



**AMERICAN[®]
ELECTRIC
POWER**

Validating Technology for CO₂ Removal From Flue Gas – Coal Fired Boilers

Alstom's Chilled Ammonia Process (CAP)

At AEP's Mountaineer Plant; New Haven, WV

Presentation Outline

- American Electric Power Overview
- CAP Technology Overview
- CO₂ Handling and Storage
- Permits, Legal Approval, & Outreach
- Questions and Answers

AEP Overview

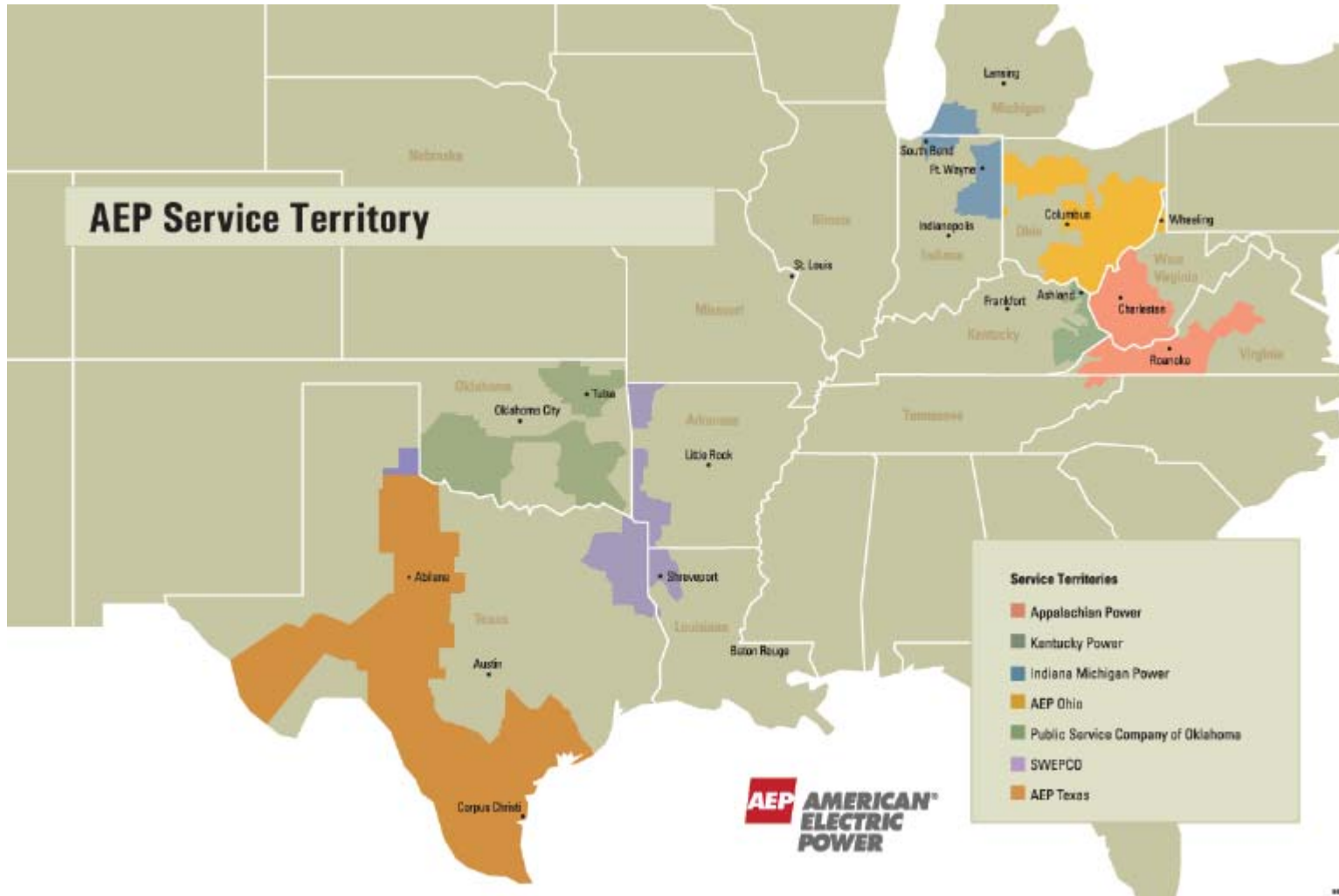
- American Electric Power (AEP) is one of the largest electric utilities in the United States. 37,700MW generating capacity with approximately 5 million customers.

- AEP is made up of seven operating companies.
 1. AEP Ohio ≈1.5 Million Customers
 2. **Appalachian Power** ≈ **1 Million Customers**
 3. AEP Texas ≈ 900,000 Customers
 4. Indiana – Michigan Power ≈ 575,000 Customers
 5. Public Service Oklahoma ≈ 514,000 Customers
 6. Southwest Electric Power Company ≈ 459,000 Customers
 7. Kentucky Power ≈ 175,000 Customers



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AEP Service Territory





Appalachian Power

President and Chief Operating Officer:
Dana Waldo

Appalachian Power Company (APCo)

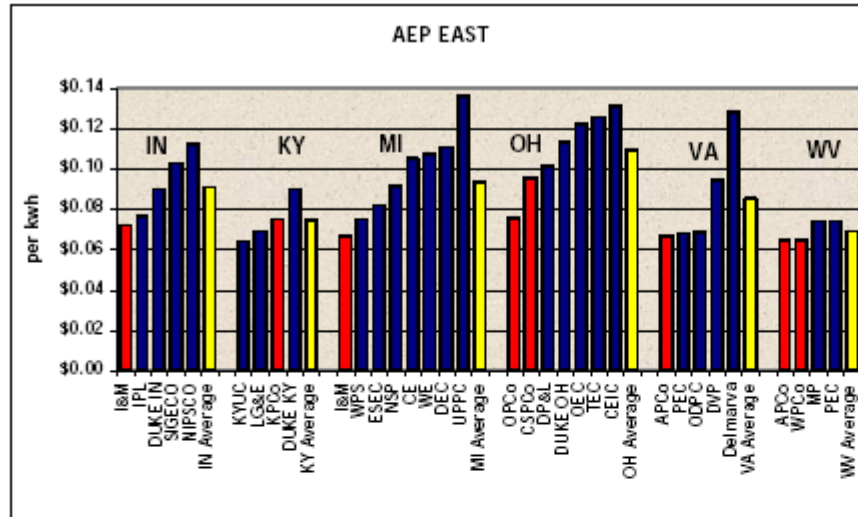
(organized in Virginia in 1926) is engaged in the generation, transmission and distribution of electric power to approximately 949,000 retail customers in the southwestern portion of Virginia and southern West Virginia, and in supplying and marketing electric power at wholesale to other electric utility companies, municipalities and other market participants. APCo covers a service territory of 19,049 square miles, and at December 31, 2006, APCo and its wholly owned subsidiaries had 2,461 employees. Among the principal industries served by APCo are coal mining, primary metals, chemicals and textile mill products. In addition to its AEP System interconnections, APCo also is interconnected with the following unaffiliated utility companies: Carolina Power & Light Company, Duke Energy Corporation and Virginia Electric and Power Company. APCo has several points of interconnection with TVA and has entered into agreements with TVA under which APCo and TVA interchange and transfer electric power over portions of their respective systems. APCo is a member of PJM.



