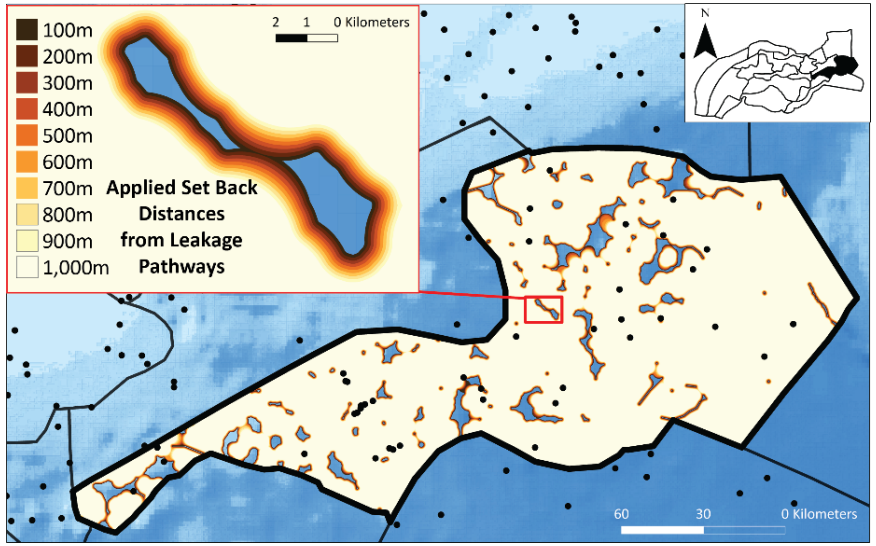
Provides top-down, volumetric saline storage estimates for regional, long-term planning

