SAND2016-0318C

Exceptional service in the national interest

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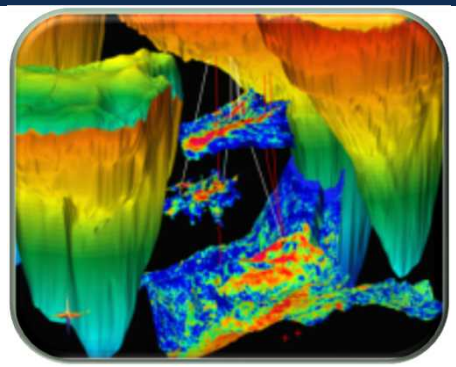

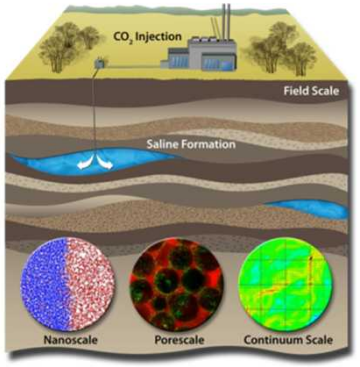

Biomimetic Desalination, Wettability Control for CO_2-WAG, and Integrated Assessment of CO_2 Storage and Water Production

Jason E. Heath, Peter H. Kobos, Patrick V. Brady, Erik K. Webb

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U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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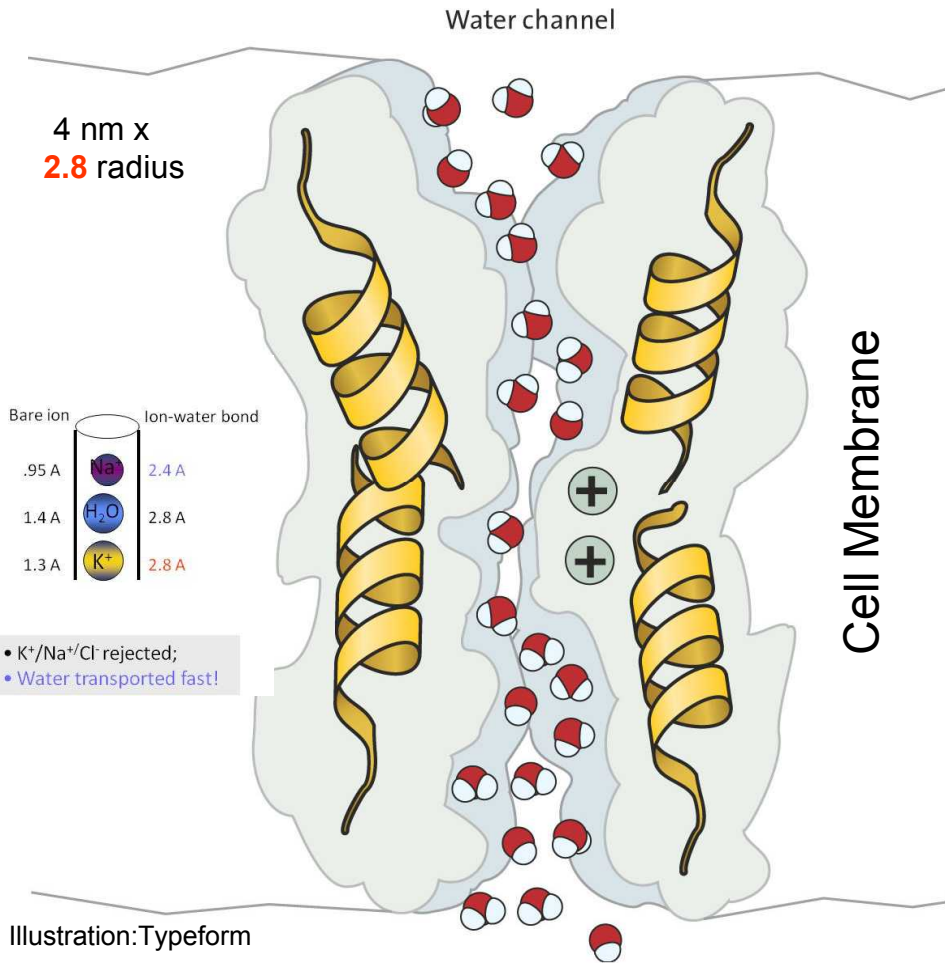
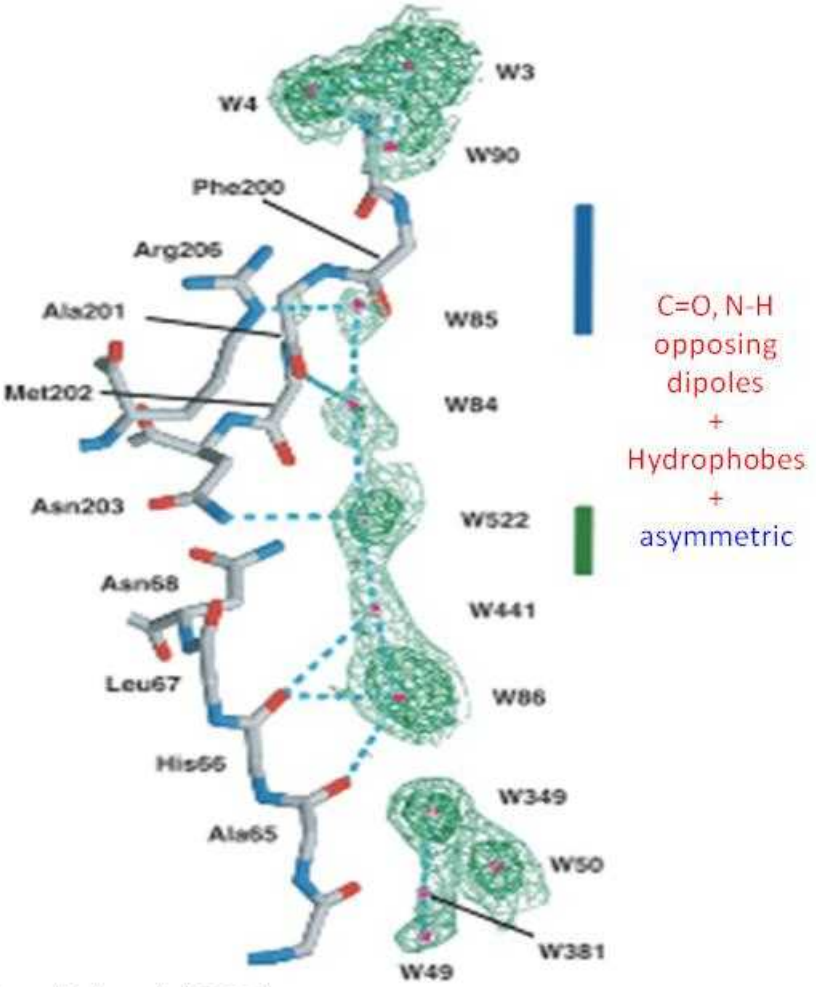
Biomimetic Membranes:

Susan Rempe and Jeff Brinker (SNL)

Sandia National Laboratories

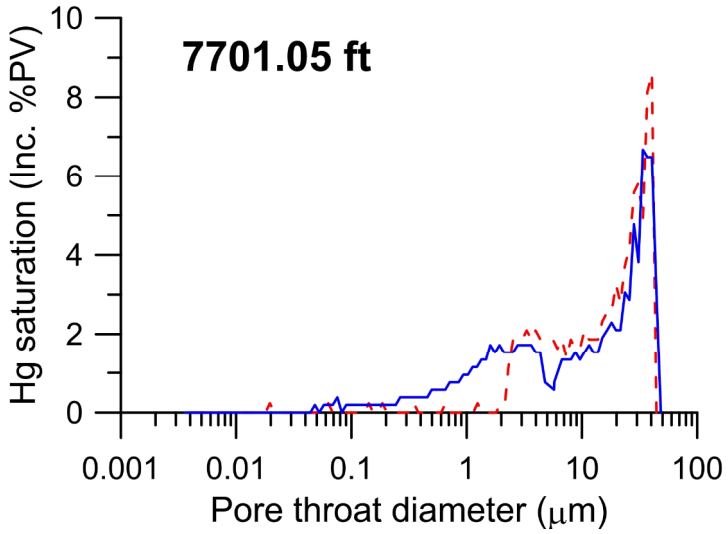


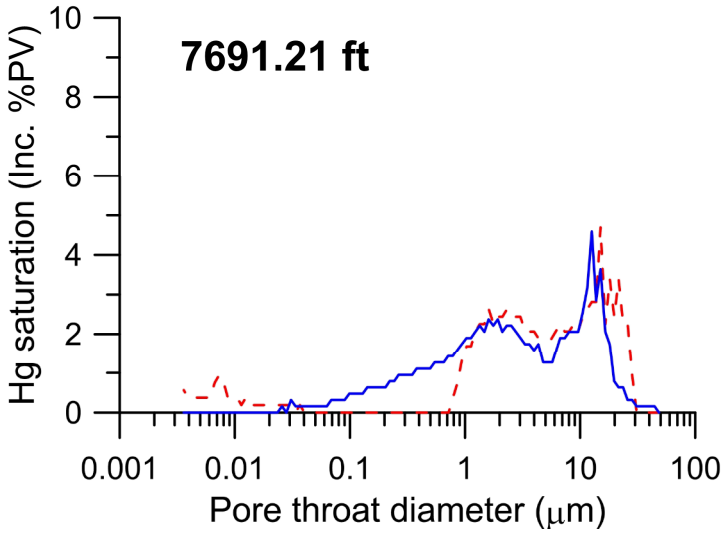
Aquaporin molecule
(www.nobelprize.org)



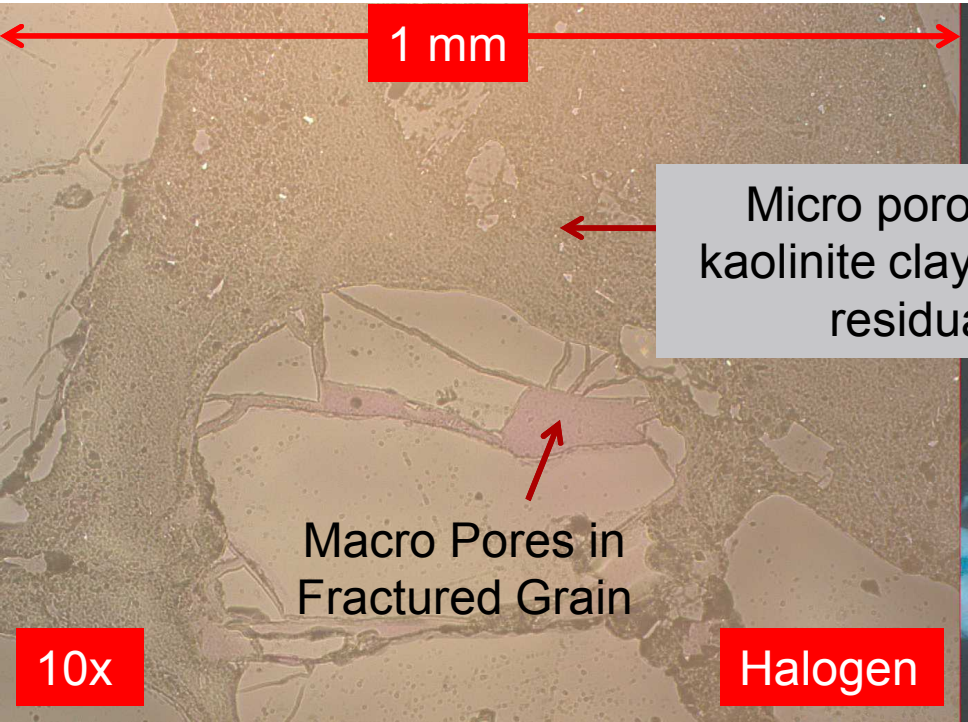
Tajkhorshid et. al. (2002).