PRINCIPAL INDUSTRIES SERVED:
Coal mining
Primary metals
Chemicals
Textile mill products
Paper products

Total Customers at 12/31/06:	
• Residential	810,000
• Commercial	128,000
• Industrial	4,000
• Other	<u>7,000</u>
Total	949,000
Generating Capacity	6,297 MW
Generating Capacity by Fuel Mix:	
• Coal:	80.8%
• Hydro/Pump:	10.8%
• Nat Gas	8.4%
Transmission Miles	6,731
Distribution Miles	49,413

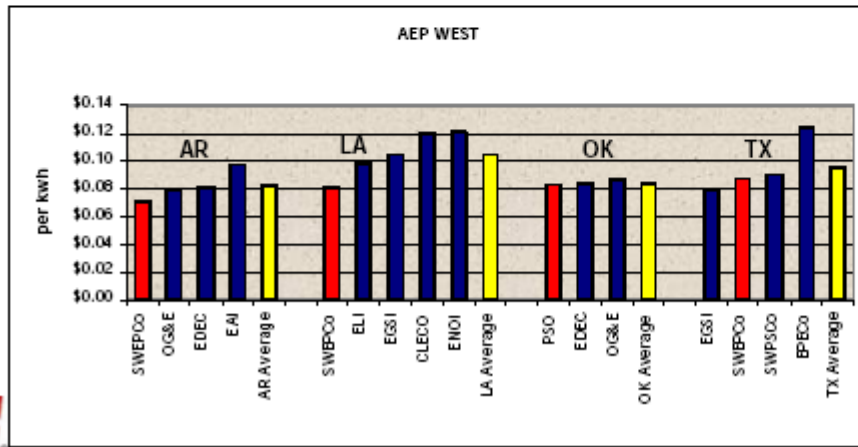
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Residential Average rates for 1,000 kWh - 12 months ended 7/01/2007

Source: Summer 2007 EEI Typical Bills and Average Rates Report

Our low cost provider status in most of our jurisdictions, coupled with our scale and scope, allows us the flexibility to navigate current and future macro-economic issues.



- AEP Company
- Other Company within state
- State Average



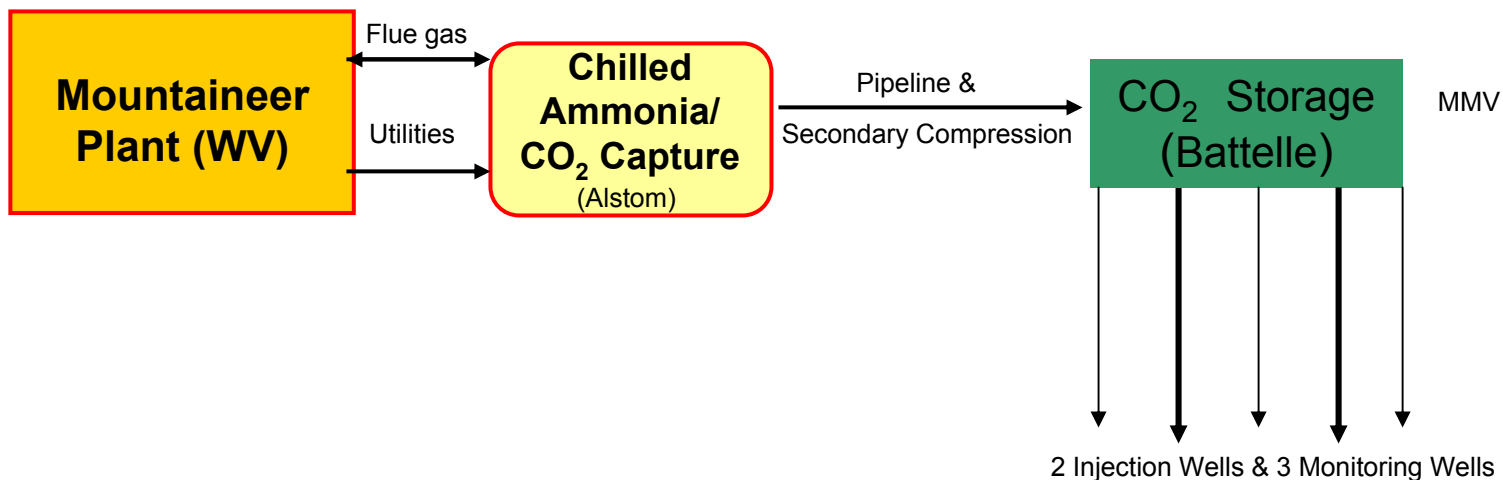
Project Objectives

- Determine ability of CAP process to meet goals of:
 1. Low Parasitic Load
 2. Define equipment issues
 3. Define operation constraints

- Define integration issues
 1. Power plant
 2. CO2 capture
 3. CO2 transport
 4. CO2 Storage
 5. What can be done, What needs to be done, and how does AEP get there.

