



# Washington Group International

Integrated Engineering, Construction, and Management Solutions



## GREENFIELD NO<sub>x</sub> STRATEGIES

2005 NO<sub>x</sub>/PCUG Conference  
Detroit, Michigan

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# Safety Topic

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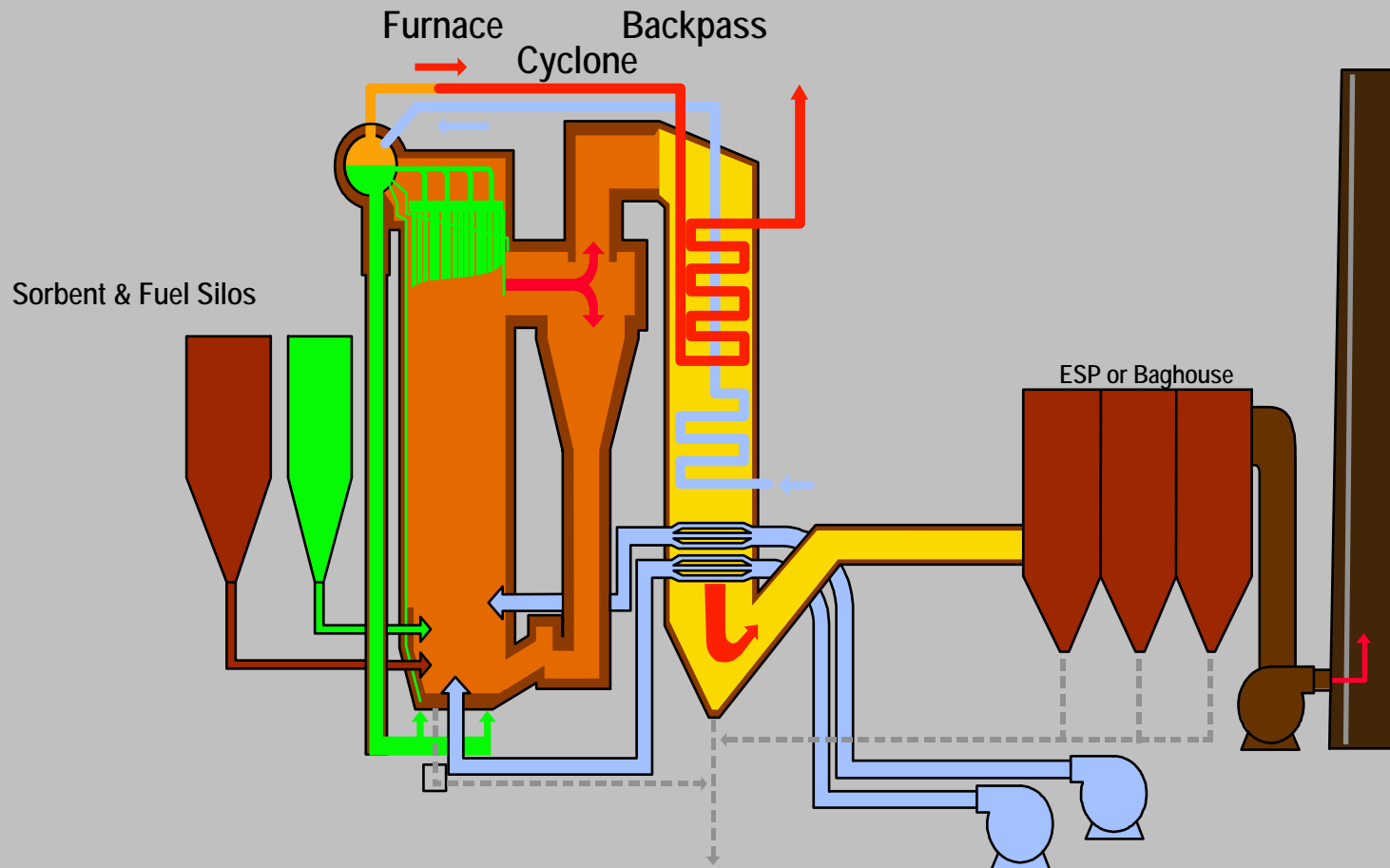


... it is also  
against the law  
in many U.S.  
cities and  
states!

