Centralia, Washington
Deep Coal Seam CO₂ Sequestration Evaluation – Final Report

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Acknowledgments

• Will Greenough with TransAlta for data access and geologic and operational insights.

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Centralia Power Plant and Coal Mine:

**Project Objectives**

- Evaluate geology and $\text{CO}_2$ storage potential of deep coals and saline aquifer sandstones near the 1400-MW Centralia power plant.
- Develop conceptual reservoir testing program for $\text{CO}_2$ storage at Centralia.

**Key Conclusions**

- While not geologically ideal (structurally complex), the Centralia region coals may have 13 years of storage capacity for Centralia power plant (50% storage).
- Sandstones, though generally not of high quality, do have zones with up to 30% porosity and 2 mD of permeability. May add another 9 to 73 years of capacity.
- A well test program with 3-5 coreholes could measure the reservoir properties of coal seams and saline aquifer sandstones at low cost.
Project Concept: Inject CO2 into Deep Coal Seams (and Saline Aquifers)

Burlington Resources Allison Unit CO2-ECBM Pilot San Juan Basin, New Mexico

#112 Production Well
#142 CO2 Injector
#114 Production Well

Note: Depths, elevations, thicknesses expressed in feet

Commercial Analogs

- Nearby commercial oil and gas activities provide insights for CO2 storage at Centralia.
- CBM exploration wells (red) SW of Centralia suggest coals may have favorable gas content for ECBM.
- Jackson Prairie gas storage field (green) south of Centralia utilizes Eocene Skookumchuk sandstones (good P&P) and anticlinal closure. Similar features exist near Centralia.
- Mist gas field (purple) in northern Oregon produces and stores gas from Eocene Cowlitz Fm sandstones, similar to those at Centralia.

Advanced Resources International
**REGIONAL CENTRALIA STRUCTURE MAP**

- Numerous NW-trending faults and folds complicate CO2 storage at Centralia.
- Town of Centralia directly west of coal fields complicates surface access.

**CENTRALIA COMPARED WITH SAN JUAN BASIN**

- Map shows Centralia coal fields and structures superimposed on the San Juan basin, the most productive CBM basin.
- By comparison Centralia is small and structurally complex, with numerous faults and steep dips.
- Geologically, Centralia is not ideal but coupled with saline aquifer storage could be a good storage solution for Centralia.
• Thickness and depth of the Big Dirty seam near Centralia, within the Eocene Skookumchuck Fm.

• Seam is about 10 m thick and deeper than 150 m in the Centralia syncline west of the coal mine.

• Centralia coal field and adjacent areas (green) where the Big Dirty seam may be deeper than 150 m (500 feet), based on water well logs, and prospective for CO₂ storage.
• Detailed structure map of Tono basin, Centralia coal mine, showing surface geology, many small faults.
• DOE conducted an underground coal gasification test in the 1970’s (yellow coreholes).
• Tono is deep enough for CO2 storage but quite small.
• Conceptual CO2 injection & storage wells on 40-ac spacing (green dots).

RESERVOIR SIMULATION

• Given that coal seam reservoir properties are poorly known at Centralia, reservoir simulation helps evaluate the range of CO2 injection and CH4 production behavior as well as optimize well spacing.

• Most Likely case (below) assumed 1 millidarcy of permeability and 100% initial methane saturation.

• Indicates that 40-acre well spacing could be efficient, with CO2 saturating much of the reservoir over a 20-year injection period. Methane production is modest but might pay back the capex for shallow wells.

• Other sensitivities evaluated alternate perm/saturation assumptions.
COAL SEAM STORAGE CAPACITY

- Deep coal resources in the Centralia region could have about 50 million metric tonnes of storage capacity.
- Assuming 50% capture that would be equivalent to 13.1 years of emissions from the Centralia power plant.
- Saline aquifers in Eocene Skookumchuck Fm and adjacent sandstones could add another 9 to 73 years, for total 22 to 86 years (50% capture).

<table>
<thead>
<tr>
<th>Coal Mass</th>
<th>Prospective Area</th>
<th>Coal Area Depth, Pressure, Thickness, Ash, Moisture, Density, Billion daf</th>
<th>Adjusted Net 75% Area</th>
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<tbody>
<tr>
<td>km²</td>
<td>acres</td>
<td>m</td>
<td>psi</td>
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<tr>
<td>Total Centralia Syncline Prospect</td>
<td>107</td>
<td>26400</td>
<td>500</td>
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<tr>
<td>Adjusted Net 75% Area</td>
<td>80</td>
<td>19800</td>
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<table>
<thead>
<tr>
<th>CH₄ and CO₂ Potential</th>
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<th>100% Sat.</th>
<th>100% Sat.</th>
<th>75% Sat.</th>
<th>100% Sat.</th>
<th>100% Sat.</th>
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</thead>
<tbody>
<tr>
<td>CH₄ Gas Content (d.a.f.)</td>
<td>MM m³/t</td>
<td>Bcf</td>
<td>MM m³</td>
<td>Bcf</td>
<td>MM m³</td>
<td>Bcf</td>
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<tr>
<td>CO₂ Content (daf)</td>
<td>MM m³/t</td>
<td>Bcf</td>
<td>MM m³</td>
<td>Bcf</td>
<td>MM m³</td>
<td>Bcf</td>
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<tr>
<td>Total Centralia Syncline Prospect</td>
<td>4.16</td>
<td>133</td>
<td>5.54</td>
<td>178</td>
<td>21.70</td>
<td>695</td>
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<tr>
<td>Adjusted Net 75% Area</td>
<td>4.16</td>
<td>133</td>
<td>5.54</td>
<td>178</td>
<td>21.70</td>
<td>695</td>
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</tbody>
</table>

- Centralia CO₂ Emissions 100% 8.00 million t/y 6.5 Years storage capacity
- Centralia CO₂ Emissions 50% 4.00 million t/y 13.1 Years storage capacity

**CONCLUSIONS : TEST COREHOLE PROGRAM AT CENTRALIA**

- Reservoir properties at Centralia could be moderately favorable for CO₂ storage
- However, coal seam & sandstone reservoir properties have not been tested and require a corehole program to more fully evaluate the CO₂ storage potential.
- Focus on relatively deep narrow synclines near Centralia, where formation pressure is likely to be adequate.
- Full program of coal seam desorption, injection/falloff, and lab testing.

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<th>Activity</th>
<th>Corehole</th>
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<tr>
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<td>Coring</td>
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<td>3</td>
<td>90000</td>
</tr>
<tr>
<td>Supervision</td>
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<td>3</td>
<td>60000</td>
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<tr>
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- Sandstone core and log evaluation to measure P&P and understand 3D
- Total cost for a basic 3-well program is estimated at approximately $1 million.