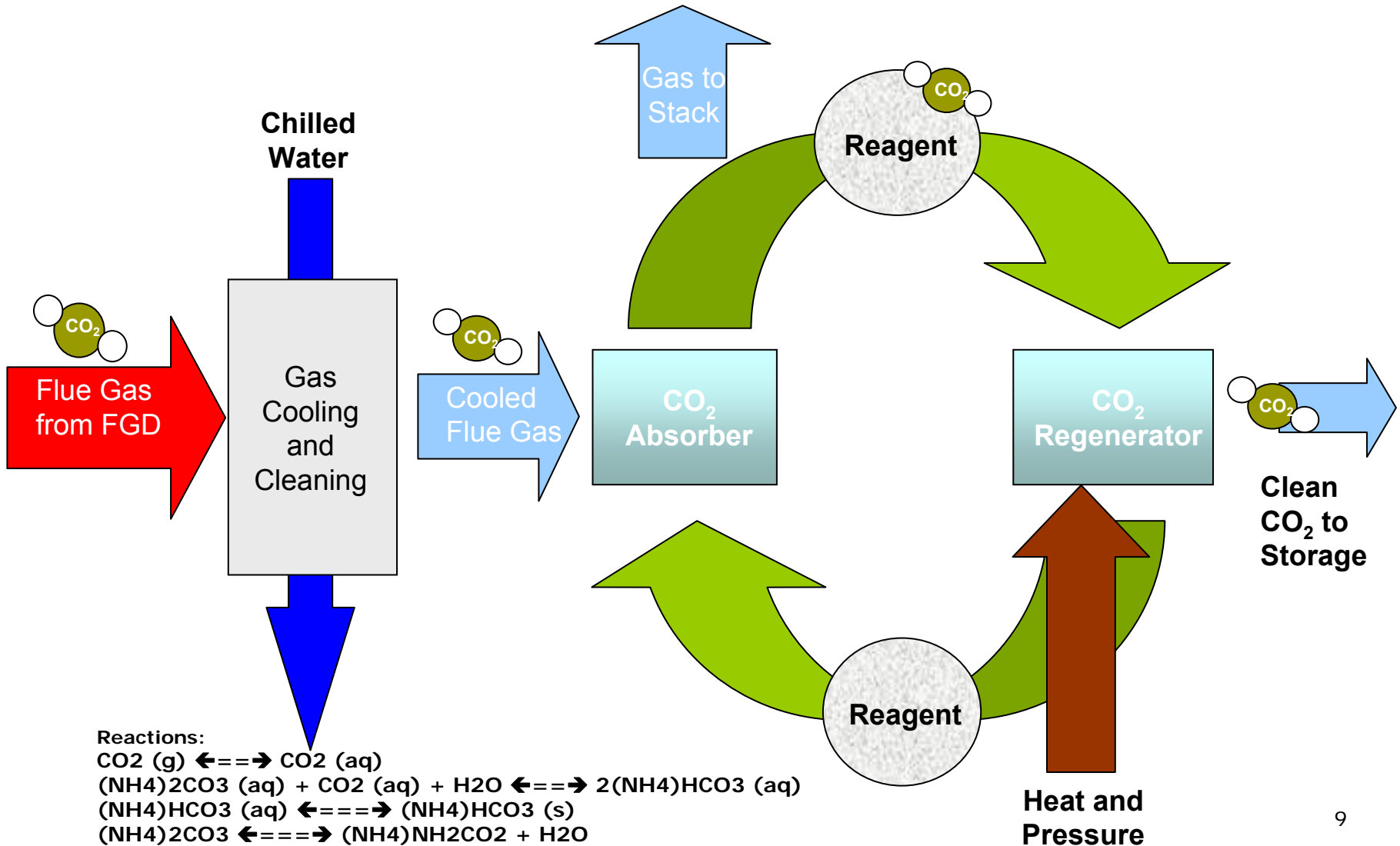
Product Validation Facility (PVF) at AEP's Mountaineer Plant

2009 Startup



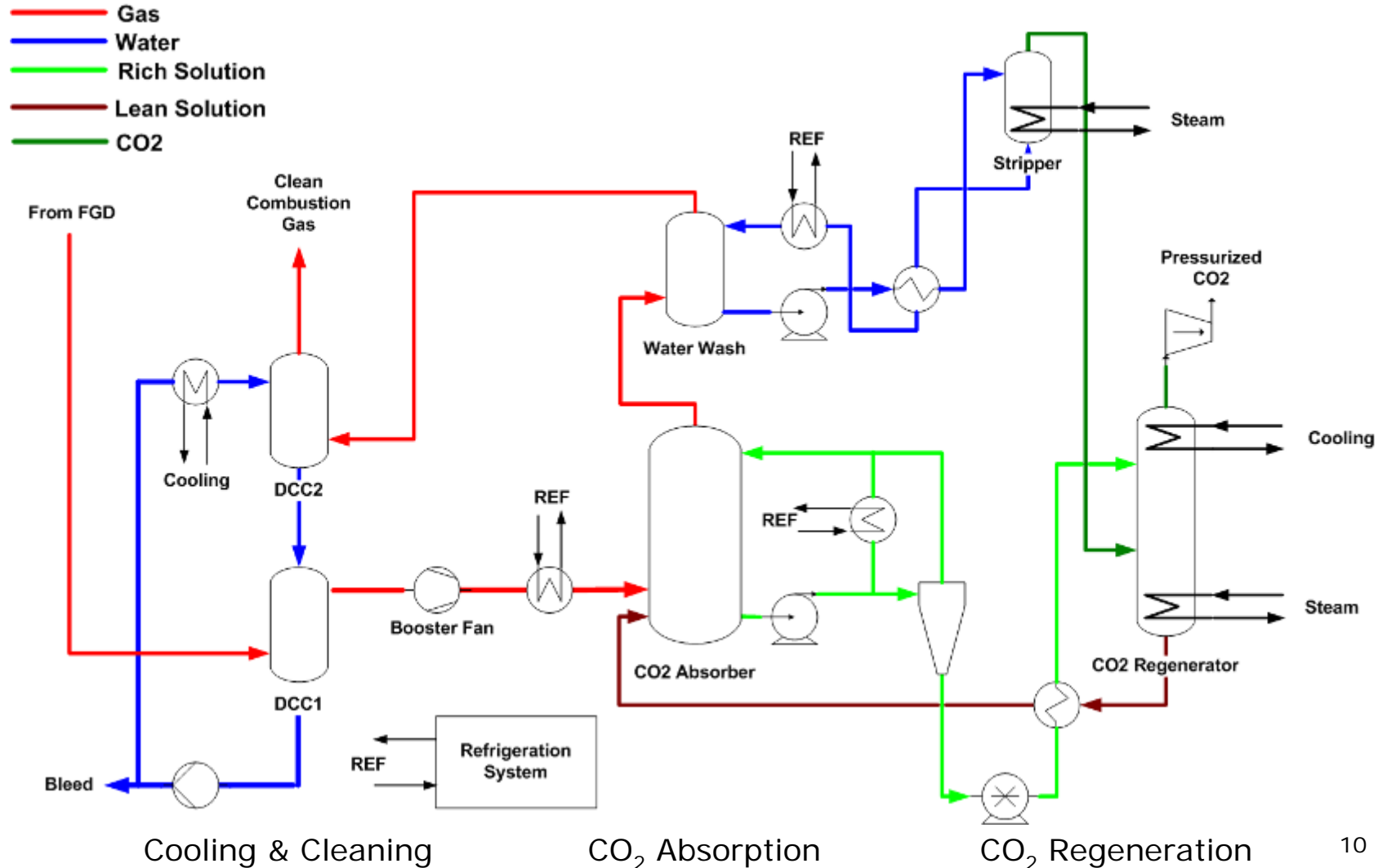
- ❑ AEP unit design based upon scale up of WE \approx 1.7 MWe Pilot Plant.
- ❑ Pilot unit has been operating since June 2008.
- ❑ 20 MW (electric) slip stream from FGD outlet
- ❑ Capture and store \sim 100k–165k tonnes of CO₂ per year
- ❑ Started engineering, planning, and permitting in Sep 07
- ❑ Started construction 2Q 2008, in operation \sim 1 Sep 09
- ❑ Alstom responsible for CAP island, AEP responsible for utilities to/from CAP island and CO₂ storage (Battelle as contractor)

