AEP CCS Program Overview

Gary O. Spitznogle
Director – New Tech Development & Policy Support
December 7, 2010

Characterization...
Simulation...
Validation...
AEP’s Generation Fleet
>38,000 MW Capacity

Coal/Lignite 66%

Nat. Gas/Oil 22%

Nuclear 6%

Pumped Storage/Hydro/Wind 6%

5.2 million customers in 11 states
Industry-leading size and scale of assets:

<table>
<thead>
<tr>
<th>Asset</th>
<th>Size</th>
<th>Industry Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Generation</td>
<td>~38,300 MW</td>
<td># 2</td>
</tr>
<tr>
<td>Transmission</td>
<td>~39,000 miles</td>
<td># 1</td>
</tr>
<tr>
<td>Distribution</td>
<td>~213,000 miles</td>
<td># 1</td>
</tr>
</tbody>
</table>
Site Characterization and Feasibility Study
The foundational work for AEP’s CCS program began in 2003

Seismic Survey
Summer 2003

Drilling and Testing
2003 - 2005

Modeling and Analysis
2006 - 2007

More than $7.5 million for site characterization and feasibility assessment conducted by Battelle under funding by DOE and others
Rose Run Sandstone Core Analysis

Rose Run Sandstone - 116 ft total thickness, ~30 ft porous sandstone.

Full Rock Core 7762-7772
- Lithology = Sandstone
- Density = 2.68 g/mL
- Porosity = 9.1%
- Permeability ~ 36 mD

Hydraulic Core Tests 7763.5 ft
- Lithology = Sandstone
- Density = 2.68 g/mL
- Porosity = 9.1%
- Permeability ~ 36 mD

Full Rock Core 7772-7782
- Lithology = Sandstone
- Density = 2.64 g/mL
- Porosity = 10.4%
- Permeability ~ 49 mD

Hydraulic Core Tests 7775 ft
- Lithology = Sandstone
- Density = 2.64 g/mL
- Porosity = 10.4%
- Permeability ~ 49 mD

Full Rock Core 7818-7828
- Lithology = Sandstone
- Density = 2.63 g/mL
- Porosity = 11.5%
- Permeability ~ 36 mD

Hydraulic Core Tests 7819 ft
- Lithology = Sandstone
- Density = 2.63 g/mL
- Porosity = 11.5%
- Permeability ~ 36 mD
Alstom’s Chilled Ammonia Process
Post-Combustion Capture

Chilled Water

Gas Cooling and Cleaning

Flue Gas from FGD

Cooled Flue Gas

CO₂ Absorber

Reagent

CO₂ Regenerator

Clean CO₂ to Storage

Reagent

Heat and Pressure

Reactions:

\[ \text{CO}_2 \text{ (g)} \rightleftharpoons \text{CO}_2 \text{ (aq)} \]
\[ (\text{NH}_4)\text{CO}_3 \text{ (aq)} + \text{CO}_2 \text{ (aq)} + \text{H}_2\text{O} \rightleftharpoons 2(\text{NH}_4)\text{HCO}_3 \text{ (aq)} \]
\[ (\text{NH}_4)\text{HCO}_3 \text{ (aq)} \rightleftharpoons (\text{NH}_4)\text{HCO}_3 \text{ (s)} \]
\[ (\text{NH}_4)\text{CO}_3 \rightleftharpoons (\text{NH}_4)\text{NH}_2\text{CO}_2 + \text{H}_2\text{O} \]
AEP CCS Validation Facility
1,300 MWe Mountaineer Plant, New Haven, WV

- **Scale:** 20 MWe slipstream
  - ~1.5% of power plant flue gas

- **Cost:** >$100M
  - Project initiated in September 2007
  - Funding by AEP, Alstom, RWE, & EPRI

- **Capture:** Alstom Chilled Ammonia Process
  - Ammonium Carbonate/Bicarbonate Reaction
  - >85% CO₂ capture rate

- **Sequestration:** Deep saline formation storage
  - ~100,000 tons CO₂ per year
  - ~1.5 miles below the plant surface

- **First CO₂ Capture:** September 1, 2009
- **First CO₂ Storage:** October 1, 2009
- **Planned operation:** 1 to 5 years
Alstom’s Chilled Ammonia - CO₂ Capture Process
(20 MWe Equivalent or Approximately 1.5% of Unit Flue Gas)
CO$_2$ Sequestration at Mountaineer Plant Site

- WMMS (Well Monitoring & Maintenance System) Building
- CO$_2$ Booster Pump House and Flow Metering
- Well Field AEP-1, AEP-2, & MW-3
Monitoring System Design
At Mountaineer Plant

- Passive Seismic/Tiltmeters
- Surface CO₂ H&S Gas Meters
- Groundwater/Soil Gas
- System CO₂ PVT Monitoring
- Periodic Wireline Logging
- Periodic Brine Sampling
- Injection Wells
- Deep Monitoring Wells
- Crosswell Seismic
- Pressure Gauges
- CO₂ Pipeline
- Slipstream Capture
- CO₂ Capture and Separation
- Deep Monitoring Wells

Monitoring System Design
At Mountaineer Plant
Copper Ridge Thin Sections

Vugular Porosity vs. Crystalline Dolomite

Sidewall core from depth of 8,177 feet just below a proposed perforation interval

Sidewall core from depth of 8,178 feet in non-perforated interval
Validation Facility Progress Update
First Year of Operation

- ~4,400 hours operation
- ~21,000 metric tons captured
- ~15,000 metric tons stored
  - ~13,500 into AEP-1
    - Copper Ridge
  - ~1,500 into AEP-2
    - Rose Run
- Process availability approaching 100%
  - Both capture and storage
- >90% CO₂ capture rate
AEP CCS Commercialization Project
1,300 MWe Mountaineer Plant, New Haven, WV

- **Scale:** Full commercial demonstration
  - 235 MWe Slipstream

- **Cost:** ~$668M

- **Funding:** CCPI Round III Selection
  - DOE awarded 50% cost share, up to $334M
  - Cooperative agreement signed in January, 2010

- **Capture:** Alstom Chilled Ammonia Process
  - ~90% CO₂ capture rate

- **Sequestration:** Battelle is Storage Contractor
  - Deep saline reservoirs
  - ~1,500,000 tons CO₂ per year
  - ~1.5 miles below the surface
  - Pipeline system with off-site wellheads

- **NEPA Process Underway**

- **Geologic Experts Advisory Group:** Actively Meeting
  - Battelle, Schlumberger, CONSOL, MIT, Univ. of Texas, Ohio State, WVU, Virginia Tech, LLNL, WV Geo. Survey, OH Geo. Survey, WV DOE, NETL, RWE, & CATF

- **Planned Operation:** Startup in second half of 2015
Remaining Challenges

Capture Process:
- CO₂ absorption
- Steam requirement for liberation of CO₂
- Power plant integration and optimization
- Parasitic load

CO₂ Storage:
- Property rights
- Liability
- Permit requirements
- USEPA designation of CO₂
- State cooperative agreements/consistency