# Overview

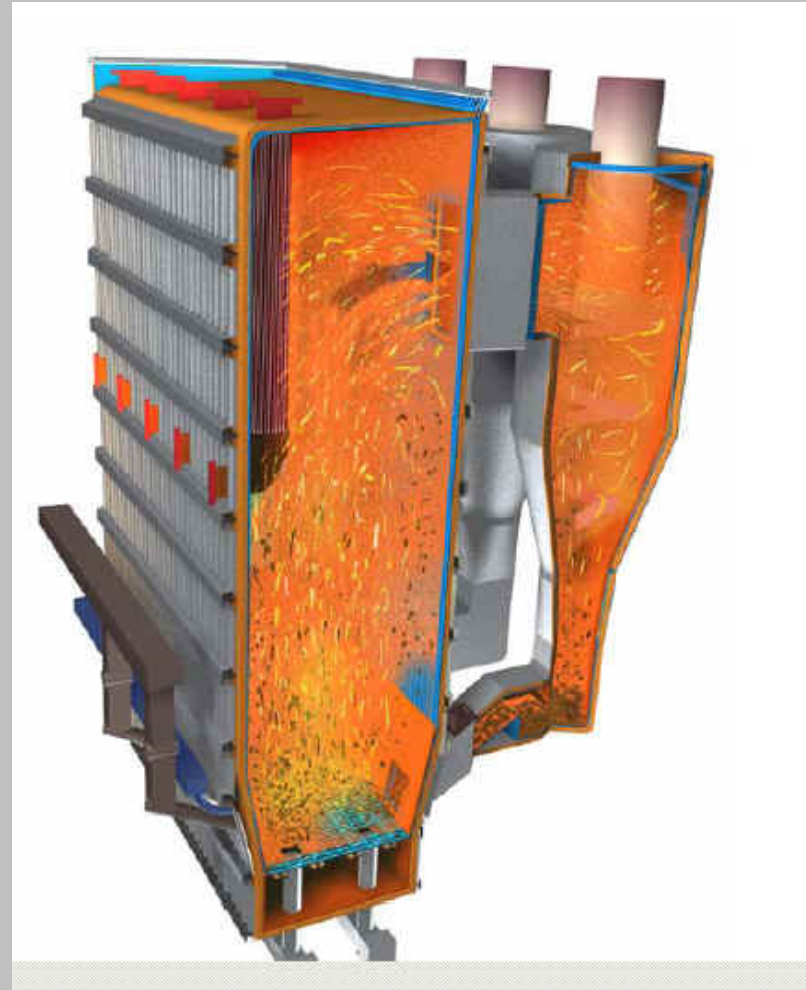
- ◆ Basic Circulating Fluidized Bed Arrangement
- ◆ Compare Selection Criteria: PC & CFB
- ◆ CFB Emission Results & Recent Projects
- ◆ NOx Control Technologies

