Meeting the Carbon Challenge: AEP’s Perspective

Energy Summit
Advancing Domestic Resources
in an
Era of Carbon Challenges

Michael W. Rencheck
SVP – Chief Nuclear Officer
American Electric Power

December 4, 2007
AEP Company Overview

AEP’s Generation Fleet
38,388 MW Capacity

- Coal/Lignite: 67%
- Natural Gas/Oil: 24%
- Nuclear: 6%
- Pumped Storage/Hydro/Wind: 3%

5.1 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>~208,000 miles</td>
<td># 1</td>
</tr>
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</table>
“With Congress expected to take action on greenhouse gas issues in climate legislation, it’s time to advance this technology (CO$_2$ Capture) for commercial use”

Mike Morris

AEP President, Chairman and CEO
Achieving all targets is aggressive, but potentially feasible.

EIA Base Case 2007

<table>
<thead>
<tr>
<th>Technology</th>
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<th>Target</th>
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<tr>
<td>Efficiency</td>
<td>Load Growth ~ +1.5%/yr</td>
<td>Load Growth ~ +1.1%/yr</td>
</tr>
<tr>
<td>Renewables</td>
<td>30 GWe by 2030</td>
<td>70 GWe by 2030</td>
</tr>
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<td>Nuclear Generation</td>
<td>12.5 GWe by 2030</td>
<td>64 GWe by 2030</td>
</tr>
<tr>
<td>Advanced Coal</td>
<td>No Existing Plant</td>
<td>150 GWe Plant Upgrades</td>
</tr>
<tr>
<td></td>
<td>Upgrades 40% New</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plant Efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>by 2020–2030</td>
<td></td>
</tr>
<tr>
<td>CCS</td>
<td>None</td>
<td>Widely Deployed After 2020</td>
</tr>
<tr>
<td>PHEV</td>
<td>None</td>
<td>10% of New Vehicle Sales by 2017; +2%/yr Thereafter</td>
</tr>
<tr>
<td>DER</td>
<td>&lt; 0.1% of Base Load in 2030</td>
<td>5% of Base Load in 2030</td>
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AEP is Pursuing a Portfolio of Options to Address Sustainability

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<th>AEP Plan</th>
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<tr>
<td>Efficiency</td>
<td>Load Growth ~ +1.5%/yr</td>
<td>Load Growth ~ +1.1%/yr</td>
<td>DSM: 1000MW reduction in demand by 2012</td>
</tr>
<tr>
<td>Renewables</td>
<td>30 GWe by 2030</td>
<td>70 GWe by 2030</td>
<td>Wind PPAs through 2015; 1610MW nameplate or 232MW capacity for planning purposes; Also, voluntary green energy tariffs (Ohio program started 2007)</td>
</tr>
<tr>
<td>Nuclear Generation</td>
<td>12.5 GWe by 2030</td>
<td>64 GWe by 2030</td>
<td>Evaluation of COL</td>
</tr>
<tr>
<td>Advanced Coal Generation</td>
<td>No Existing Plant Upgrades 40% New Plant Efficiency by 2020-2030</td>
<td>150 GWe Plant Upgrades 46% New Plant Efficiency by 2020; 49% in 2030</td>
<td>1246MW IGCC (WV and OH) by 2017; 600MW (447MW AEP) USC Turk plant (AK) by 2011</td>
</tr>
<tr>
<td>CCS</td>
<td>None</td>
<td>Widely Deployed After 2020</td>
<td>Chilled Ammonia: Mountaineer (WV) 2009 &amp; Northeastern (OK) 2012; FutureGen: DOE along with AEP and Alliance members 2012; Oxy-coal 2015 (Sub-critical PC unit retrofit)</td>
</tr>
<tr>
<td>PHEV</td>
<td>None</td>
<td>10% of New Vehicle Sales by 2017; +2%/yr Thereafter</td>
<td>Joined Electric Drive Transportation Association (EDTA) in May 2007</td>
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<td>DER</td>
<td>&lt; 0.1% of Base Load in 2030</td>
<td>5% of Base Load in 2030</td>
<td>Pursuit of NaS Energy Storage - 25MW of storage by 2010 and 1000MW of other storage/fuel cells by 2020</td>
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AEP Leadership in Technology:
IGCC/USC and Future Gen