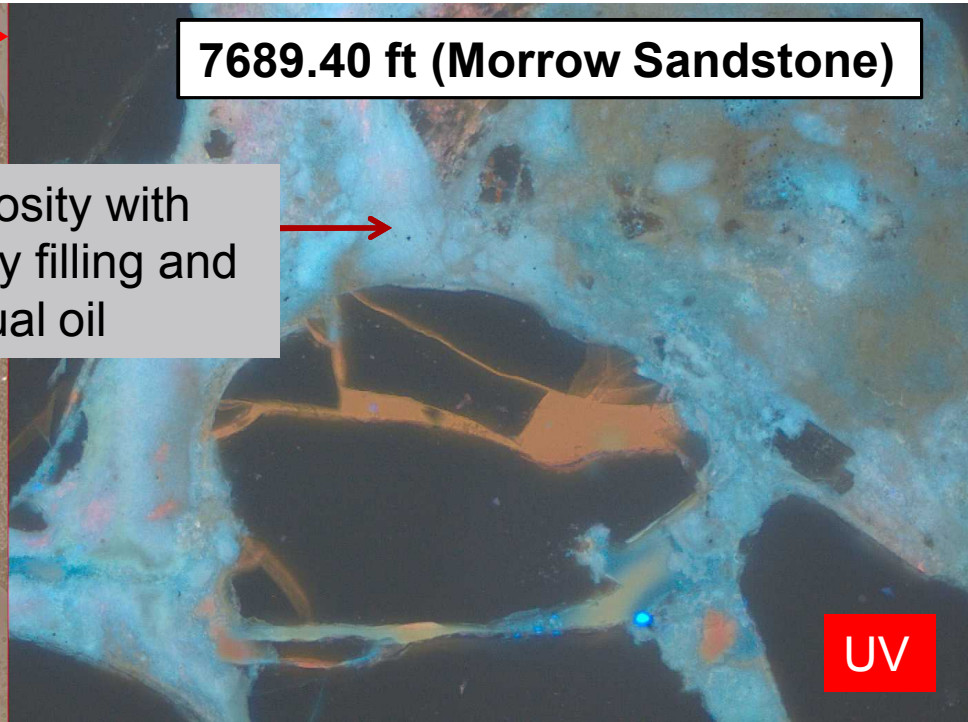
EOR: Where is the oil?

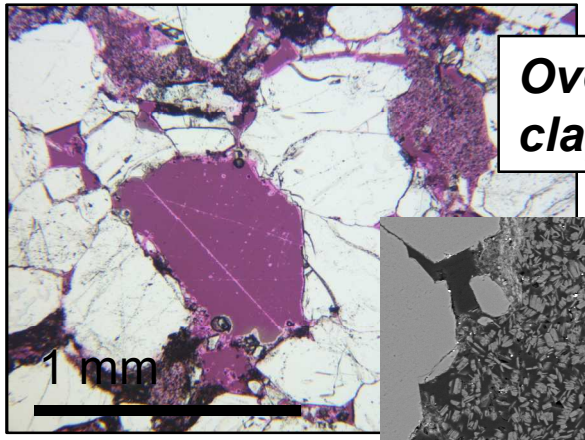




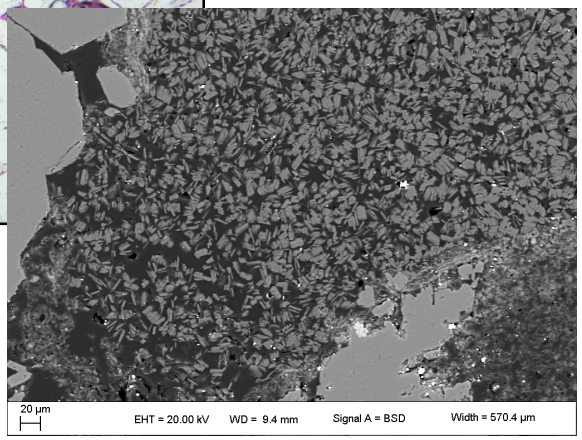
Not cleaned
Cleaned (Dean Stark)





