# ***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*

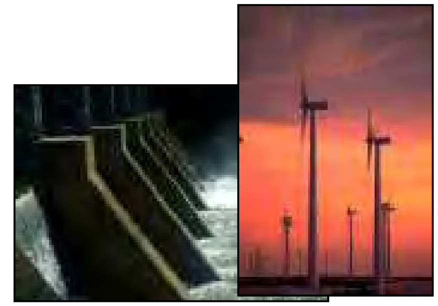

December 4, 2007

# AEP Company Overview

Coal/Lignite
67%

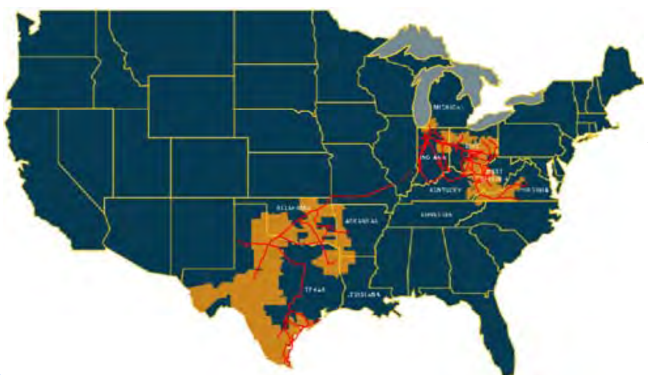
Natural Gas/Oil
24%

Nuclear
6%



Pumped Storage/ Hydro/Wind
3%

**AEP's Generation Fleet**
**38,388 MW Capacity**



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

| Asset | Size | Industry Rank |
|---|---|---|
| Domestic Generation | ~38,300 MW | # 2 |
| Transmission | ~39,000 miles | # 1 |
| Distribution | ~208,000 miles | # 1 |

# AEP is Strongly Committed to Addressing GHG and Environmental Sustainability

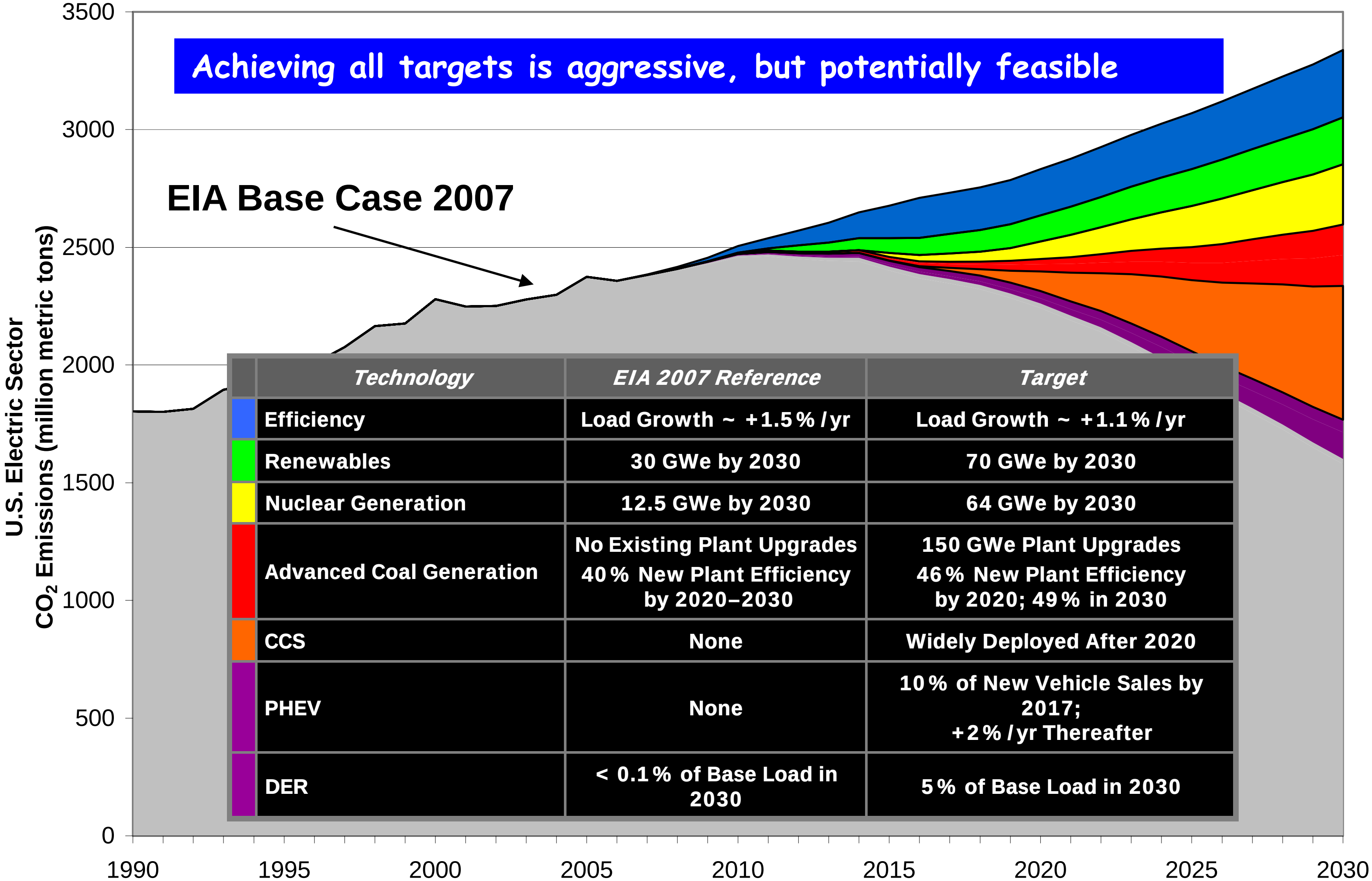
*"With Congress expected to take action on greenhouse gas issues in climate legislation, it's time to advance this technology ($CO_2$ Capture) for commercial use"*

