



a McDermott company

# The Babcock & Wilcox Company

*Generating Powerful Solutions<sup>SM</sup>*

## *Flue Gas Desulfurization Technologies*



# B&W

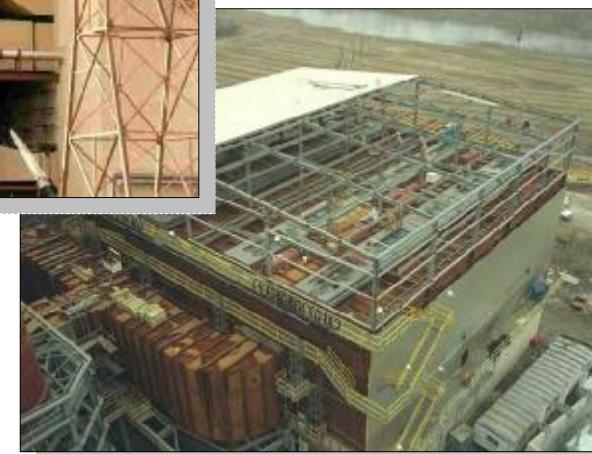
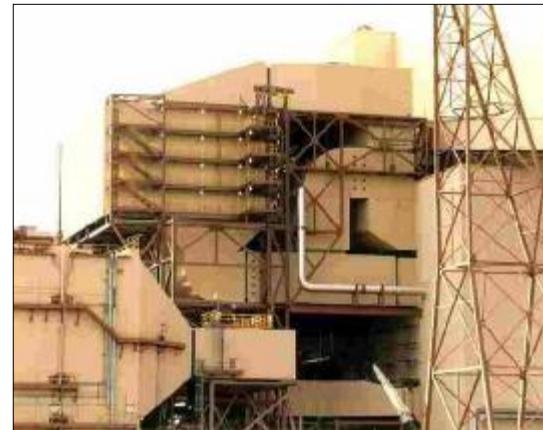
## *Wet FGD Technology*

June 2004



# *B&W Environmental Products & Services*

- Wet FGD
- Wet ESP & other SO<sub>3</sub> control technologies
- Mercury Control
- SCR
- Dry FGD
- Fabric Filter
- Dry Electrostatic Precipitator
- Environmental Upgrades



# B&W Database

***First Commercial Unit - 1970***

## ***Sources of Data***

- Seven Major Pilot Plants
- Performance Tests on 71 Units
- Major Test Programs at 8 Field Units

***Fuel Sulfur Concentrations: 0.3 to 8%***

***SO<sub>2</sub> Inlet Concentration – up to 17,000 mg/Nm<sup>3</sup>***

***High SO<sub>2</sub> Removals – 98% - 99%***

***Tray Towers, Open Spray Towers, Packed Towers***



## *Recent Wet Scrubber Experience*

***19 new units placed in service since 1998***

***20 new units sold since 2001***

***B&W has 55% of Recent U. S. Market***

### ***Tray Retrofit in 22 Units***

- Competitor units
- Open and packed towers
- Increase removal
- Reduce power consumption
- Take pumps out of service
- Eliminate blockage in packed towers



