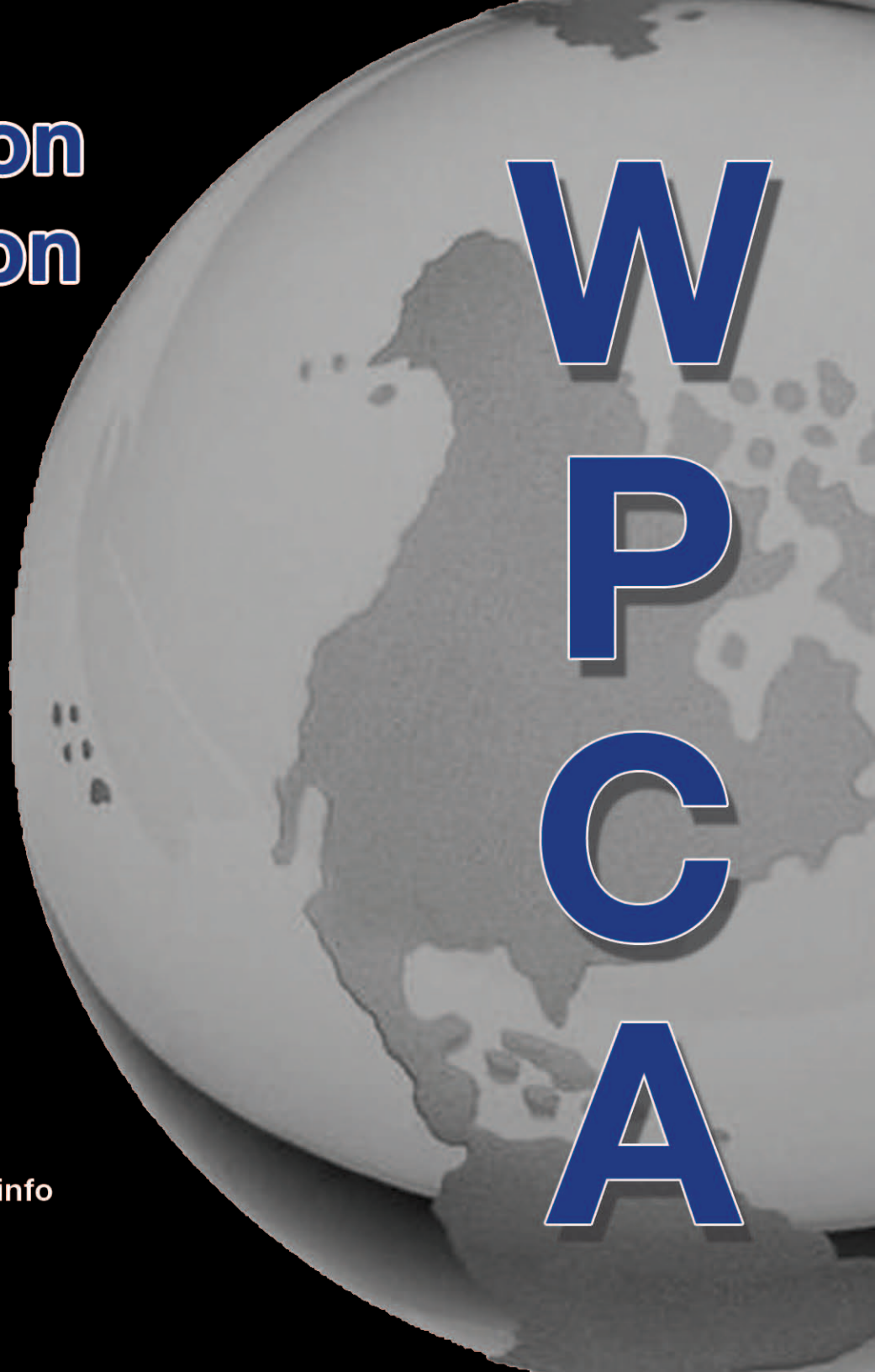
Worldwide Pollution Control Association



Duke Energy Seminar

September 3 – 5, 2008

Concord, NC

WPCA

Vist our website at www.wpca.info

Dry Scrubber Fundamentals

WPCA / Duke Seminar
September 3, 2008
Charlotte, NC

"Dry Scrubber" Can Have Several Meanings

- Furnace Sorbent Injection (FSI)
- Dry Sorbent Injection (DSI)
- Spray Dry Absorption (SDA)
- Flash Dry Absorption (FDA)
- Circulating Dry Scrubbers (CDS)

Spray Dry FGD Fundamentals

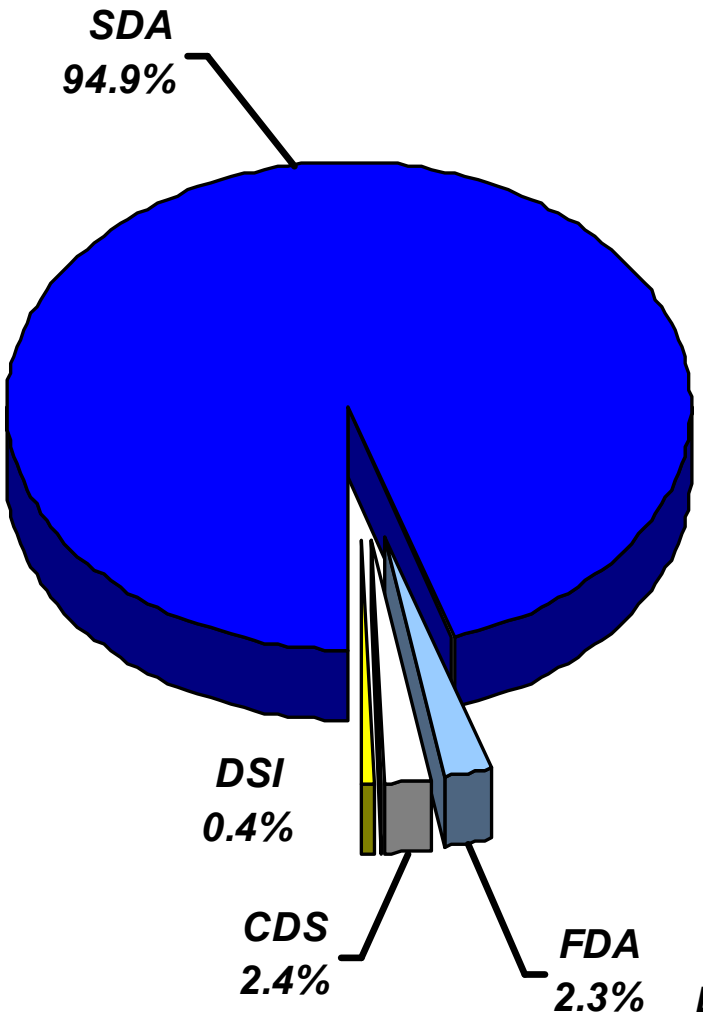
- Coal-Fired Dry FGD Installations
- SDA Process Fundamentals
- SDA Process Flowsheets
- Key Component Design Considerations
- Key Operating Considerations

US / Canadian Coal-Fired Dry FGD Installations

by Dry FGD Technology

US / Canadian Dry FGD Technology Installations

%of Total 37,680 MW



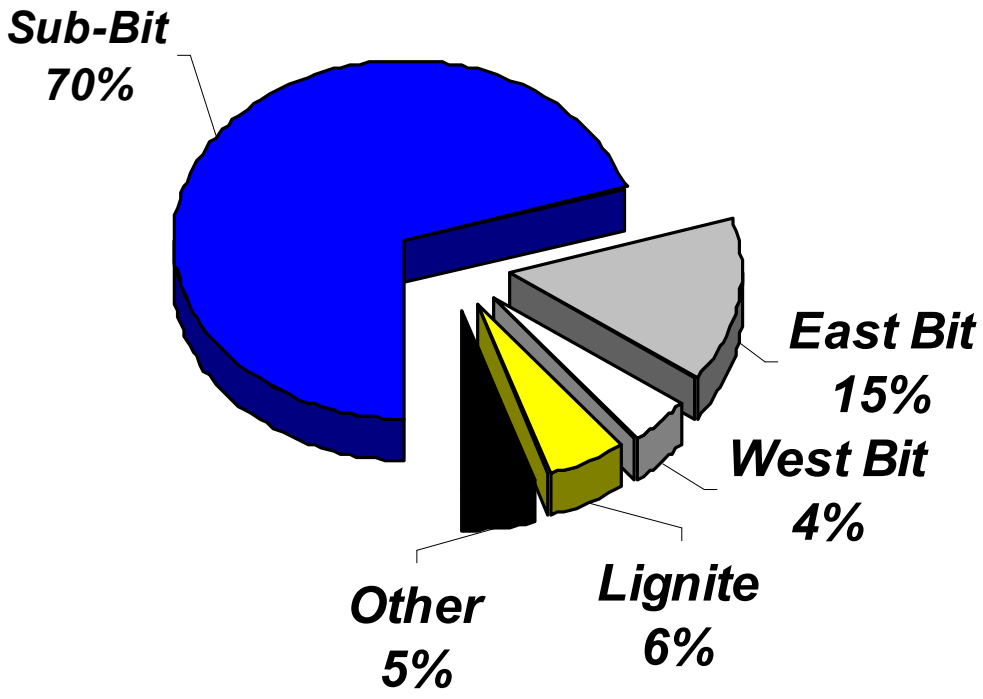
B&W Estimate based on market data July, 2008

US / Canadian Coal-Fired SDA Installations

by Coal Type

US / Canadian Coal-Fired Spray Dry FGD Systems

% of Total 36,120 MW Installed / Committed



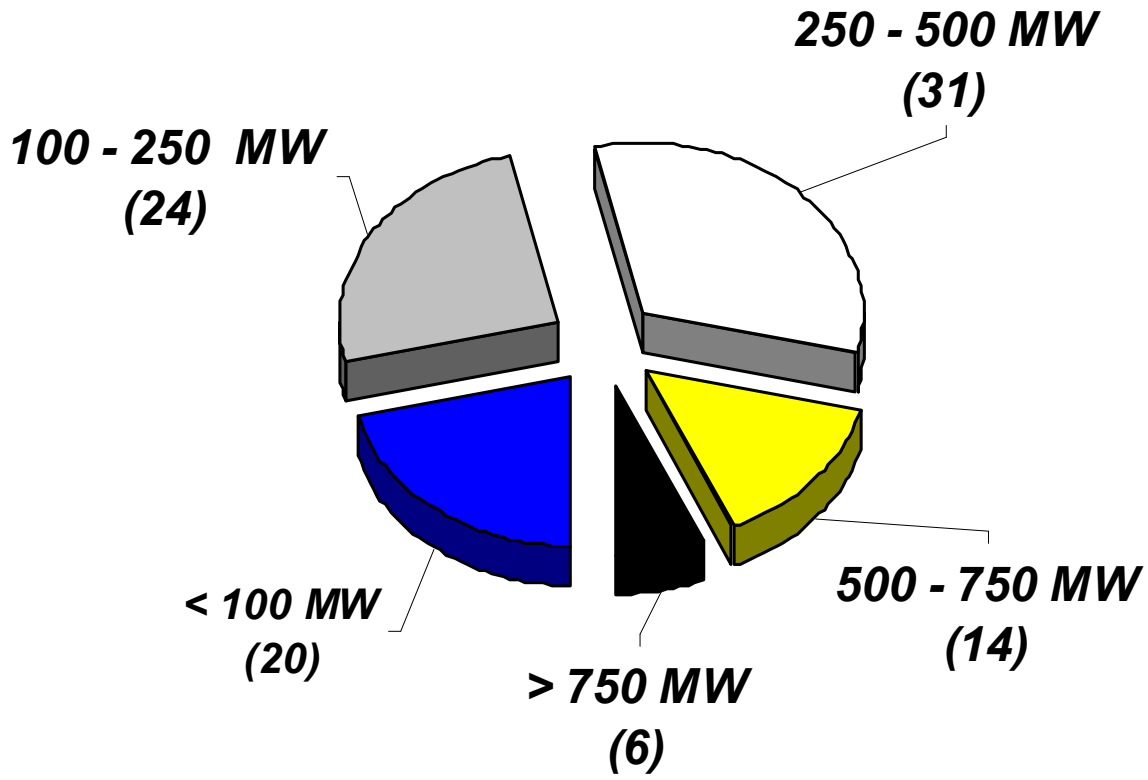
B&W Estimate based on market data July, 2008