*Mike Morris*

*AEP President, Chairman and CEO*

# EPRI $CO_2$ Reduction "Prism"

## 2030 $CO_2$ below 1990 level




| Technology | EIA 2007 Reference | Target |
|---|---|---|
| Efficiency | Load Growth ~ +1.5%/yr | Load Growth ~ +1.1%/yr |
| Renewables | 30 GWe by 2030 | 70 GWe by 2030 |
| Nuclear Generation | 12.5 GWe by 2030 | 64 GWe by 2030 |
| Advanced Coal Generation | No Existing Plant Upgrades<br>40% New Plant Efficiency by 2020–2030 | 150 GWe Plant Upgrades<br>46% New Plant Efficiency by 2020; 49% in 2030 |
| CCS | None | Widely Deployed After 2020 |
| PHEV | None | 10% of New Vehicle Sales by 2017;<br>+2%/yr Thereafter |
| DER | < 0.1% of Base Load in 2030 | 5% of Base Load in 2030 |

ELECTRIC POWER RESEARCH INSTITUTE

# AEP is Pursuing a Portfolio of Options to Address Sustainability

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

# AEP Leadership in Technology:
## IGCC/USC and Future Gen

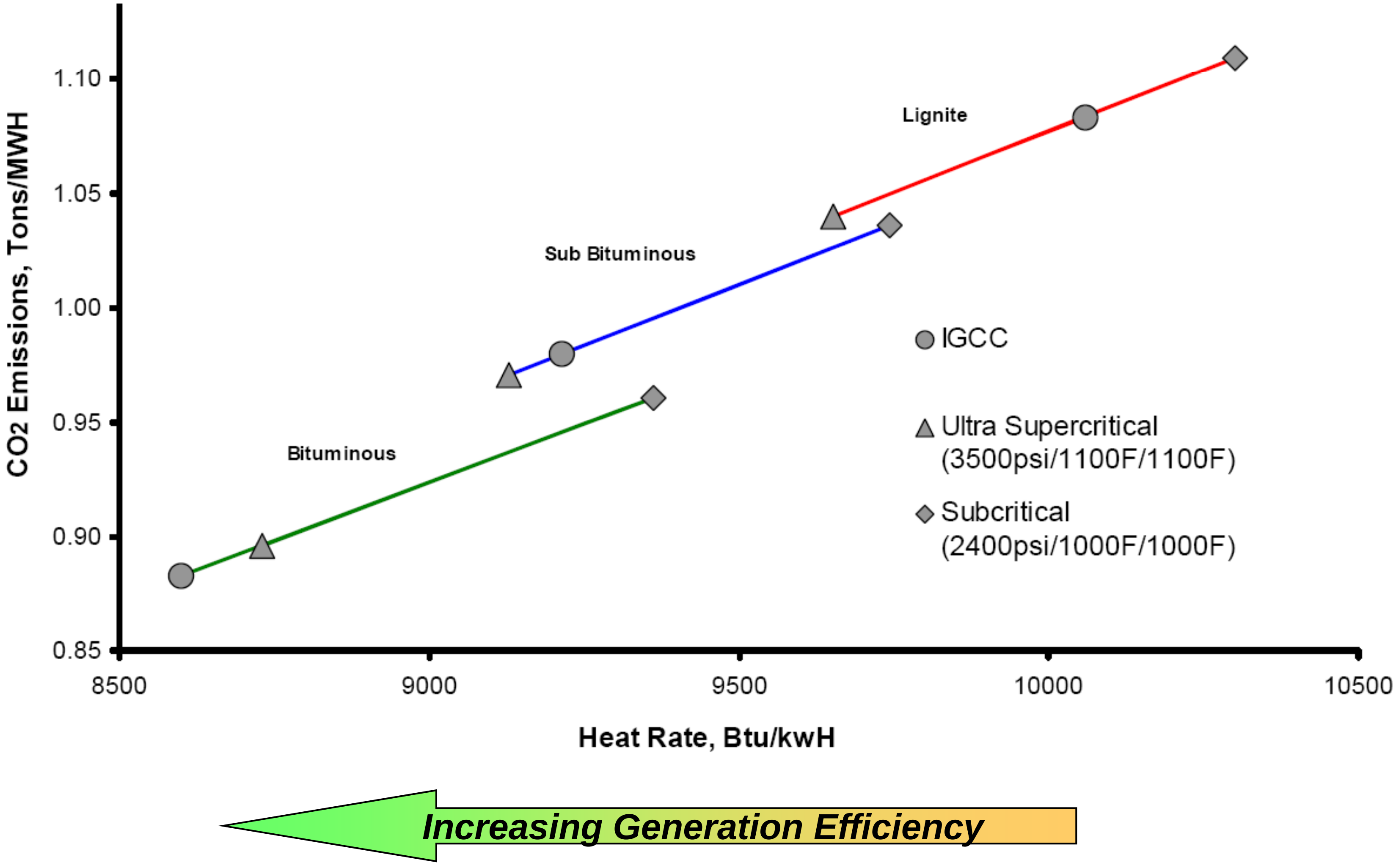
***NEW ADVANCED GENERATION***

- **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 1100ºF) coal plant in Arkansas**

