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MICKEY LELAND ENERGY FELLOWSHIP PROGRAM

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Offsetting Water Requirements and Stress with Enhanced Water Recovery from CO₂ Storage

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U.S. DEPARTMENT OF
ENERGY

Fossil
Energy

Motivation

U.S.-CHINA CLEAN
ENERGY RESEARCH CENTER
中美清洁能源联合研究中心

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

Saline Aquifer Storage

- Considerable CO₂ storage potential
- Brine Production
 - Increase CO₂ storage
 - Brine desalination and beneficial water use
 - Reduced risks linked to reservoir pressure
 - CO₂ plume management
- Costs benefit analysis
 - Additional production wells
 - Water desalination
 - CO₂ Storage

NETL Carbon Storage Atlas 5th edition, 2015

Subsurface Flow

- FEHM - Finite Element Heat and Mass Transfer Code
- Simulate CO₂ flow and transport in a deep, saline aquifer
- Rock Springs Uplift Formation – BEST (Brine Extraction Storage Test)
- Scenarios
 - CO₂ injection at constant set pressure with hydrostatic brine production
 - Baseline no brine production
 - 1 brine production well
 - 2 brine production wells
 - 3 brine production wells
 - 4 brine production wells

Baseline No Brine Production

Offsetting Water Requirements and Stress with Enhanced Water Recovery from CO₂ Storage

Offsetting Water Requirements and Stress with Enhanced Water Recovery from CO₂ Storage

Ongoing Work

- Cost benefit analysis
 - Production wells
 - Increase installation and production cost
 - Increase CO₂ capacity and treated water for beneficial use
- Predicting Engineered Natural Systems for CO₂ Storage (CO₂-PENS)
- NRAP Integrated Assessment Model – Carbon Storage (NRAP-IAM-CS)
- Water Treatment Model (CO₂-PENS WTM)
- BEST cost estimates

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Questions?

THE OHIO STATE
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Offsetting Water Requirements and Stress with Enhanced Water Recovery from CO₂ Storage

Brine Characterization

Lower Madison formation water chemistry BEST desalination techniques

- High temperature, TDS, chloride level, alkalinity level, and silica level
- CaCO₃ saturation
- At or near CaSO₄ anhydrite saturation
- Presence of sulfide
- Relatively high boron concentration
- Moderate presence of iron in ferrous form
- Direct contact flash
- Flash evaporation with surface condenser
- Dedicated cooling tower
- Nanofiltration
- Membrane Distillation (no outside energy)
- Nanofiltration and reverse osmosis
- MVR evaporator
- MED evaporator (no outside energy)
- MVR evaporator and crystallizer

Rock Springs Uplift

- Previously studied area that define capabilities and risks of long-term CO₂ storage
- Mesh for FEHM previously built
- Previous reports on subsurface conditions provide ideal location to model subsurface flow
- Wyoming supplies more energy (primarily fossil-based) to the rest of the Nation and has more producing federal oil and natural gas leases than any other state
- Used a generated FEHM mesh that is laterally centered on the RSU #1 well with the approximate lateral extents of 6 by 6 km and from depths below the surface from 2.8 to 4.3 km. Distinct porosities and permeabilities applied to Madison layer

Characterization of Rock Springs Reservoir

- 5 mi by 5 mi Seismic Survey
- Stratigraphic Test Well
- Downhole Well Tests
- Petrophysical Logs
- Core Tests
- Reservoir Fluid Tests
- Predictive Models

Tests Identified

- Prime injection zones
- Sealing capacity
- Reservoir and confining layer heterogeneity
- Rock mechanics
- Stress vectors
- Geochemistry
- Compositional variance of the formation fluids
- Pressures
- Temperatures
- Geologic and diagenetic history
- Burial history
- Microseismic variance
- Reservoir response to step-rate injection tests
- Seismic character and attributes
- Seal by-pass systems
- Preliminary responses to injected fluids