US / Canadian Coal-Fired SDA Installations

by Unit Generating Capacity

US / Canadian Coal-Fired Spray Dry FGD Systems

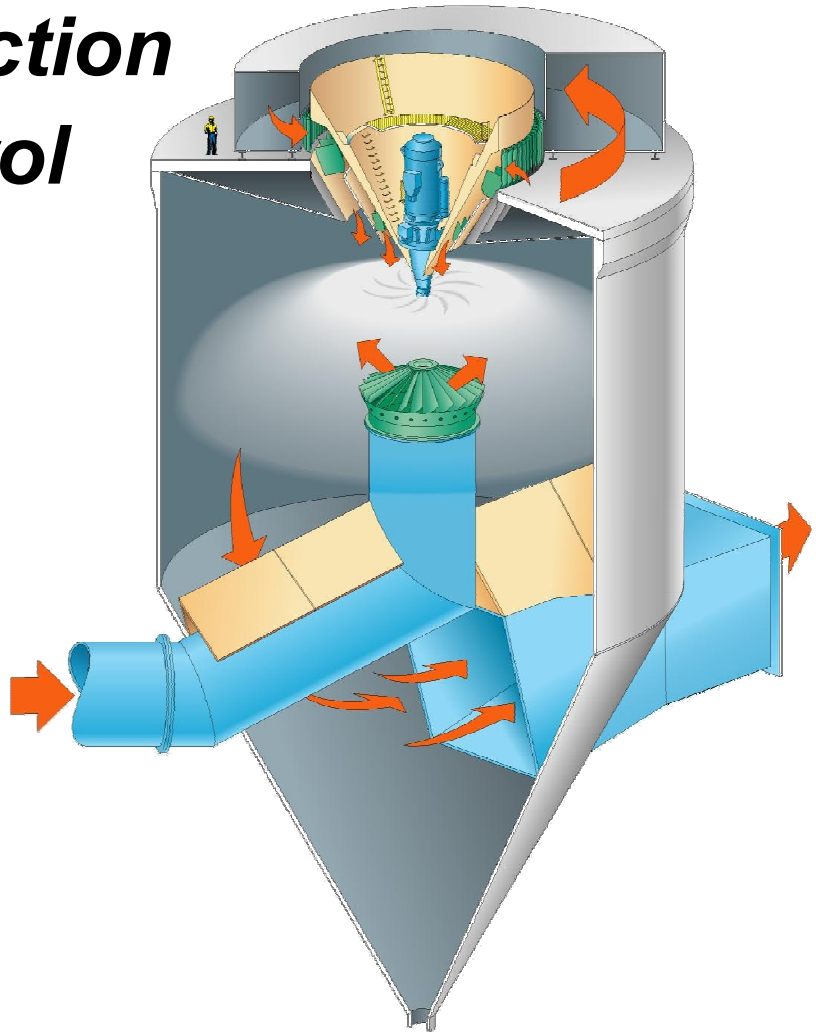
Total Installations / Committed Projects by Unit Size



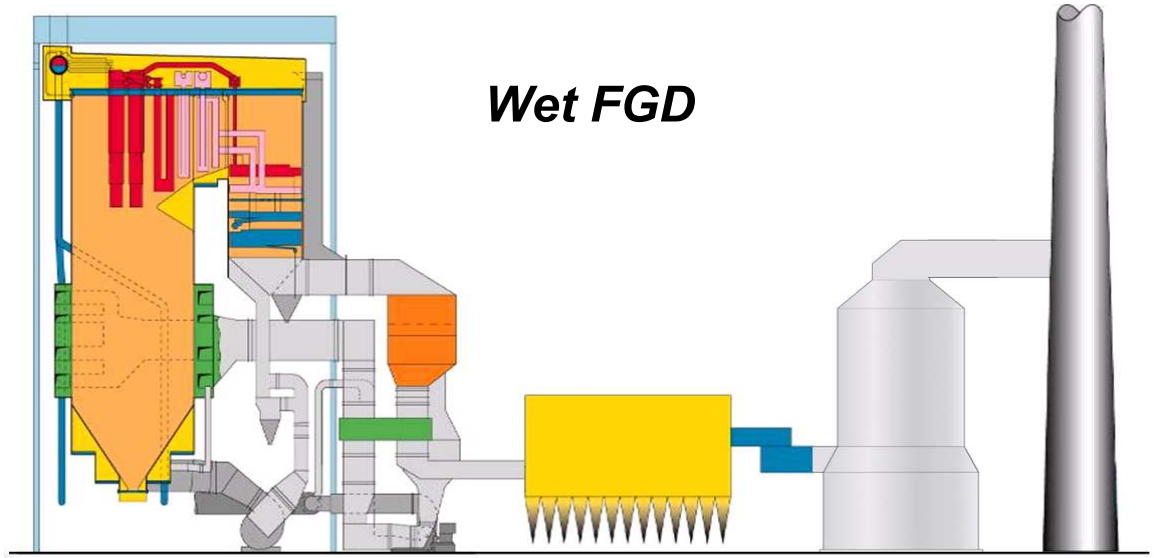
B&W Estimate based on market data July, 2008

SDA Process Fundamentals

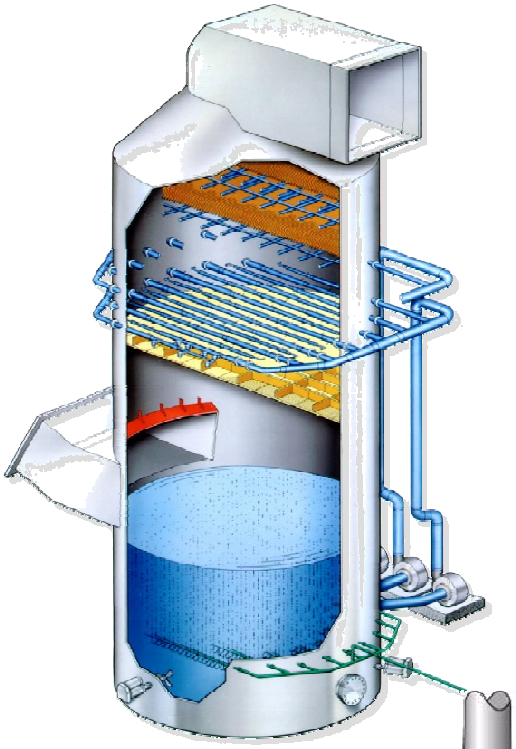
- *AQCS Configuration / Selection*
- *Two stage emissions control*
- *Slurry Atomization*
- *Absorption and drying*
- *Terminology*