Chilled Ammonia Process Overview





Chilled Ammonia Process Flow Diagram



Features of the Chilled Ammonia Process

- Energy efficient capture of CO₂
 - Use of ambient conditions / natural cooling sources for flue gas cooling
 - Effective utilization of low-grade reject heat
 - Lower heat of absorption/reaction than other technologies
 - Lower energy consumption expected than from other amine based post combustion CO₂ technologies
- Tolerant to trace contaminants (SO_x, HCl, NO_x) in the flue gas
- Low cost and stable reagent, reagent flexibility
- Potentially salable byproduct (ammonium sulfate) stream

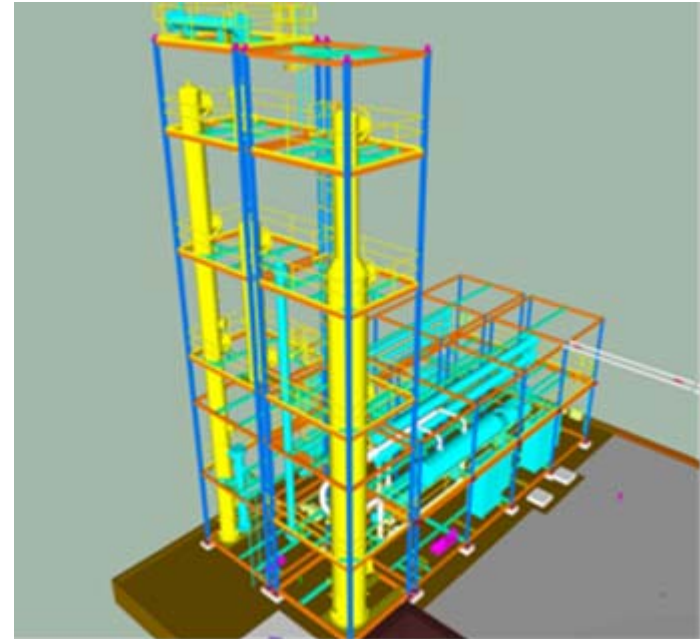


**Alstom Research & Development Facility
SRI CO₂ Capture Pilot Plant
Palo Alto, California – 0.25 MW2**

Graphics courtesy of Alstom Power

Features of the Chilled Ammonia Process

- Regeneration
 - Very low heat of vaporization
 - Lower sensible heat loss due to higher CO₂ loading in rich stream
 - High purity product stream (99.5+ % CO₂)
 - Preheat of rich feed stream with hot, lean solution leaving regenerator
 - High pressure regeneration results in reduced CO₂ compression energy

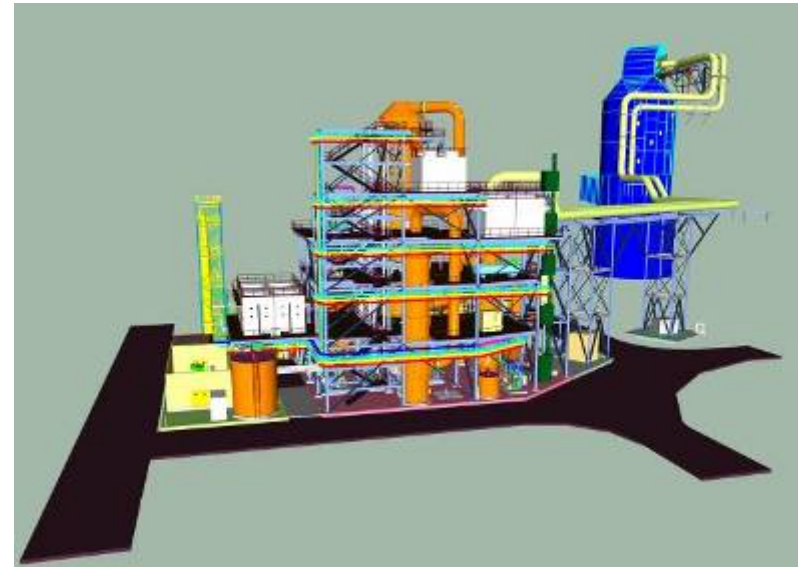


**Mountaineer PVF
Regenerator & Stripper System**

Graphics courtesy of Alstom Power

Mountaineer Carbon Capture Plant Summary

Location	New Haven, WV
Capacity	100,000 tonnes CO ₂ /yr 110,230 tons CO ₂ /yr
Size	~ 20 MWe 50,584 scfm
CO₂ Storage	Deep geological formations
Upstream APC Equipment	ESP, SCR, WFGD, SO ₃ Sorbent injection
Start-Up	3 rd Qtr 2009
Fuel	Bituminous Coal
Reagent	Ammonium carbonate
Regeneration Energy	Steam – turbine extraction
Chiller Refrigerant	R410A
Byproduct	Ammonium sulfate