Fills assessment need before site-specific, or commercial estimates

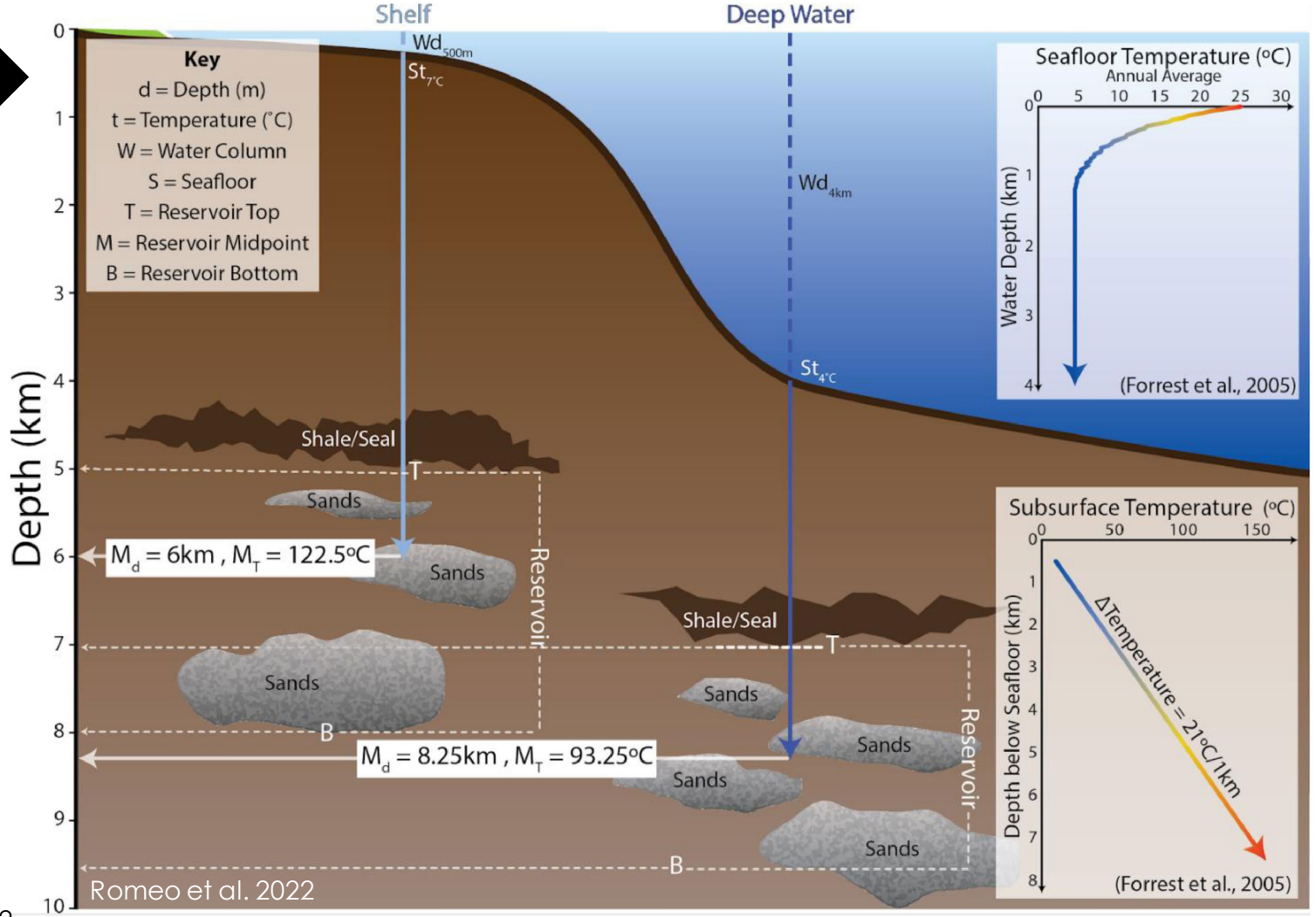
OCSS Methodology

Accounting the offshore saline system

- **CO_2 density and phase** given overlying water column
- **Setback distances** to **support risk mitigation**
- Depositional environments
  (Gorecki et al., 2009)