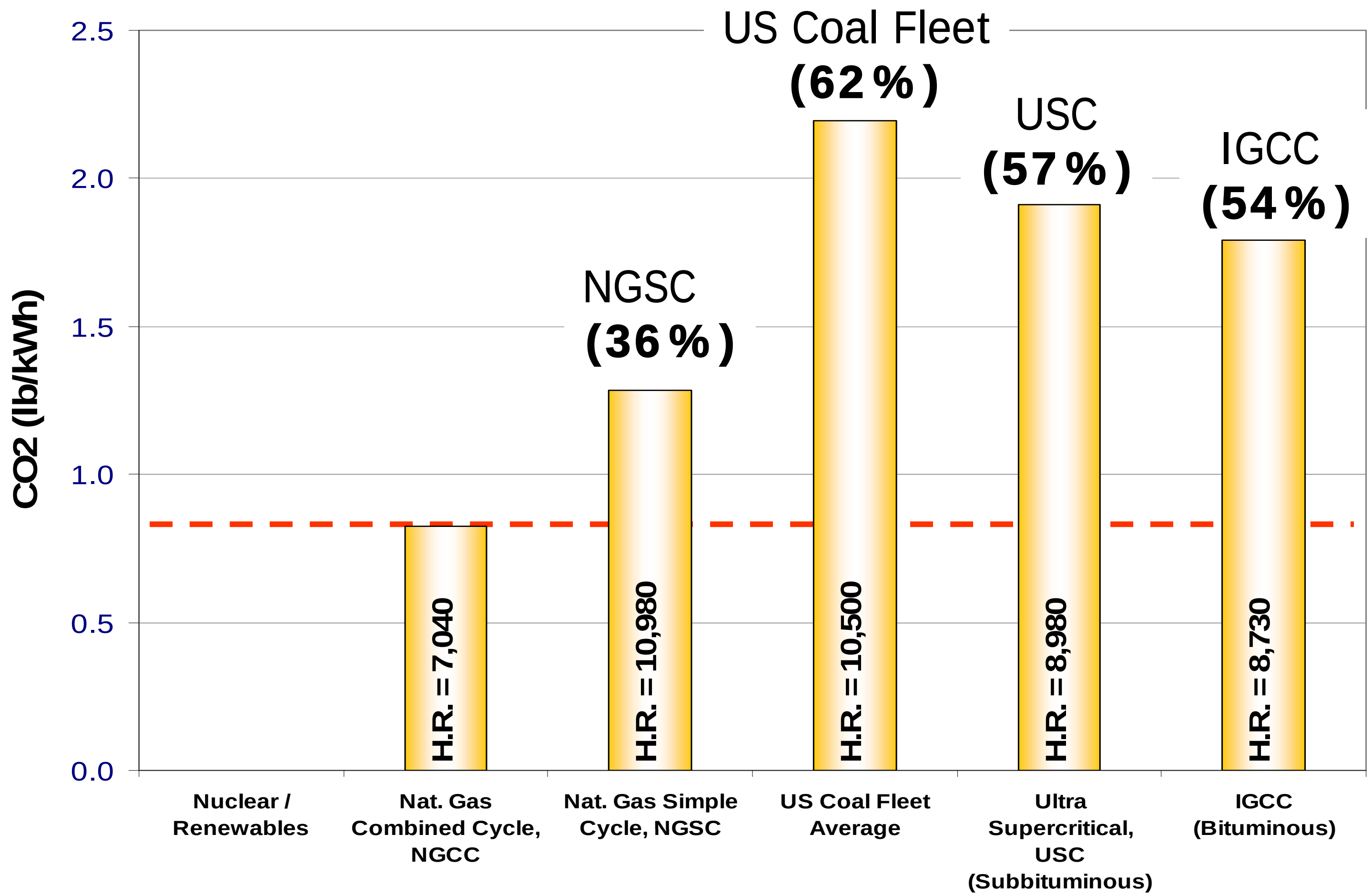
- **FutureGen - First Near Zero Emissions Hydrogen/ Electric (coal-fueled IGCC with CCS)-DOE along with AEP and Alliance members. COD 4Q 2012; then 3 yrs (2013-2015) $CO_2$ storage; and another 2 yrs (2016-2017) for long term storage validation**

# Efficiency and $CO_2$ Emission Rates



# Carbon Intensity for Different Systems

***$CO_2$ Reduction Necessary to Achieve NGCC Emission Levels***




*Note: H.R.= Heat Rate (efficiency). Values represent typical heat rates, used here for illustrative purposes only.*