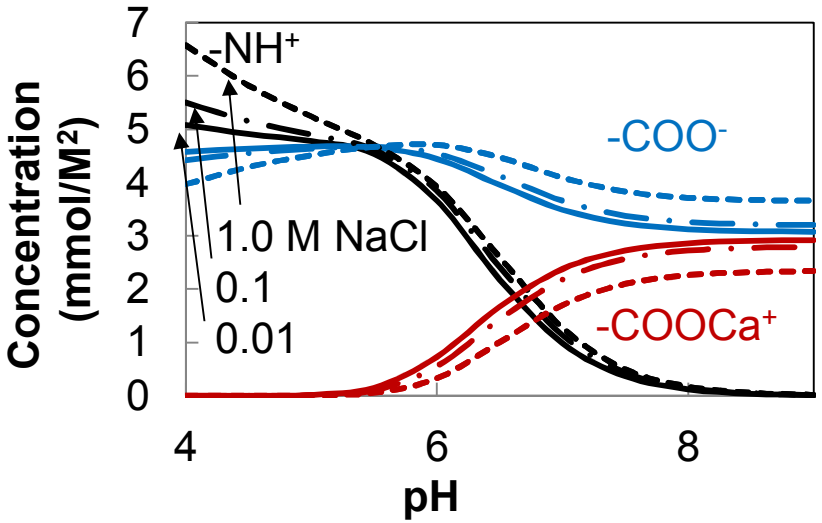


Oversized and clay-filling pores

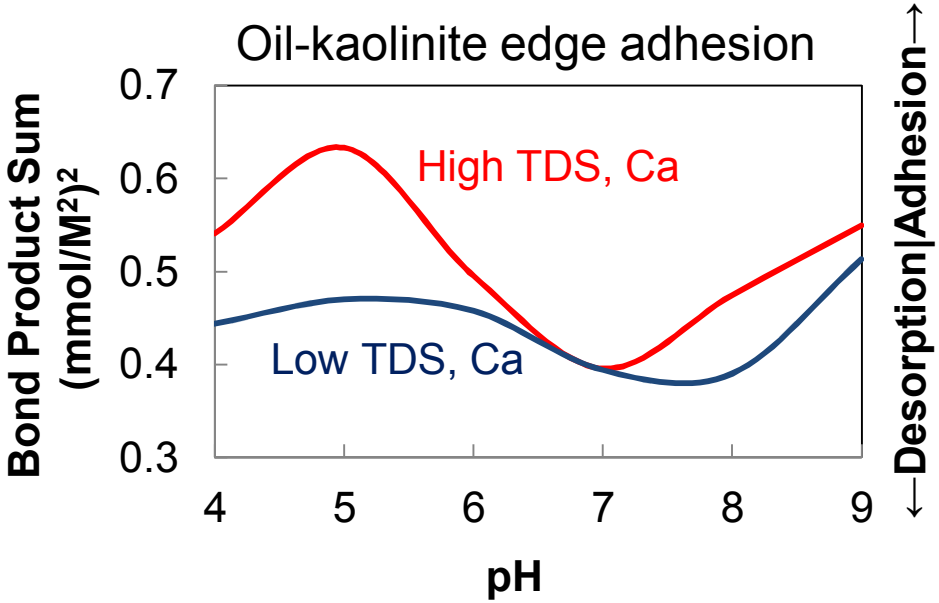


Wettability Control by Water Chemistry in CO_2-Water-Alternating-Gas Operations

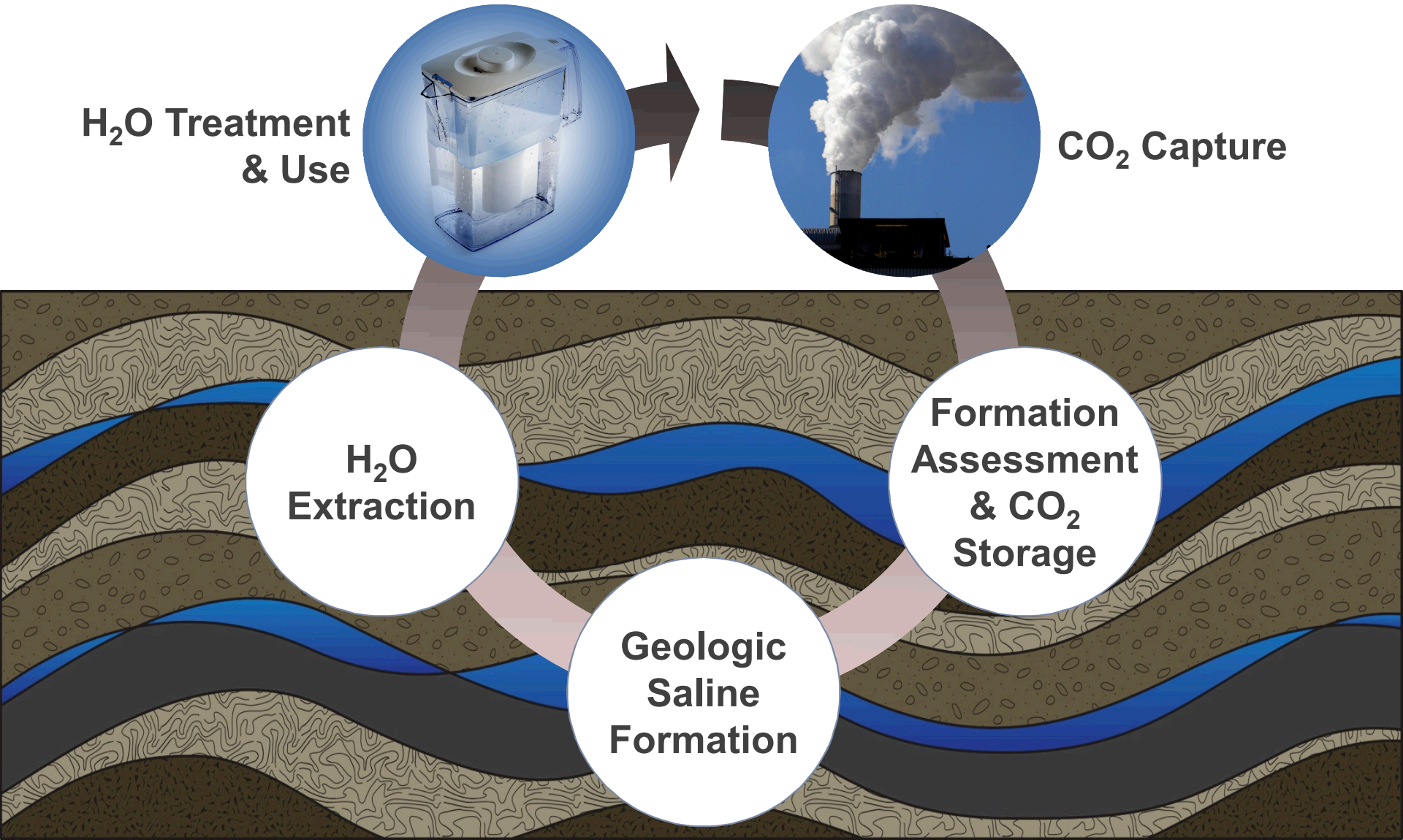
Oil surface chemistry



Mineral surface chemistry



Water, Energy and CO_2 Sequestration Simulation (WECSsim) Model:



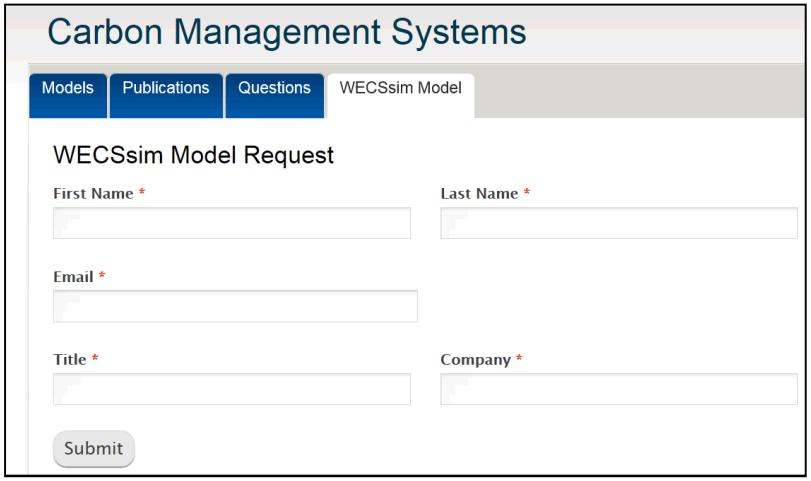
DOE-sponsored Efforts on FE and Water for WECSsim

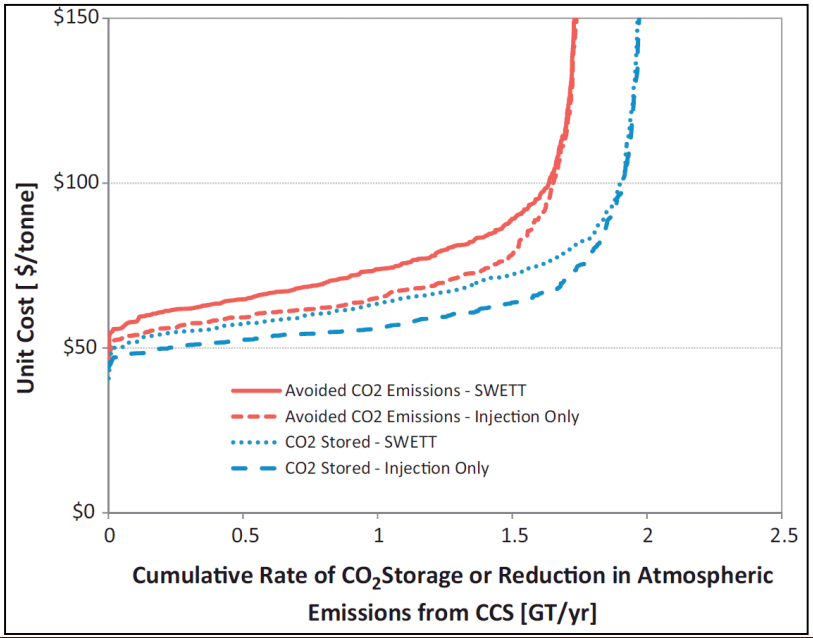
Sandia National Laboratories

Rapid ability to capitalize on previous work to address:

- Can we extract and treat water economically?
- What geologic parameters are necessary to store CO_2?
- How much CO_2 can we store?
- How much water can we extract and treat?

- 7+ years of investment
- Regional to National Assessment
- Refined and available software product





All Coal & Natural Gas Plants with Geological CO_2 Storage Database(s)

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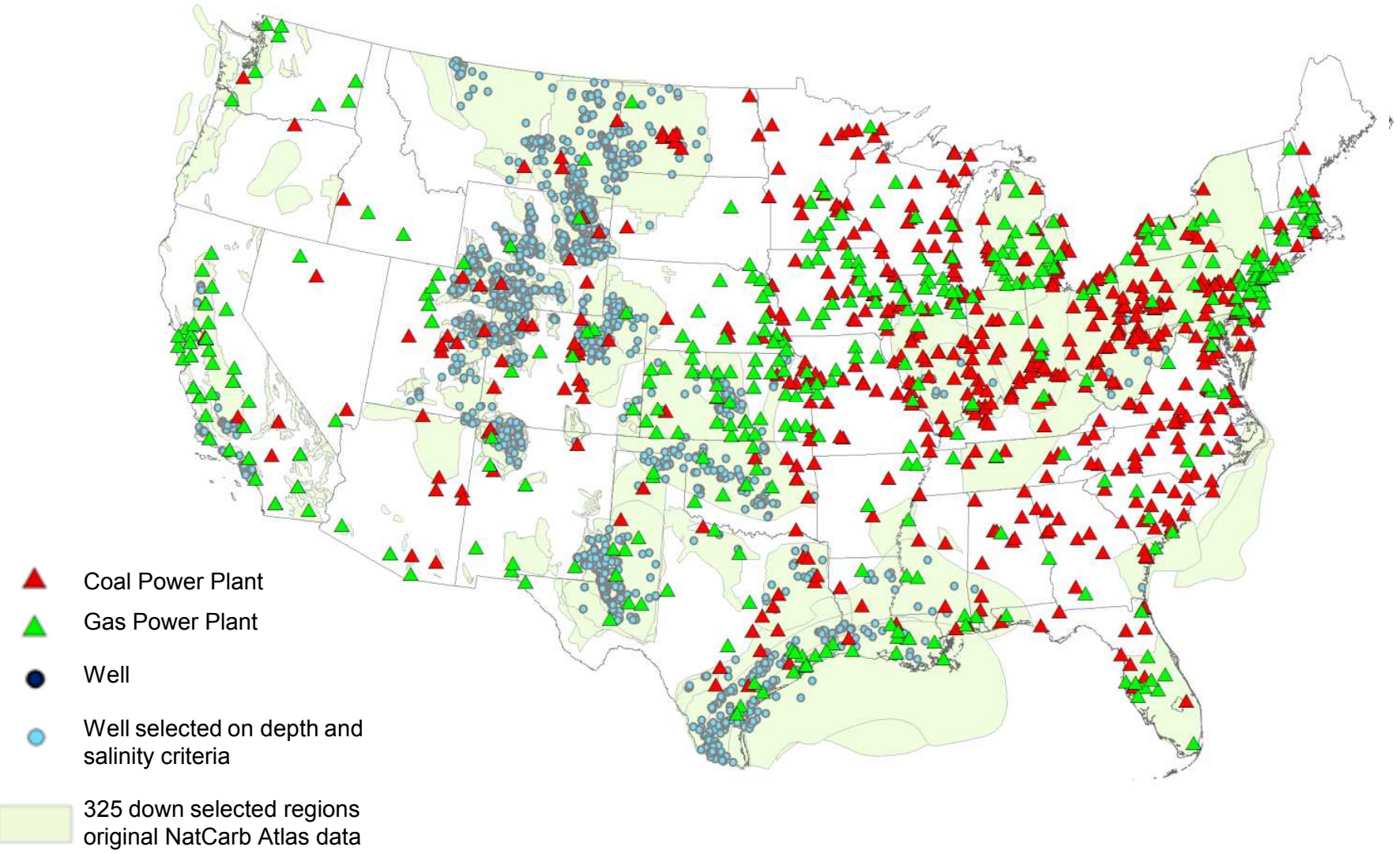