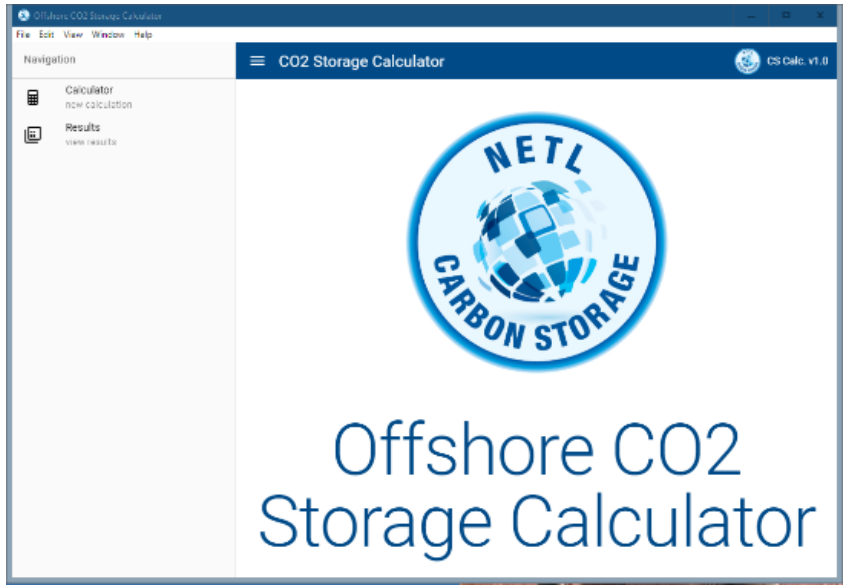
Romeo et al. 2022



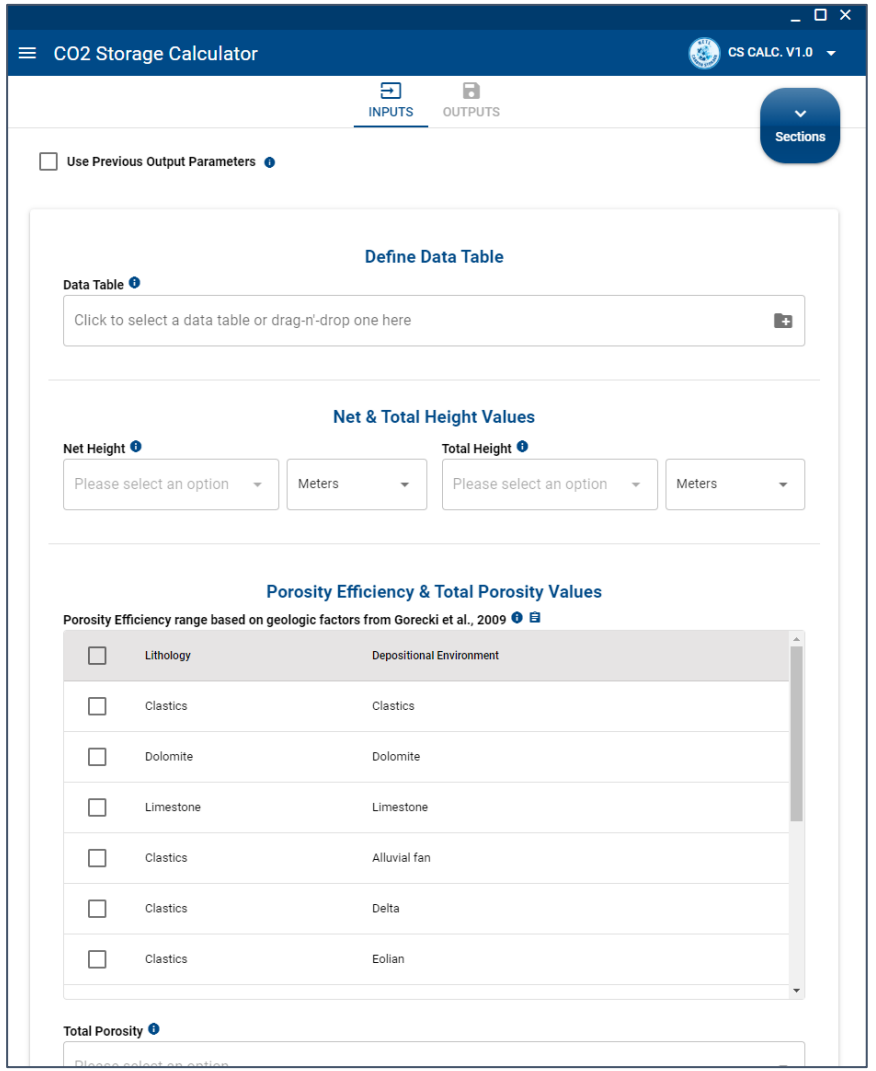
Offshore CO_2 Saline Storage Calculator

Desktop tool mechanizing the OCCS Methodology

- **Standalone** (Python v3.7)
- Enables **multi-scale assessments**
- Leverages **power of spatial data**
- **Flexible tool enables customization**
  - 10 - 20 parameters
  - Data availability
    - Interpreted well logs
    - Literature
    - Spatial data



Tool is currently available on EDX Energy Data eXchange



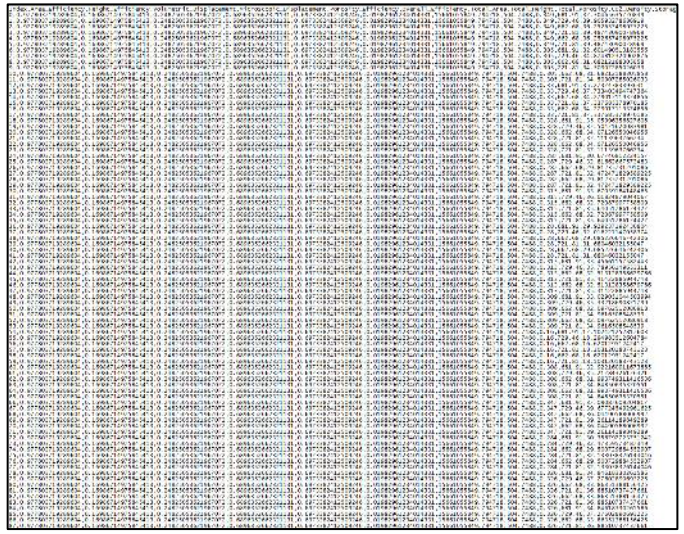
OCSS Calculator Outputs

Tool outputs for visualization and additional analytics

A. Data table
B. Summary table
C. Variable distributions*
D. Phase distributions*
E. Spatial data*

** Optional outputs*

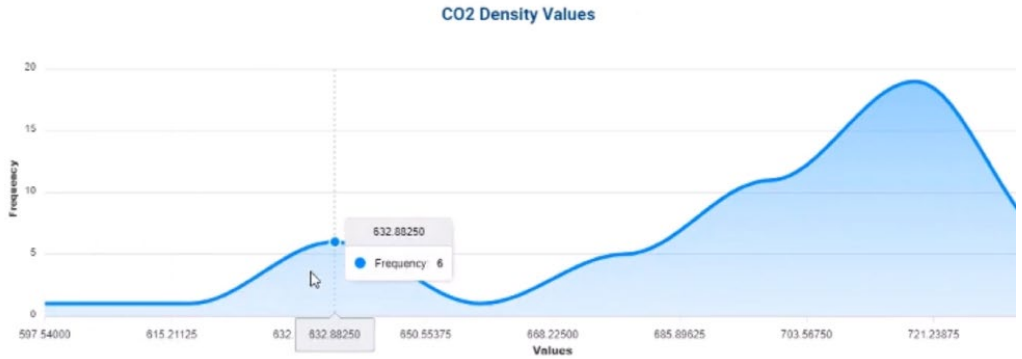
A.



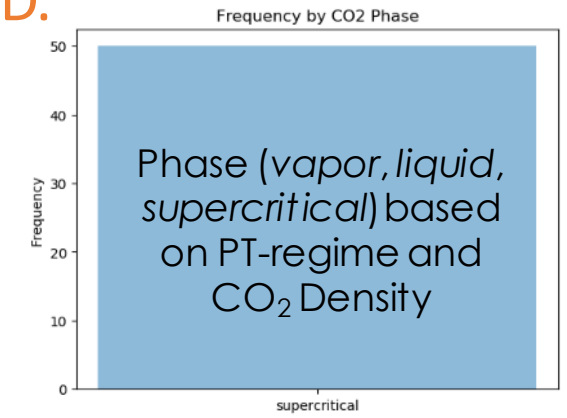
B.