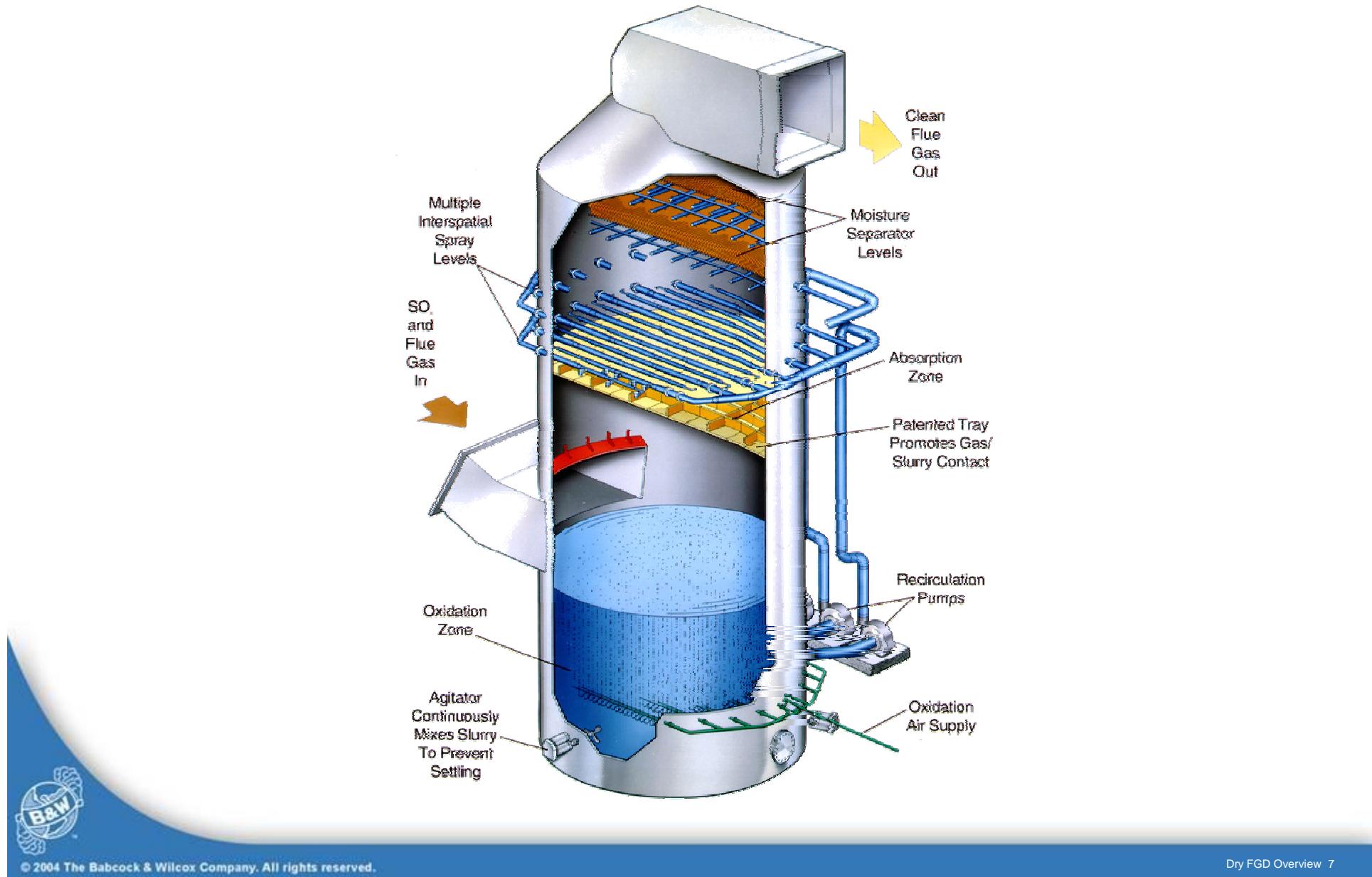
## B&W Recent Sales of WFGD

<b>Utility</b>	<b>Unit</b>	<b>MW</b>	<b>Gas Flow</b>
<b>New Brunswick</b>	<b>Coleson Cove 1–3*</b>	<b>1150 Total</b>	<b>1,870</b>
<b>Progress Energy</b>	<b>Asheville 1&amp;2</b>	<b>198</b>	<b>850</b>
<b>Progress Energy</b>	<b>Roxboro 1 &amp; 2</b>	<b>385</b>	<b>1,620</b>
<b>Progress Energy</b>	<b>Roxboro 3 &amp; 4</b>	<b>700</b>	<b>2,930</b>
<b>Progress Energy</b>	<b>Mayo</b>	<b>745</b>	<b>3,120</b>
<b>AEP</b>	<b>Mitchell 1 &amp; 2</b>	<b>800</b>	<b>3,360</b>
<b>AEP</b>	<b>Cardinal 1 &amp; 2</b>	<b>600</b>	<b>2,520</b>
<b>Cinergy</b>	<b>Gibson 1</b>	<b>660</b>	<b>2,750</b>
<b>Cinergy</b>	<b>6 other units</b>	<b>500 - 600</b>	<b>2,000 – 2,500</b>

**Coleson Cove – 3 boilers – 2 absorbers  
Gas Flow in 1000 Nm<sup>3</sup>/h  
All single tower systems**



# B&W WFGD Absorber Tower



# *B&W Wet FGD Licensee in China*

**Wuhan Kaidi Power  
Environmental  
Co.,Ltd**

**Zhejiang Tiandi  
Environmental  
Engineering  
Co., Ltd**



# *Wet FGD Projects – B&W Licensee Tiandi*

*10,585 MW sold since 2003*



Plant Name	Size	Remarks
Beilun Phase 1	2 x 600 MW	Boilers supplied by BWBC
Beilun Phase 2	3 x 600 MW	
Xiaoshan	2 x 125 MW	
Wenzhou Phase 3	2 x 300 MW	
Qianqing	1 x 135 MW	
Changxing	4 x 300 MW	Boilers supplied by BWBC
Lanxi	4 x 600 MW	Boilers supplied by BWBC
Wenzhou Phase 2	2 x 300 MW	Under commerical negotiation
Yueqing	4 x 600 MW	Suspend



## *B&W's Chinese Licensees' Experience – Cont'd.*

### **Tiandi**

	<b><u>MW</u></b>
• Qianqing	135
• Xiaoshan	250
• Changxing	1200
• Wenzhou Phase 3	600
• Lanxi	2400
• Beilun I	1200
• Beilun II	1800
• Wenzhou Phase 2	600
• Yueqing	2400