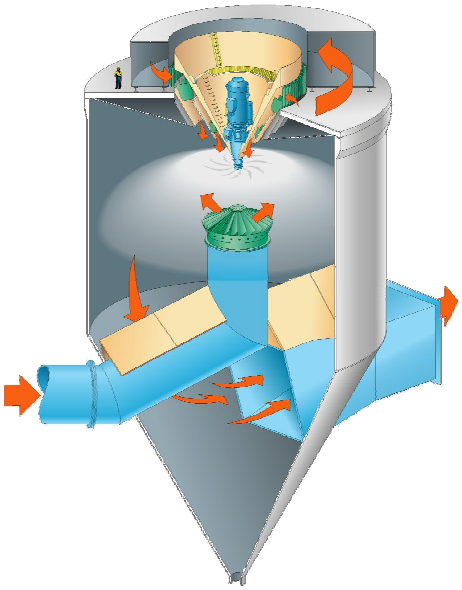


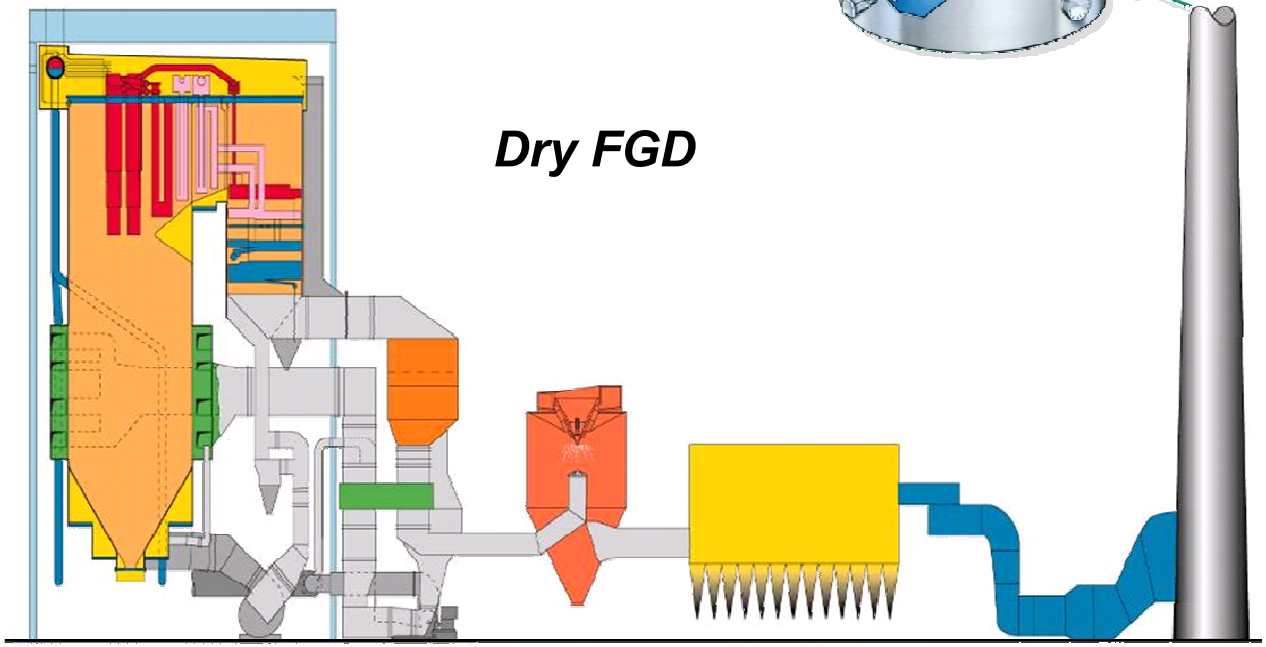
Typical FGD Configurations



Wet FGD





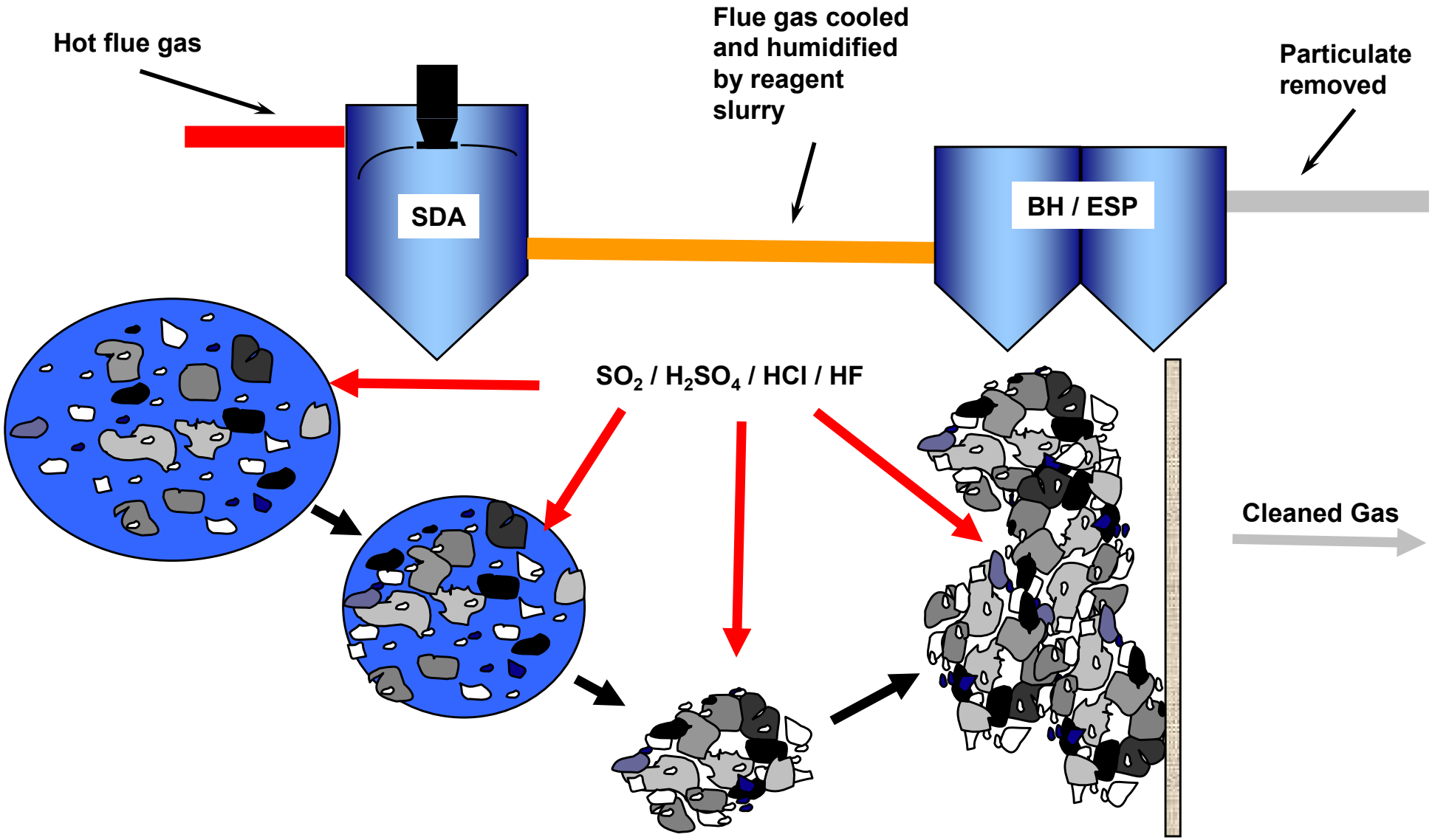


Dry FGD

Dry vs. Wet FGD Considerations

- ***Lower sulfur fuel range***
- ***Lower capital cost***
- ***Lower aux. power consumption***
- ***Lower water consumption***
- ***Improved secondary emissions control in combination with fabric filter***
- ***Limited value by-product***

Spray Dryer Absorption Process



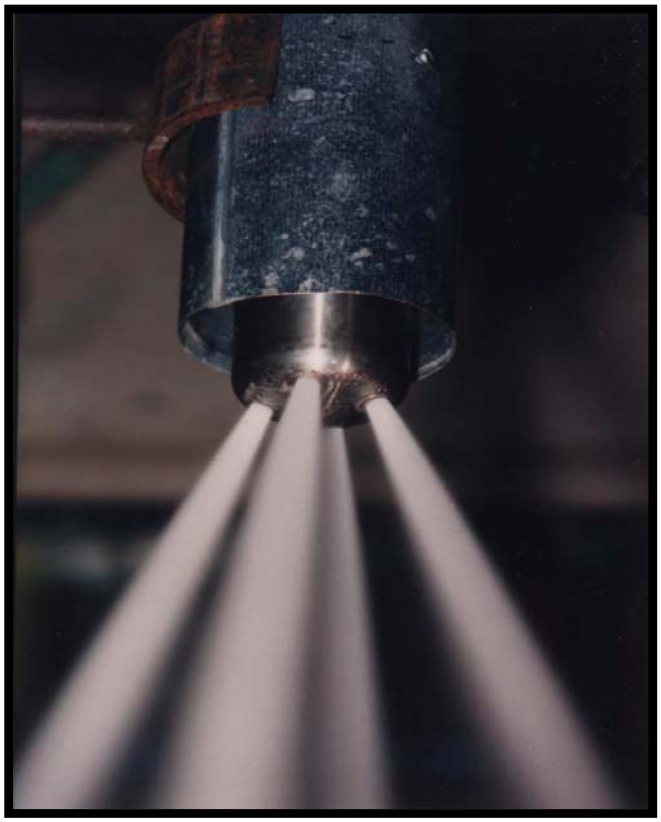
"Dryer" performance is critical for long term operability

Two Stage Emissions Control Process

Slurry Atomization

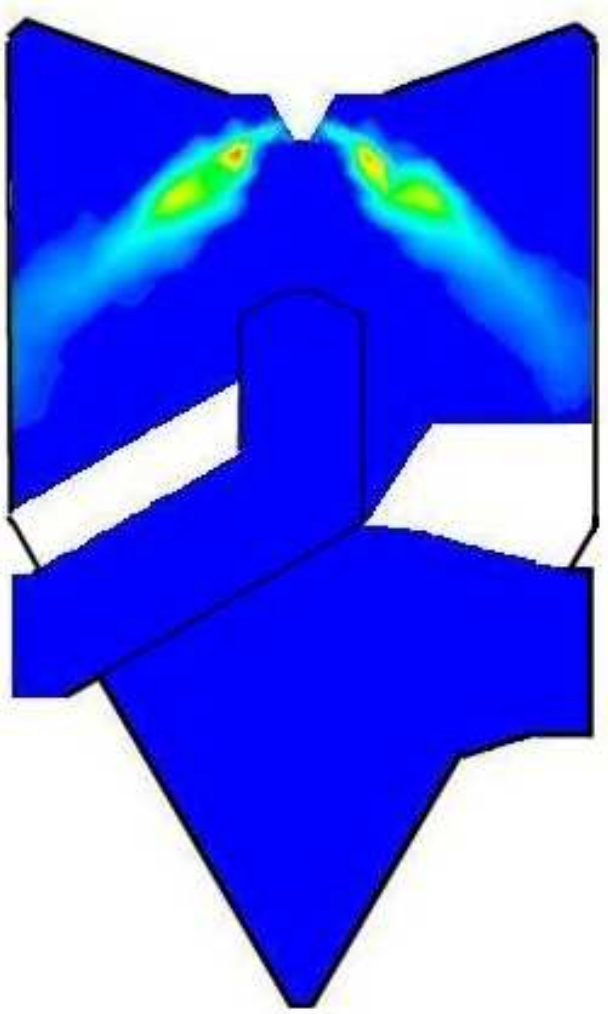
Rotary Wheel

Dual Fluid



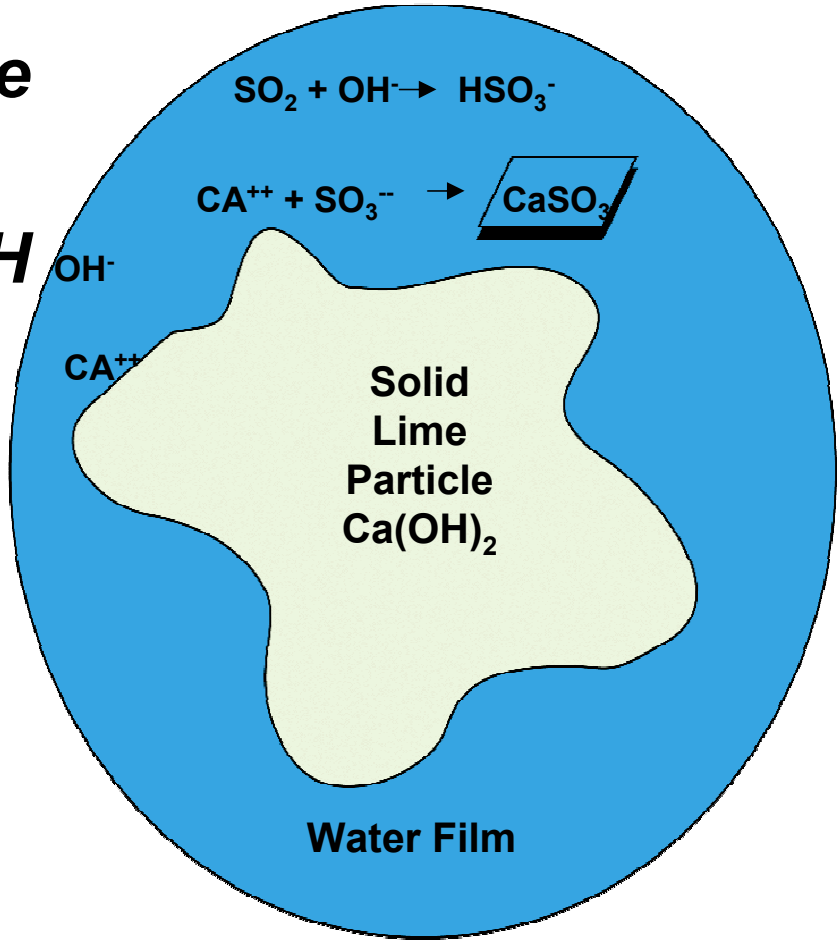
Atomization

- *Good mixing of reagent and flue gas for acid gas control*
- *Fine drops for evaporation and drying*
- *Controlled spray "cloud" for long term operability*
- *Stable temperature control*



SO_2 Absorption

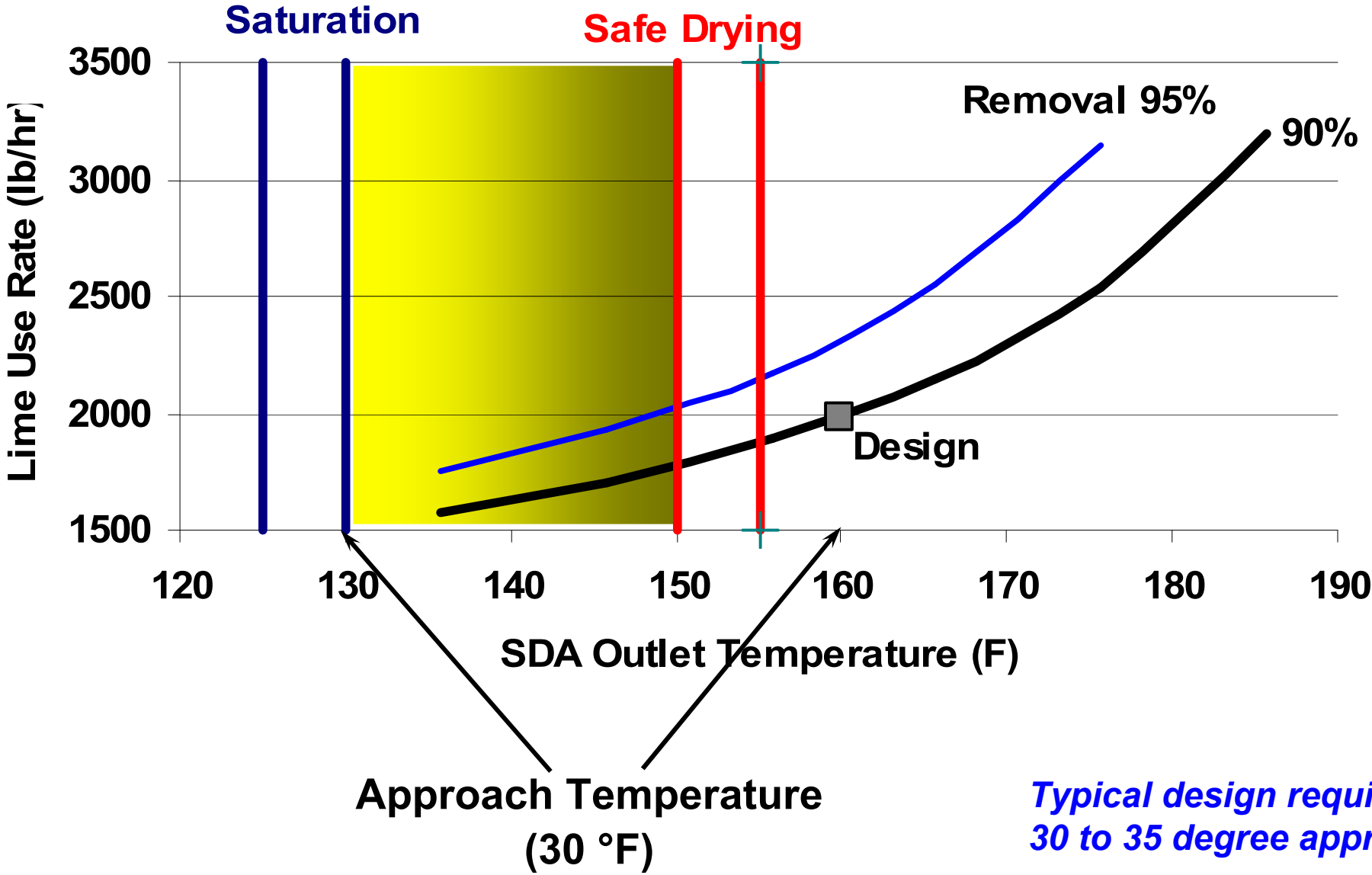
- *Absorption of acid gases most rapid when water is present*
- *Dissolution rate of SO_2, reagent solubility or absorption may be rate limiting*
- *High reagent solubility and drop pH promote absorption*
- *Inert solids provide more surface area and enhance gas/reagent contact*
- *Enhanced by good distribution of high surface area reagent*