# Typical CFB Arrangement



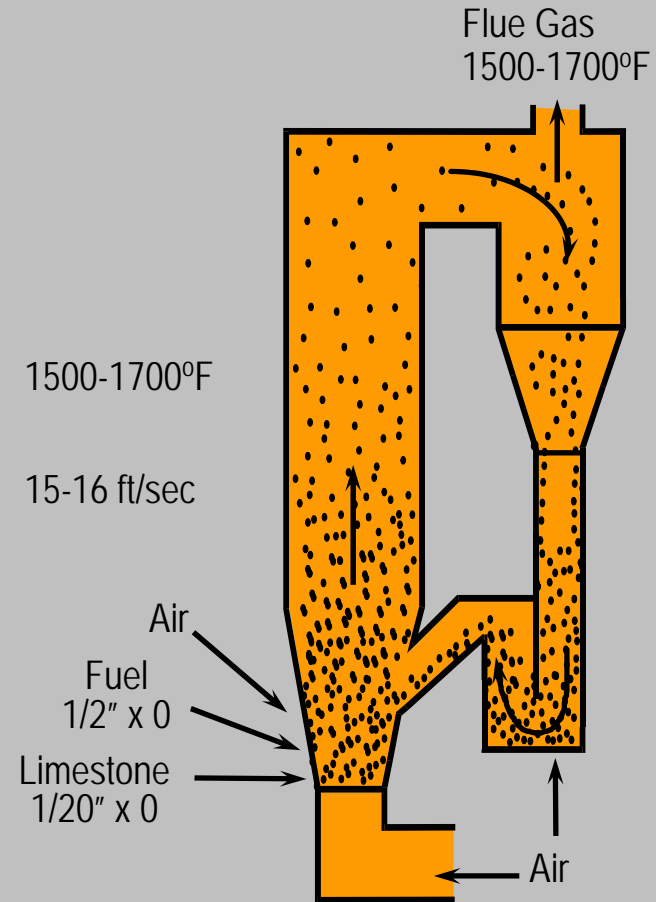
# Typical CFB Furnace

- Fuel and Sorbent Injected into Furnace
- Solids Collected in Cyclone(s)
- Unreacted Fuel/Sorbent Returned to Furnace



# CFB Furnace Characteristics

<u>Feature</u>	<u>Benefit</u>