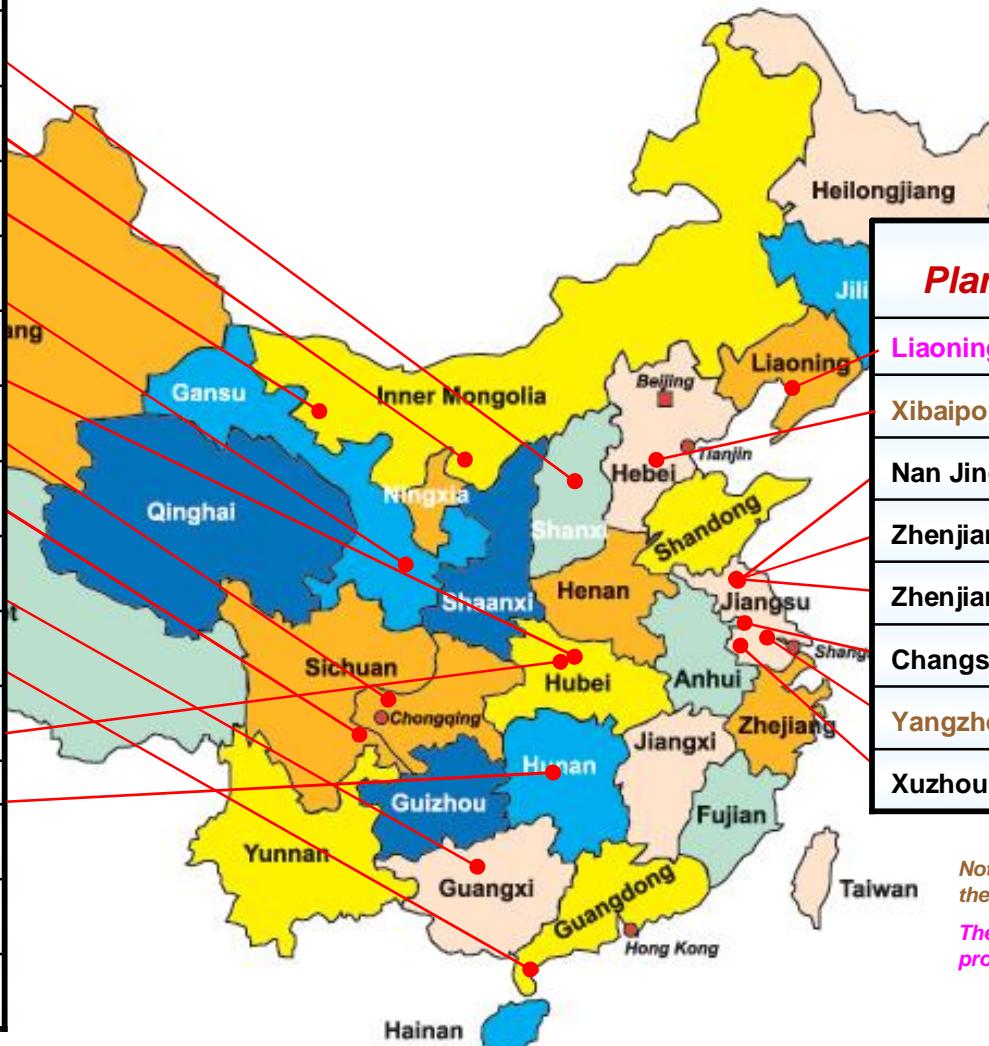
**TOTAL MW:**    **10585**



# Wet FGD Projects – B&W Licensee Kaidi

17,880 MW sold since 2002

<b>Plant Name</b>	<b>Size</b>
Taiyuan	1 x 200 MW
Wulashan	2 x 300 MW
Hai Bo Wan	2 x 330 MW
Zhang Ye	2 x 300 MW
Yangluo	2 x 600 MW
Luohuang	2 x 600 MW
Guang'an	2 x 300 MW
Heshan	2 x 300 MW
Zhanjiang	2 x 600 MW
Hubei Huanggang	2 x 600 MW
Hunan Jinzhushan	2 x 600 MW
Yuanbaoshasan	1 x 600 MW
Da Tang Jinzhushan	2x 600 MW
Hu Bei Dabieshan	2x 600 MW



<b>Plant Name</b>	<b>Size</b>
Liaoning qinghe	1 x 600 MW
Xibaipo	2 x 600 MW
Nan Jing	2 x 135 MW
Zhenjiang (Phase 1)	2 x 140 MW
Zhenjiang (Phase 2)	2 x 135 MW
Changshu	3 x 600 MW
Yangzhou No. 2	4 x 600 MW
Xuzhou	2 x 300 MW

Note: The plant name in brown means the boilers are supplied by BWBC

The plant name in pink means the project is booked but non-approved



# *B&W's Chinese Licensees' Experience*

## MW      Kaidi      MW

• Taiyuan	200	• Wulashan	600
• Zhenjiang Phase 2	280	• Zhenjiang Phase 1	270
• Guang'an	600	• Xibaibo	1200
• Heshan	600	• Yuanbaoshan Phase 3	600
• Chang Shu	1800	• Liaoning Qinghe	600
• Nan Jing	270	• Hubei Huang Gang	1200
• Xuzhou	600	• Hunan Jin Zhu Shan	1200
• Zhanjiang	1200	• Baotou 3 <sup>rd</sup> Thermal	600
• Yangzhou 2	2400		
• Hai Bo Wan	660		
• Zhang Ye	600		
• Yangluo	1200		
• Luohuang	1200		