Geology and Well Placement to Cost Relationship

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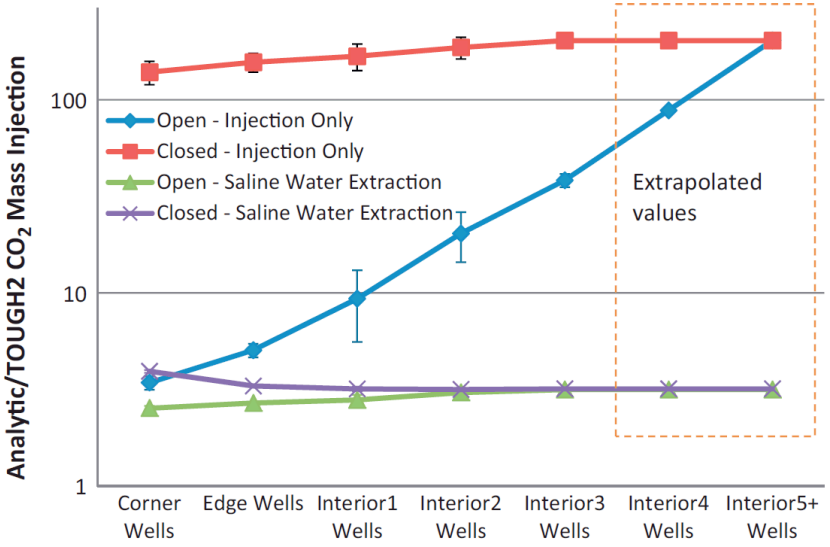
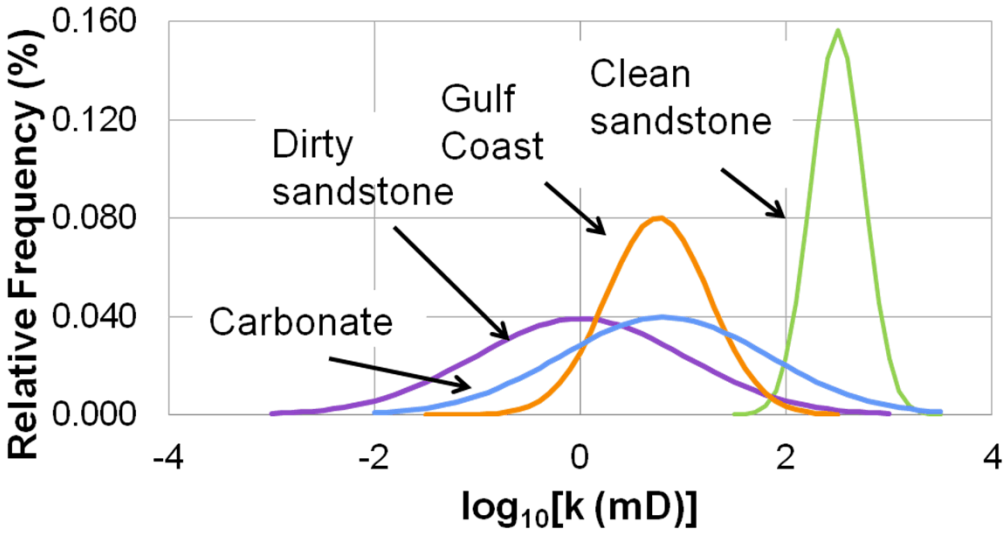
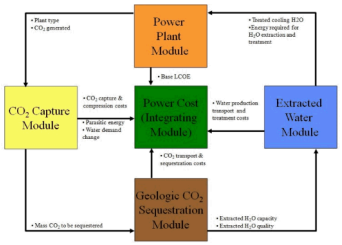
Well Placement and Boundary Condition Scenarios



Injectivity equation: permeability sampled from 4 Rock Types

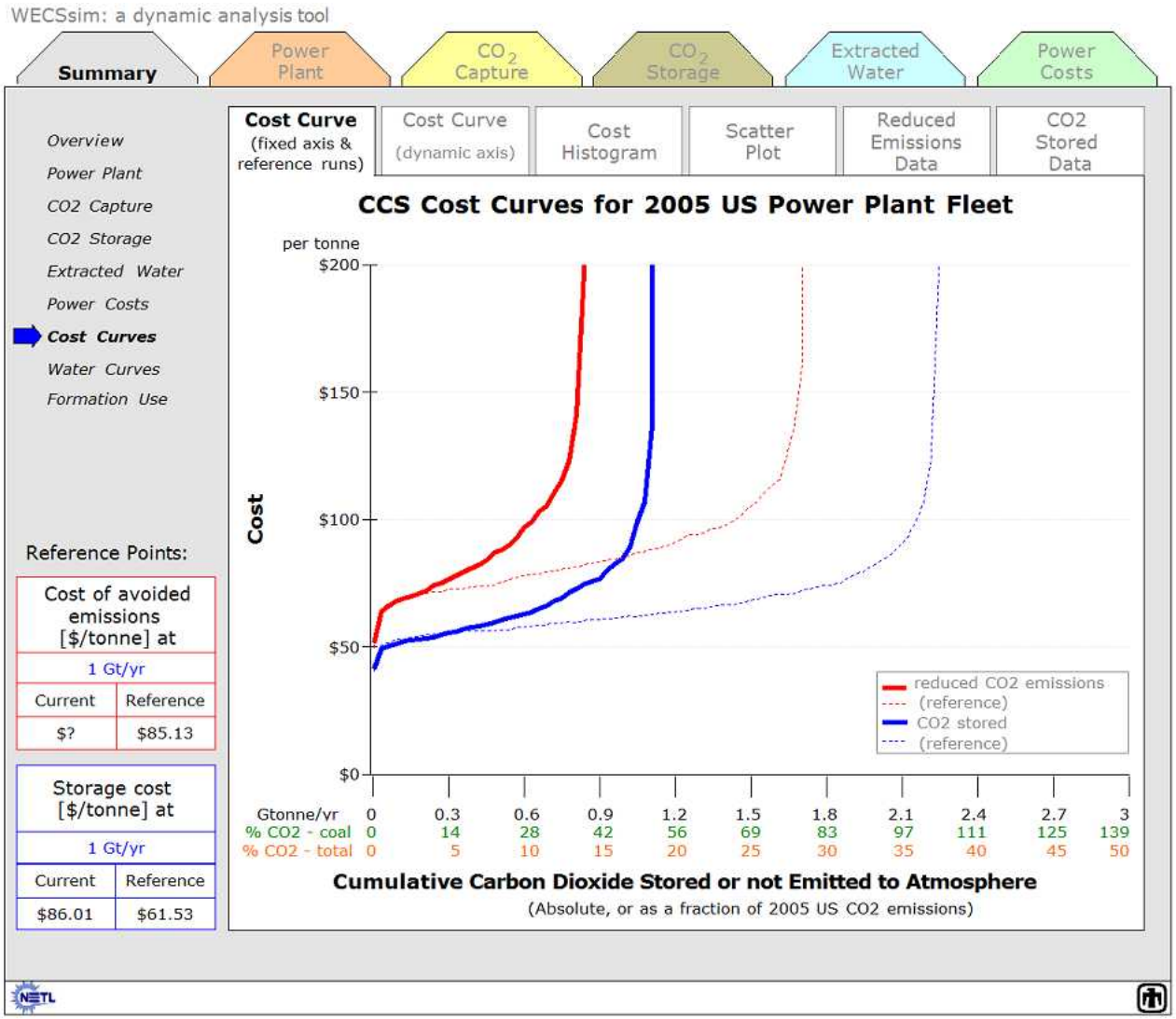




Geomechanical constraint also on brine extractor pressure

$$P_{crit} < \frac{3S_{H\max} - C - S_{h\min}}{2}$$

Base Case (90% Capture) and 50% CO_2 capture: Fleet-wide Cost Curves



Key Messages

Sandia National Laboratories

- Systems-Level Capabilities
  - Geosciences, Water Treatment, Energy and Water Integration
  - Systems Modeling for Performance and Cost Assessment
- Existing, Ready-to-Use WECSsim
  - Ability to incorporate new water treatment technology parameters
  - Ability to analyze multi-scale analysis from the single prototype plant to national scale
  - Integrated Geoscience-to-Costs capability
- Capitalize on Existing Capabilities
  - Ability to run new and custom CO_2 sequestration, Extracted Water Production and treatment scenarios
- For More Information, please see our website:
  - http://energy.sandia.gov/climate-earth-systems/

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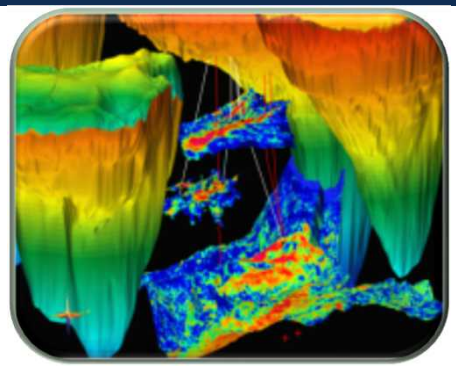

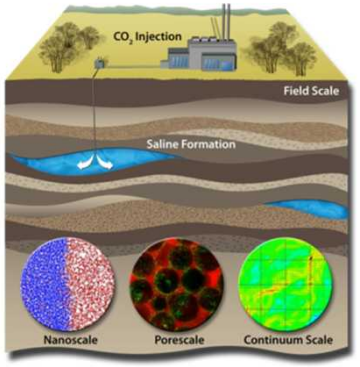

Thank You

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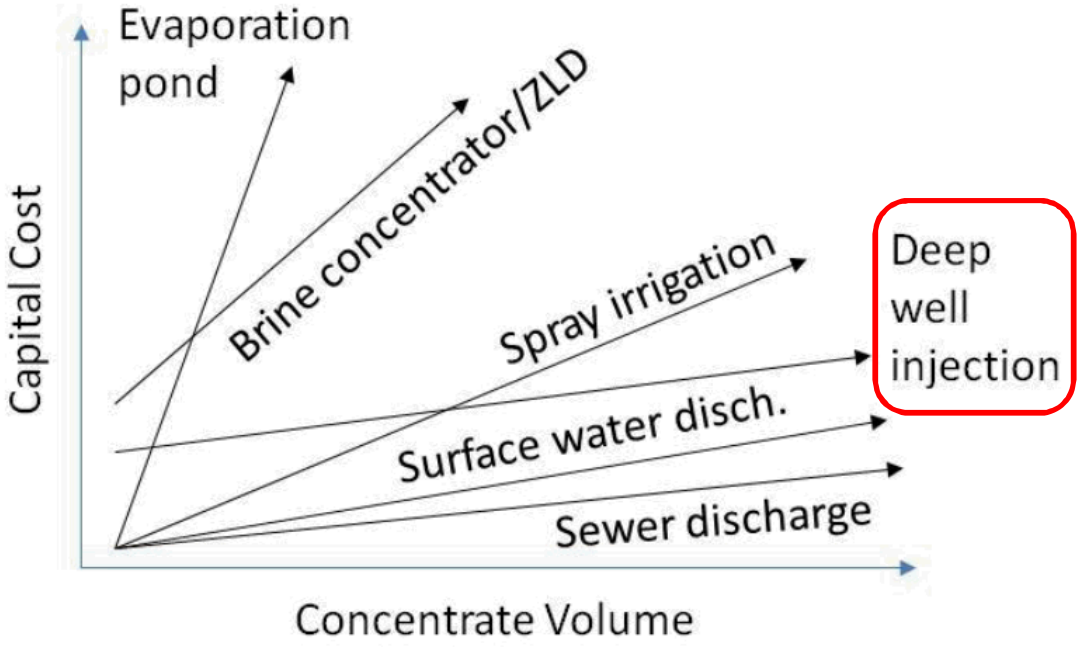
200,000
mg/L