Drying

- *Initial, rapid first order drying period determined by:*
  - *Outlet temperature*
  - *Feed slurry solids loading*
  - *Drop size*
  - *Chloride content*
- *Second order drying period brings solids to final moisture content*
- *Particles / agglomerates leave SDA at 1 to 2% surface moisture*

Key SDA Terminology and Operating Concepts

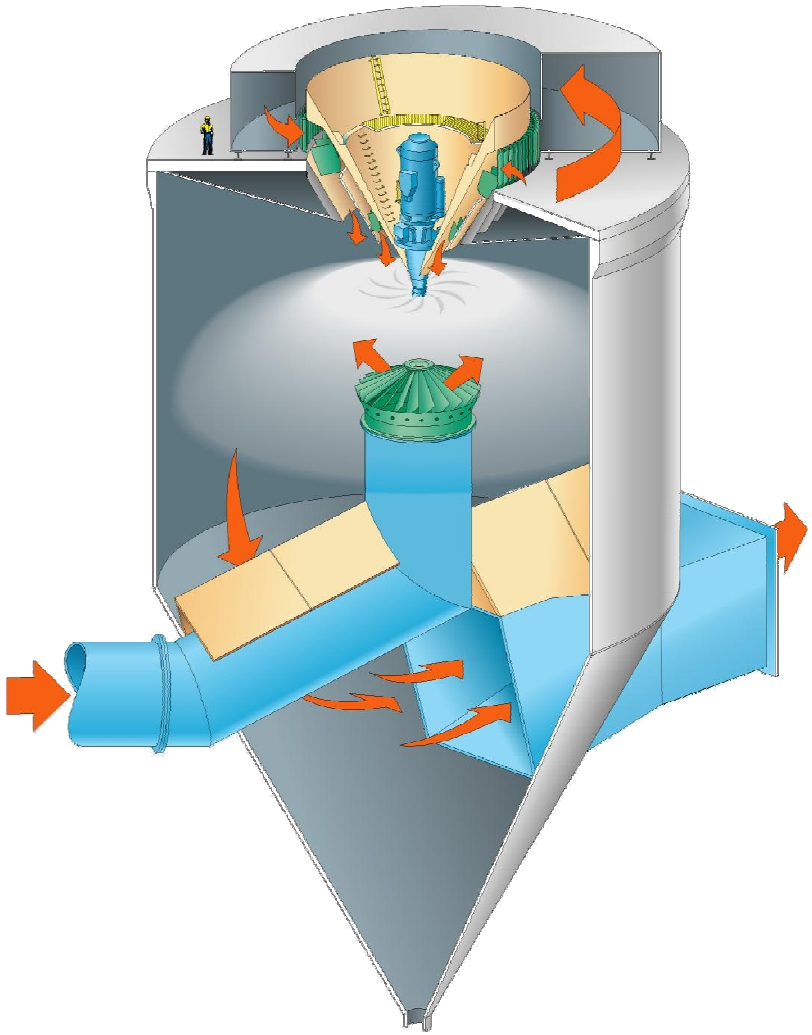


Typical design requirement – 30 to 35 degree approach

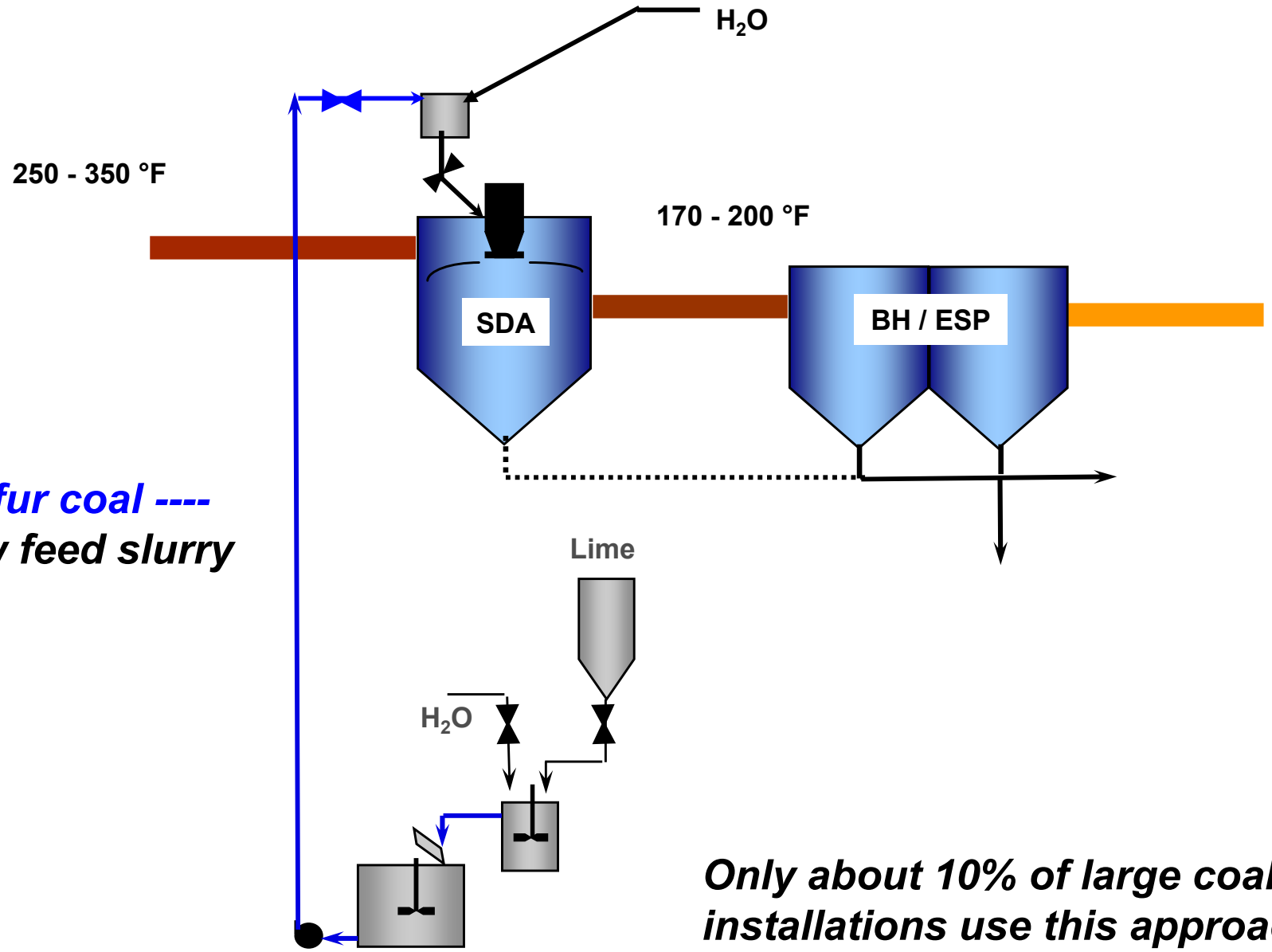
Flue gas <u>and</u> process water determine acceptable operating conditions