**TOTAL MW: 17,880**



# B&W

## *Dry FGD Technology*

June 2004



# *Spray Dry FGD Experience Base*

## **B&W Develops Dual-Fluid Atomization SDA**

**2 Coal Installations - 1980's**

**1,040 MWe**

**Patents and Demonstrates LIMB / E-SO<sub>x</sub> / LIDS**

## **B&W Acquires Joy Environmental Tech (1995)**

**Niro Licensee in North America (Exclusive)**

**20 Coal Installations - 1980-95**

**4,530 MWe and 420 MWt**

**14 WTE Installations - 10,000 TPD capacity**

## **B&W as Niro Licensee (1995+)**

**8 Coal Installations / Contracts**

**1,850 MWe**

## **Niro World-Wide (1980-2002)**

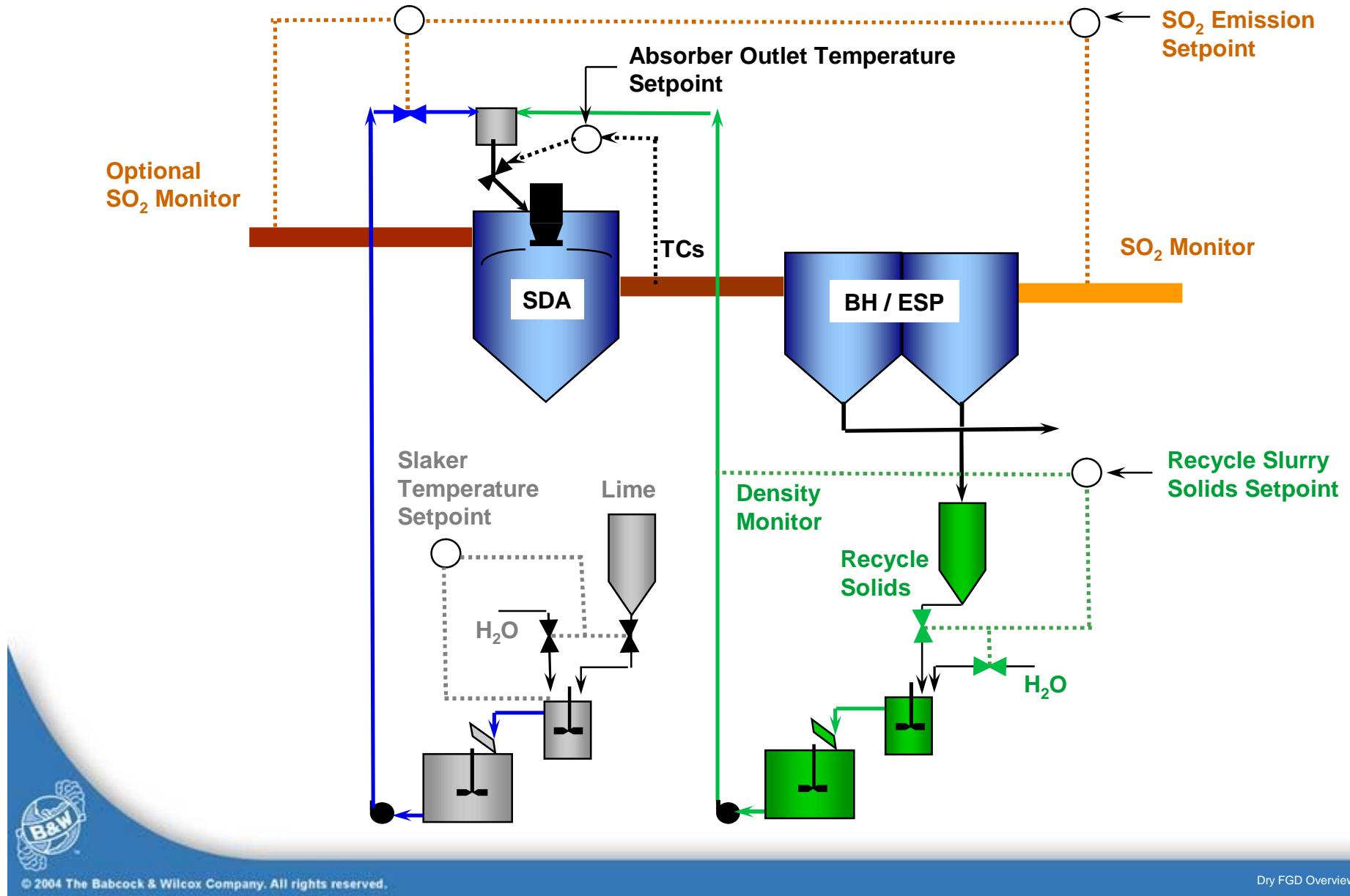
**53 Coal Installations**

**(10,500 MWe power, 3,000 MWt heating)**

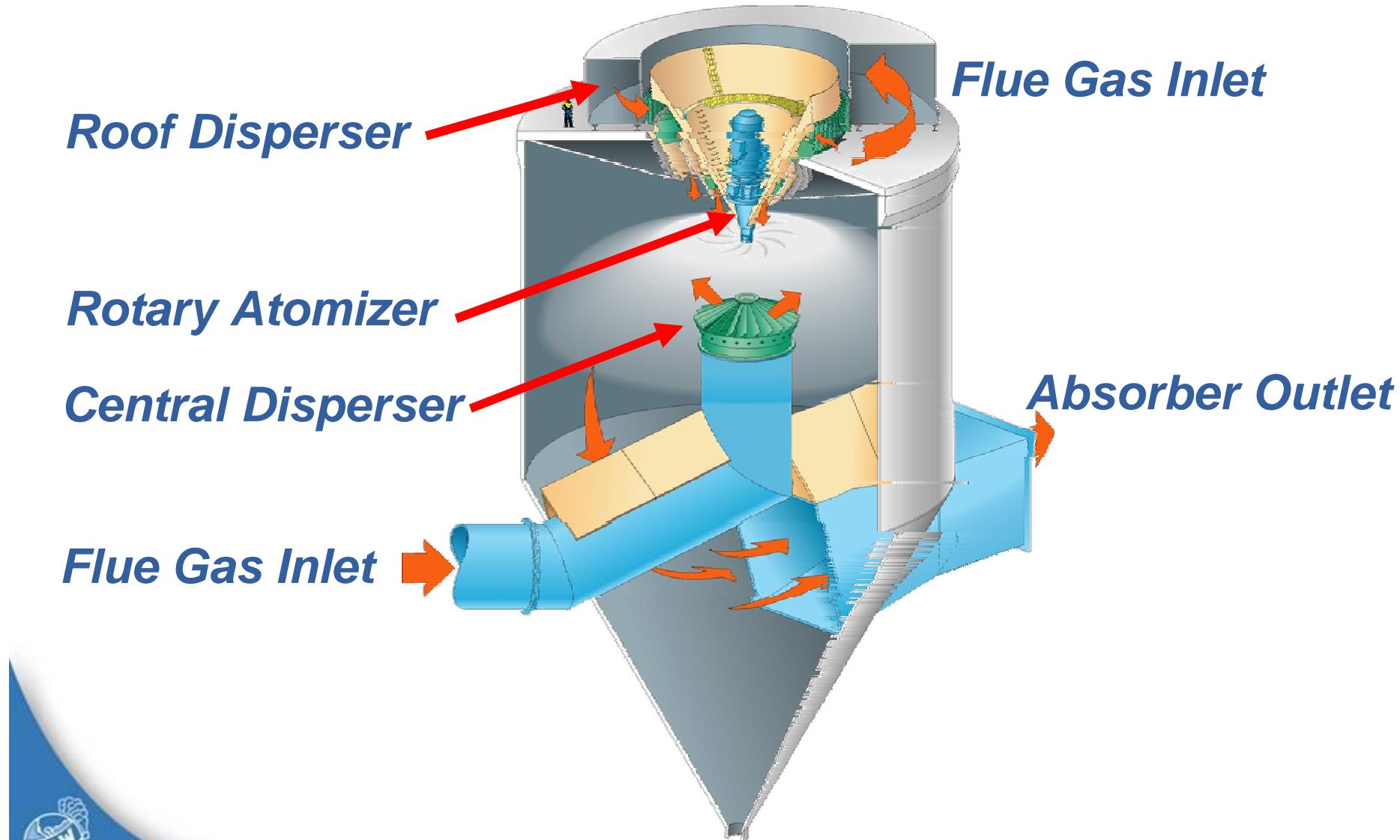
**64 WTE Installations**



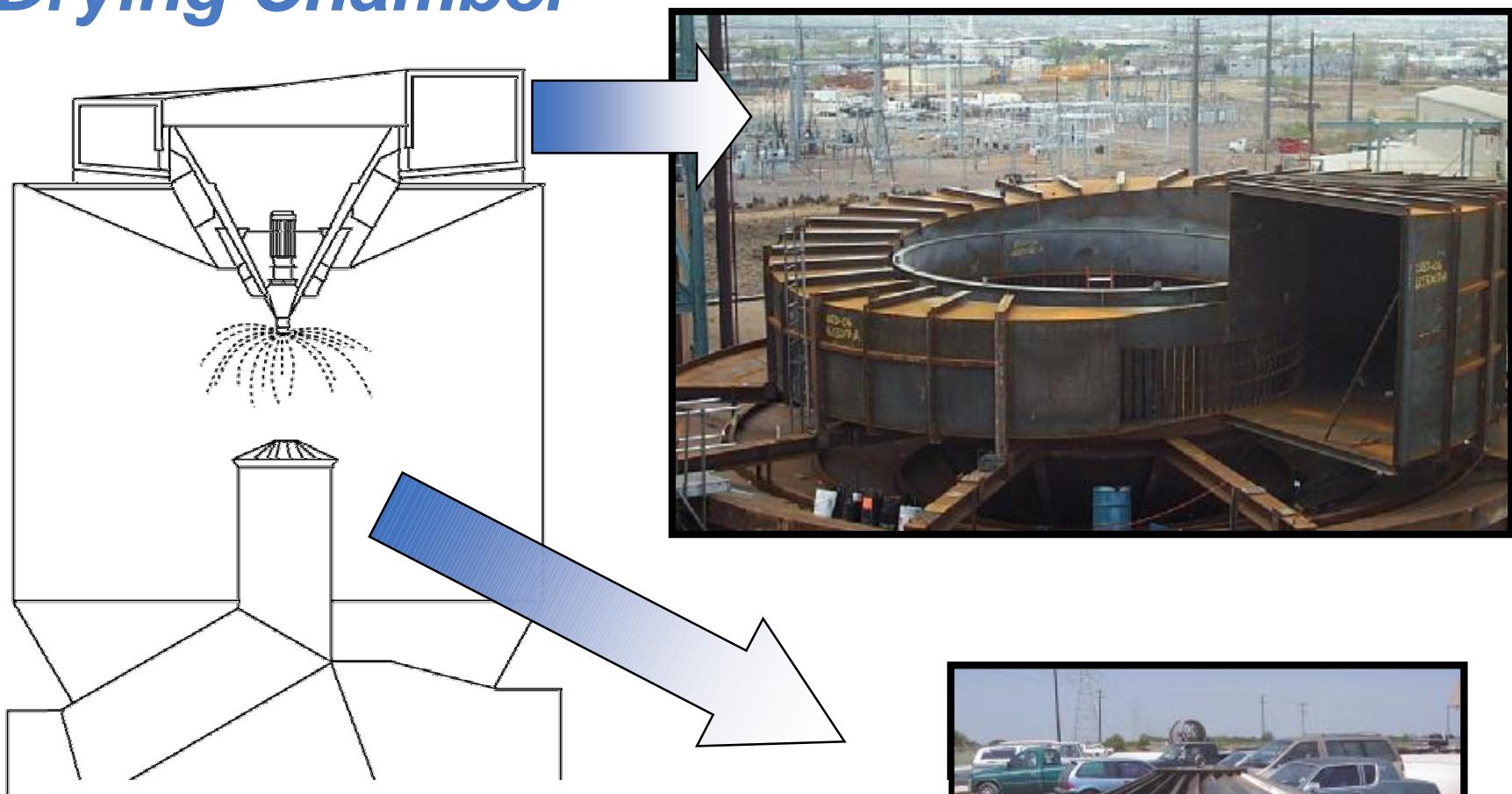
# Dry FGD System Overview



# B&W – Niro Spray Dry Absorber



# Drying Chamber



**Absorber diameter up to 19.8 m**

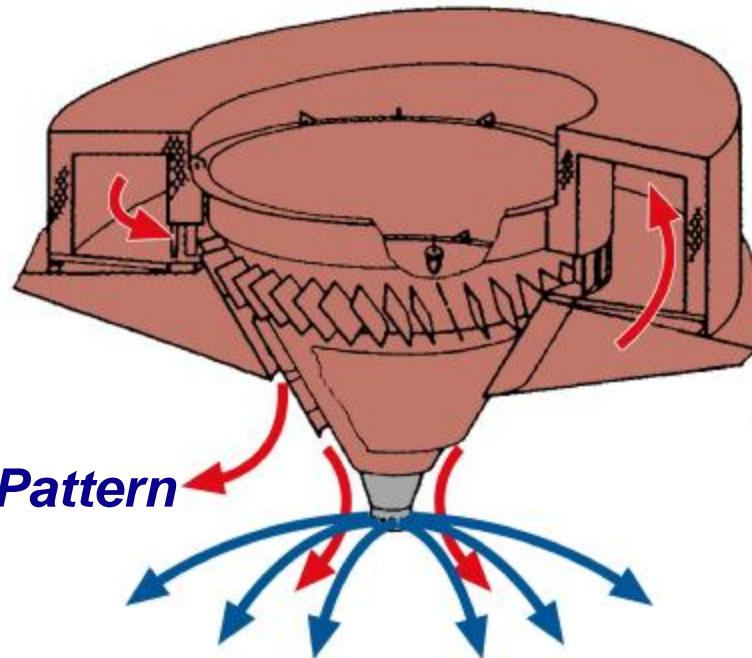
**Flue gas volume up to 1,495,000  
Nm<sup>3</sup>/hr per module**