NEW ADVANCED GENERATION

• IGCC---AEP was the first to announce plans to build two 600+ MW IGCC commercial scale facilities in Ohio and West Virginia by the middle of next decade

• USC--AEP will be the first to employ the new generation ultra-supercritical (steam temperatures greater than 1100°F) coal plant in Arkansas

• FutureGen - First Near Zero Emissions Hydrogen/ Electric (coal-fueled IGCC with CCS)-DOE along with AEP and Alliance members. COD 4Q 2012; then 3 yrs (2013-2015) CO₂ storage; and another 2 yrs (2016-2017) for long term storage validation
Efficiency and CO₂ Emission Rates

Increasing Generation Efficiency
Carbon Intensity for Different Systems

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

- **US Coal Fleet** (62%)
- **USC** (57%)
- **IGCC** (54%)

- **NGSC** (36%)

Note: H.R. = Heat Rate (efficiency). Values represent typical heat rates, used here for illustrative purposes only.
CO$_2$ Capture Techniques

Post-Combustion Capture

- Evaluated available CO$_2$ capture options, considering both commercial and emerging technologies
  - Commercially available Amine based technologies
    - Currently installed on much smaller scale than PC plant and other industrial applications
    - High parasitic demand - reduced unit output
      - Conventional Amine ~25-30%
      - High steam consumption for regenerating solvent (60% of parasitic load)
    - Requires very clean flue gas
  - Chilled Ammonia Process (CAP)
    - Demonstration scale under construction at WE Energies Pleasant Prairie Plant (complete end of 2007)
    - Aspirational Goal - Lower Parasitic Demand
      - Power and steam parasitic load ~ 10-15%
      - Lower steam consumption (35% of parasitic load)
    - Requires clean flue gas but less sensitive to contaminants
    - Flue gas cooled to 40 to 60 °F
Alstom’s Chilled Ammonia Process

Post-Combustion Capture

(Ammonium Bicarbonate)

Flue Gas From FGD

Absorber (40-60°F)

Regenerator (203–250°F)

Conc. CO₂ To Storage

(Ammonium Carbonate – “Baker’s Ammonia”)
CHILLED AMMONIA PROCESS

Regenerators

Flue Gas Chillers

CO₂ Absorbers

CO₂ Compressors
Chilled Ammonia Technology Program

**2009 Commercial Operation**

**Phase 1**
- **1300 MW Mountaineer Plant (WV)**
- MOU (Alstom)
- Chilled Ammonia
- **CO₂ (Battelle)**
- Slip Stream: 20 MWe
- Project Validation:
  - 20 MWₑ (megawatts electric) scale (a scale up of Alstom/EPRI 5 MWₜ (megawatts thermal) field pilot, under construction at WE Energies)
  - ~100,000 tonnes CO₂ per year
  - In operation 2Q 2009
  - Approximate cost $80 - $100M
  - CO₂ for geologic storage

**2012 Commercial Operation**

**Phase 2**
- **450 MW Northeastern Plant (OK)**
- MOU (Alstom)
- Chilled Ammonia
- **CO₂ (EOR)**
- Slip Stream: 200 MWe (90% removal of 50% slip stream)
- Commercial Scale Retrofit:
  - ~200 MWₑ scale (megawatt electric)
  - ~1.5MM tonnes CO₂ per year
  - Approx. capital $250 - $300M (CO₂ capture & compression)
  - Energy penalty ~ 35-50MW steam, 25-30MW compression
  - Retrofit NOx Controls and FGD Required: $225 - $300M (required for capture equip.)
  - CO₂ for Enhanced Oil Recovery (EOR) or geologic storage