	A	B
1	Efficiency Values	N=500
2	Percentile	P-Value
3	10%	0.002217
4	50%	0.010381
5	90%	0.030359
6	Storage Potential Values	N=62500000
7	Percentile	P-Value
8	10%	8.798893
9	50%	48.93849
10	90%	197.8562

C.



D.



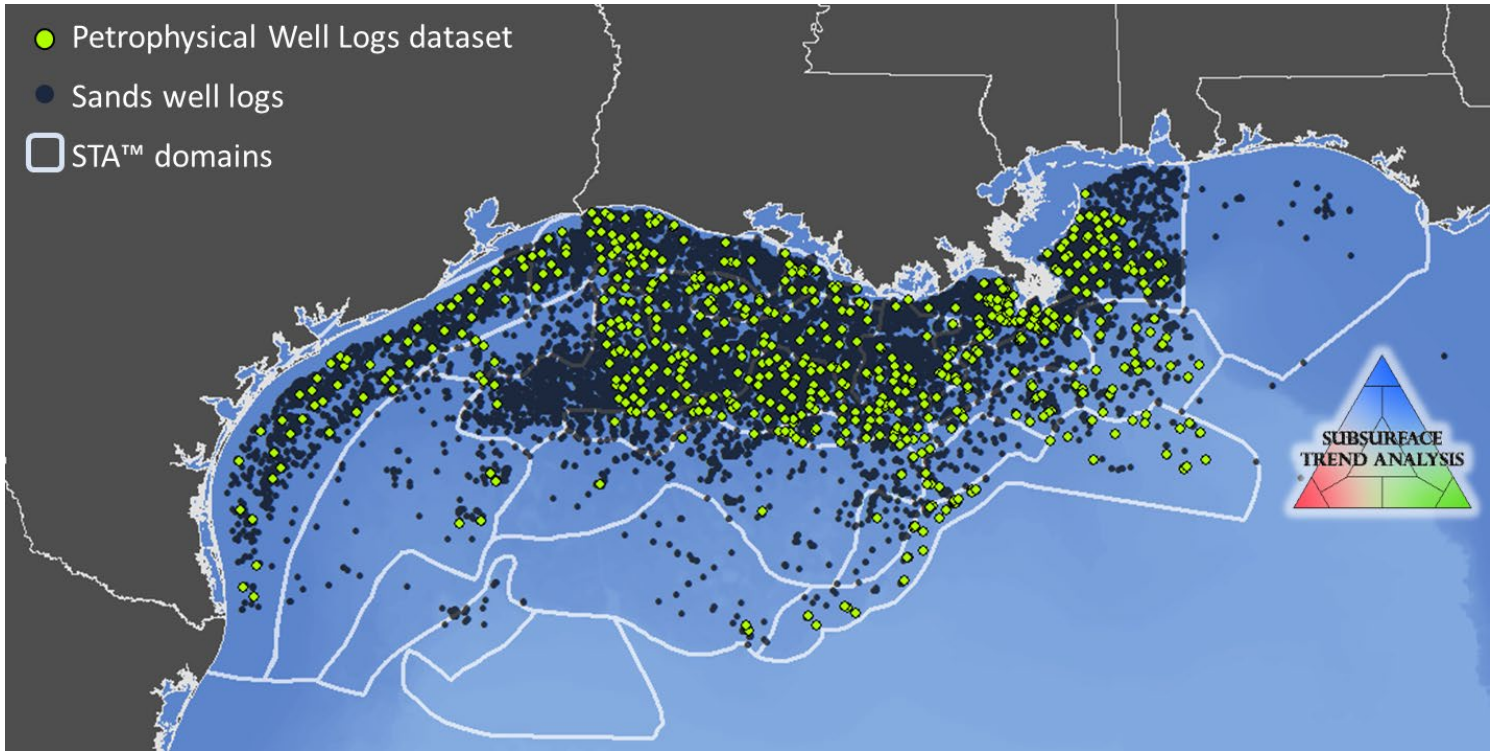
Phase (*vapor*, *liquid*, *supercritical*) based on PT-regime and CO_2 Density

E.

https://edx.netl.doe.gov/dataset/offshore-co2-saline-storage-calculator

Applications in the Northern Gulf of Mexico

Evaluated 18 geologic domains for saline storage resources



Domains defined by **Subsurface Trend Analysis™**
(Mark-Moser et al., 2018; Rose, Bauer, Mark-Moser 2020)

All data is available on EDX Energy Data eXchange


International Journal of Greenhouse Gas Control
Volume 119, September 2022, 103736

Data-driven offshore CO_2 saline storage assessment methodology

Lucy Romeo, Randal Thomas, MacKenzie Mark-Moser, Andrew Bean, Jennifer Bauer, Kelly Rose