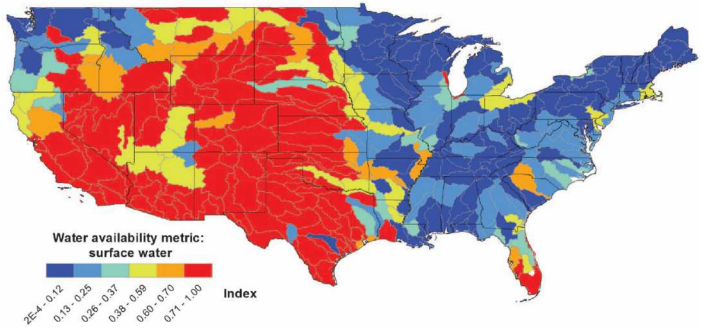
Salinity and Treatment Options

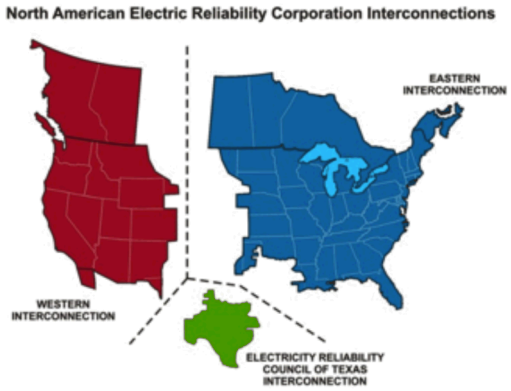


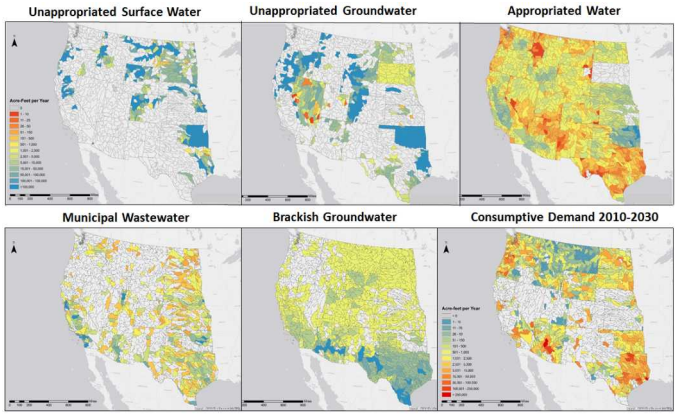
from Mike Mickley (2006)

Energy Water Nexus

- Ensure thermoelectric power production remains viable and cost effective by reducing water dependencies and water impacts.
- Develop Impacts, Adaptation and Vulnerability (IAV) climate assessments for watersheds and surface and groundwater supply and utilization.







Software Tools:
Energy-Water Decision Support Computer Modeling

Analysis & Collaboration:
Siting of New Thermoelectric Power in the Western U.S. for the Western Electricity Coordinating Council (WECC)

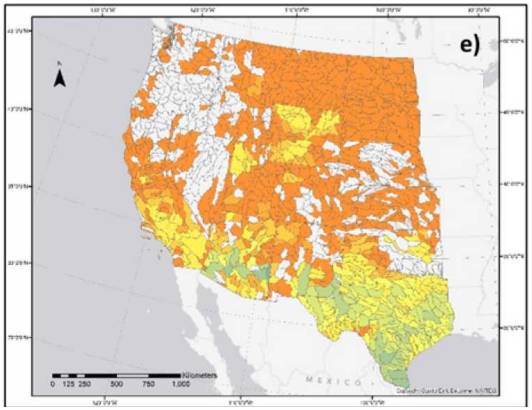
Impact Metrics:
Water Availability, Costs and Projections of Supply and Demand balances

Tidwell, Kobos et al., 2012; Tidwell, Malczynski, Kobos et al., 2013; https://snlwm.maps.arcgis.com/home/index.html

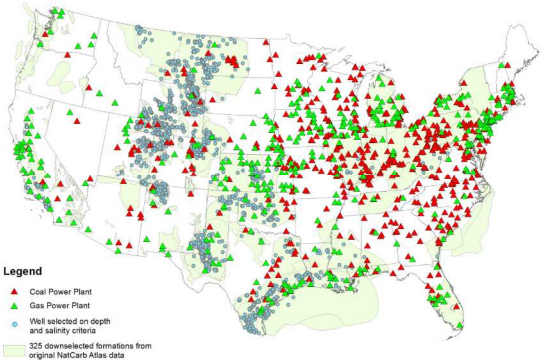
SNL's CO_2 and H_2O Research

Sandia National Laboratories

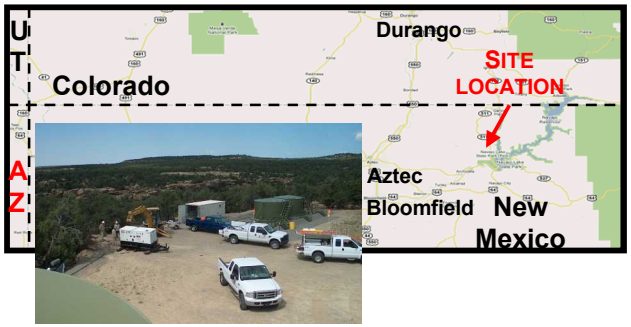
Water Atlas of WECC (ongoing Eastern U.S.)



WECSsim

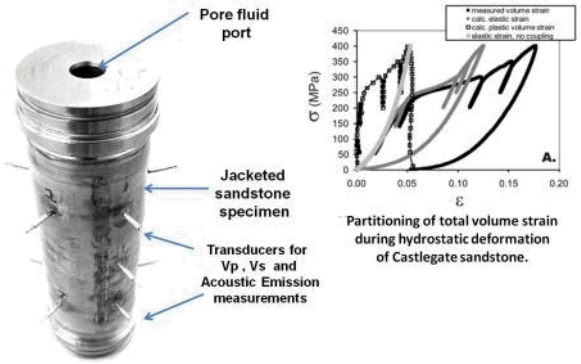


Nanofiltration Treatment of Produced Water

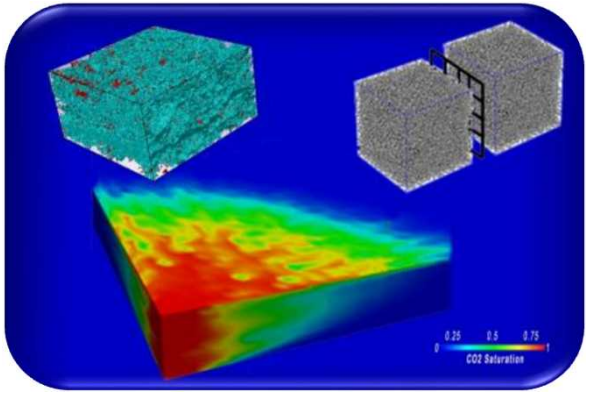


Southwest CO_2 Partnership EOR / CO_2 storage project

Elasto-plasticity for Geomaterials



Center for Frontiers of Subsurface Energy Security (EFRC)



WECSsim Modular Structure

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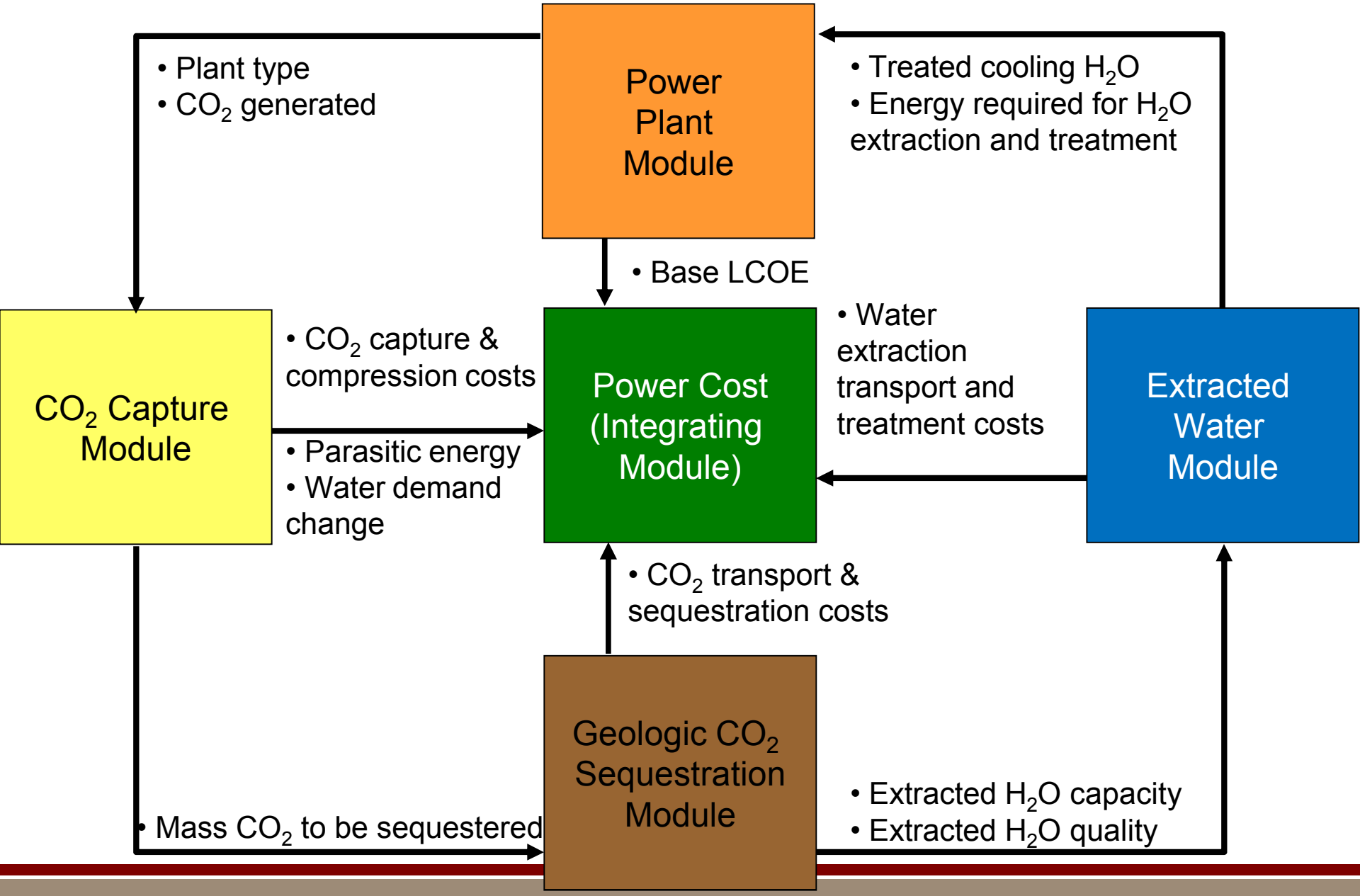
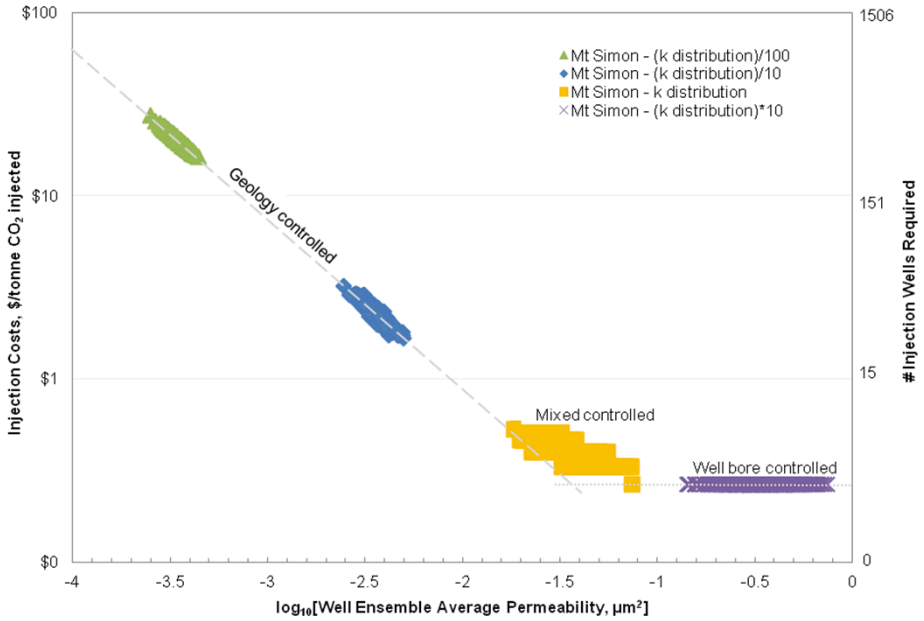