SDA Process Flowsheets

- *Single Pass*
- *Solids Recycle*
- *Fly Ash Pre-Collection*



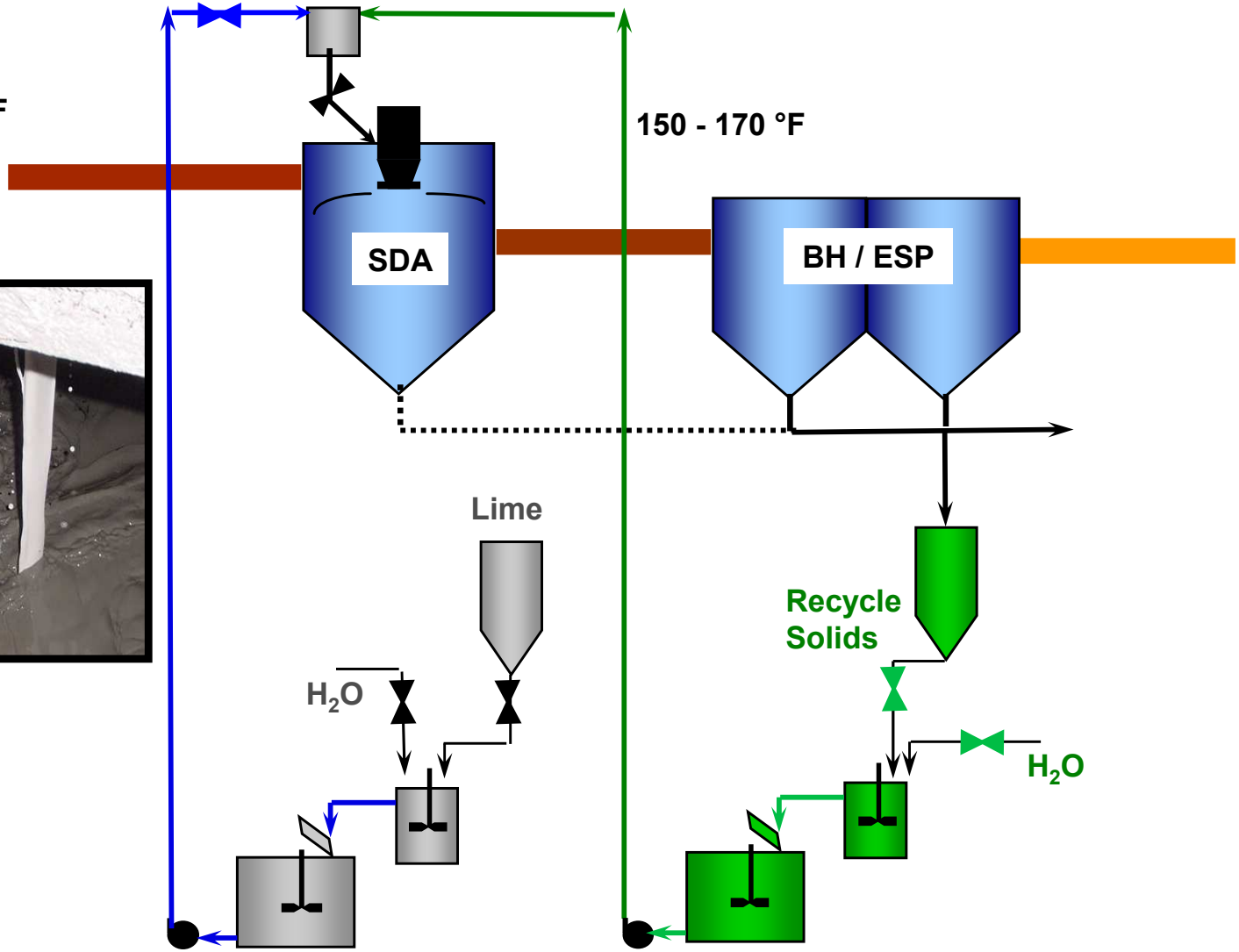
Single Pass or Lime Only



Low sulfur coal ----
Very low feed slurry solids

Only about 10% of large coal-fired installations use this approach

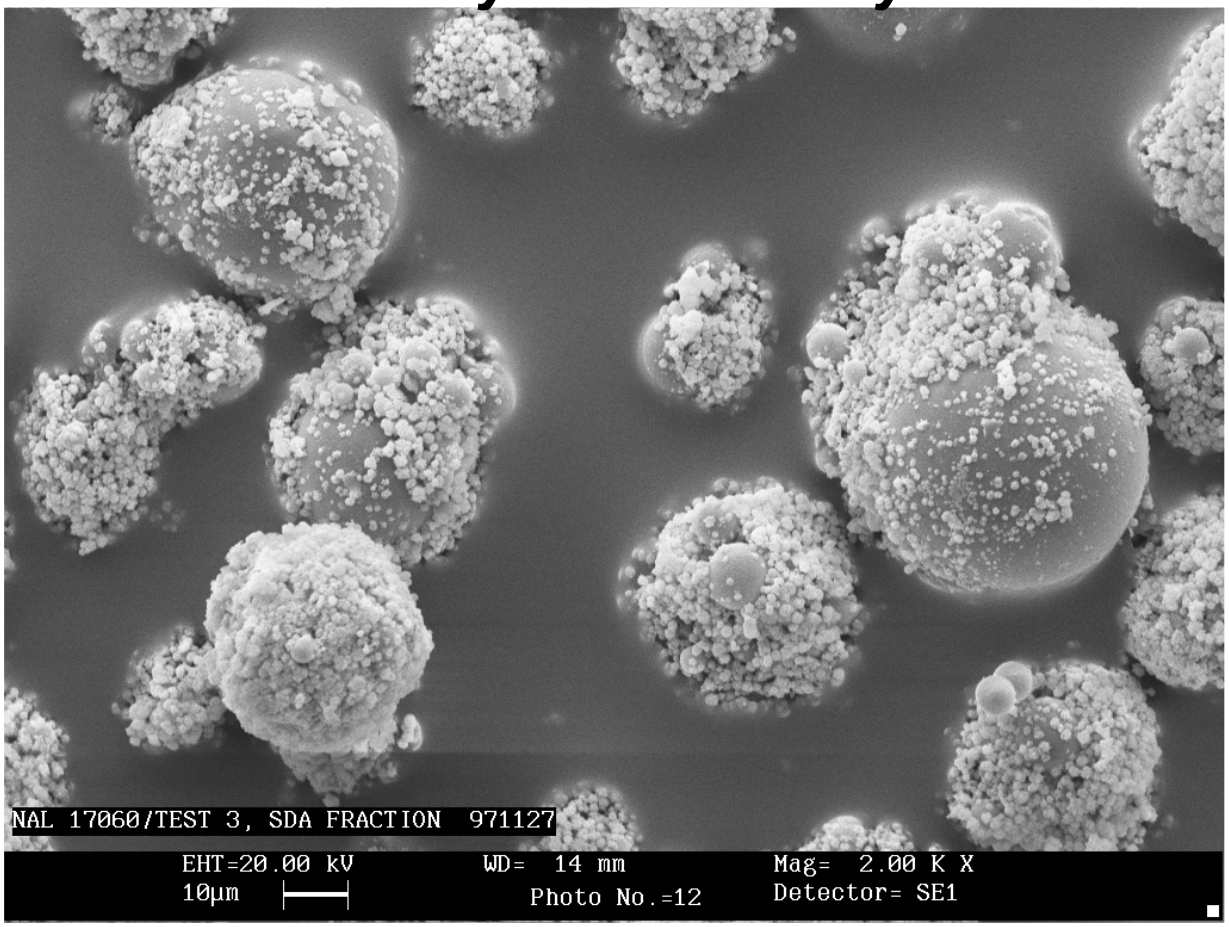
Solids Recycle



Spray Dry FGD Solids

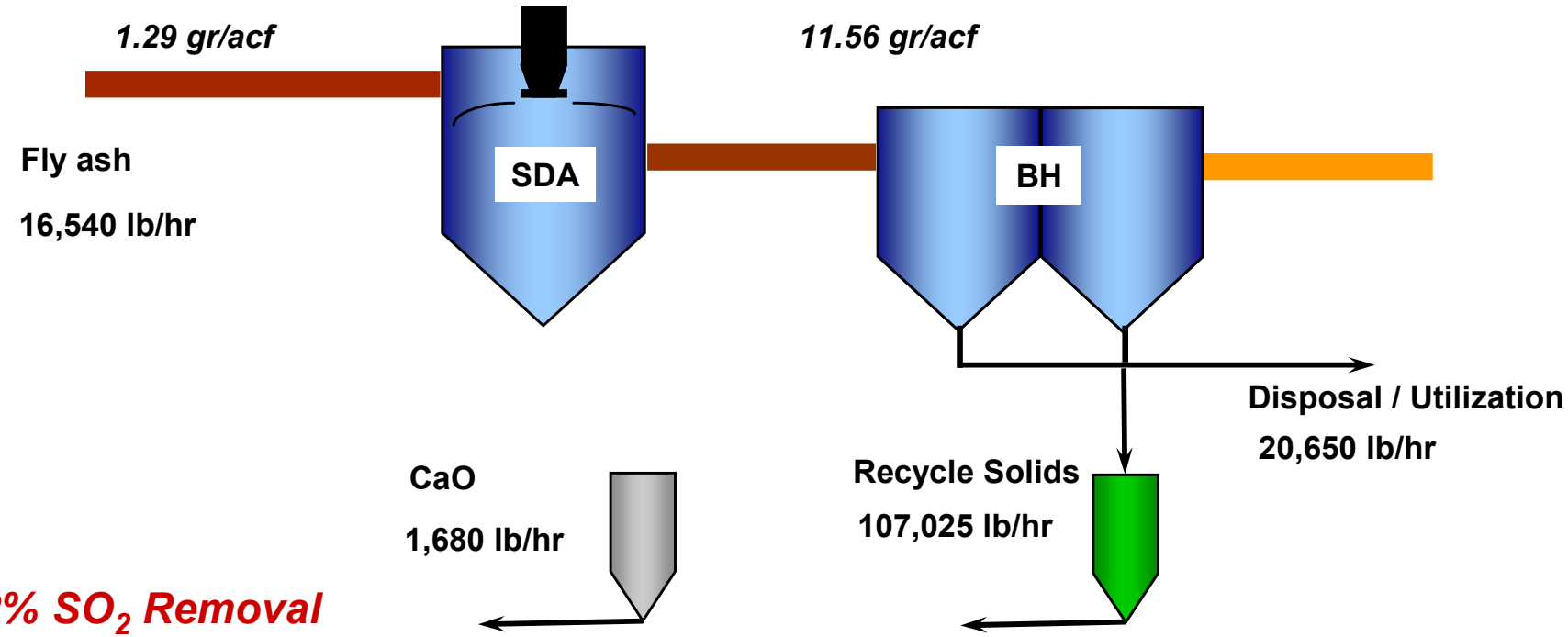
Lime Only
Single Pass

By-Product Recycle



Lime "carried" on larger fly ash particle surfaces has more readily available surface area for reaction than an agglomerate of fine lime particles.

Example Mass Balance – Sub-Bituminous Coal

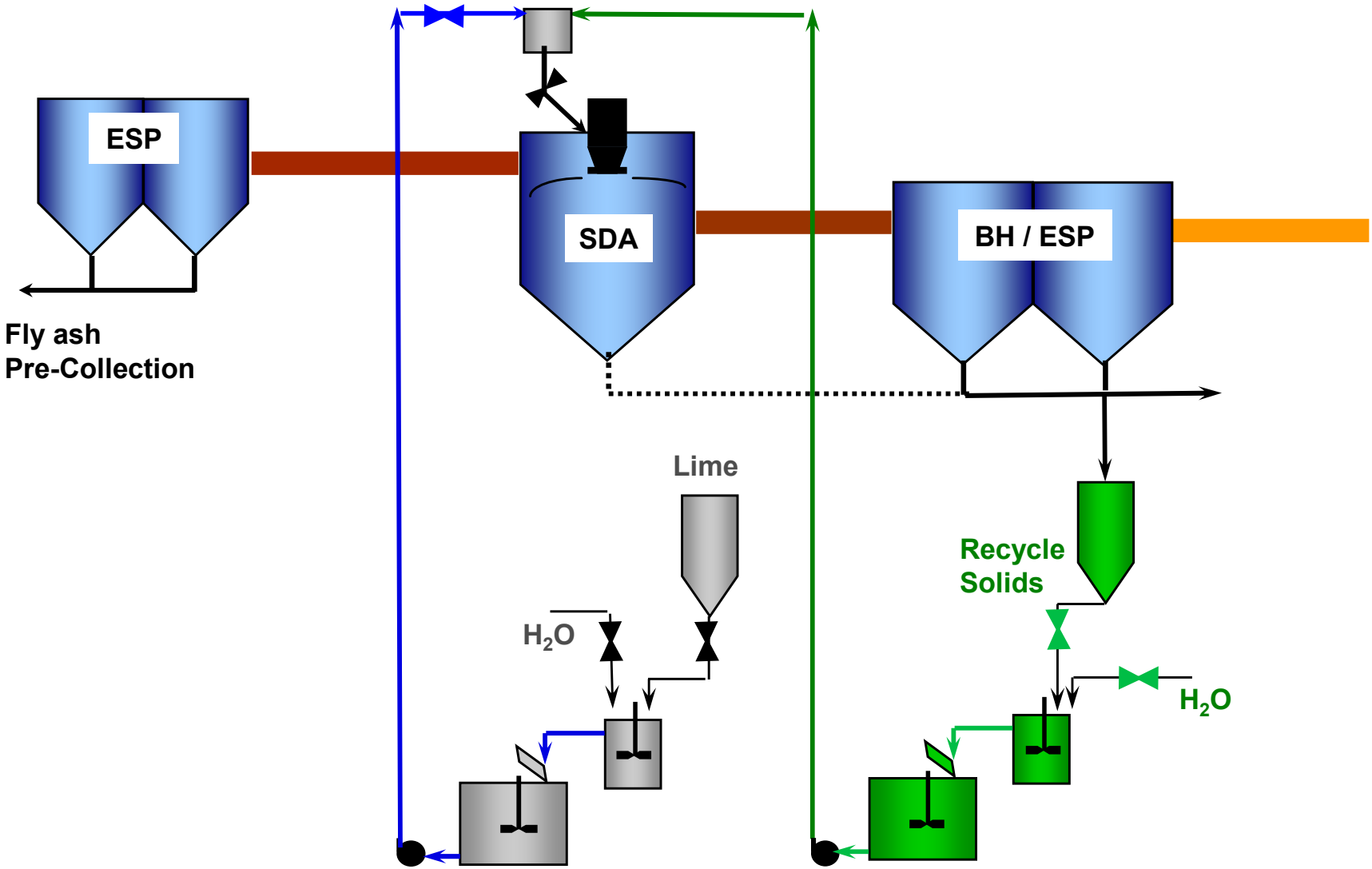


92% SO_2 Removal

By-product / Recycle Solids Composition (wt. %)