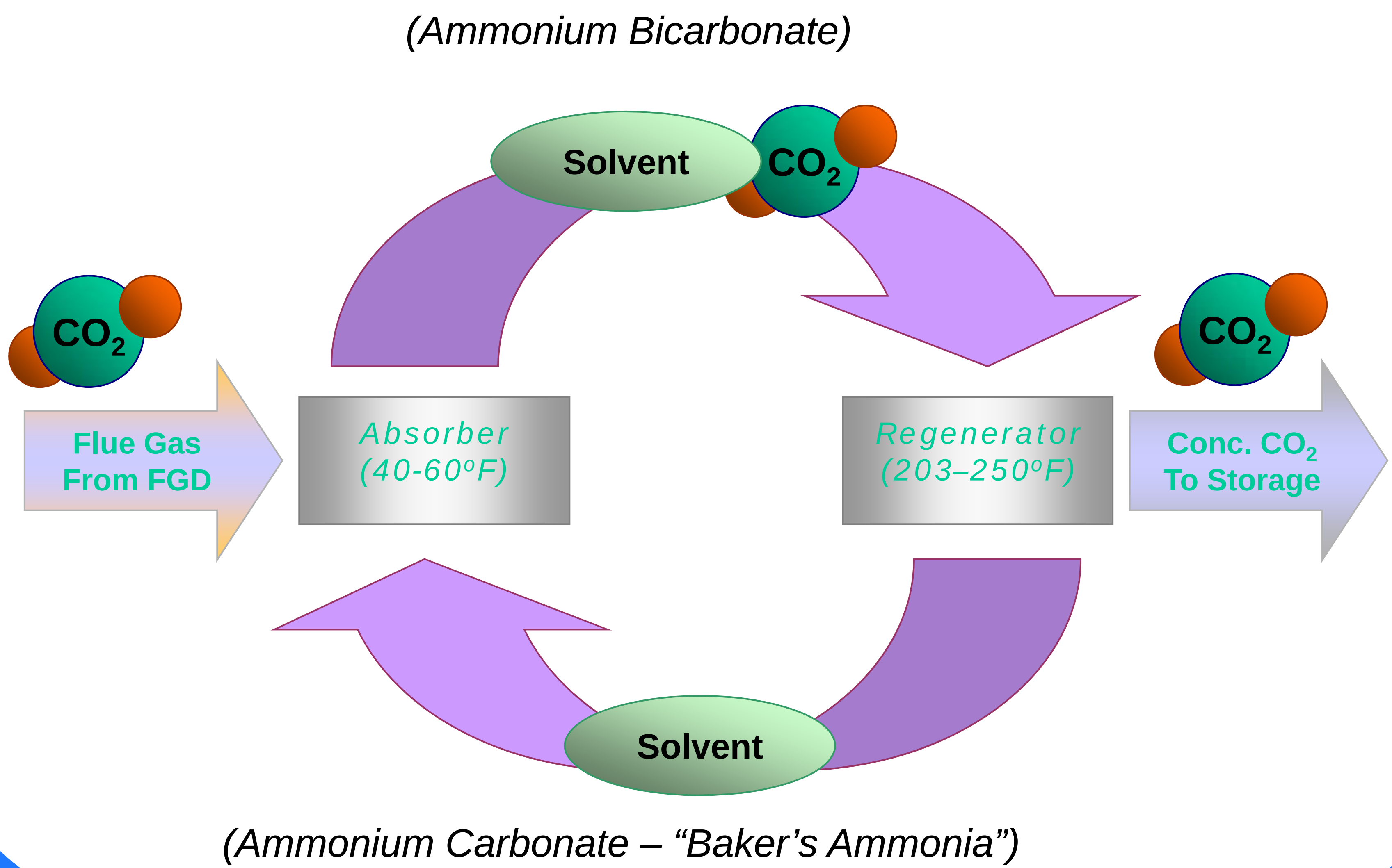
# $CO_2$ Capture Techniques

*Post-Combustion Capture*

- Evaluated available CO2 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 $^{o}$F

# Alstom's Chilled Ammonia Process

## *Post-Combustion Capture*

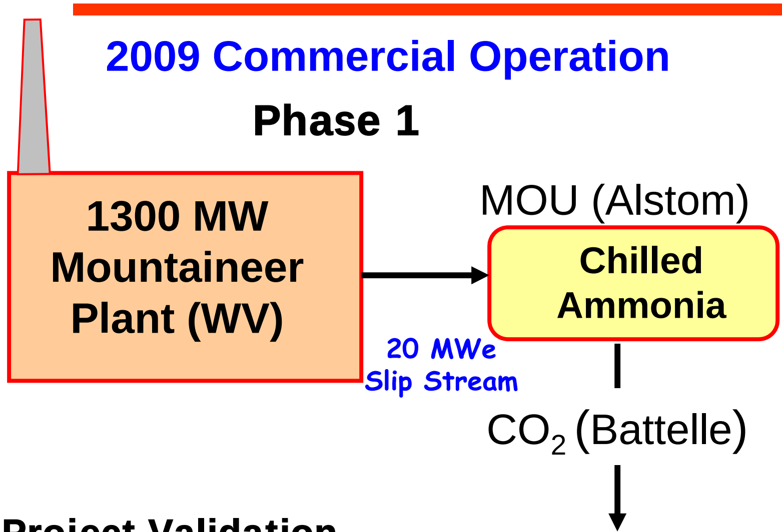


# CHILLED AMMONIA PROCESS

# Chilled Ammonia Technology Program

## 2009 Commercial Operation

### Phase 1



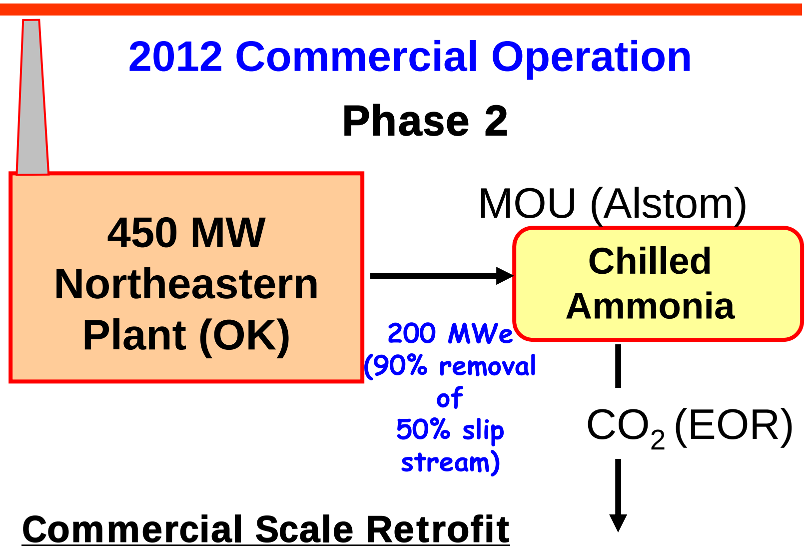

**Project Validation**

- 20 $MW_e$ (megawatts electric) scale (a scale up of Alstom/EPRI 5 $MW_t$ (megawatts thermal) field pilot, under construction at WE Energies)
- ~100,000 tonnes $CO_2$ per year
- In operation 2Q 2009
- Approximate cost $80 – $100M
- $CO_2$ for geologic storage