Low Furnace Temps.	Low NO <sub>x</sub> Low SO <sub>2</sub> Fuel Flexibility
Hot Circulating Solids	Handles Poor Fuels Simple Feed Systems
Long Solid Residence Time	Good Fuel Burnout Good Sorbent Utilization



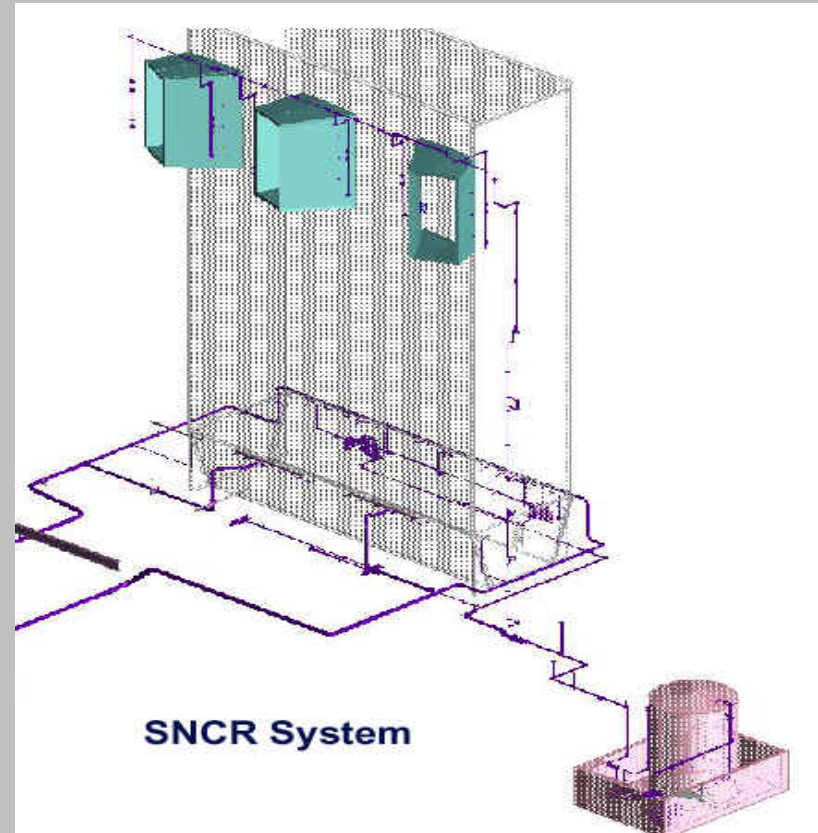
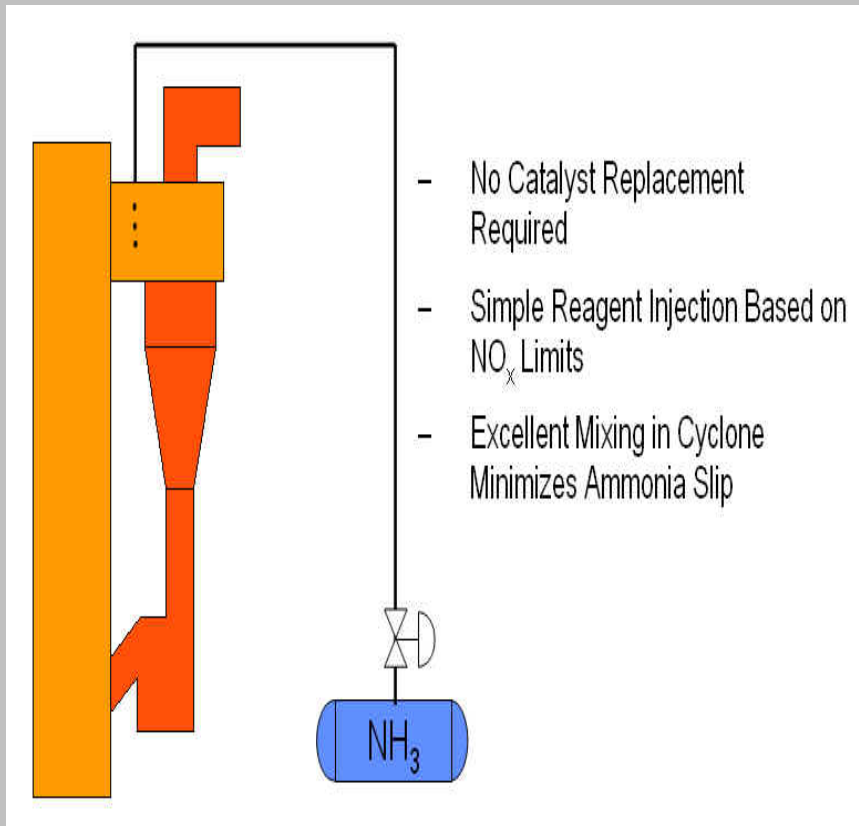
# Inherent Sulfur Capture