# *Roof Gas Disperser Functions*

## **Scroll**

***Uniform Distribution  
Gas Stream Rotation***



## **Upper Cone**

***Breaks Rotation  
Bends Atomizer Cloud  
Establishes SDA Flow Pattern***

## **Lower Cone & Vanes**

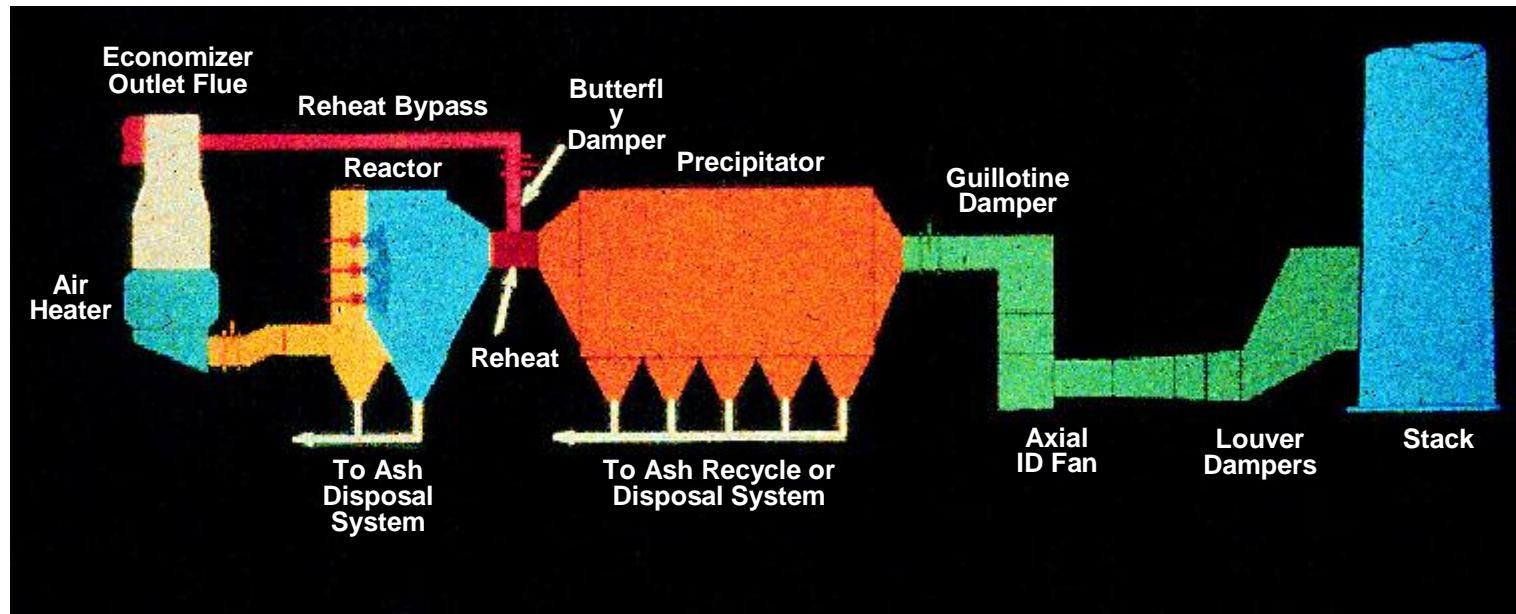
***Straightens Flow (1/3 of Total)  
Keeps Area Above Atomizer Clean***



# *Missouri Basin Power Project Laramie River Station*

## *Unit No. 3 Environmental Control System*

### **Four (4) 33% Reactor/Precipitator Trains**



# Laramie River Station B&W Contract DSR-1

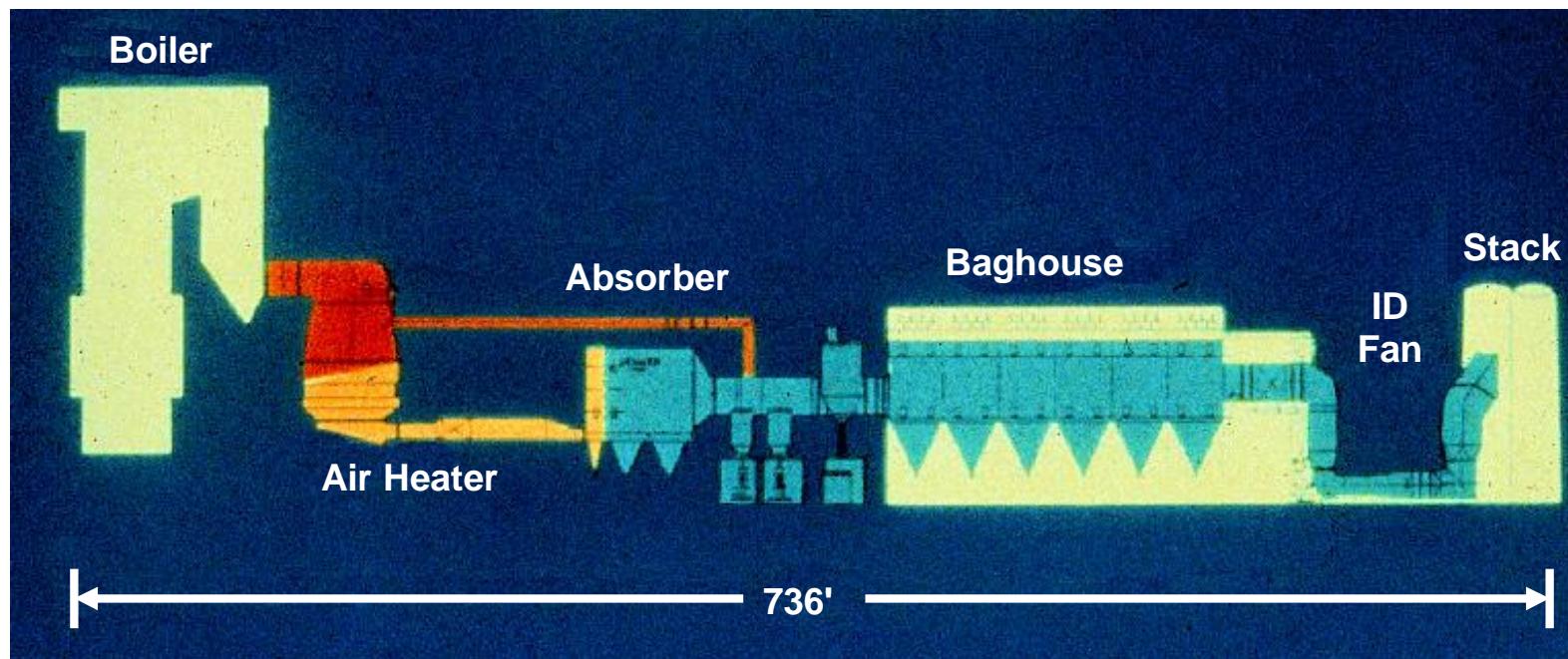
	<i>Design</i>	<i>Actual</i>	
		<u>1985</u>	<u>1986</u>
Boiler load (MW, Gross)	586	605	612
Gas flow (m <sup>3</sup> /hr)	4,078,000	2,660,000	4,519,000
Gas temperature (C)	141	141	135
Coal sulfur (%)	0.54	0.39	0.47
Coal ash (%)	7.89	5.59	5.19
Coal ash alkali (%)	24.92	28.32	28.32
SO <sub>2</sub> emissions (kg/kJ)	0.08	0.06	0.05
SO <sub>2</sub> removal efficiency (%)	85	86.3	87.2
Particulate emissions (kg/kJ)	0.04	0.012	--