Cost Drivers & Supply Curve:

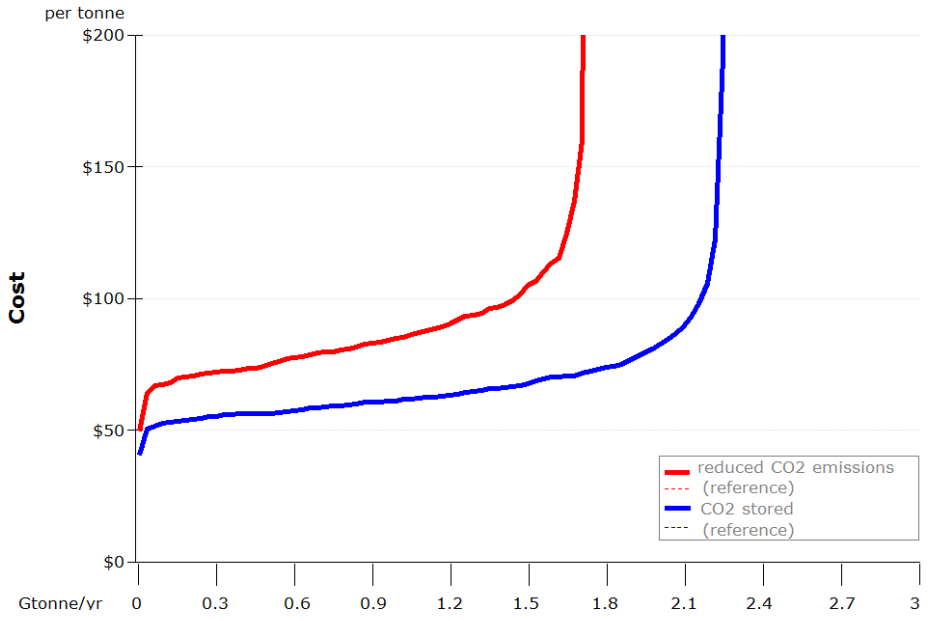
Permeability ↑ = Well Costs ↓



Site-Specific Geology

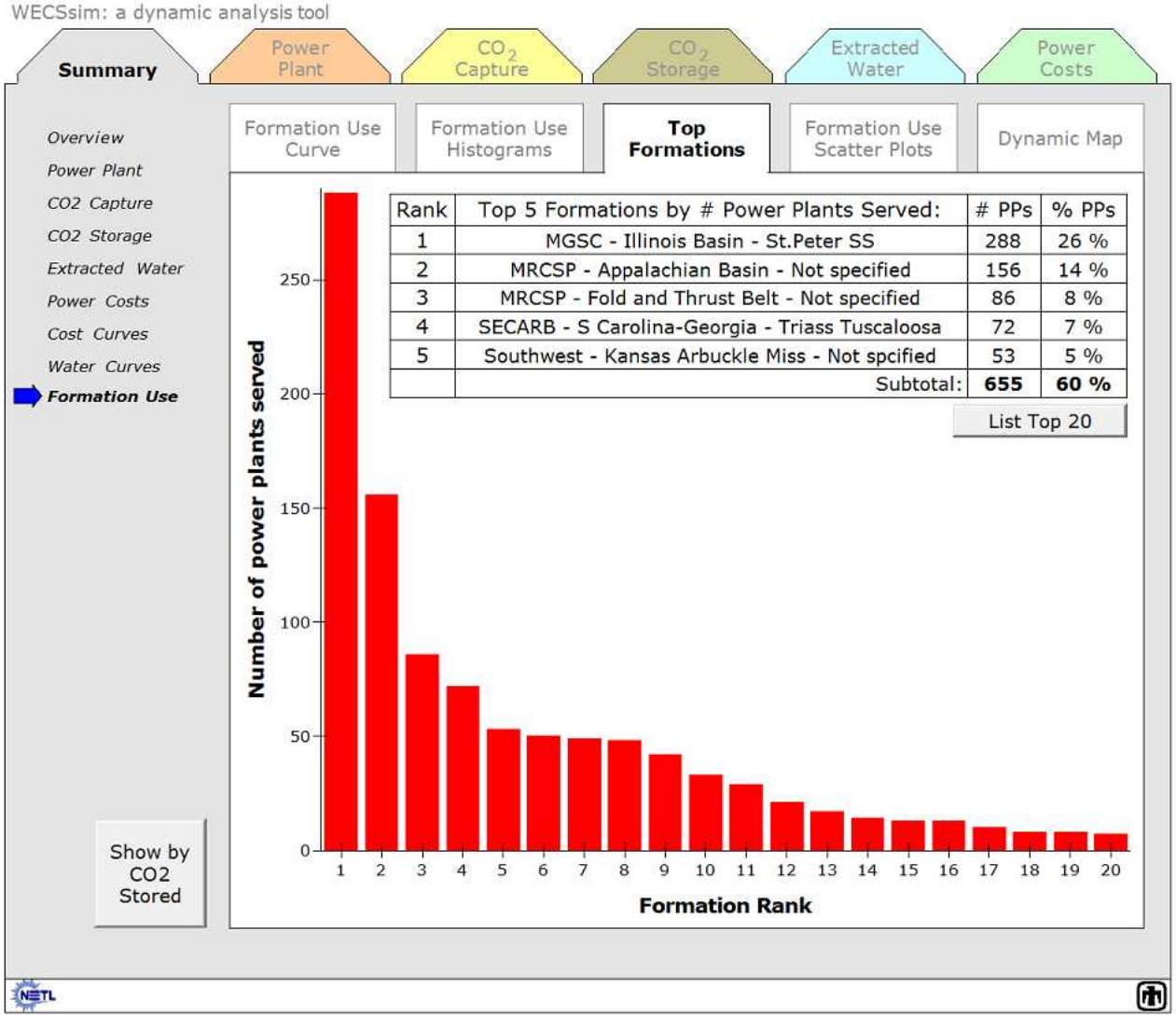
Informs

Developing a National, CO_2 Storage Supply Curve

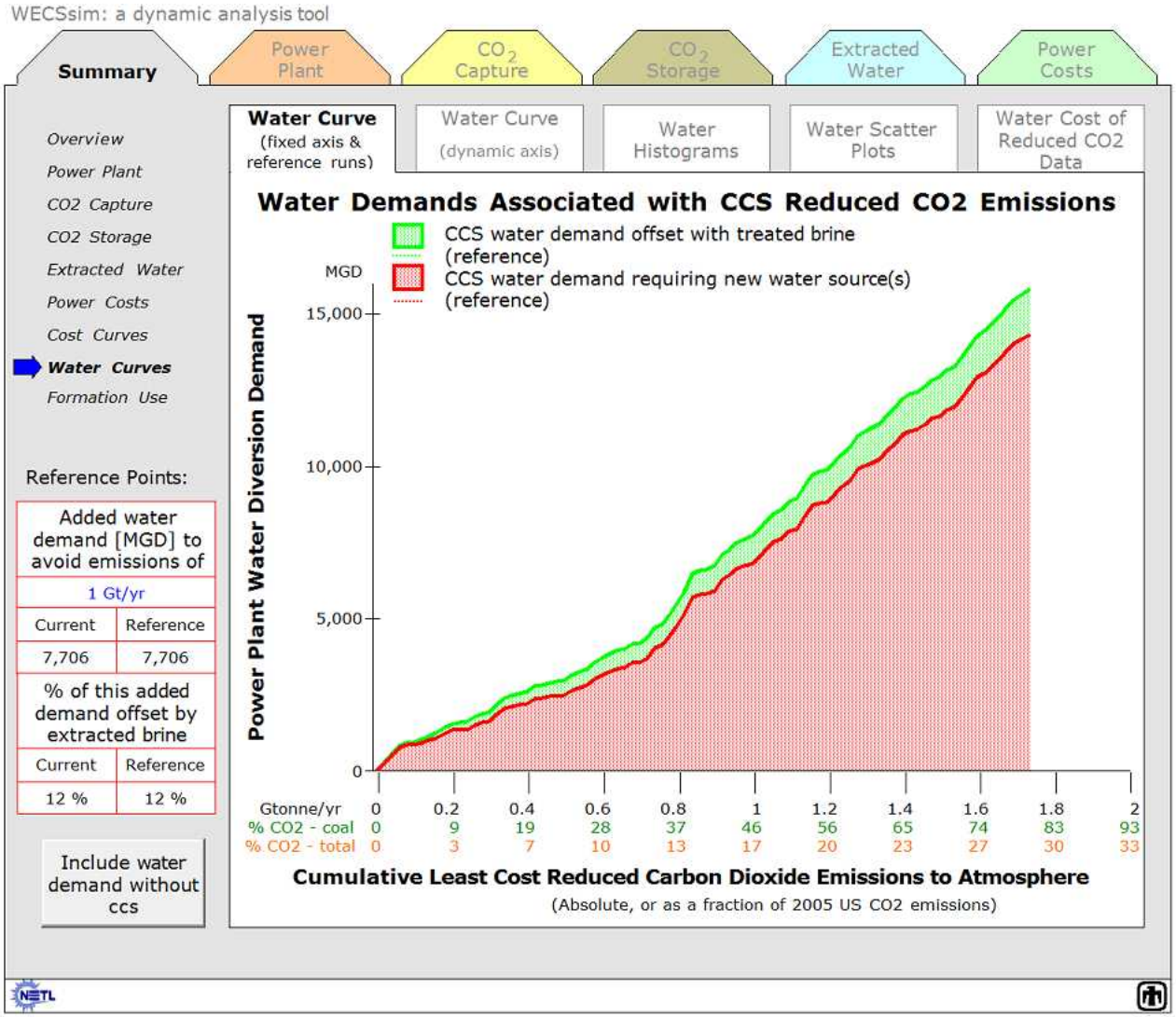


National Level CO_2 and H_2O Volumes and Costs

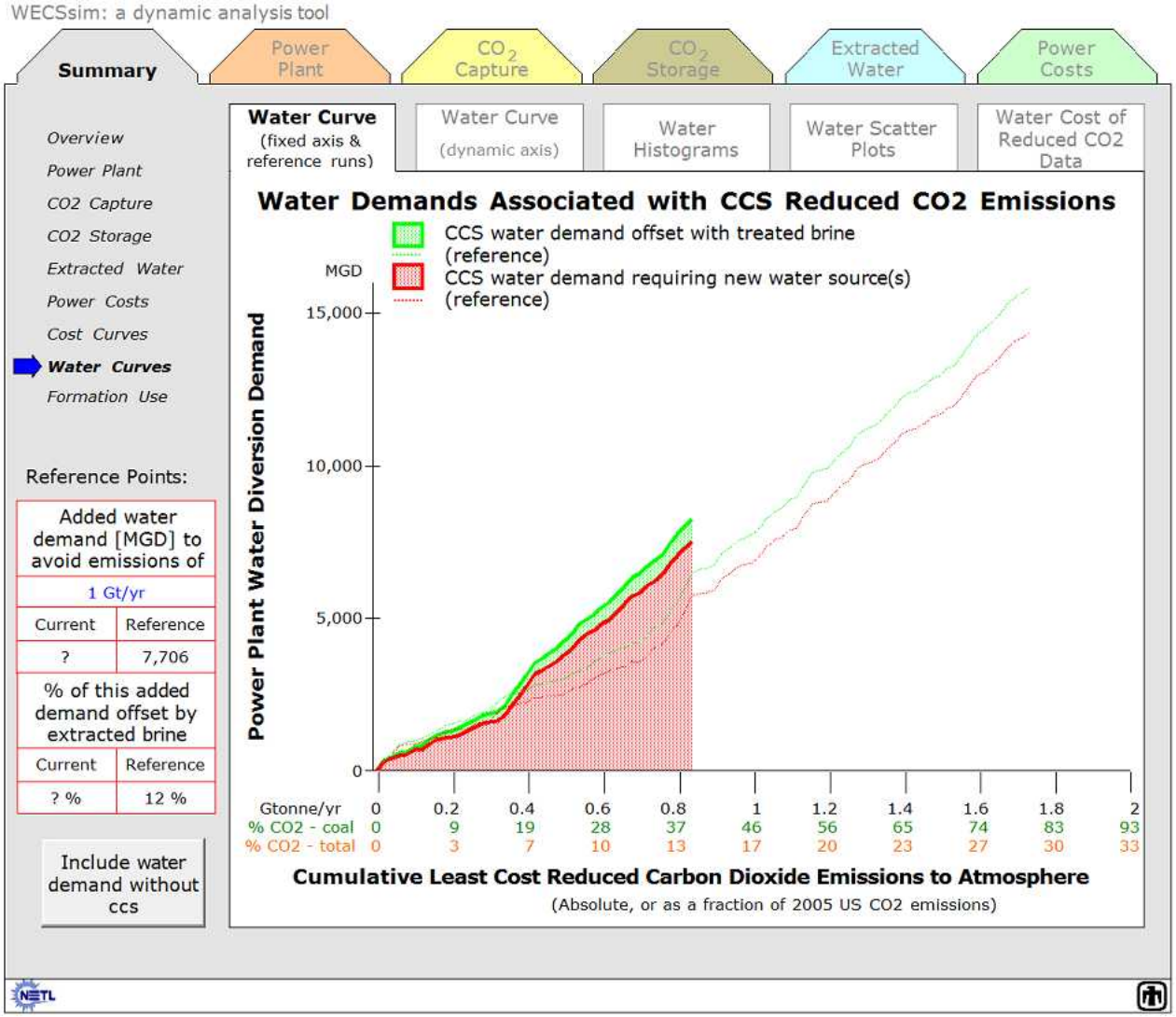
Top Formations (CCS Sinks) Illustrative Scenario