- ◆ Circulating Sorbent Provide Heat Transfer and SO<sub>x</sub> Reduction.
- ◆ Depending on Fuel 90 to 95 % Sulfur Capture in Bed Achievable
- ◆ Polishing Dry Scrubber and Baghouse Increases Sulfur Capture

# Low Operating Temperature Reduces NOx

- ◆ CFB Operates Between 1500 F to 1700 F
- ◆ Thermal NOx Minimized

# Simple SNCR Technology Reduces NOx



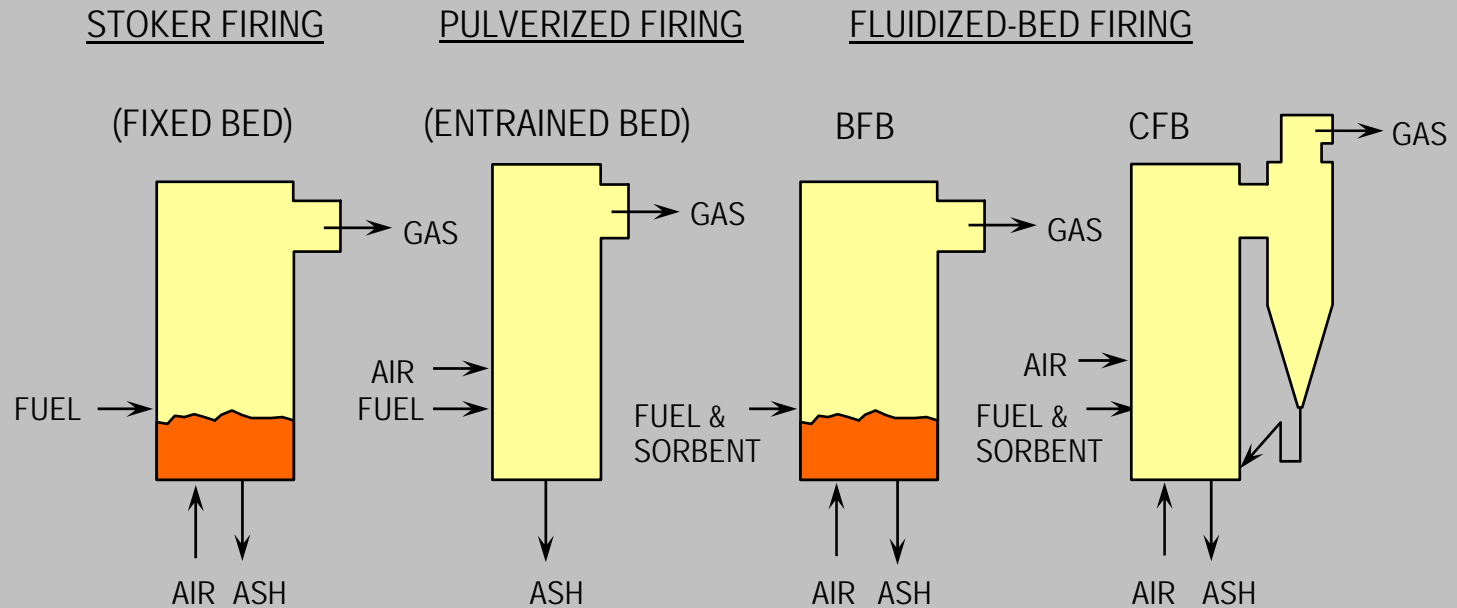
# Selection Criteria

- ◆ Unit Size
- ◆ Fuel Characteristics
- ◆ Emissions Levels

# Unit Size

- ◆ PC Boilers Up to 1300 MW in Service
- ◆ Supercritical as well as Subcritical PC Boilers Proven
- ◆ Present Proven CFB Size Approx. 300MW
- ◆ Larger CFB's as well as Supercritical Designs in Progress

# Combustion Type Comparison



VELOCITY	8-10 ft/sec	15-30 ft/sec	4-10 ft/sec	15-22 ft/sec
FUEL FEED SIZE	1-1/2"x0	1/100"x0	1/2"x0	1/2"x0
FURNACE TEMP.	2000-2500°F	2200-2800°F	1500-1700°F	1500-1700°F

# CFB Technology Offers Fuel Flexibility

- Coal
  - Anthracite
  - Bituminous
  - Sub-Bituminous
  - Lignite
- Waste Coal
  - Bituminous Gob
  - Anthracite Culm
- Petroleum Coke
- Oil
- Refinery Bottoms
- Natural Gas
- Peat
- Agricultural Waste
  - Woodwaste
  - Rice Husks
  - Bagasse Pith
- Tires
- Sludge
- Refuse Derived Fuel

# CFB Technology Can Accommodate A Wide Range of Fuel Properties

## *Range of Fuel Properties for CFB's*

Moisture	Up to 60%	(Brown Coal, Peat, Sludge)
Ash	Up to 76%	(Waste Anthracite)
Sulfur	Up to 6%	(Waste Bituminous, Petroleum Coke)
Volatiles	Down to 5%	(Anthracite)
HHV	Down to 2600 Btu/lb	(Waste Anthracite)

# CFB Boilers Have Low Emissions

<u>Boiler</u>	<u>Fuel</u>	<u>SO<sub>2</sub></u>		<u>NO<sub>x</sub></u>	
		<u>(lb/10<sup>6</sup>Btu)</u>	<u>(ppm)</u>	<u>(lb/10<sup>6</sup>Btu)</u>	<u>(ppm)</u>
Plant "A"	Sub-Bituminous	0.02	10	0.04	28
Plant "B"	Sub-Bituminous	0.05	27	0.05	37
Plant "C"	Sub-Bituminous	0.06	32	0.06	44
Plant "D"	Bituminous	0.17	90	0.16	119
Plant "E"	Bituminous	0.26	140	0.27	200
Plant "F"	Anthracite	0.45	239	0.05	34
Plant "G"	Bituminous Waste	0.30	159	0.20	153
Plant "H"	Anthracite Waste	0.12	66	0.11	78
Plant "I"	Petroleum Coke	0.38	200	0.13	95