Fly Ash	79.75	Inerts	0.62
Free Water	1.00	Crystal Water	1.77
$CaSO_3$	13.25	$CaSO_4$	2.73
CaF_2	0.00	$Ca(OH)_2$	0.34
$CaCl_2$	0.16	$CaCO_3$	0.38

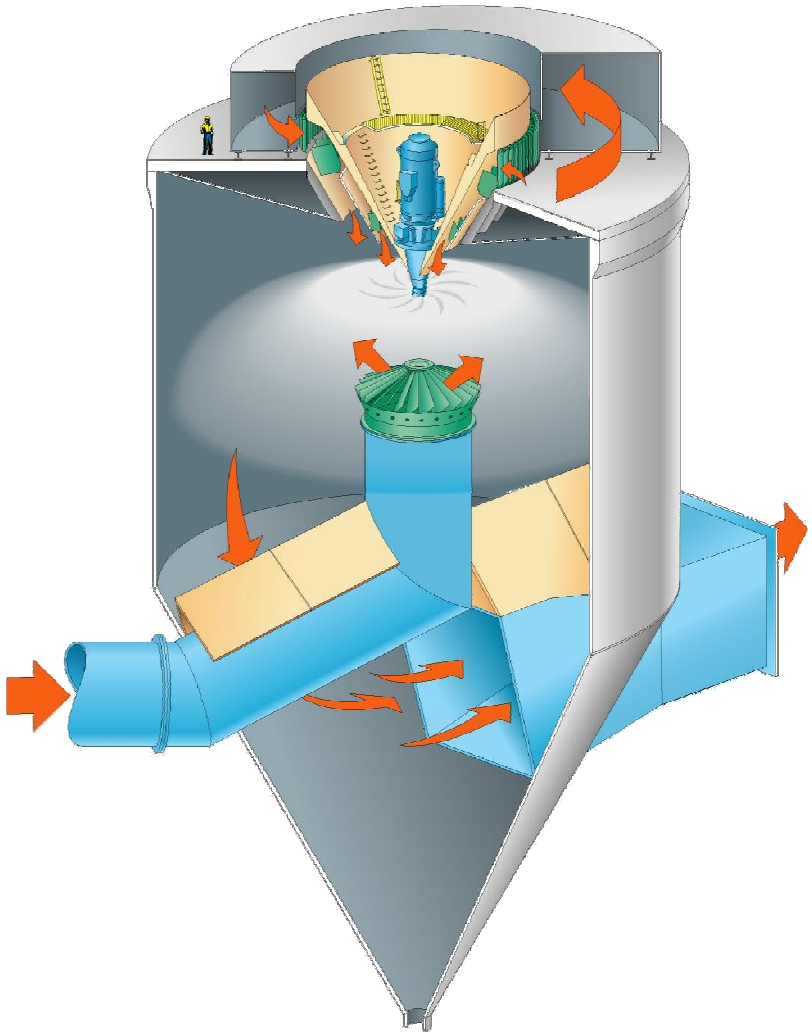
Fly Ash Pre-Collection



Typical European "semi-dry" FGD practice

Key Component Design Considerations

- *Reagent Preparation*
- *SDA Components*
- *Typical design criteria*



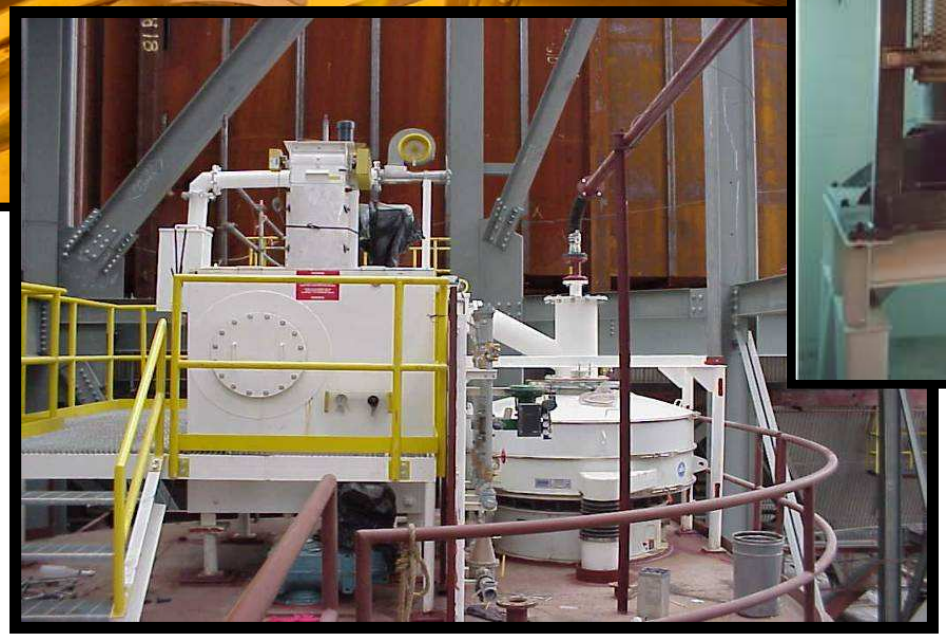
Typical Lime Specification

Quicklime (CaO)

- *Material Sizing – ¾ inch with no more than 50% passing less than 10 mesh*
- *Availability – 90% CaO or greater per ASTM C25*
- *Reactivity*
  - *40°C temperature rise or greater in 3 minutes*
  - *Total temperature rise in 10 minutes max*

Lime Slaking

Horizontal Ball Mill



Detention Slaker

Vertical Ball Mill

Recycle Slurry Make Up

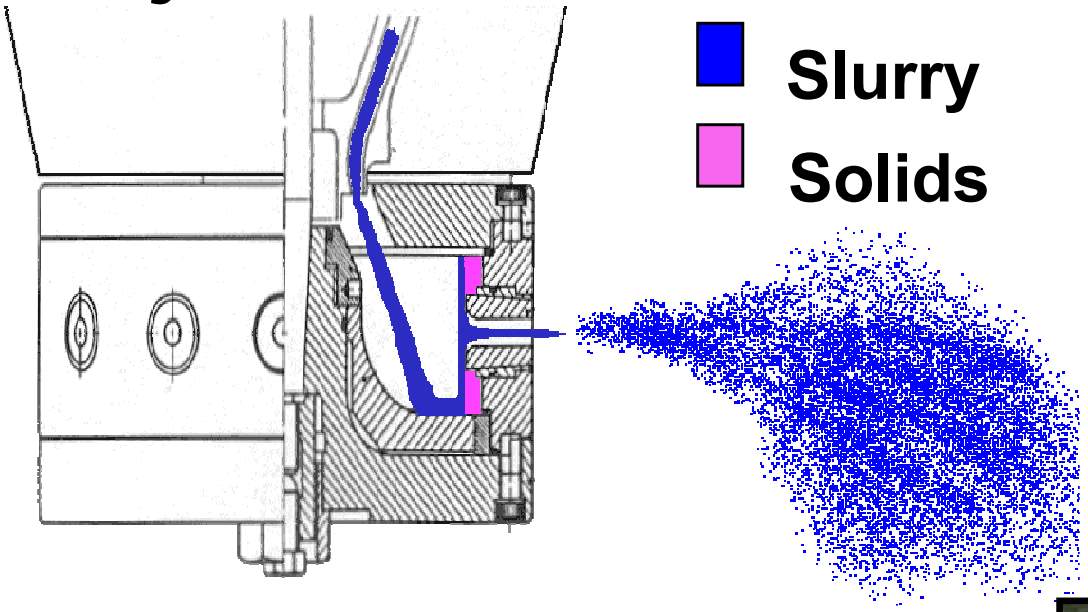
Minimize wet/dry interface zone

Minimize dusting

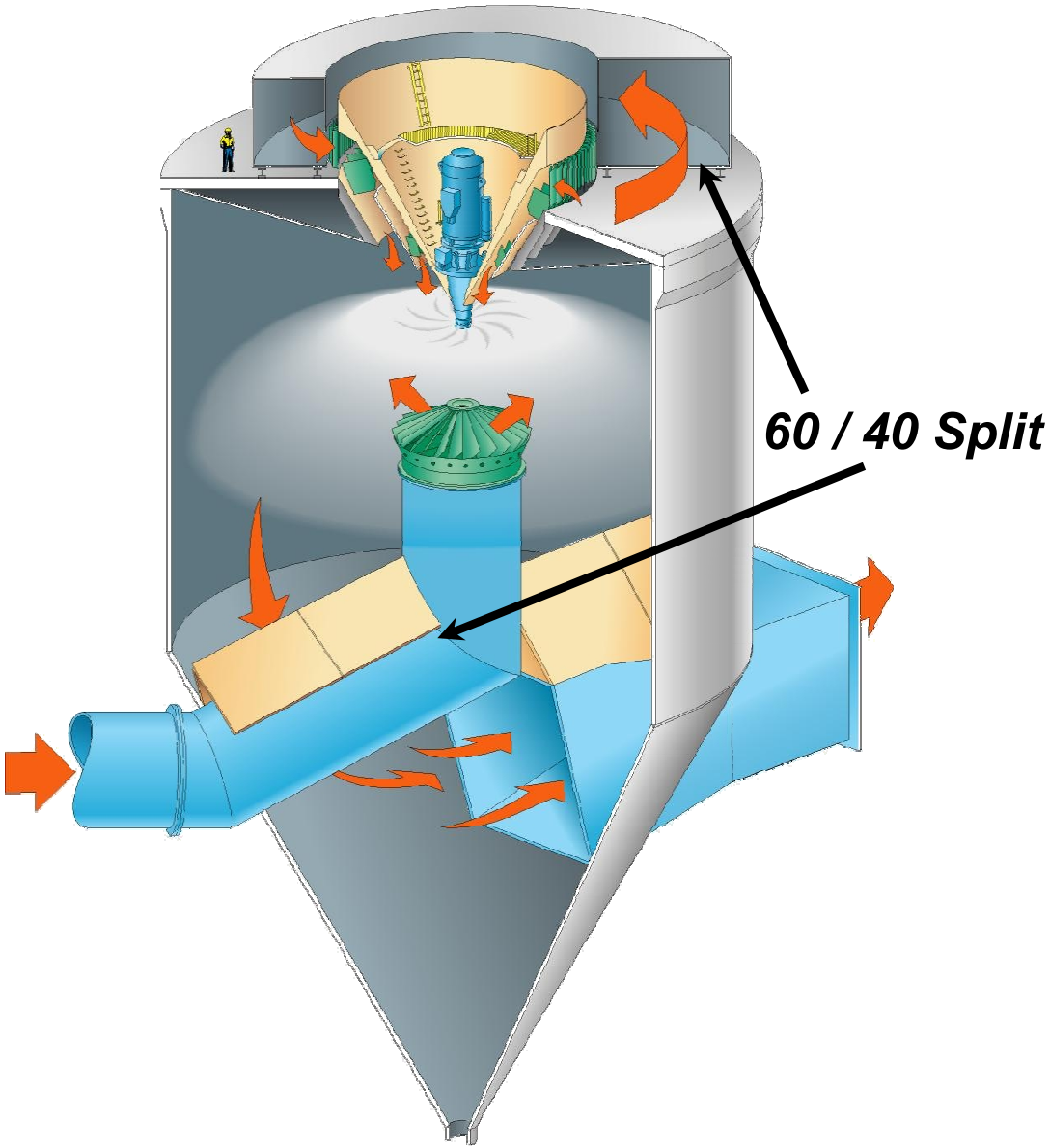
Two x 100% capacity trains for a 600 MW installation