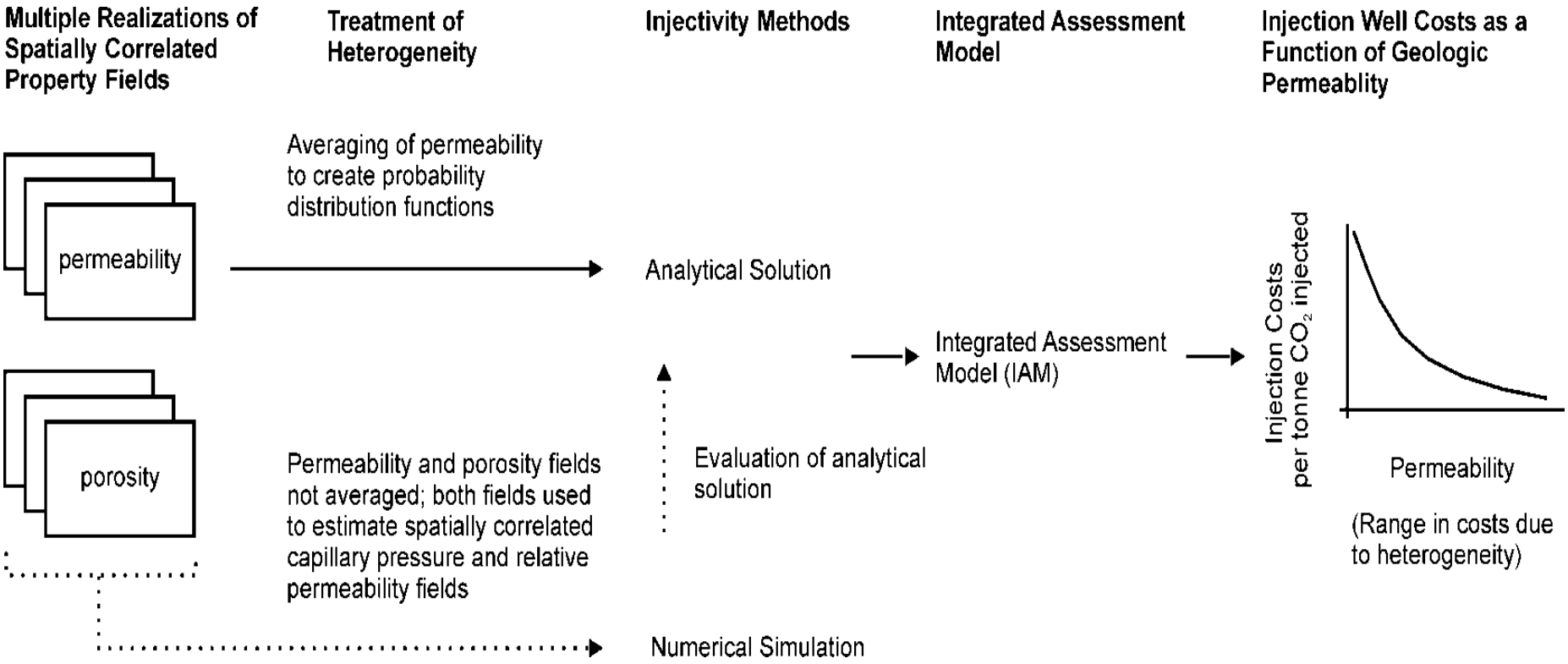
National Fleet Water Curves



Base Case (90% Capture) and 50% CO_2 capture: Water Demands

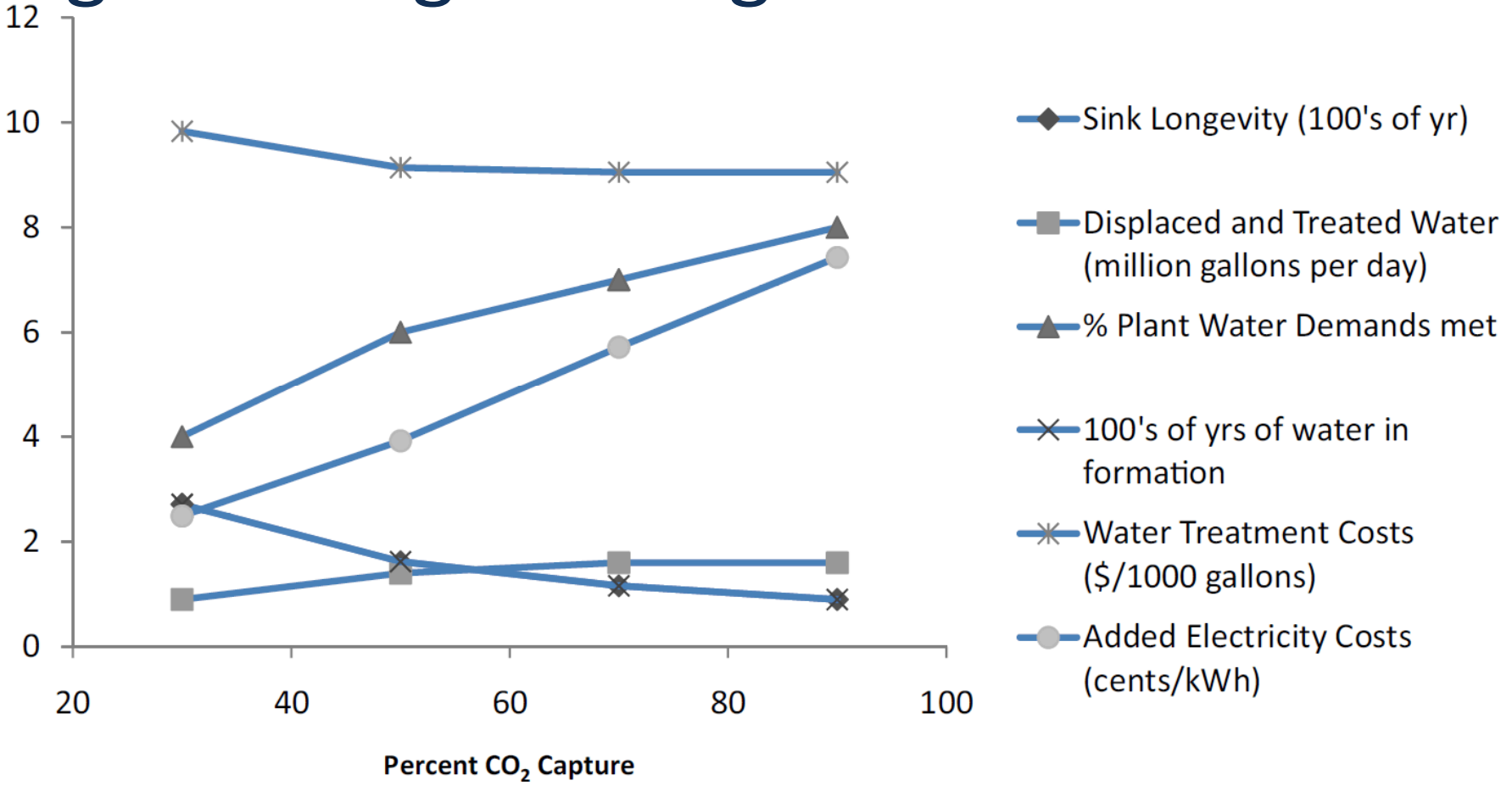


Methods behind the Permeability-to-Cost Analysis



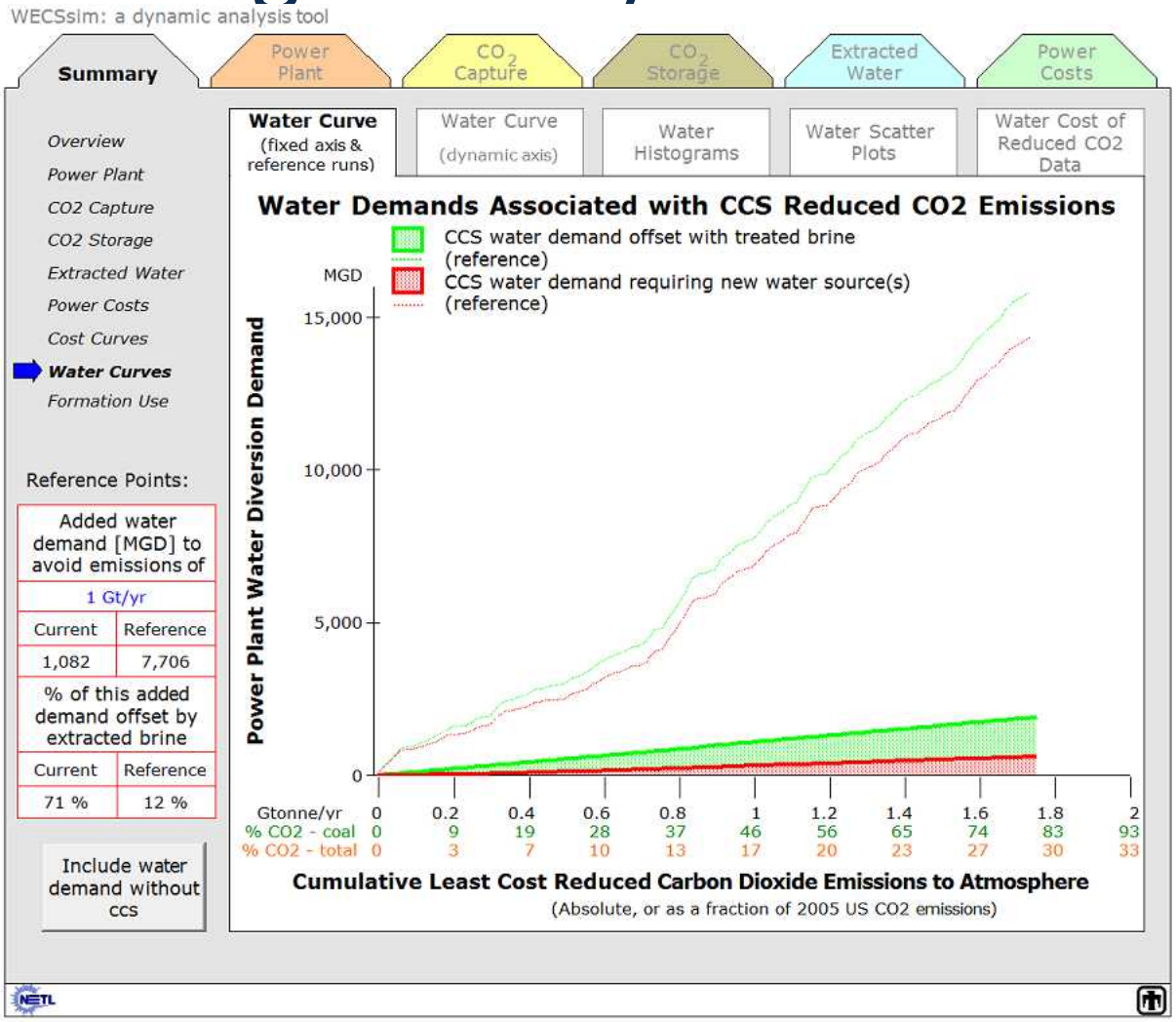
Source: Heath, J.E., Kobos, P.H., Roach, J.D., Dewers, T.A. and S.A. McKenna, 2012, "Geologic Heterogeneity and Economic Uncertainty of Subsurface Carbon Dioxide Storage,"
SPE Economics & Management Journal, January 32-41.

Single Power Plant to Single Geologic Storage Site

