CO$_2$ Capture and Storage
*AEP’s Perspective*

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Fuels and CO₂ Emission Rates

Note: C/H is the mass ratio of carbon to hydrogen
Efficiency and CO₂ Emission Rates

- Increasing Generation Efficiency

The graph illustrates the relationship between CO₂ emissions and heat rate, showing how different types of fuel (e.g., Bituminous, Sub Bituminous, Lignite) affect emissions. The legend notes specific conditions for Ultra Supercritical (3500psi/1100F/1100F) and Subcritical (2400psi/1000F/1000F) systems.
Carbon Intensity for Different Systems

CO₂ Reduction Necessary to Achieve NGCC Emission Levels

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

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

- **Post-Combustion Capture**
  - Conventional or Advanced Amines, Chilled Ammonia
  - **Key Points**
    - Amine technologies commercially available in other industrial applications
    - Relatively low CO$_2$ concentration in flue gas – More difficult to capture than other approaches
    - High parasitic demand
      - Conventional Amine ~25-30%, Chilled Ammonia target ~10-15%
    - Amines require very clean flue gas

- **Modified-Combustion Capture**
  - Oxy-coal
  - **Key Points**
    - Technology not yet proven at commercial scale
    - Creates stream of very high CO$_2$ concentration
    - High parasitic demand, >25%

- **Pre-Combustion Capture**
  - IGCC with Water-Gas Shift – FutureGen
  - **Key Points**
    - Most of the processes commercially available in other industrial applications
      - Have never been integrated together
    - Turbine modified for H$_2$-based fuel, which has not yet been proven at commercial scale
    - Creates stream of very high CO$_2$ concentration
    - Parasitic demand (~20%) for CO$_2$ capture - lower than amine or oxy-coal options
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”)

Solvent

CO₂
Alstom’s Chilled Ammonia Process
*Post-Combustion Capture*

- **Flue Gas**
  - High CO2, Low Sulfur

- **FGD**

- **Flue Gas Chiller**

- **CO2 Absorber**
  - Concentrated CO2
  - CO2 to Compression
  - CO2 Geologic Storage by AEP/Battelle

- **Booster Compressor**

- **Regenerator**

- **Final Wash**
  - Lean Reagent
  - Rich (CO2) Reagent

- **Stack**

- **Lean Reagent**
B&W’s Oxy-Coal Process

Modified Combustion Capture
FutureGen’s Water-Gas Shift Process
Pre-Combustion Capture
CO₂ injection should also be possible in shallower sandstone and carbonate layers in the region.

Rose Run Sandstone (~7800 feet) is a regional candidate zone in Appalachian Basin.

A high permeability zone called the “B zone” within Copper Ridge Dolomite has been identified as a new injection zone in the region.

Mount Simon Sandstone/Basal Sand - the most prominent reservoir in most of the Midwest but not desirable beneath Mountaineer site.
Sedimentary Rocks
A Microscopic View

Permeability much less than 0.01 mD
Shale with Extremely Low Permeability
Forms Good Caprock

Permeability 10 – 100 mD
Sandstone with Medium Permeability
Forms Good Host Reservoir Medium Cost

Permeability 100 – 1,000 mD
Sandstone with High Permeability
Forms Excellent Host Reservoir at Low Cost
Enhanced Oil Recover (EOR)
CO$_2$ Storage Key Points

- Will require multiple wells
  - Very geology-dependent
    - A 500 MW power plant could require a dozen or more wells at a spacing of several thousand feet or more

- Deep saline vs. EOR
  - Deep Saline = Permanent storage
  - EOR = CO$_2$ recycle and store…how much stays put?

- Challenges with storage
  - Not proven yet
  - Capacity and injection rates very site-specific
  - Long-term liability and ownership are points not yet resolved on federal or state level
Chilled Ammonia Technology Program

**Phase 1**
2009 Commercial Operation

- **Mountaineer Plant (WV)**
  - MOU (Alstom)
  - Chilled Ammonia
  - CO₂ (Battelle)

  *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 total cost $80 – $100M
  - Using Alstom “Chilled Ammonia” Technology
  - Located at the AEP Mountaineer Plant in WV
  - CO₂ for geologic storage

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

**Phase 2**
2011 Commercial Operation

- **Northeastern Plant (OK)**
  - MOU (Alstom)
  - Chilled Ammonia
  - CO₂

  *Commercial Scale Retrofit*
  - ~ 200 MWₑ scale (megawatt electric)
  - ~1.5MM tonnes CO₂ per year
  - In operation 2011
  - Approx. capital $250 – $300M (CO₂ capture & compression)
  - Approx. O&M cost $12M per year
  - Energy penalty ~ 35 – 50 MW steam, 25 – 30 MW for CO₂ compression
  - Retrofit NOx Controls and Wet FGD Required: ~$225 – $300M (required for CO₂ capture equipment)
  - Located at AEP’s Northeastern Plant Unit 3 or 4 in Oklahoma
  - CO₂ for Enhanced Oil Recovery (EOR) or geologic storage

  **Phase 2 will capture and sequester 1.5 Million metric tons CO₂/year**
Oxy-Coal CO$_2$ Capture & Storage Project

**Demonstration Scale**
- 10 MW$_e$ scale
- Teamed with B&W at its Alliance Research Center and 16 other utilities
- Demo completion 4Q 2007
- AEP funding of $50k

**Commercial Scale**
- Retrofit on existing AEP sub-critical unit (several available)
- 150 – 230 MW$_e$ scale retrofit
- 4,000 – 5,000 tons CO$_2$ per day
- Teamed with B&W
- AEP funding of ~ $200k – $3M for feasibility study
- Feasibility study completed 2Q 2008

Combustion conversion technology for existing coal fleet -- longer lead time with enhanced viability and long-term potential