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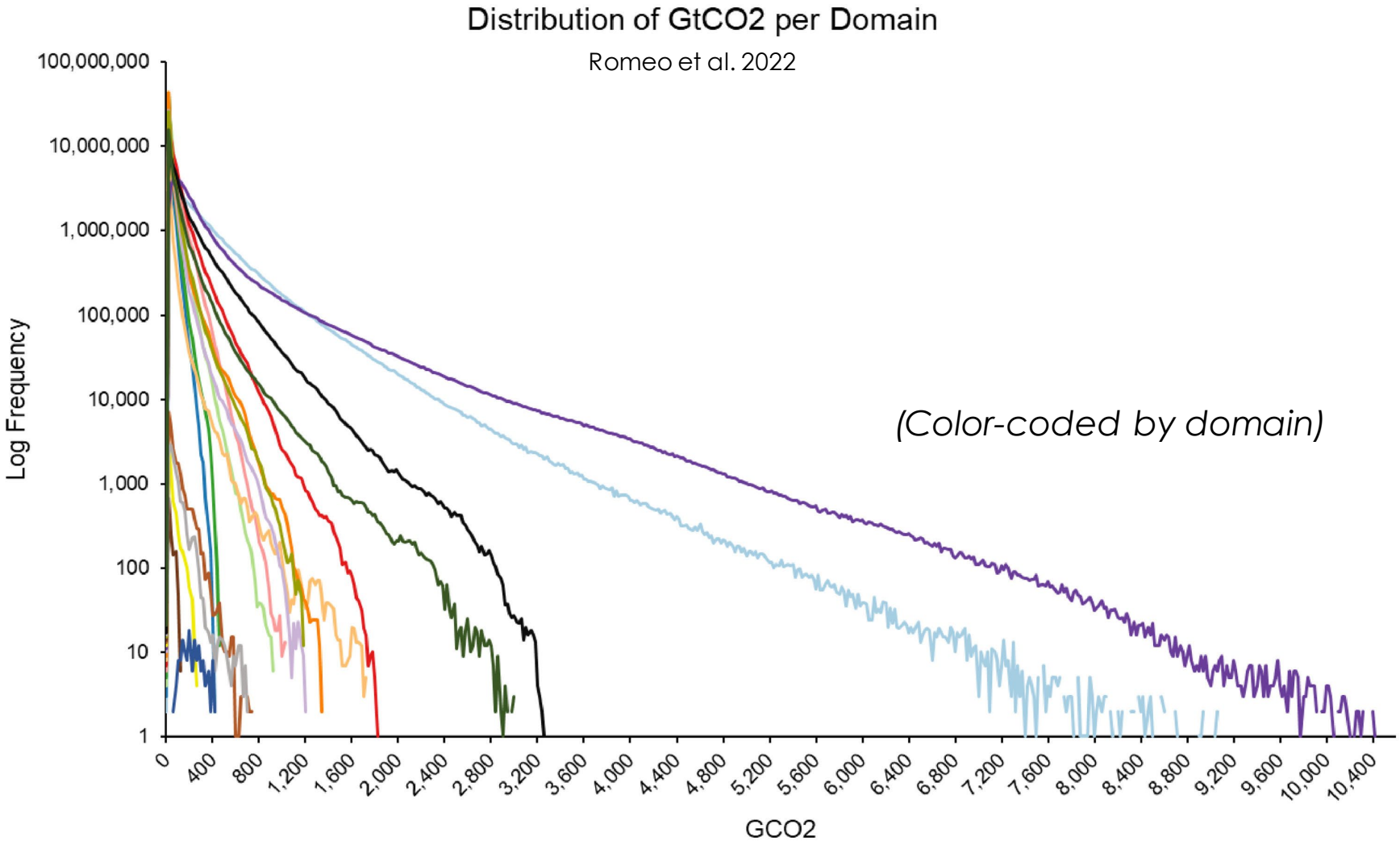
- **Well logs** (Bean et al., 2018)
  - 2–50 logs selected per domain
    - Net sand thickness of >10ft
    - Shale seal (>50 ft)
- **Expert knowledge** & **literature**
  - Depositional environments: Alluvial fan, slope basin, delta, peritidal, and shelf
  - Effective porosity, microscopic, and volumetric displacements (Gorecki et al., 2009)
- **Spatial data** representing potential leakage pathways
  - Faults, plumes, chemosynthetic communities, and seeps