# *Colorado-UTE Electric Association*

## *Craig Station - Unit 3*

### *B&W Contract DSR-2*



# *Craig Station Performance Criteria*

	<i>Design</i>	<i>Actual</i>	
		<u>1985</u>	<u>1986</u>
<b>Boiler load (MW) [Gross/Net]</b>	<b>447/411</b>	<b>410</b>	<b>434</b>
<b>Gas flow (m<sup>3</sup>/hr)</b>	<b>3,058,000</b>	<b>3,228,000</b>	<b>3,568,000</b>
<b>Gas temperature (C)</b>	<b>118</b>	<b>129</b>	<b>134</b>
<b>Coal sulfur (%)</b>	<b>0.7</b>	<b>0.32</b>	<b>0.72</b>
<b>Coal ash (%)</b>	<b>14.0</b>	<b>6.56</b>	<b>7.74</b>
<b>Coal ash alkali (%)</b>	<b>19.41</b>	<b>11.52</b>	<b>9.48</b>
<b>SO<sub>2</sub> emissions (kg/kJ)</b>	<b>0.09</b>	<b>0.05</b>	<b>0.07</b>
<b>SO<sub>2</sub> removal efficiency (Min. %)</b>	<b>80</b>	<b>84.4</b>	<b>88.0</b>
<b>Particulate emissions (kg/kJ)</b>	<b>0.013</b>	<b>0.007</b>	<b>--</b>



# Dry Scrubbers - Availability Data

<i>Installation</i>			<b>90</b>	<b>91</b>
<b>Studstrupvaerket MKS 3</b>	<b>Denmark</b>	<b>350 MWe</b>	<b>99.4</b>	<b>99.3</b>
<b>Studstrupvaerket MKS 4</b>	<b>Denmark</b>	<b>350 MWe</b>	<b>99.8</b>	<b>99.3</b>
<b>Duernrohr EVN</b>	<b>Austria</b>	<b>350 MWe</b>	<b>&gt; 99</b>	<b>100</b>
<b>Duernrohr VKG</b>	<b>Austria</b>	<b>410 MWe</b>	<b>&gt; 99</b>	<b>100</b>
<b>Salzburger Stadtwerke</b>	<b>Austria</b>	<b>112 MWt</b>	<b>99.3</b>	<b>&gt; 99</b>
<b>Mainkraftwerke</b>	<b>Germany</b>	<b>250 MWt</b>	<b>97.7</b>	<b>&gt; 97</b>
<b>Walheim</b>	<b>Germany</b>	<b>260 MWe</b>	<b>99.5</b>	<b>&gt; 99</b>
<b>Vaesteraas</b>	<b>Sweden</b>	<b>585 MWt</b>	<b>99.4</b>	<b>&gt; 99</b>
<b>Sherco, Unit 3</b>	<b>USA</b>	<b>860 MWe</b>	<b>100</b>	<b>&gt; 99</b>
<b>Rawhide, Unit 1</b>	<b>USA</b>	<b>275 MWe</b>	<b>100</b>	<b>&gt; 99</b>
<b>Holcomb Station, Unit 1</b>	<b>USA</b>	<b>280 MWe</b>	<b>98.7</b>	<b>98.2</b>
<b>Antelope Valley, Unit 1</b>	<b>USA</b>	<b>450 MWe</b>	<b>&gt; 99</b>	<b>&gt; 99</b>
<b>Antelope Valley, Unit 2</b>	<b>USA</b>	<b>450 MWe</b>	<b>&gt; 99</b>	<b>&gt; 99</b>



# *Public Service of Colorado*

## *Hayden Station (200 and 280 MW)*

**Scope:** New dry scrubber and baghouse  
Retrofit low NO<sub>x</sub> burners

**Value:** \$30 million

**Structure:** Partnership, price cap, risk and reward sharing



# PSC Hayden Unit 1 (184 MW) and Unit 2 (262 MW)

# Bituminous coal

**0.4 - 0.6% sulfur**

**350 - 500 ppmdv SO<sub>2</sub>**

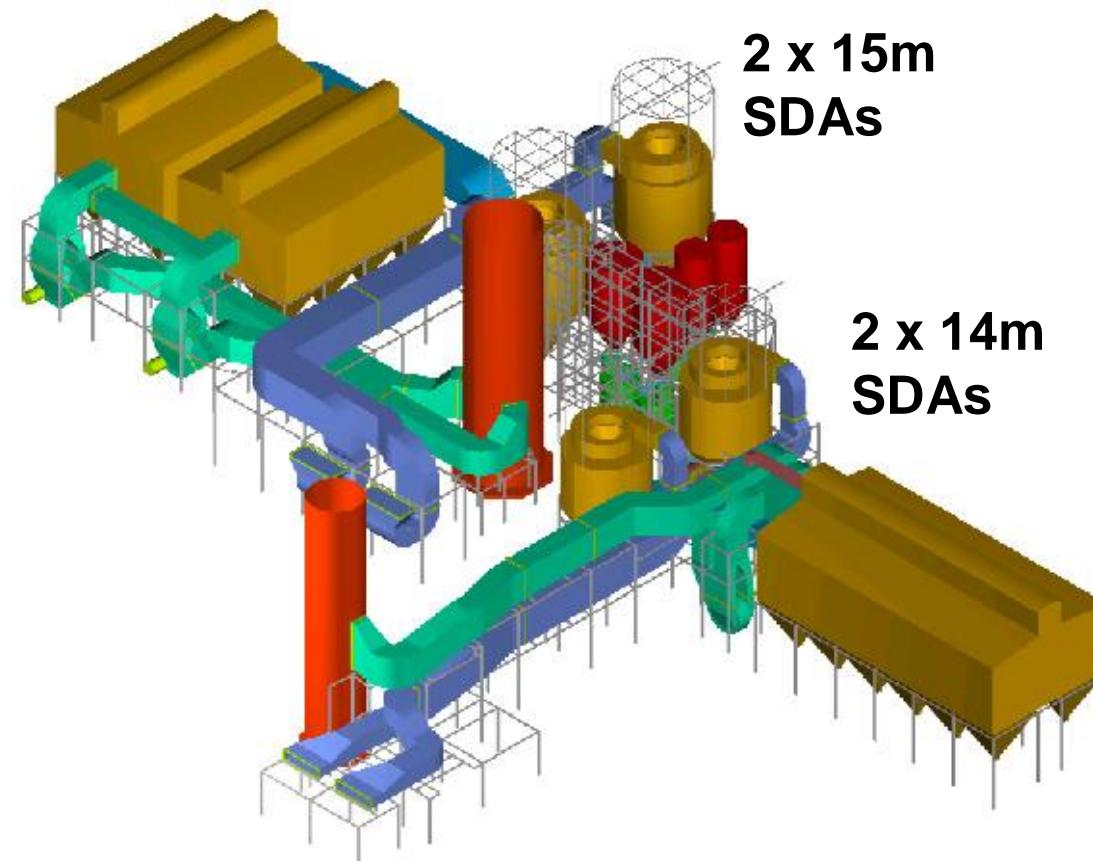
## **Unit 1 : 1,655,000 m<sup>3</sup>/hr**