**Phase 1 will capture and sequester 100,000 metric tons of $CO_2$/year**

## 2012 Commercial Operation

### Phase 2




**Commercial Scale Retrofit**

- ~ 200 $MW_e$ scale (megawatt electric)
- ~1.5MM tonnes $CO_2$ per year
- Approx. capital $250 – $300M ($CO_2$ capture & compression)
- Energy penalty ~ 35–50MW steam, 25–30MW compression
- Retrofit NOx Controls and FGD Required: $225 – $300M (required for capture equip.)
- $CO_2$ for Enhanced Oil Recovery (EOR) or geologic storage

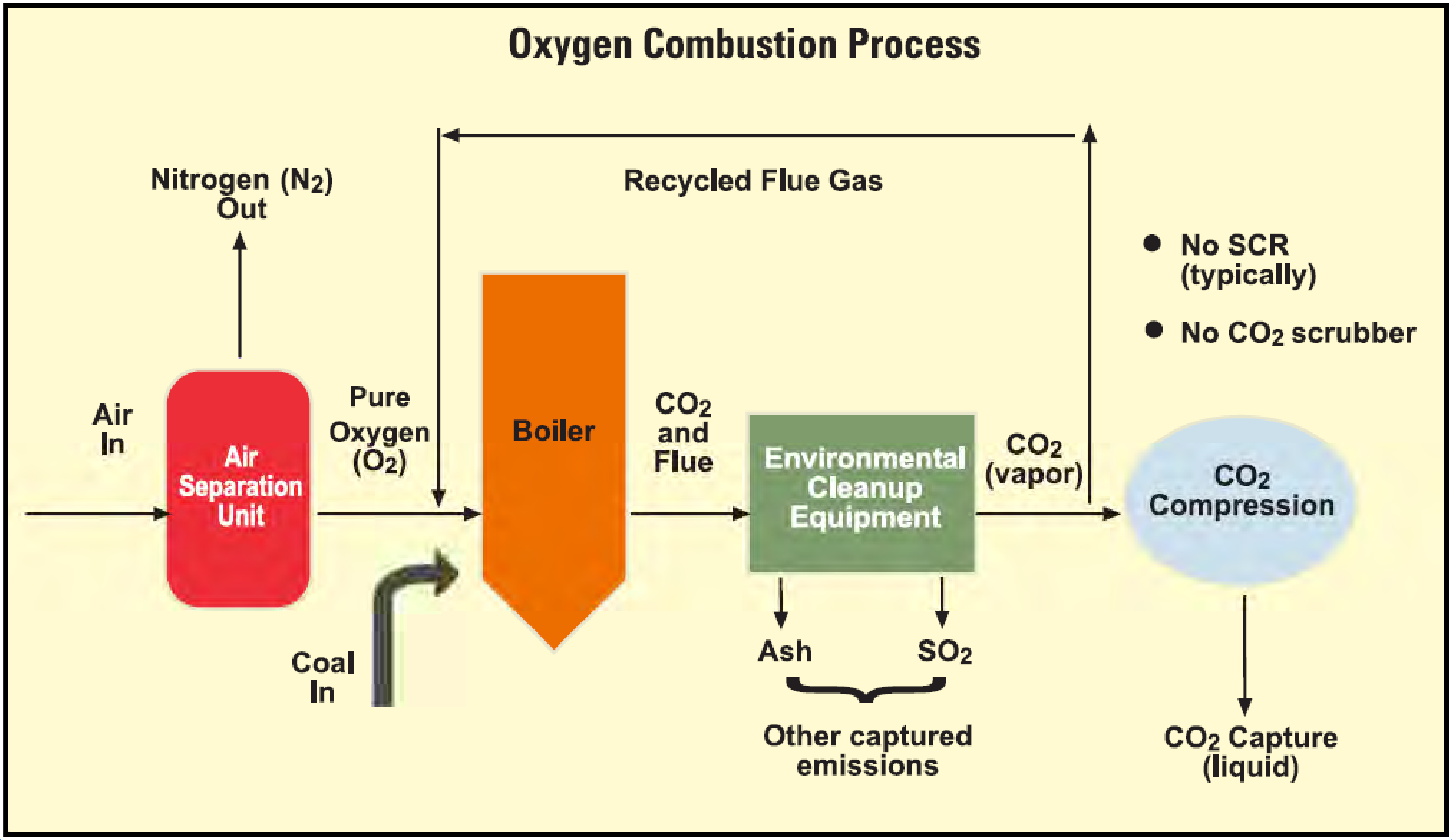
**Phase 2 will capture and sequester 1.5 Million metric tons $CO_2$/year**