**American Electric Power
 Mountaineer Power Plant
 CCS Product Validation Facility
 New Haven, WV**

Graphics courtesy of Alstom Power

CO₂ Transport System

- ❑ Design by Enerteq Engineering Company.
- ❑ ~1,800 ft of 4" carbon steel pipe.
- ❑ 2 corrosion monitoring ports.
- ❑ 78 stage pump, Variable Frequency Drive, 1,500 psi to 2,844 psi (maximum allowable surface pressure for Copper Ridge B-Zone).
- ❑ System designed to modulate flow to the two injection wells based upon test plan from Battelle.
- ❑ Kinder-Morgan spec used as design basis for moisture.



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Site Characterization and Feasibility Study

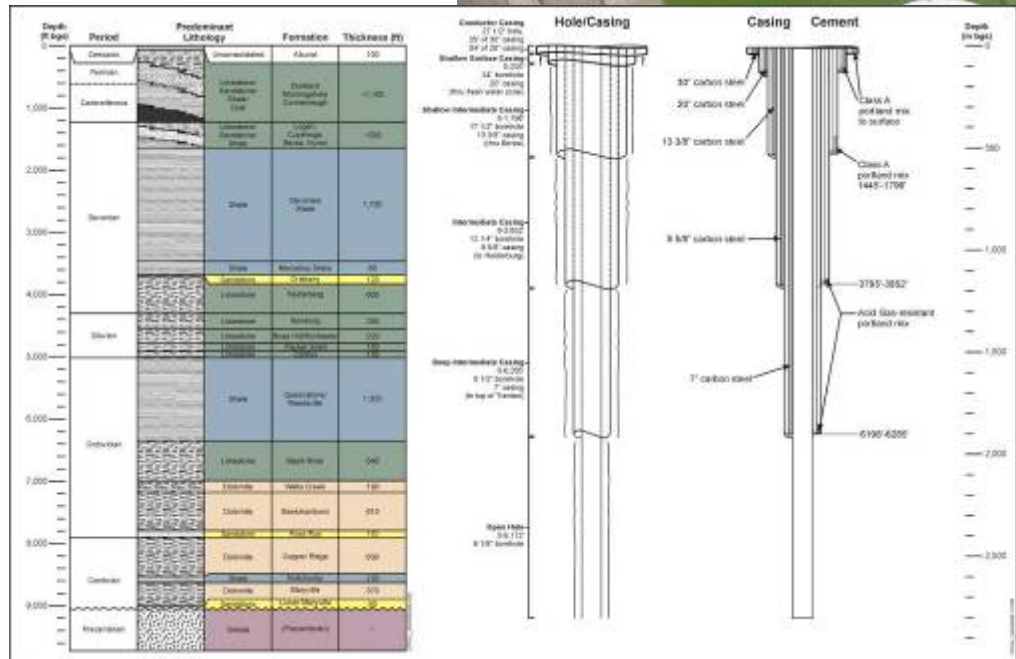


Seismic Survey
Summer 2003

Drilling and Testing
AEP#1 Well – 2003-05

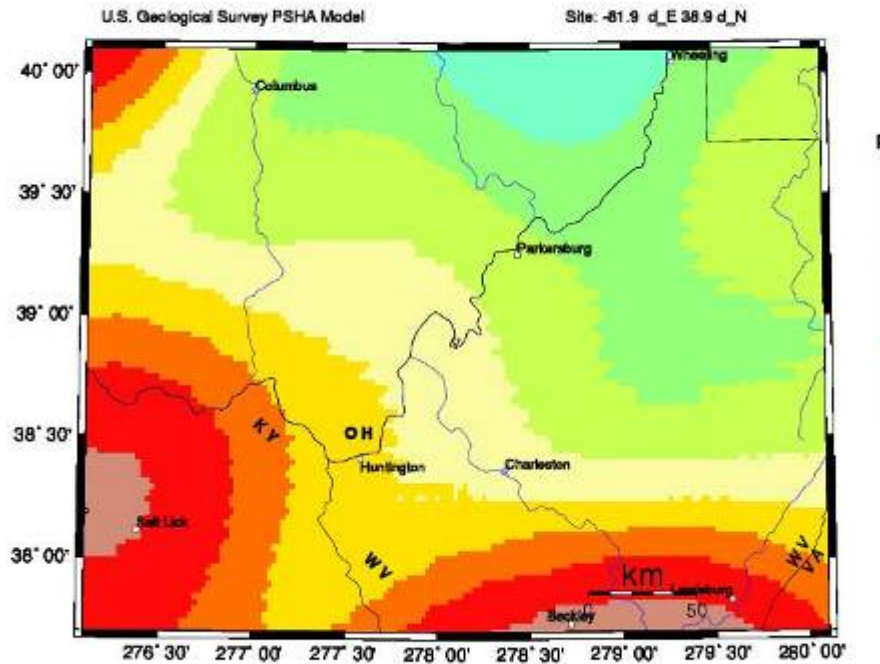


Site characterization and feasibility assessment conducted by Battelle under previous funding by DOE and others



