Future of Coal in America
Update on CO₂ Capture & Storage Project at AEP’s Mountaineer Plant

Presentation to National Conference of State Legislators Task Force on Energy Supply

Jeff Gerken
Program Manager – Technology Development
New Generation Development

January 29, 2010
5.2 million customers in 11 states
+21,000 employees
One of largest U.S. electricity generators (39,000 MW capacity)
- 1785 MW wind (IPP & PPA)
- Plan to add 1000MW renewables by 2011
Consume 77 million tons coal/year
- 25,647MW coal-fired capacity
A leading consumer of natural gas
2009 - emitted ~150 MM tons CO$_2$e
Coal & transportation assets
- Control over 9,000 railcars
- Own & operate almost 3,000 hopper barges & 58 towboats
- Operate 1 active coal handling terminal with 20 million tons of capacity
39,000 miles of transmission lines
- Includes 2,116 miles of 765kV lines
214,062 miles of distribution lines

AEP Generation Capacity Portfolio

<table>
<thead>
<tr>
<th></th>
<th>Coal/Lignite</th>
<th>Gas /Oil</th>
<th>Nuclear</th>
<th>Other - (hydro, wind, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>67%</td>
<td>24%</td>
<td>6%</td>
<td>3%</td>
</tr>
</tbody>
</table>
According to an EPRI analysis, Increase in Real Electricity Prices 2000 to 2050 For Two Scenarios

**Limited Portfolio**
(phase out of Coal, no CCS, no expansion of Nuclear)

- +210%

**Full Portfolio**
(Advanced Nuclear, CCS success, new coal deployed with CCS)

- +80%

*Source: EPRI, 2009*
Coal Will Continue to be the Major Fuel Source for Electricity Generation in the U.S.

Reference case from EIA “Annual Energy Outlook 2009”
Carbon Intensity for Different Systems

- **NGSC** – 36%
- **US Coal Fleet** – 62%
- **USC (subbituminous)** – 57%
- **IGCC (bituminous)** – 54%

**CO₂ Reduction Necessary to Achieve NGCC Emission Levels**

- **H.R. = 8,870**
- **H.R. = 8,980**
- **H.R. = 10,500**
- **H.R. = 10,980**
- **H.R. = 7,040**

Note: “H.R.” = Heat Rate (efficiency). Values represent typical heat rates, used here for illustrative purposes only.
CO₂ Capture Techniques

- **Post-Combustion Capture**
  - Conventional or Advanced Amines & Chilled Ammonia
    - Amine technologies commercially available and used in other industrial applications
    - High parasitic demand
      - Conventional Amine ~ 28-32%, Chilled Ammonia target ~ 15-22%

- **Modified-Combustion Capture**
  - Oxy-coal
    - Technology not yet proven at commercial scale
    - High parasitic demand, >25%, due to large oxygen demand and high flue gas recirculation

- **Pre-Combustion Capture**
  - IGCC with Water-Gas Shift : \( \text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2 \)
    - Process well-suited for CO₂ capture - Capture occurs prior to combustion
    - Parasitic demand for CO₂ capture - lower than Post-combustion or oxy-coal options
    - IGCC plant costs higher than Pulv. Coal, CO₂ capture cost lower than Pulv. Coal
Chilled Ammonia CCS

Phase 1

Currently in Operations

Mountaineer Plant (WV) \rightarrow Alstom Chilled Ammonia 20 MWe Scale

\begin{itemize}
  \item CO₂ Storage (Battelle)
\end{itemize}

\textbf{Captures and Stores}
\textbf{\sim100,000 metric tons of CO₂/year}

Phase 2

2012-2015 Commercial Operation

Mountaineer Plant (WV) \rightarrow Alstom Chilled Ammonia \sim235 MWe Scale

\begin{itemize}
  \item CO₂ Storage
\end{itemize}

\textbf{Captures and Stores}
\textbf{1.5 Million metric tons CO₂/year}
Chilled Ammonia CCS Validation Facility

- **Location:** AEP Mountaineer Plant
  - 1,300 MW\textsubscript{e} Supercritical Pulverized Coal Unit
  - High Sulfur Eastern Bituminous Coal
  - SCR, ESP and Wet FGD

- **20 MWe scale**
  - Approximately 1.5% of power plant flue gas
  - (Scale-up of Alstom/EPRI 1.7 MW field pilot at WE Energies)

- **Approximate total cost >$100M**
  - Funding provided by AEP, Alstom, RWE, & EPRI

- **Using Alstom “Chilled Ammonia” CO\textsubscript{2} capture technology**
  - >85% CO\textsubscript{2} capture rate
Chilled Ammonia Process Overview, Ammonium Carbonate/Ammonium Bicarbonate reaction