Rotary Atomizer Assembly

Rotary Atomizer Wheel



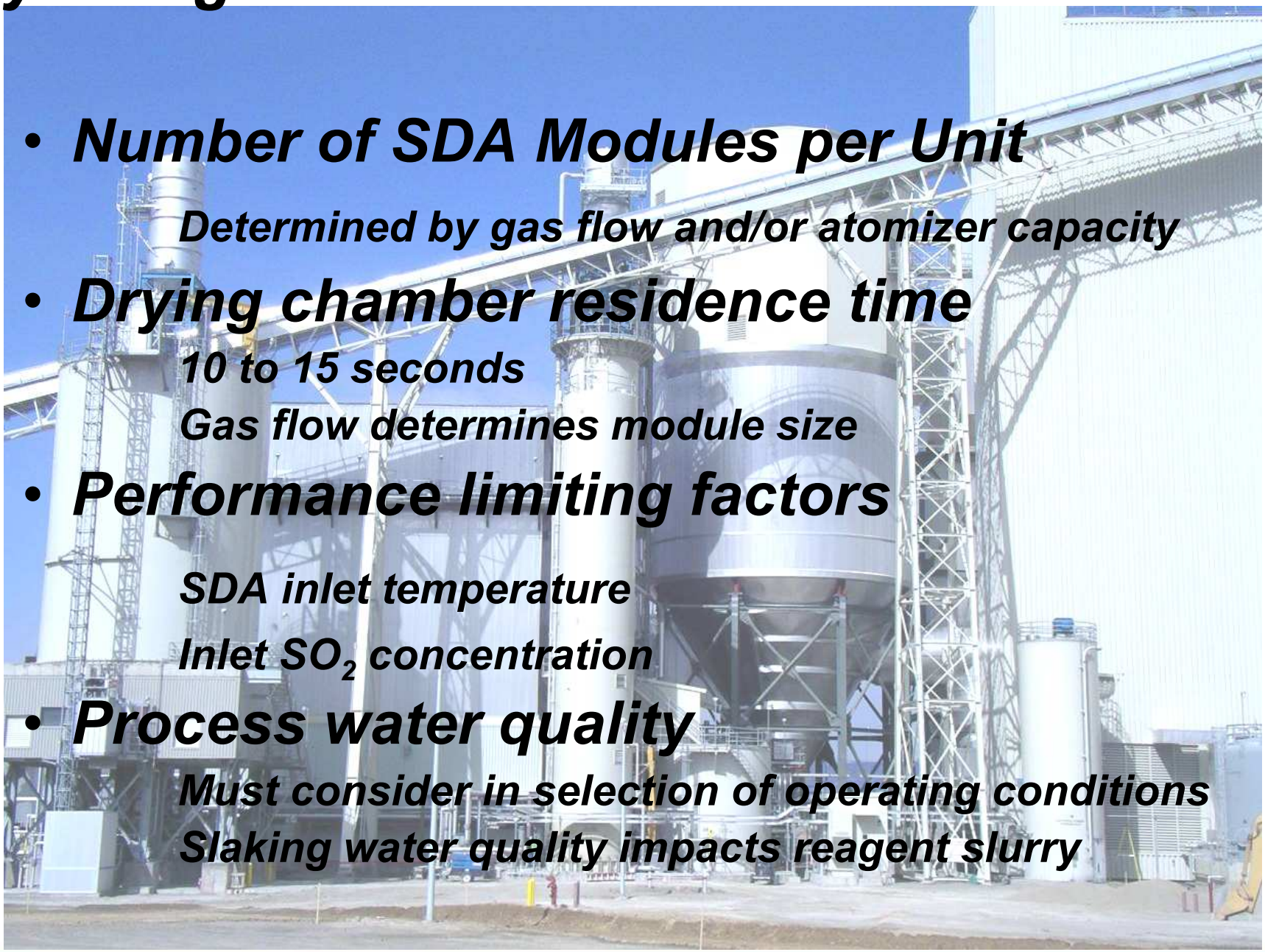
Flue Gas Distribution



Roof Gas Disperser

Central Gas Disperser

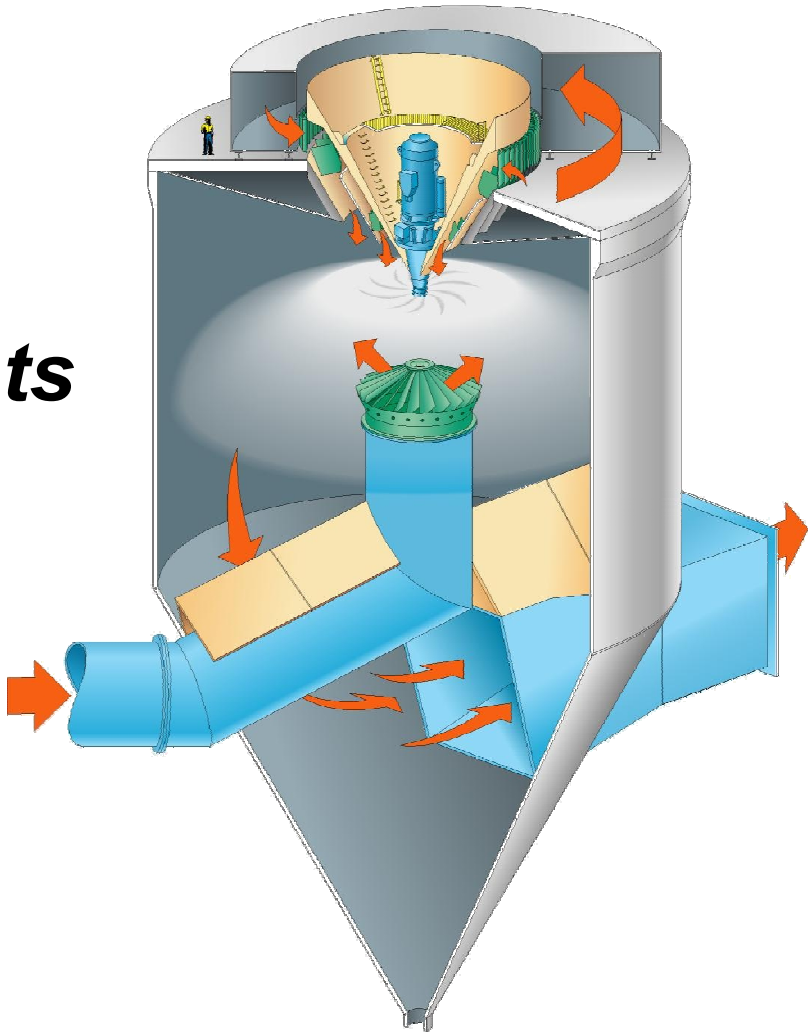
Key Design Considerations



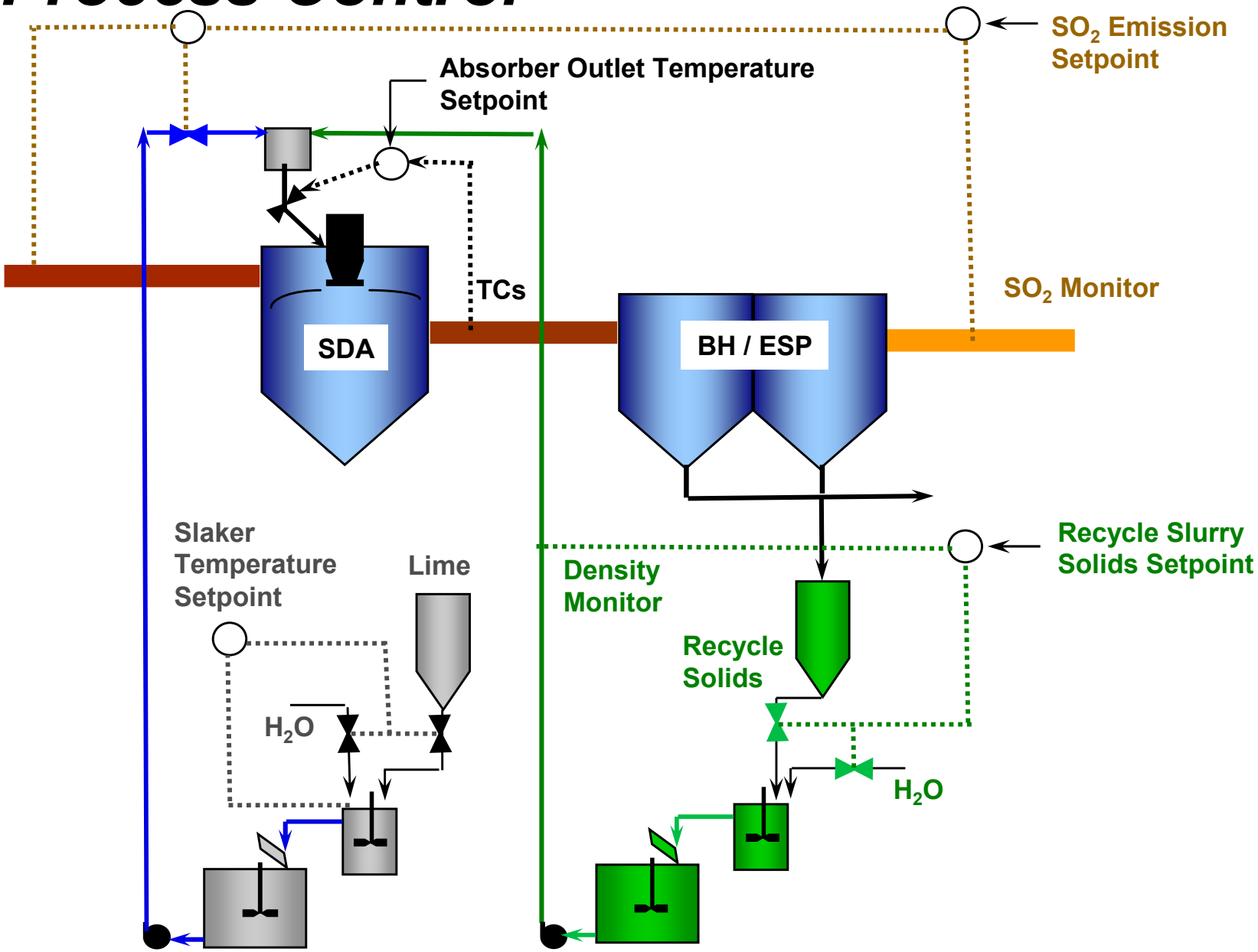
- **Number of SDA Modules per Unit**
  - Determined by gas flow and/or atomizer capacity
- **Drying chamber residence time**
  - 10 to 15 seconds
  - Gas flow determines module size
- **Performance limiting factors**
  - SDA inlet temperature
  - Inlet SO_2 concentration
- **Process water quality**
  - Must consider in selection of operating conditions
  - Slaking water quality impacts reagent slurry