Seismic Activity of West Virginia

P[eq] with $M \geq 4.75$ in 2475 yrs & 50 km

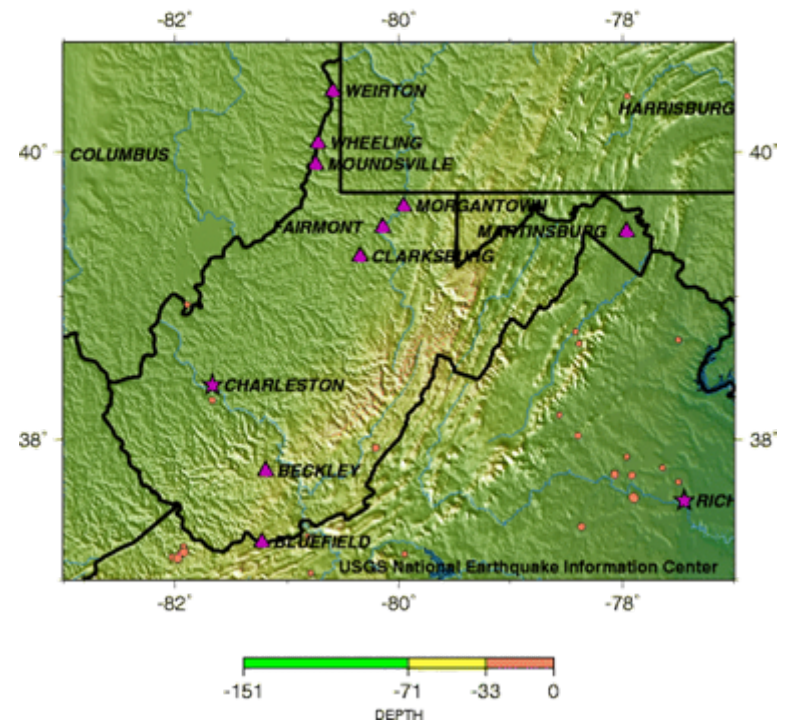


GMT 3.00 Sep 4 19:55:45 Earthquake probabilities from USGS OEP_02-120 PSH-4A, 50 km maximum horizontal distance, site of interest: triangle, epicenters: asterisks, backslashes: rivers etc.

Probability of seismic activity at magnitudes greater than or equal to 4.75 occurring in the next 2475 years.

Source: USGS

Seismicity of West Virginia
 1990 - 2006



Recorded seismic activity of WV, 1990-2006. Size of circle reflects severity of magnitude.

Source: USGS

Upper Injection Zone Cores from AEP#1 Test Well

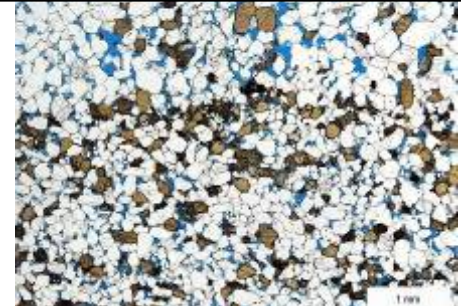
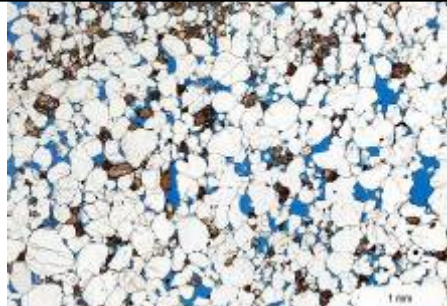
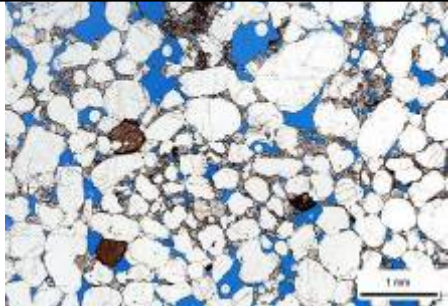
Rose Run Sandstone- 116 ft total thickness, 30 ft porous sandstone



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

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

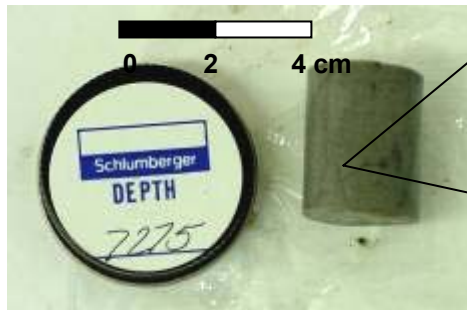
Hydraulic Core Tests 7819 ft	
Lithology	= Sandstone
Density	= 2.63 g/mL
Porosity	= 11.5%
Permeability	= 36 mD



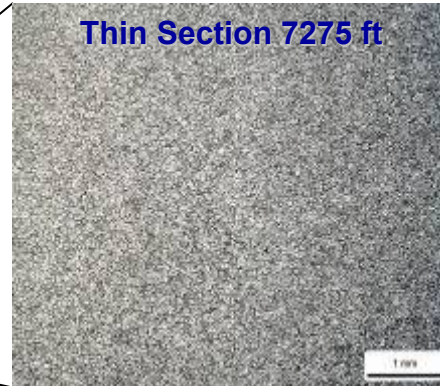
Immediate Caprock above Injection Zone

Beekmantown Dolomite 7210-7755 ft

Rotary Sidewall Core 7275 ft



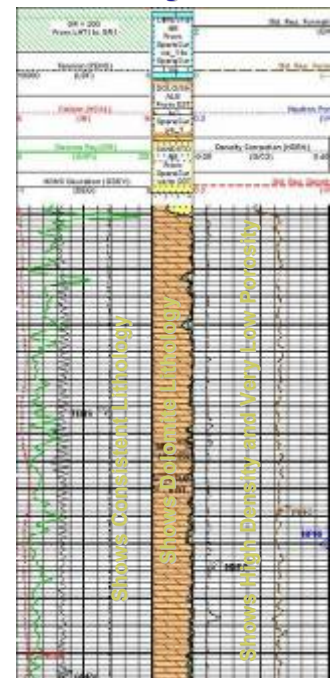
Thin Section 7275 ft



Hydraulic Core Tests 7275 ft

Lithology	= Dolomite
Density	= 2.82 g/mL
Porosity	= 0.38%
Permeability	= <0.001 mD