# $CO_2$ Capture Techniques

## *Oxy Coal Firing*

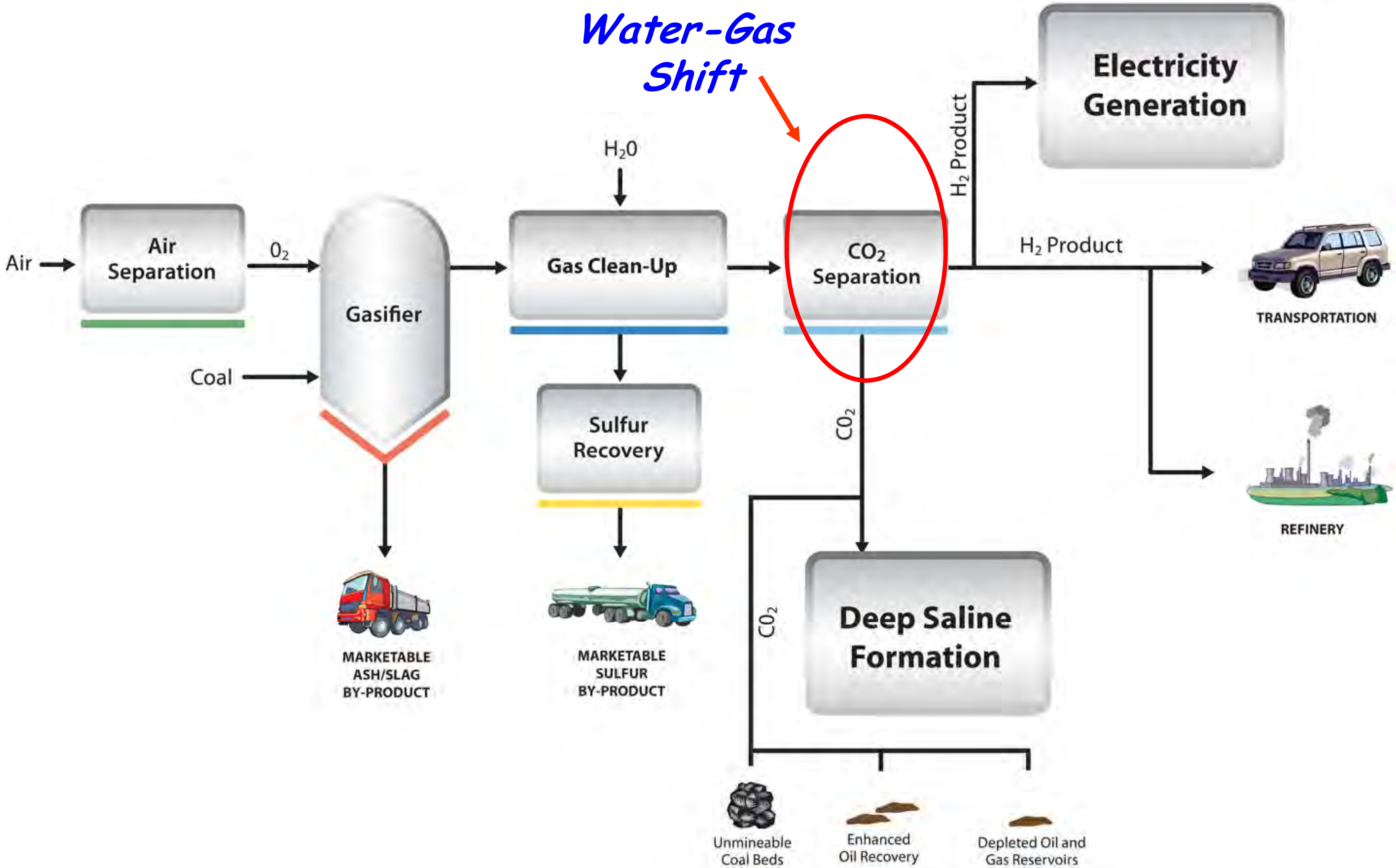
- Modified-Combustion Capture – Oxy Coal Firing
  - *Key Points*
    - Technology not yet proven at commercial scale
    - Creates stream of high $CO_2$ concentration
    - High parasitic demand, >25%
  - *Demonstration Scale*
    - 10 MWe scale
    - Teamed with B&W at its Alliance Research Center and 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 $CO_2$ per day
    - Retrofit targeted between 2013 and 2015