# BACT Levels the Equipment Field

## PULVERIZED COAL SYSTEM

- Low NO<sub>x</sub> Burners
- Over-Fired Air
- SCR
- ESP /Baghouse
- Dry/Wet SO<sub>2</sub> Scrubber

## CIRCULATING FLUIDIZED BED SYSTEM

- SNCR
- Dry Polishing SO<sub>2</sub> Scrubber
- Baghouse

# PC NOx Control Technologies

- ◆ In Furnace
  - Furnace design
  - Overfire Air Systems
  - Low NOx Burners
  - Advanced Overfire Air Systems
  - Reburn
  - Neural Net

# PC NOx Control Technologies

- ◆ Post Combustion
  - SNCR
  - SCR
  
- ◆ Developing
  - MultiPollutant Control Systems
    - NOx
    - SOx
    - Hg
    - Particulate

# PC NOx technology Target Levels

- ◆ In Furnace 0.1 to 0.2 Lb/MMBtu NOx
- ◆ Post Combustion <0.05 Lb/MMBtu NOx
- ◆ Multi-pollutant <0.05 Lb/MMBtu NOx

# In Furnace NOx Control - Advantages

- ◆ Well established technical basis
- ◆ Extensive Industry Experience
  - Equipment performance
  - Cost Profiles
  - BOP effects
- ◆ Significant NOx reductions are achievable.
- ◆ Continued innovation to support existing station
- ◆ ?????

# In Furnace NOx Control - Issues

- ◆ Cannot always get to New Source requirements.
- ◆ System tuning is Key to maintaining emissions
- ◆ More complex systems will affect
  - Availability
  - Capacity factor
  - Maintenance Costs
  - Outage Durations
  - ??????

# Post Combustion NOx Control - Advantages

- ◆ Well established technical basis
- ◆ Extensive Industry experience
  - Equipment performance
  - Cost Profiles
  - BOP effects
- ◆ Continued development
  - SNCR reagents and injection techniques
  - SCR catalyst operating temp range
  - SCR catalyst SO<sub>2</sub> – SO<sub>3</sub> conversion
  - ????

# Post Combustion NOx Control - Issues

- ◆ Real Estate requirements
- ◆ Costs today and tomorrow
- ◆ Downstream equipment
- ◆ More complex systems will affect
  - Availability
  - Capacity factor
  - Maintenance Costs
  - Outage Durations
  - ??????

# New Source NOx Control Summary

- ◆ NOx control technology is:
  - Available
  - Proven
  - Competitive
  - Continues to be Improved
- ◆ Operations and Maintenance is understood
- ◆ Bottom Line - We can get there from here

# NOx Control - Tomorrow

- ◆ Multi-pollutant systems being developed to
  - Control NOx, Sox, Hg and Particulate
  - Minimize equipment costs
  - Simplify controls and operability
  - Minimize maintenance
  - Reduce cost over individual control
  - ?????
- ◆ Know your fuel source

# Multi- pollutant Systems

- ◆ Many process in various stages of development
- ◆ Technical challenges to overcome before fully commercial
- ◆ Scale up issues to overcome before fully commercial
- ◆ Expect savings over component systems in the range of 10% – 25%
- ◆ Some Process are in commercial demonstration
- ◆ Commercial Availability ?
- ◆ ??????

# Multi-pollutant Systems - Enviroscrub

## Pahlman Process™ Multi-Pollutant Technology

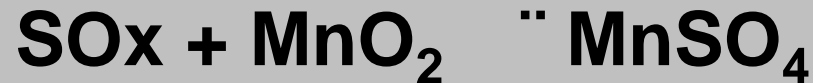
[NO<sub>x</sub>/SO<sub>x</sub>/Hg/PM 2.5]





# Multi-pollutant Systems - Enviroscrub

## Simplified Pollutant Capture Reactions



- The manganese valance state is reduced from a +4 to a +2 during the pollutant capture reaction