Wireline Log 7100-7300 ft



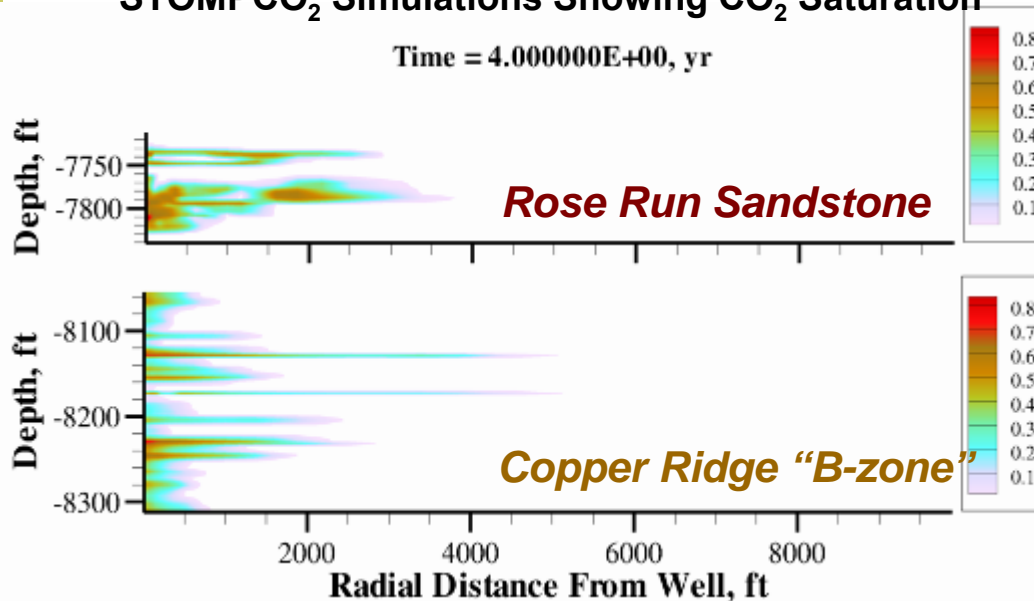
- Presence of multiple, thick, low- permeability containment zones has been established through wellbore observations and seismic survey

Area of Review

- “The Area of Review (AOR) is to be, at a minimum, the anticipated size of the CO₂ plume as modeled or calculated from the injection volume and the characteristics of the injection zone.”
- Based on modeling of ~165,000 tonnes/yr of CO₂ into a single formation, an AOR at 3,490 ft from injection well (area containing 90% CO₂) has been proposed.