Reactions:
\[
\begin{align*}
\text{CO}_2 \text{ (g)} & \rightleftharpoons \text{CO}_2 \text{ (aq)} \\
(\text{NH}_4)_2\text{CO}_3 \text{ (aq)} + \text{CO}_2 \text{ (aq)} + \text{H}_2\text{O} & \rightleftharpoons 2(\text{NH}_4)\text{HCO}_3 \text{ (aq)} \\
(\text{NH}_4)\text{HCO}_3 \text{ (aq)} & \rightleftharpoons (\text{NH}_4)\text{HCO}_3 \text{ (s)} \\
2(\text{NH}_4)\text{HCO}_3 & \rightleftharpoons (\text{NH}_4)_2\text{CO}_3 + \text{H}_2\text{O}
\end{align*}
\]
Features of the Chilled Ammonia Process

**Why Chilled Ammonia Process**

- Tolerant of flue gas quality
  - $\text{SO}_2$ in flue gas easily managed
  - Waste stream is ammonium sulfate – fertilizer
- Lower steam use for regeneration – more readily integrated into steam cycle
- Uses commodity materials for reagent
- High purity product stream (99.5+% $\text{CO}_2$) – meets US standard for pipeline quality
- High pressure regeneration results in reduced $\text{CO}_2$ compression energy (high compressor suction pressure of ~250 psi)
Capture Process

- Absorber
- Regenerator Column
- Water Clean Up Column
- Direct Contact Cooler
- Inlet Flue Gas Supply
- Clean Flue Gas Return
- CO₂ process Control Room
- Reagent Feed Tank
UIC Permitting – Area of Review
20 MW pilot is approx 1.5% of plant output
CO$_2$ Capture and Storage Key Points

- **CCS is expensive**
  - High capital cost
  - Large O&M expense (Increased plant staff & more equipment to operate and maintain)

- **Sequestration potential is widely variable**
  - May require large number of wells and many square miles of well field
  - Will not be available in every location

- **CO$_2$ not a revenue-producing commodity in the long term**
  - Enhanced Oil Recovery (EOR) is niche market open mostly to early adopters

- **Deep saline vs. EOR**
  - Deep Saline = Permanent storage, adds fluid to reservoir
  - EOR displaces fluid

- **Other challenges with storage**
  - Not proven yet in non-production applications
  - Capacity and injection rates very site-specific
  - Long-term liability and ownership not yet resolved on federal or state level
Injection Well Design Example

- Multiple well casings isolate shallow freshwater and intermediate zones from injection.

- Stainless steel casing and Acid/CO$_2$-resistant cement used in the last 1000 ft. deep injection well casing.

Injection Formations, (Rose Run and Copper Ridge)
Monitoring System Design

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

PROJECT STATUS

- September 1 – successfully captured CO₂
- October 1 - began underground injection and storage
- October 30 – facility dedicated

Next Steps

- Monitor the CO₂ behavior once underground
- Assess the parasitic load impact of the equipment on the plant
- DOE funding received for 50% of commercial phase of project ($334MM); project expected to be operational between 2012 and 2015

Project Description

- Alstom’s chilled ammonia process captures CO₂ from a 20 MWe slipstream of flue gas at AEP’s Mountaineer plant located in New Haven, WV
- Captured CO₂, transformed to a semi-liquid state, is pumped into sandstone or dolomite layers approximately 1.5 miles underground. Caprock will hold the CO₂ in place permanently.
- Target capture rate of ~300 metric tons/day or 100,000 metric tons per year
Permitting

- Needed Permits
  - Underground Injection Control (UIC) Class V (Experimental) – West Virginia Department of Environmental Protection (WV DEP)
  - Well work permit – WV DEP
  - NPDES waste water drainage permit modification – WV DEP
  - Storm Water Construction Permit – WV DEP
  - Public Lands Permit – WV Department of Natural Resources (DNR)
  - Corps permit notification – Army Corps of Engineers
  - Periodic seismic survey – Local/county engineer

- Communication and outreach
  - WV DEP and EPA Meetings
  - AEP informational presentations
  - Local town hall and community leader meetings
  - Outside stakeholders
Next Steps for AEP CCS Program

- Scale up of the CO$_2$ capture systems to commercial-scale.
- Continuing to evaluate other CO$_2$ capture technologies through US Carbon Research Center
- Ongoing assessments of geologic capacity throughout AEP fleet
New Generation Projects

- John W. Turk Jr. Ultra-Supercritical Coal Plant, located in AEP’s SWEPCo region, is a base load 600-MW advanced coal combustion plant.
  - The cost is anticipated at $1.6 billion ($2700/kw) with AEP’s share approximately $1.2 billion and will begin commercial operation in 2012.
  - Will use low-sulfur coal and state-of-the-art emission control technologies, including a design that allows for the retrofit of carbon dioxide controls.

- J. Lamar Stall Combined-Cycle gas plant is a 508-MW unit scheduled for commercial operation in 2010.
  - The total projected cost of the plant is $386 million ($760/kw).
  - The plant is located in AEP’s SWEPCo region at its existing Arsenal Hill Power Plant in Shreveport, Louisiana.
Questions?