**Unit 2 : 2,441,000 m<sup>3</sup>/hr**

## 90% SO<sub>2</sub> removal

## **SO<sub>2</sub> emissions < 62 mg/Nm<sup>3</sup>**

# Particulate emissions < 16 mg/Nm<sup>3</sup>



# *Public Service of Colorado*

- **Hayden Station**
- **Near Rocky Mountain National Park**
- **Impairing visibility**
- **Dry scrubber**
- **Team approach**
- **Successful startup**



# *KCPL Hawthorn Unit 5 (550 MW)*

**Sub-Bituminous coal**  
**0.2 - 0.7 % sulfur**

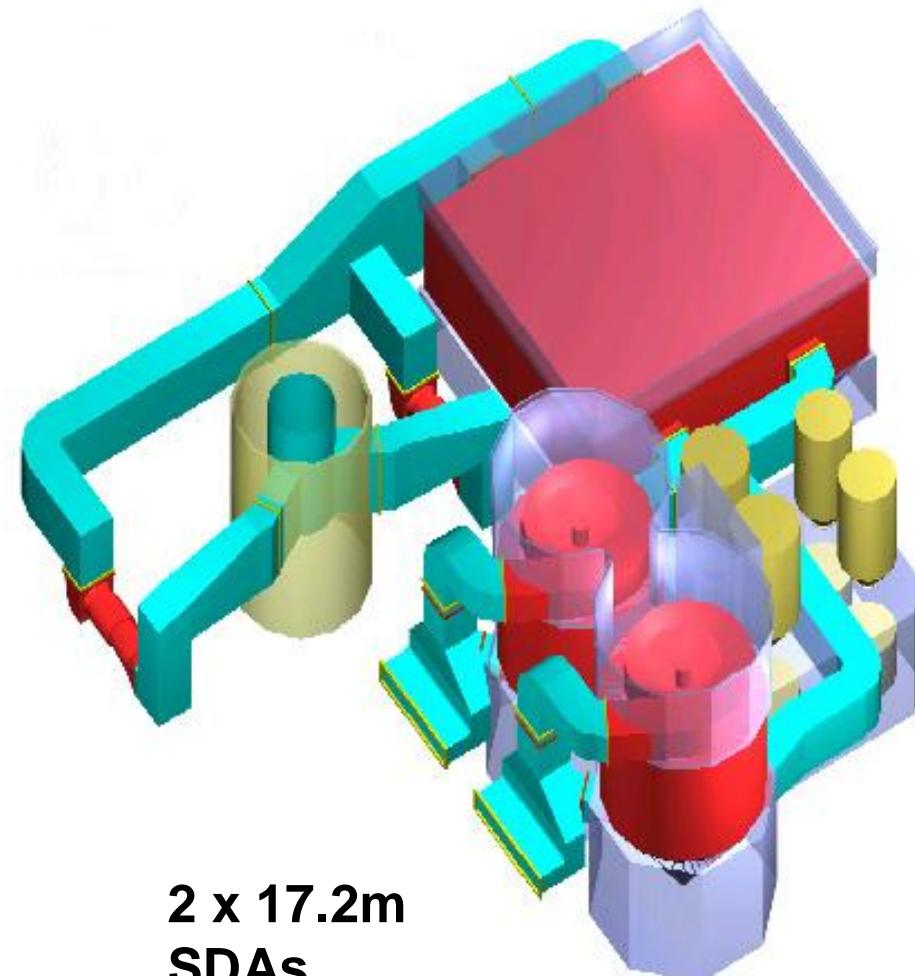
**210 - 780 ppmdv Inlet SO<sub>2</sub>**

**3,220,000 m<sup>3</sup>/hr**

**94% SO<sub>2</sub> removal**

**SO<sub>2</sub> emissions**  
**< 123 mg/Nm<sup>3</sup>**

**Particulate emissions**  
**< 18.5 mg/Nm<sup>3</sup>**



# *Increased SO<sub>2</sub> Removal Efficiency*

## *Design Removal Efficiencies*

- 1980- 1990 14 units @ 75% to 90%
- 1990- 1998 9 units @ 90% to 93%
- Most recent unit- 94%

*Overall industry: mean dry FGD design removal efficiency increased from 82% in the 1980s to 90% in the 1990s (US EPA)*



# *Mercury Emissions Control*

## *Niro/Joy Technical Leader in Early 1990s*

- Testing at 8 full scale sites

## *B&W Mercury Speciation Work - DOE/OCDO*

- E IDS- furnace injection / SDA
- AECDP- lime SDA

## *EPA Information Collection Request (ICR)*

- 10 Dry FGD field sites- 6 B&W/Niro
- Completed by May 2000

## *Activated Carbon Injection Integration*



# *Corrosion Protection Concerns*

## ***Isolated Occurrences of SDA Module Corrosion***

- Operations- poor drying and deposition
- Wastewater to SDA
- Chloride additives to reduce lime use

## ***Downstream Particulate Control Equipment***

- Inadequate insulation
- Air infiltration leakage



## *Dry FGD Summary / Conclusions*

- Spray dry absorption remains a viable SO<sub>2</sub> control technology
- Resurgence of domestic opportunities
- Site-specific requirements
- Variety of technologies available



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