Key findings

Saline storage potential

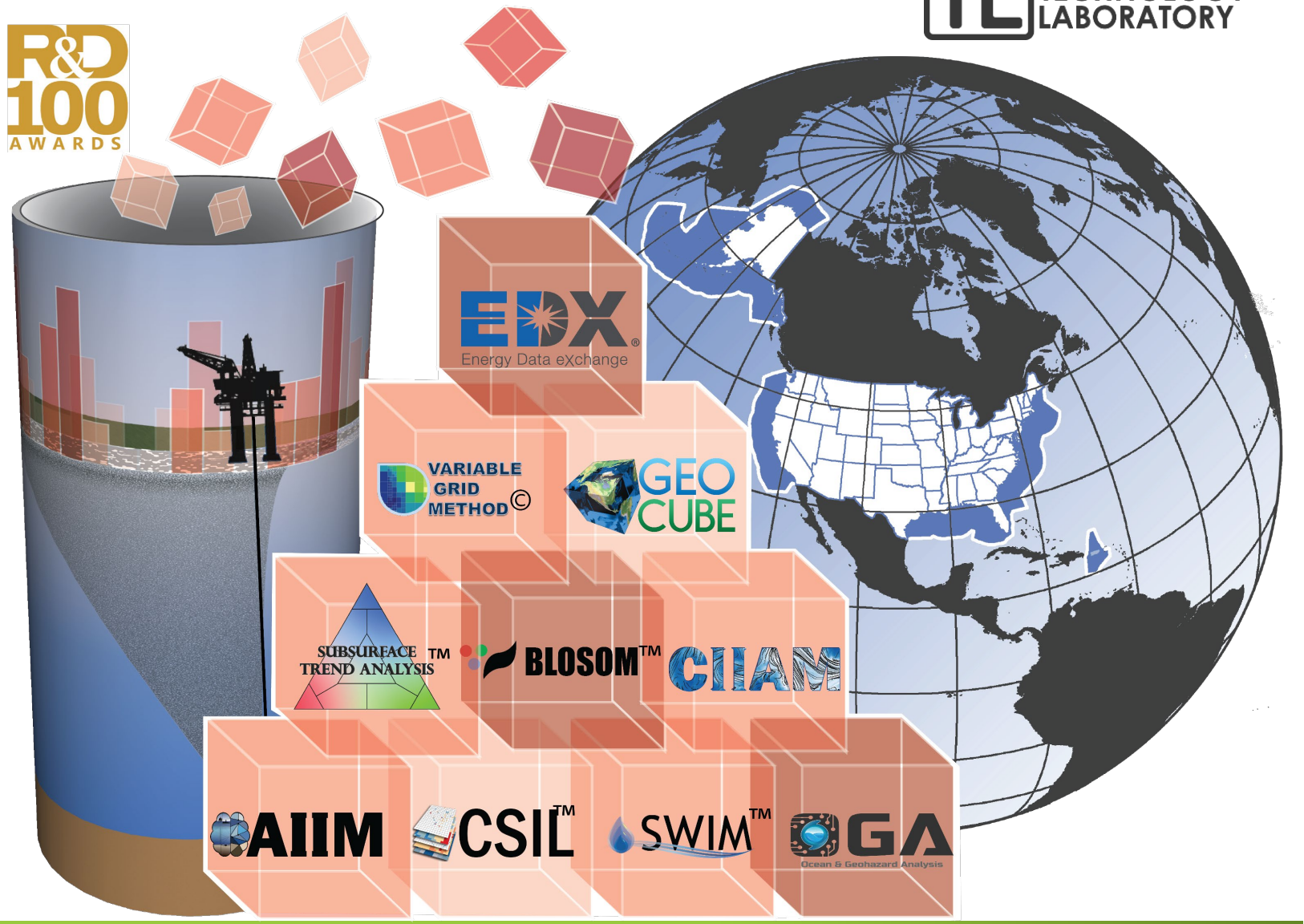
- Produced *160 – 65 million estimates*, ranging from **0.5 – 10,000 Gt**
- All resulting **densities of CO_2** at depth categorized phase as **supercritical or liquid**
- **Saline efficiency** (E_{saline}) identified as the most significant factor (0 – 0.14)
- Multiscale analysis possible
  - Total area (A_T) ranged from ~6,000 – >45,000 km^2



Streamlining with NETL Tools & Models

Offshore Risk Modeling Suite

- Model fate & transport of release events
- Map socio-economic and environmentally vulnerabilities and risks
- Assess geohazard likelihood
- Measure the current state of infrastructure integrity
- Spatially quantify uncertainty
- Share and visualize data, models, and tools