STOMP CO₂ Simulations Showing CO₂ Saturation

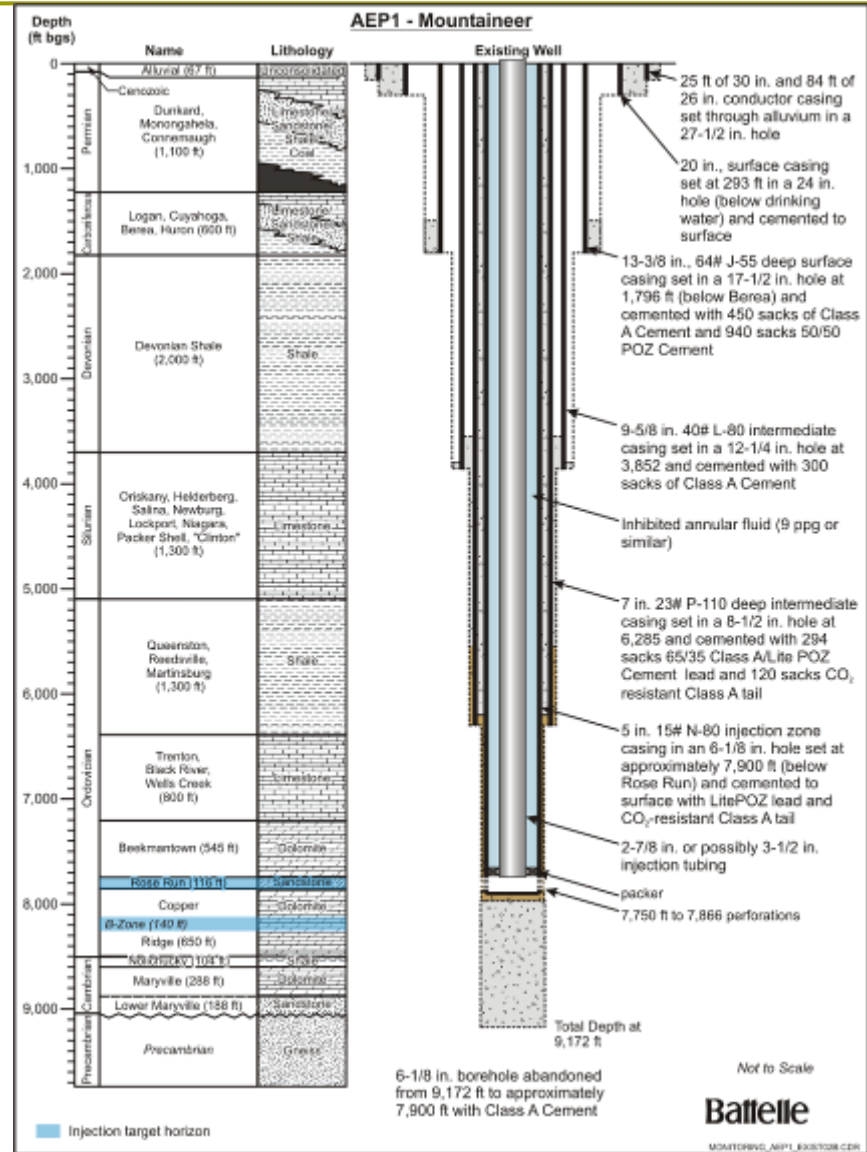
Time = 4.000000E+00, yr





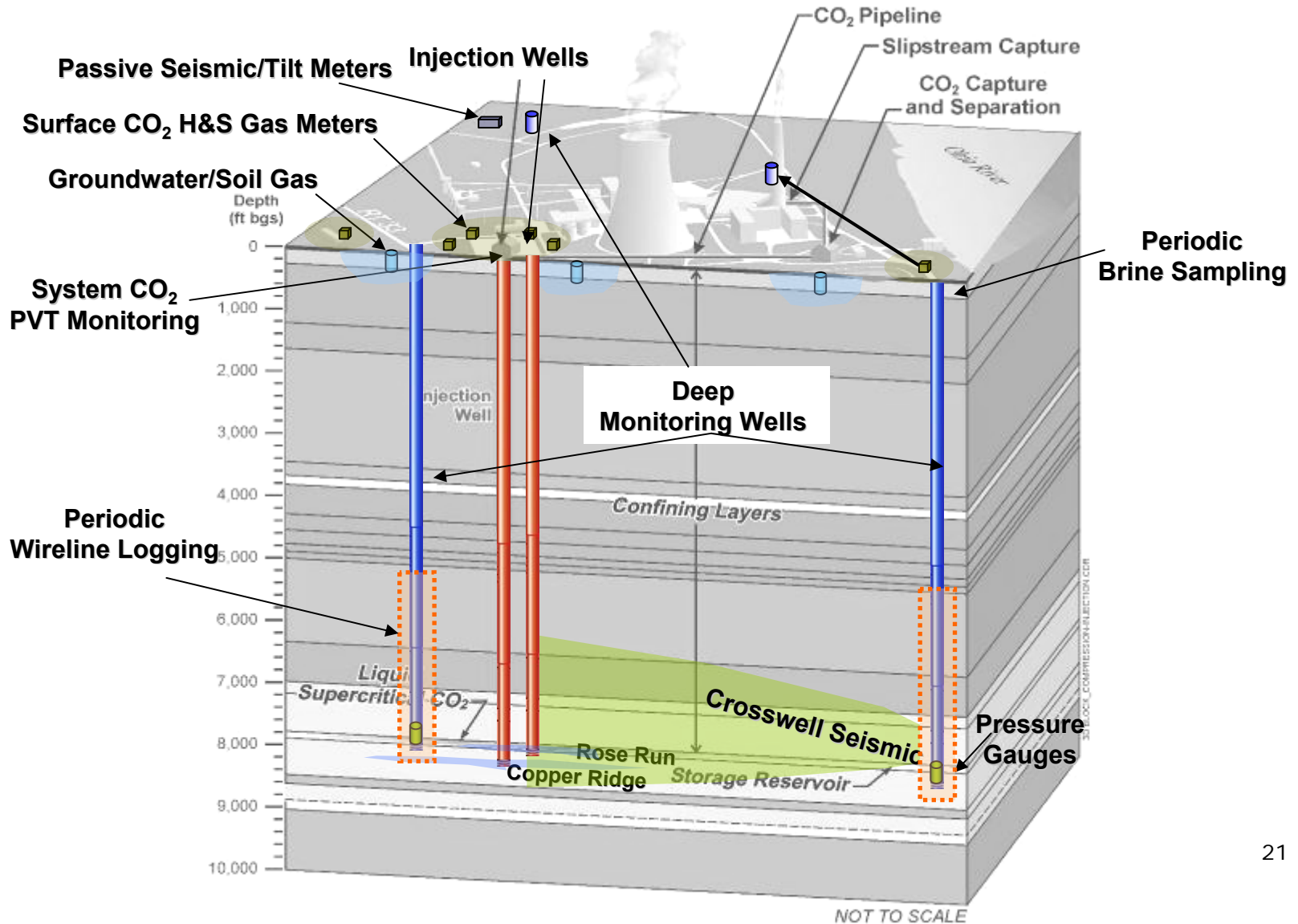
Injection Well Design Example

- Proposed well design for injection well AEP#1 for completion in Rose Run Sandstone
- Multiple well casings isolate shallow freshwater and intermediate zones from injection
- Stainless steel casing and CO₂-resistant cement used in deep injection casing in injection wells





Monitoring System Design



Permits, Legal Approval & Outreach

- Known or anticipated permits:
 - Underground Injection Control (UIC) – WV DEP
 - Monitoring well work permit – WV DEP
 - NPDES permit modification – WV DEP
 - Storm Water Construction Permit – WV DEP
 - Public Lands Permit – WV DNR
 - Corps permit notification – Corps of Engineers
 - Periodic seismic survey – Local/county engineer

- Pore space, mineral rights and legal approval

- Communication and outreach
 - WV DEP and EPA Meetings
 - AEP informational presentations
 - Local town hall and community leader meetings
 - Outside stakeholders

CAP Commercial Demonstration



- ❑ Commercial plant scheduled to commence operations sometime after 2012
- ❑ Designed to capture 1.5 MM tonnes/year

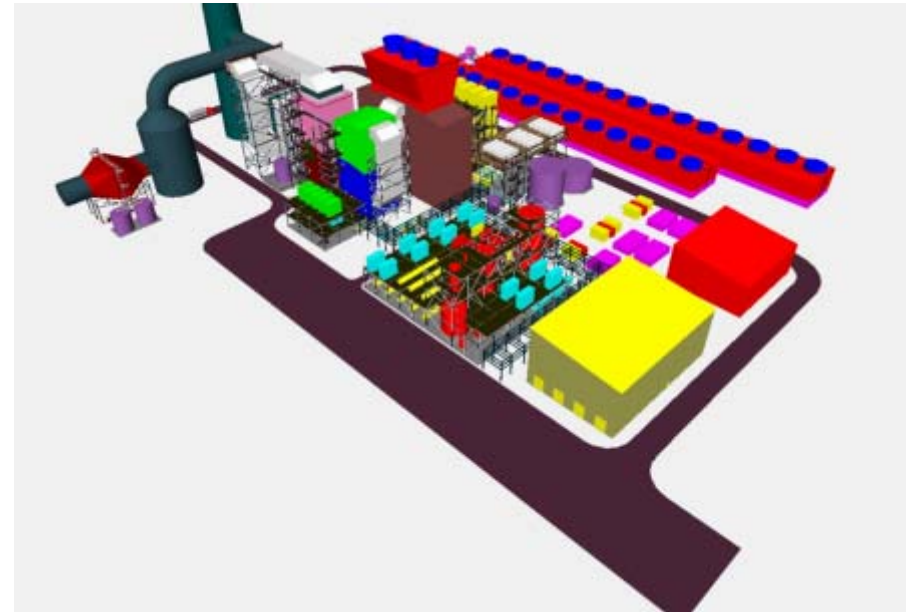


Illustration of Commercial Scale Up of the CAP

Graphics courtesy of Alstom Power

Summary

- CCS at AEP Mountaineer
 - Alstom's Chilled Ammonia Process
 - Capacity: 100,000 tonnes CO₂/yr
 - CO₂ storage program involving two underground wells

- Chilled Ammonia Process
 - Lower energy consumption than amine based CO₂ technologies expected
 - Can accommodate typical flue gas constituents without additional flue gas cleaning equipment
 - Low reagent costs, reagent flexibility
 - Higher CO₂ product stream pressure lower CO₂ compression energy



Graphics courtesy of Alstom Power