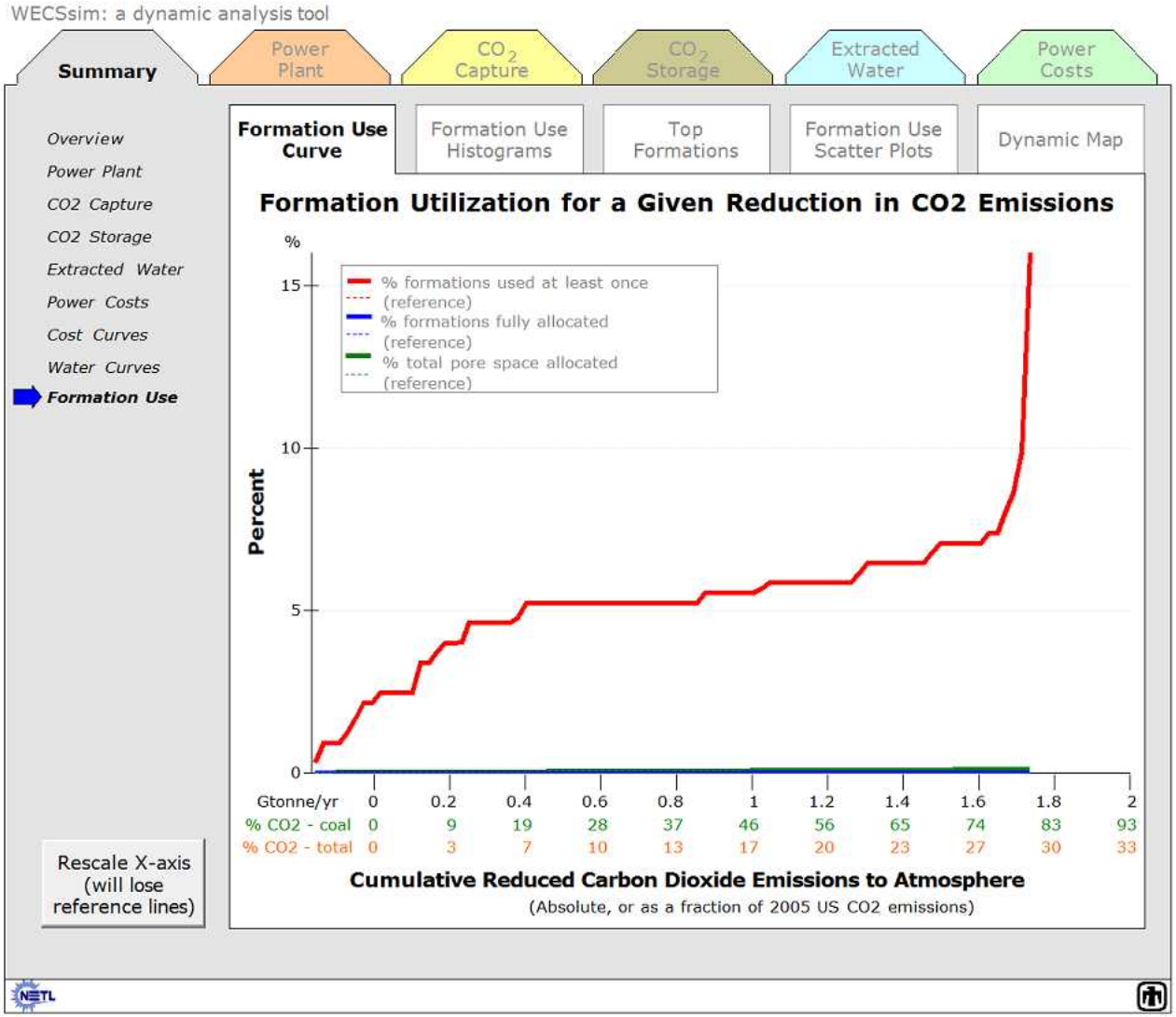


Source: Kobos et al., 2011, Combining power plant water needs and carbon dioxide storage using saline formations: Implications for carbon dioxide and water management policies, *International Journal of Greenhouse Gas Control*, 5, 899-910.

Water Efficient Makeup Power (NGCC, cooling towers)



National Formation Utilization Illustrative Scenario



Base Case (90% Capture) and 50% CO_2 capture: Geologic Formation Utilization

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