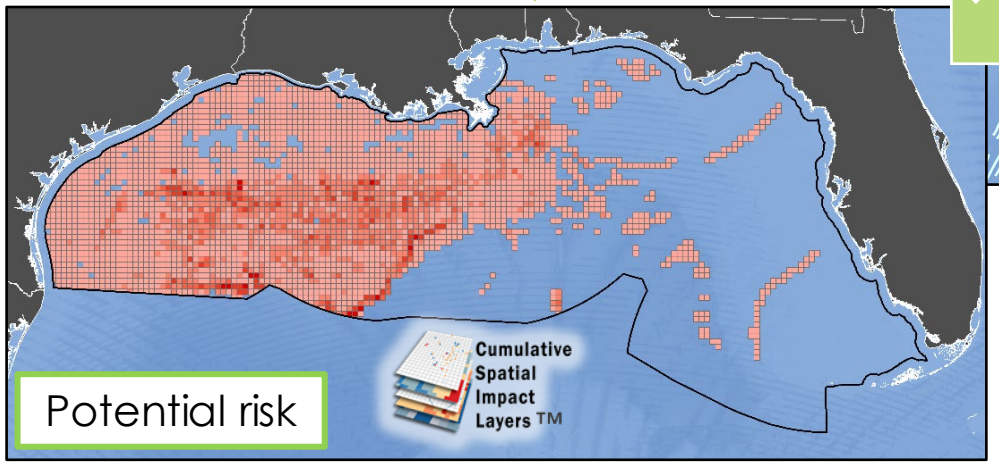
Improving resource estimates & risk prevention strategies

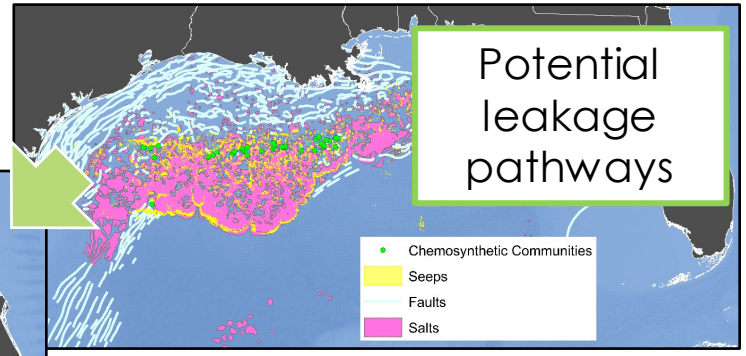
Leveraging the Offshore Risk Modeling suite to inform injection site selection

Down-select **areas** for **safe injection site selection** and **risk mitigation**

Offshore Risk Modeling Suite

6	Storage Potential Values	N=62500000
7	Percentile	P-Value
8	10%	8.798893
9	50%	48.93849
10	90%	197.8562



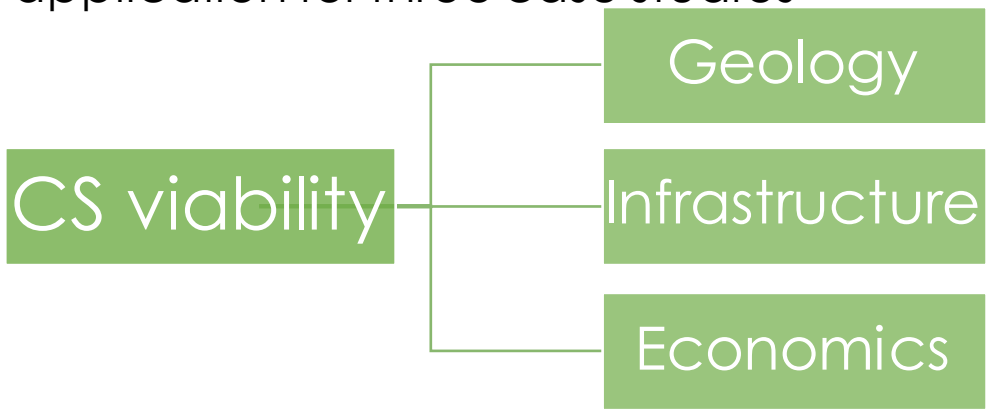


Integrating Geologic & Techno-Economic assessments of saline systems for reuse potential

Identifying resources in the deepwater and ultra-deepwater Gulf of Mexico

*Building an **analytical workflow** using **big data-driven models** to identify **optimal** and **cost-effective reservoirs**, **subsurface conditions**, and **infrastructure** for reuse*

- NETL's **Offshore CO_2 Saline Storage Calculator**, the **Offshore Cost Model**, and the **Offshore Risk Modeling Suite**
- Demonstrate & validate the application for three case studies