# $CO_2$ Capture Techniques



# FutureGen's Water-Gas Shift Process

*Pre-Combustion Capture*



# $CO_2$ Capture Techniques

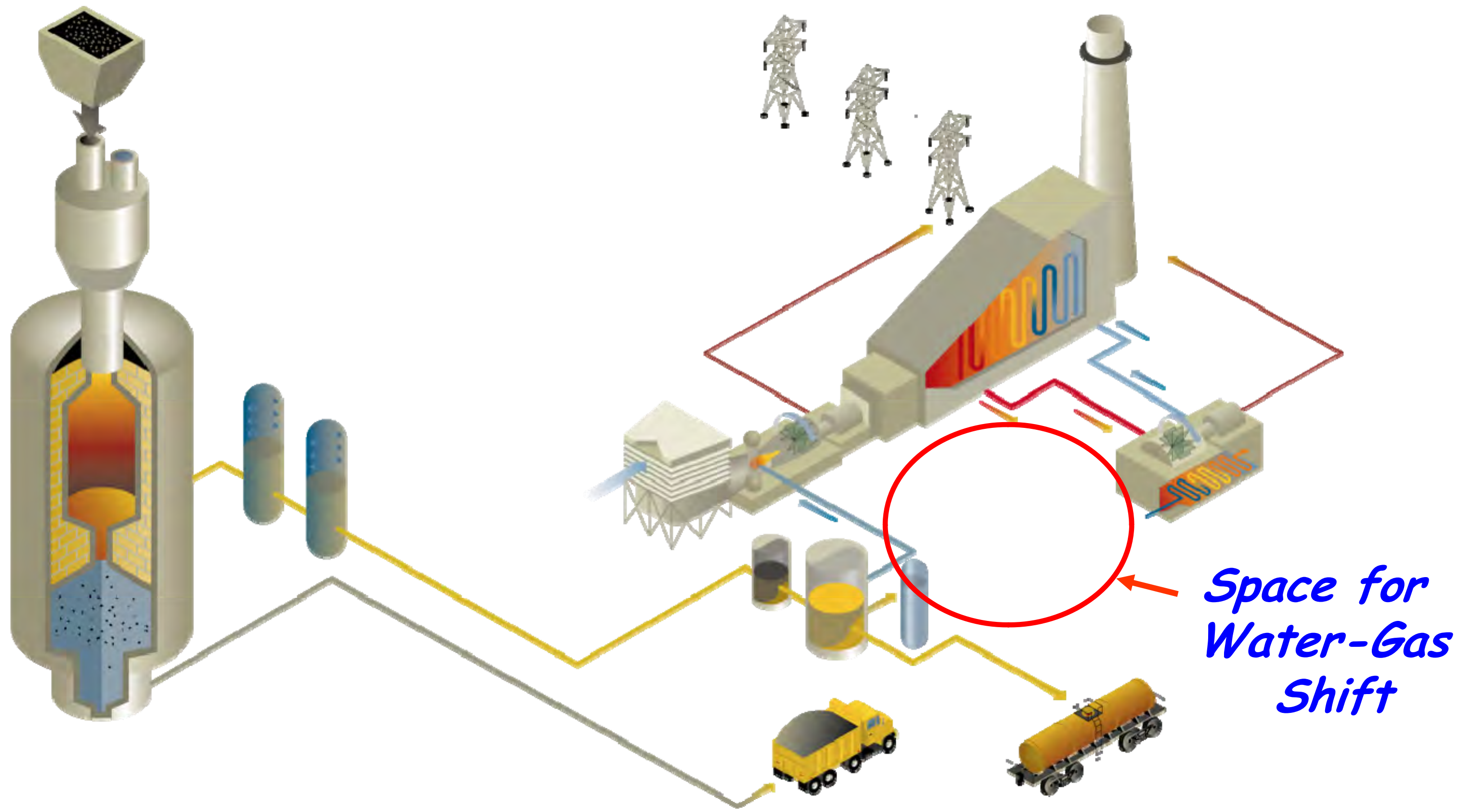
## *Pre-Combustion Capture*

- 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 $H_2$-based fuel, which has not yet been proven at commercial scale
    - Creates stream of very high $CO_2$ concentration
    - Parasitic demand (~15%) for $CO_2$ capture - lower than amine or oxy-coal options

# FutureGen's Water-Gas Shift Process

*Pre-Combustion Capture*

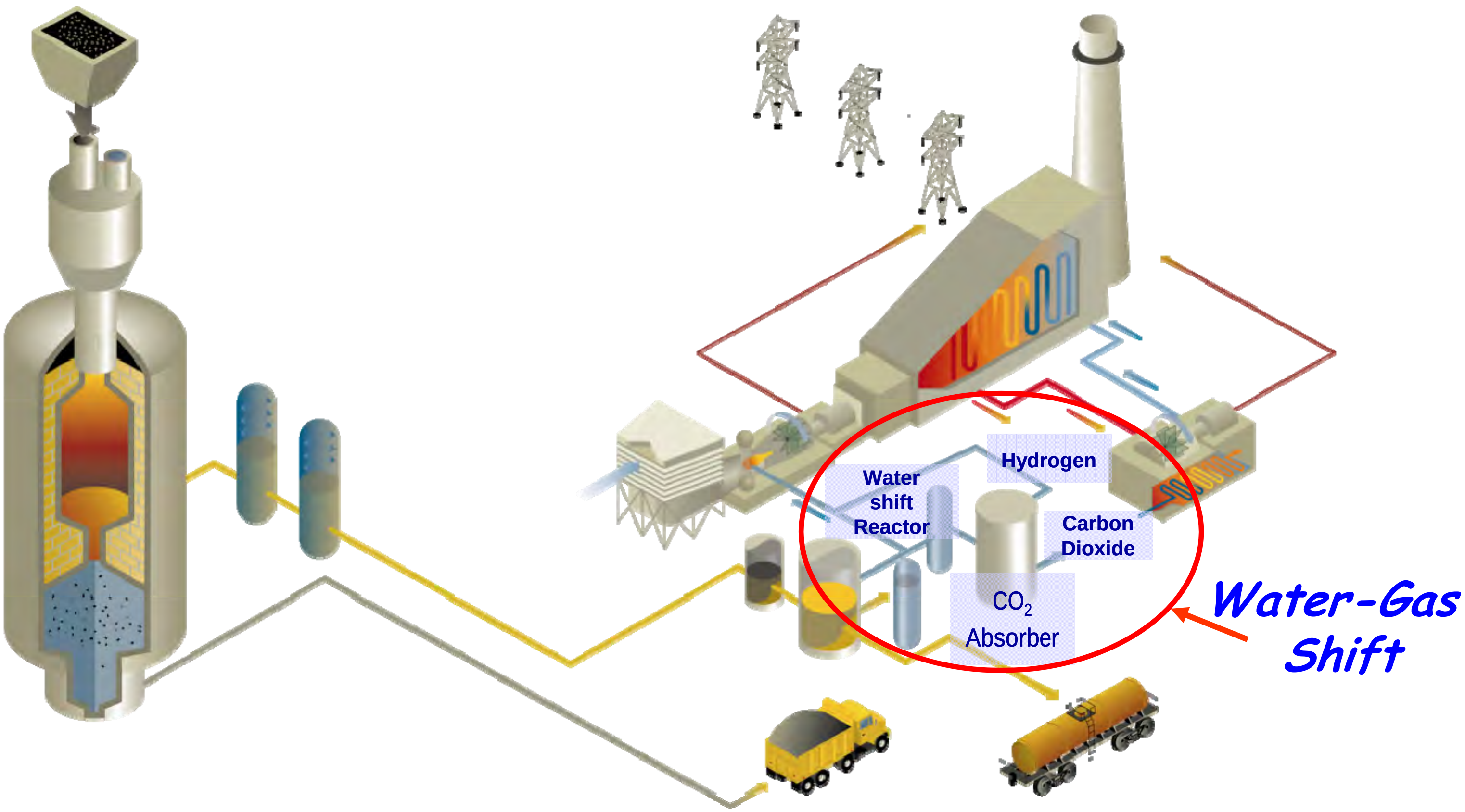
## Mountaineer IGCC without $CO_2$ Capture