**Phase 1 will capture and sequester 100,000 metric tons of CO₂/ year**

**Phase 2 will capture and sequester 1.5 Million metric tons CO₂/ year**
CO₂ Capture Techniques

Oxy Coal Firing

• Modified-Combustion Capture – Oxy Coal Firing
  
  • **Key Points**
    - Technology not yet proven at commercial scale
    - Creates stream of high CO₂ concentration
    - High parasitic demand, >25%
  
  • **Demonstration Scale**
    - 10 MWe scale
    - Teamed with B&W at its Alliance Research Center and several other utilities
    - Demo completion 4Q 2007
  
  • **Commercial Scale**
    - Feasibility study in progress
    - Retrofit on existing AEP sub-critical unit (several available)
    - 150 – 230 MWe scale retrofit
    - 4,000 – 5,000 tons CO₂ per day
    - Retrofit targeted between 2013 and 2015
CO₂ Capture Techniques

Oxygen Combustion Process

- Air In
- Pure Oxygen (O₂)
- Coal In

Air Separation Unit

Nitrogen (N₂) Out

Boiler

CO₂ and Flue

Environmental Cleanup Equipment

Recycled Flue Gas

CO₂ (vapor)

- No SCR (typically)
- No CO₂ scrubber

CO₂ Compression

Ash

SO₂

Other captured emissions

CO₂ Capture (liquid)
FutureGen’s Water-Gas Shift Process

Pre-Combustion Capture

Water-Gas Shift

Air Separation

Gasifier

Gas Clean-Up

Sulfur Recovery

CO₂ Separation

H₂ Product

Electricity Generation

H₂ Product

TRANSPORTATION

MARKETABLE ASH/SLAG BY-PRODUCT

MARKETABLE SULFUR BY-PRODUCT

Deep Saline Formation

Unmineable Coal Beds

Enhanced Oil Recovery

Depleted Oil and Gas Reservoirs

REFINERY
CO₂ Capture Techniques

Pre-Combustion Capture

• Pre-Combustion Capture
  • IGCC with Water-Gas Shift – FutureGen Design

Key Points

• Most of the processes commercially available in other industrial applications
  • Have never been integrated
• Turbine modified for H₂-based fuel, which has not yet been proven at commercial scale
• Creates stream of very high CO₂ concentration
• Parasitic demand (~15%) for CO₂ capture - lower than amine or oxy-coal options
FutureGen’s Water-Gas Shift Process
Pre-Combustion Capture

Mountaineer IGCC without CO$_2$ Capture

Space for Water-Gas Shift
FutureGen’s Water-Gas Shift Process

Pre-Combustion Capture

Mountaineer IGCC with CO₂ Capture
CO₂ Storage Key Points

• Challenges with storage
  • Geology Dependency
    • A 500 MW power plant could require a many wells at a spacing of several thousand feet or more
  • Not yet proven in large scale or in long-term
  • Uncertainty on environmental fate and long term interaction of contaminants in product CO₂ with saline (ammonia, water, SOₓ)
  • Capacity and injection rates very site-specific
  • Long-term liability and legal ownership are points not yet resolved on federal or state level
  • Competition with natural low cost sources of CO₂ for EOR opportunities
Enhanced Oil Recover (EOR)
Examples of Relative GHG Mitigation Costs for Power Sector

- Carbon Capture w/ Geologic Sequestration
- Other renewable, advanced geothermal and/or solar
- Carbon Capture for Enhanced Oil Recovery
- New Biomass Generation
- Dispatch of additional gas vs. inefficient coal
- Biomass Co-firing
- Biological Sequestration (e.g. Forestry)
- New Wind
- Nuclear
- Energy Efficiency
- Methane Offsets
Questions?

Serious issues require realistic discussion to provide commercial solutions.