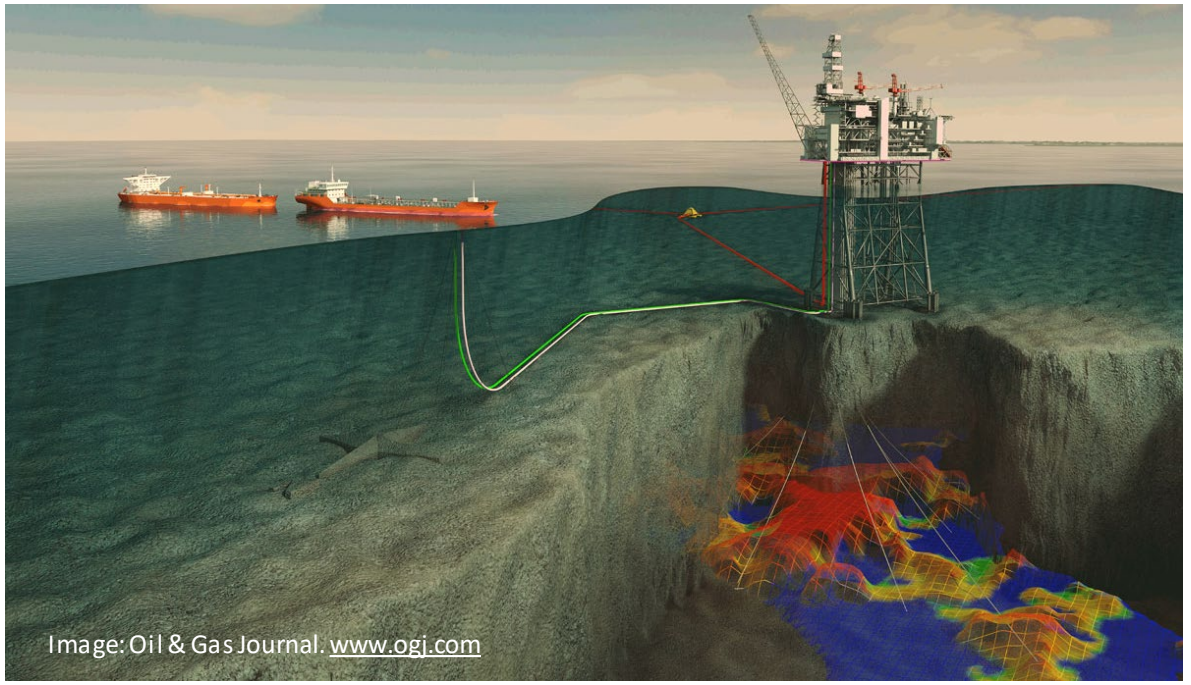


Image: Oil & Gas Journal. www.ogj.com

Values Delivered:

Identify safe, economically-viable opportunities for carbon storage, co-saline storage, geothemal, and beneficiation for renewable applications supporting regulators, industry, and research

What's next: EDX4CCS

NETL Research Carbon Storage Program

NatCarb
A National Look at Carbon Sequestration

CarbonSAFE Projects

Carbon Storage Open Database

SMART

NRAP
National Risk Assessment Partnership

EDX4CCS

- **Data,** Integration, generation, and deployment to feed SMART, NRAP, and regulatory models
- **Tools,** Develop or integrate the deployment of tools for data interaction and visualization, decision-support such as for pipelines, regulatory permitting, resource characterization, data visualization, and more
- **Core CCS EDX DisCO_2ver platform,** Broader community virtualized data computing platform, and central EDX CCS data and tool hub

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NETL SmartSearch

NETL SmartParse

GEO CUBE

EDX®

NETL Resources

Data & Tools

Bean, A., Romeo, L., Justman, D., DiGiulio, J., Miller, R., Cameron, E., and Rose, K, Petrophysical Well Log Interpretation Dataset, 2020-03-05, https://edx.netl.doe.gov/dataset/petrophysical-well-log-interpretation-dataset, DOI: 10.18141/1560053

Mark-Moser, M. Subsurface Trend Analysis domains for the northern Gulf of Mexico, 3/25/2020, https://edx.netl.doe.gov/dataset/subsurface-trend-analysis-domains-for-the-northern-gulf-of-mexico, DOI: 10.18141/1606228

Romeo, L., Wingo, P., Barkhurst, A., Thomas, R., Rose, K. 2020. Offshore CO_2 Saline Storage Calculator, https://edx.netl.doe.gov/dataset/offshore-co2-saline-storage-calculator, DOI: 10.18141/1607787

Relevant Publications

Cameron, E., Thomas, R., Bauer, J., Bean, A., DiGiulio, J., Disenhof, C., Galer, S., Jones, K., Mark-Moser, M., Miller, R., Romeo, L., Rose, K. Estimating Carbon Storage Resources in Offshore Geologic Environments, NETL-TRS14-2018, NETL Technical Report Series, U.S. Department of Energy, National Energy Technology Laboratory: Albany, OR, 2018, p 32. DOI: 10.18141/1464460.

Goodman, A., Sanguinito, S. and Levine, J.S., 2016. Prospective CO2 saline resource estimation methodology: Refinement of existing US-DOE-NETL methods based on data availability. *International Journal of Greenhouse Gas Control*, 54, pp.242-249.

Romeo, L., Thomas, R., Mark-Moser, M., Bean, A., Bauer, J. and Rose, K., 2022. Data-driven offshore CO_2 saline storage assessment methodology. *International Journal of Greenhouse Gas Control*, 119, p.103736.

Rose, K.K., Bauer, J.R. and Mark-Moser, M., 2020. A systematic, science-driven approach for predicting subsurface properties. *Interpretation*, 8(1), pp.T167-T181.

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