# Multi-pollutant Systems - Powerspan Corp

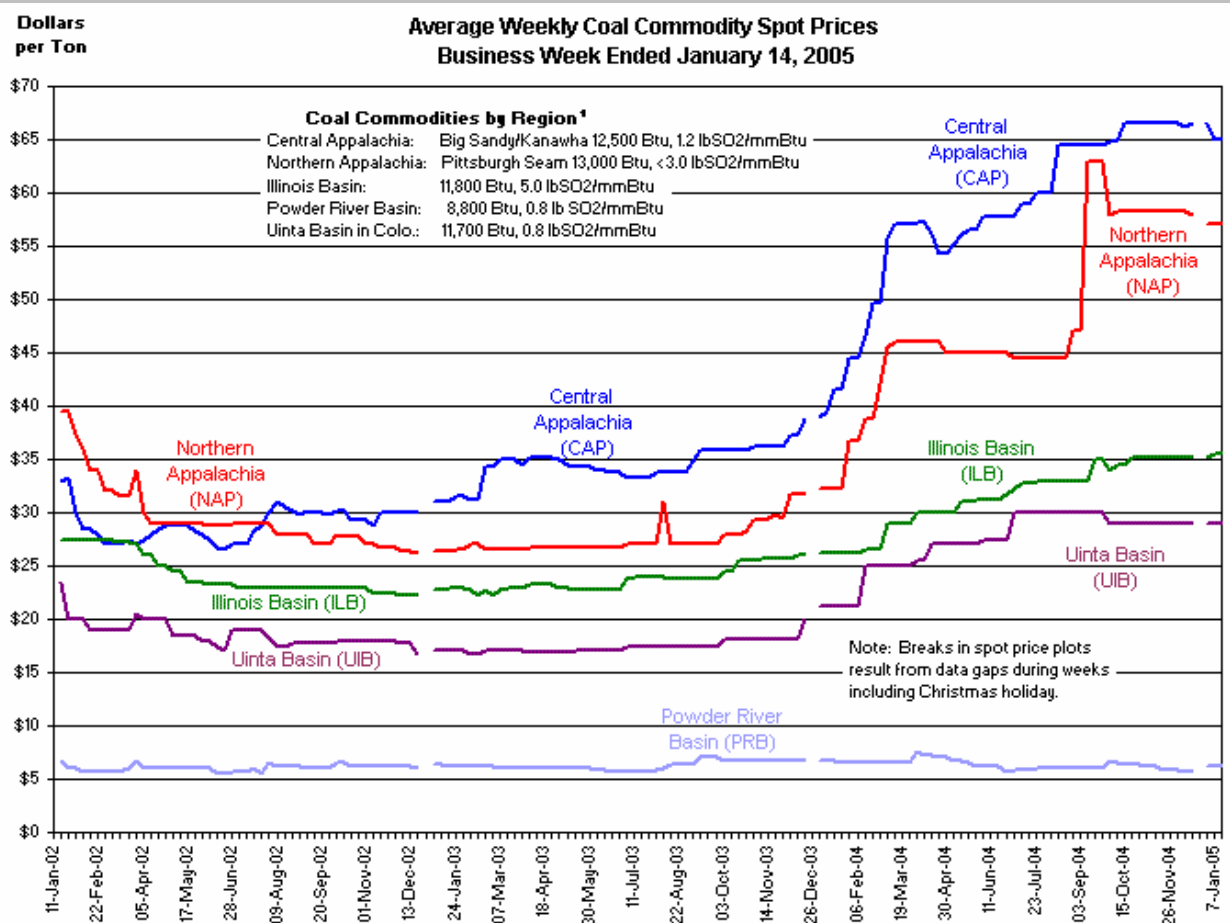
## Conventional Power Plant with ECO<sup>®</sup> Installed



# Multi-pollutant Systems - Powerspan Corp

- ◆ Barrier Discharge Reactor
- ◆ Ammonia Scrubber
- ◆ Wet ESP
- ◆ Byproduct recovery

# Know Your Coal Source



\* Coal prices shown are for a relatively high-Btu coal selected in each region, for delivery in the "prompt" quarter. The "prompt quarter" is the next calendar quarter, with quarters shifting forward after the 15th of the month preceding each quarter's end.

Source: with permission, selected from listed prices in Platts Coal Outlook, "Weekly Price Survey."