# FutureGen's Water-Gas Shift Process

*Pre-Combustion Capture*

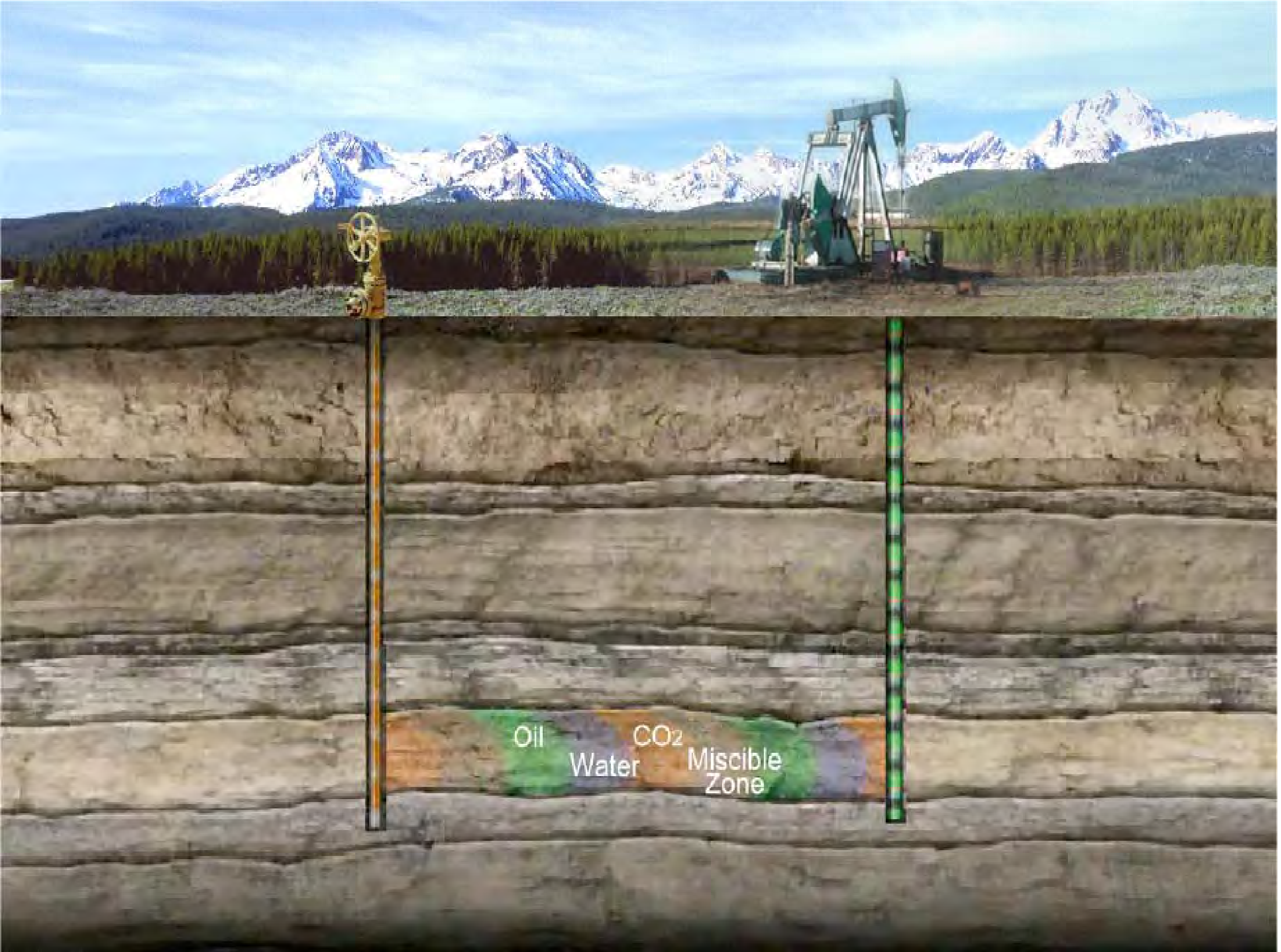
## Mountaineer IGCC with $CO_2$ Capture



# $CO_2$ Storage Key Points

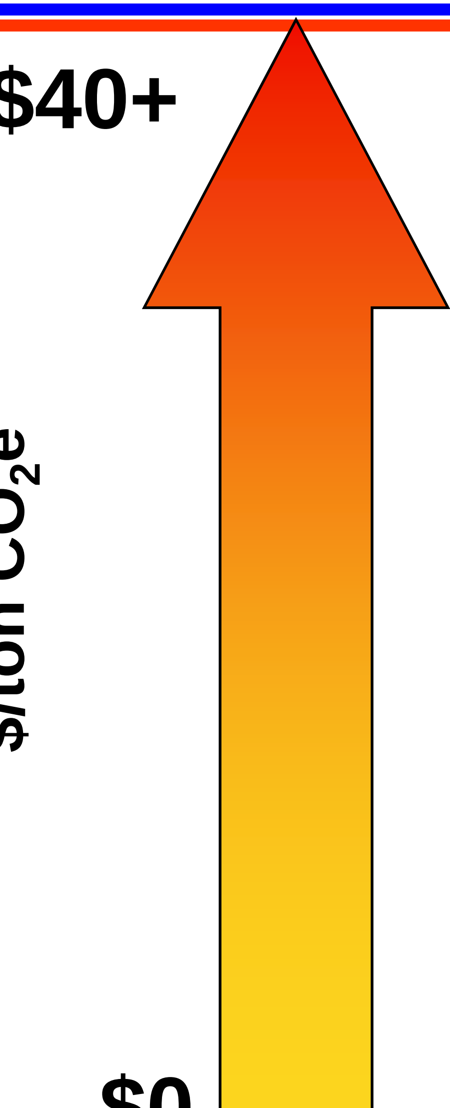
- Challenges with storage
  - Geology Dependency
    - A 500 MW power plant could require a many wells at a spacing of several thousand feet or more
  - Not yet proven in large scale or in long-term
  - Uncertainty on environmental fate and long term interaction of contaminants in product $CO_2$ with saline (ammonia, water, $SO_x$)
  - 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 $CO_2$ for EOR opportunities

# Enhanced Oil Recover (EOR)




Graphic courtesy of
USDOE National Energy
Technology Laboratory

# 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.