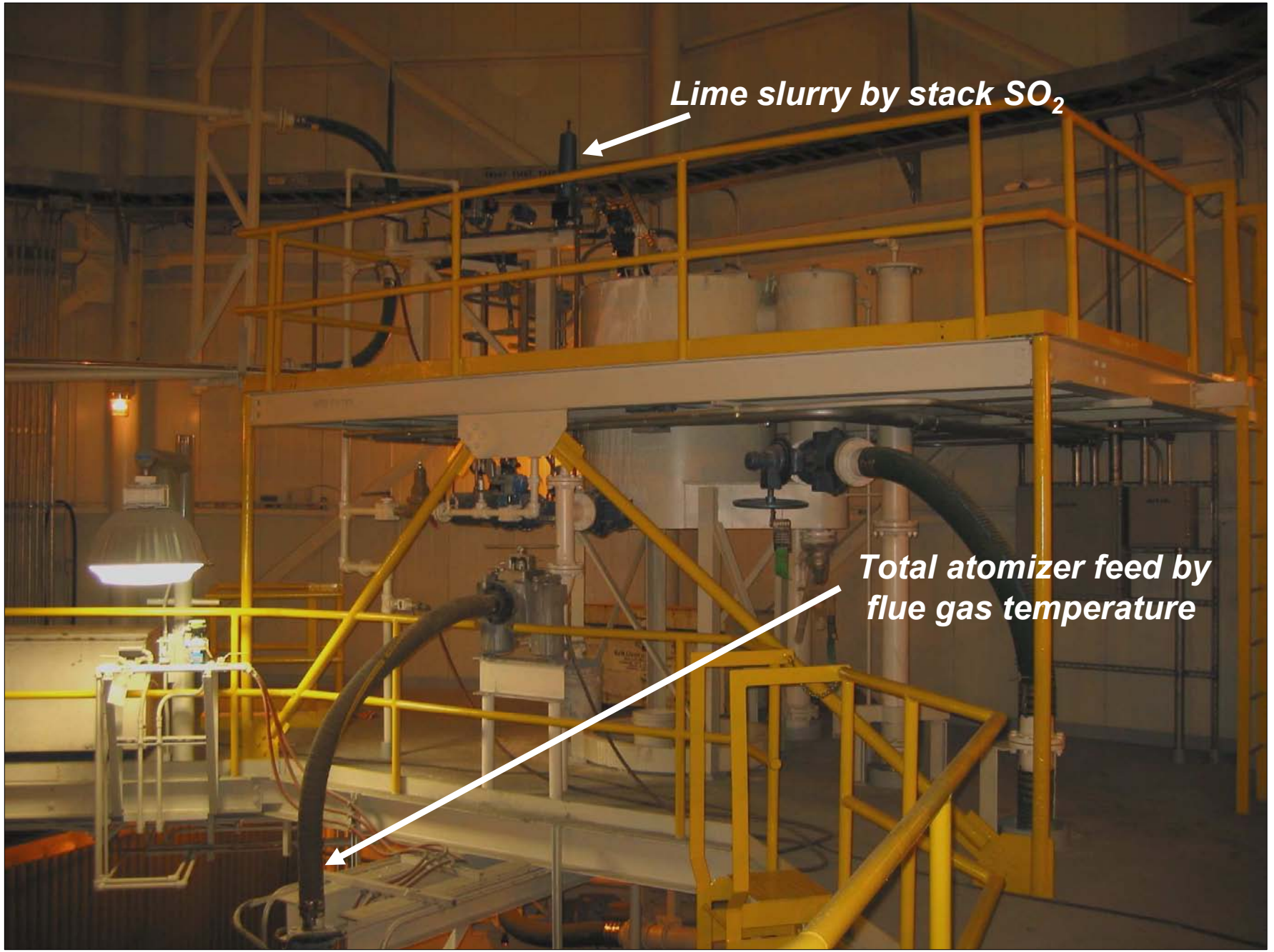
Key Operating Considerations

- ***Process control***
- ***Consumables***
- ***By-product generation***
- ***Typical emission requirements***

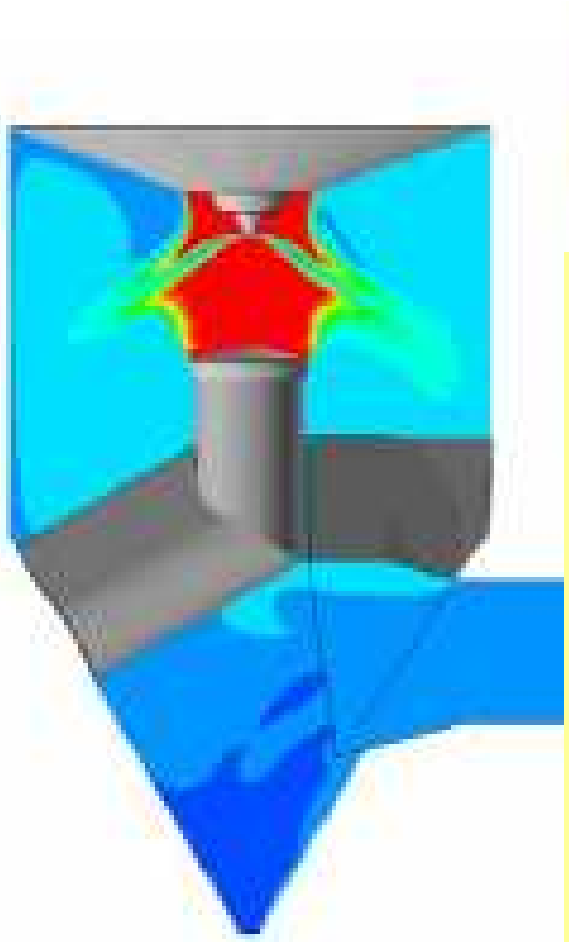


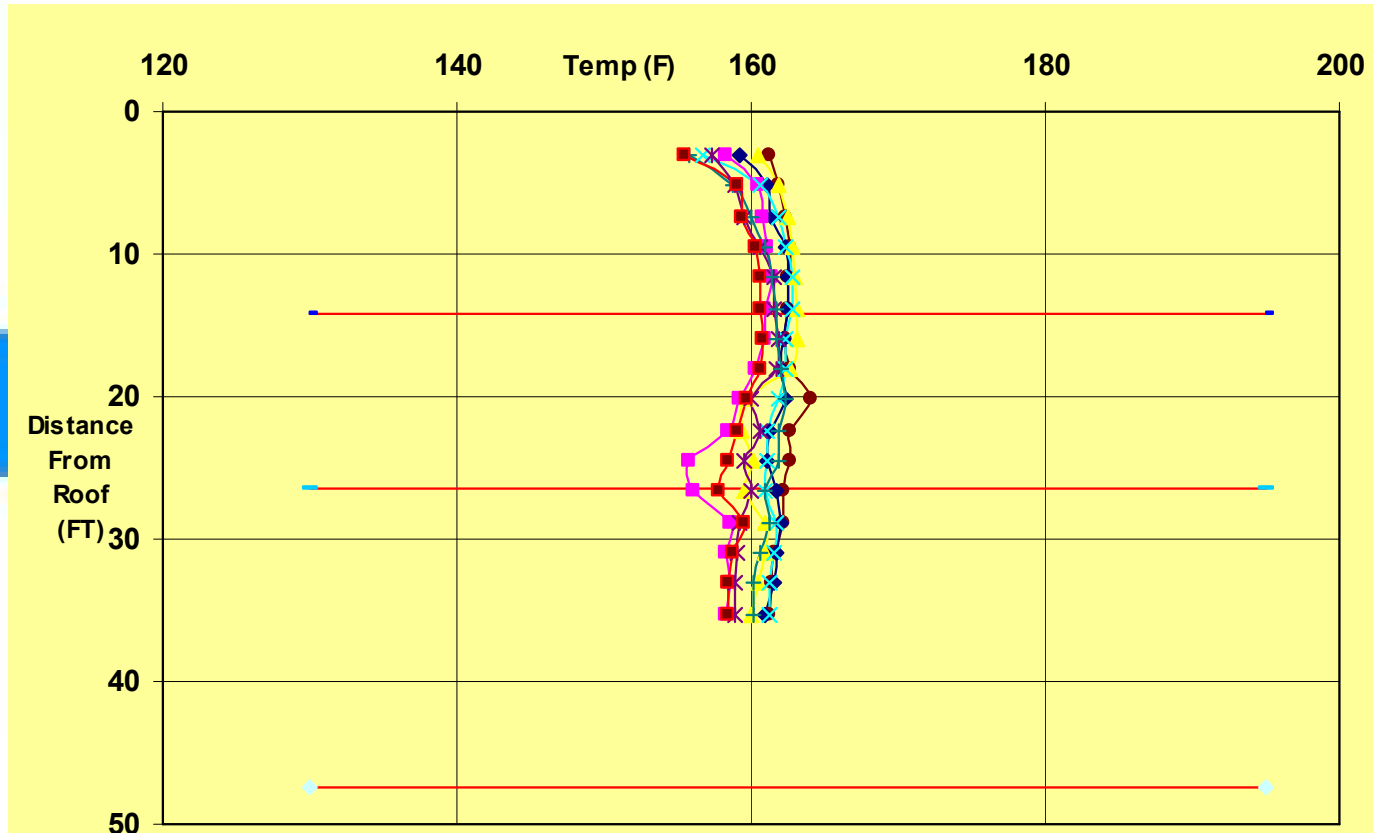
Basic Process Control





SDA Temperatures – Well Mixed Reactor





Flue gas temperature fairly even through out the chamber

Minimize Radiant Heat Loss

What Determines SDA Consumables?

Lime Use

Inlet conditions, lime and water quality and required performance

Pressure Drop

Flue gas flow and conditions, arrangement, SDA selection, FF design and operation

Power Consumption

Gas flow and temperature, slurry solids loading and flow

Water Use

Gas flow and temperature, spraydown

Estimating By-Product Generation Rate

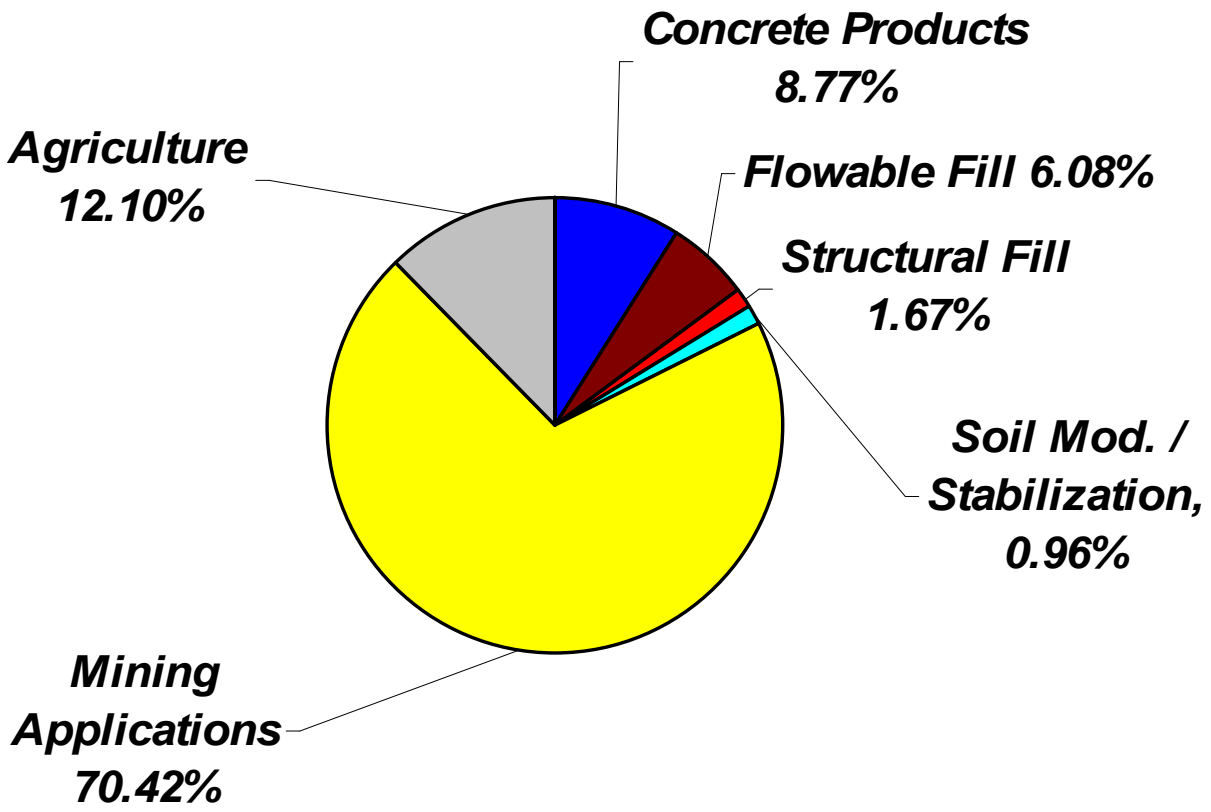
2.5 to 3.0 lb by-product solids / lb SO_2 removed

- ***Excluding fly ash***
- ***2.5 is good first estimate for Western coals***
  - ***0.2 to 1.0 % S in coal***
- ***3.0 is better estimate for Eastern coals***
  - ***1.0 to 1.5 % S in coal***
- ***90 to 94% SO_2 reduction***

SDA By-Product Utilization

159,198 tons put to beneficial use out of 1,427,263 tons generated (11.2%)

SDA By-Product Solids Use (2005)

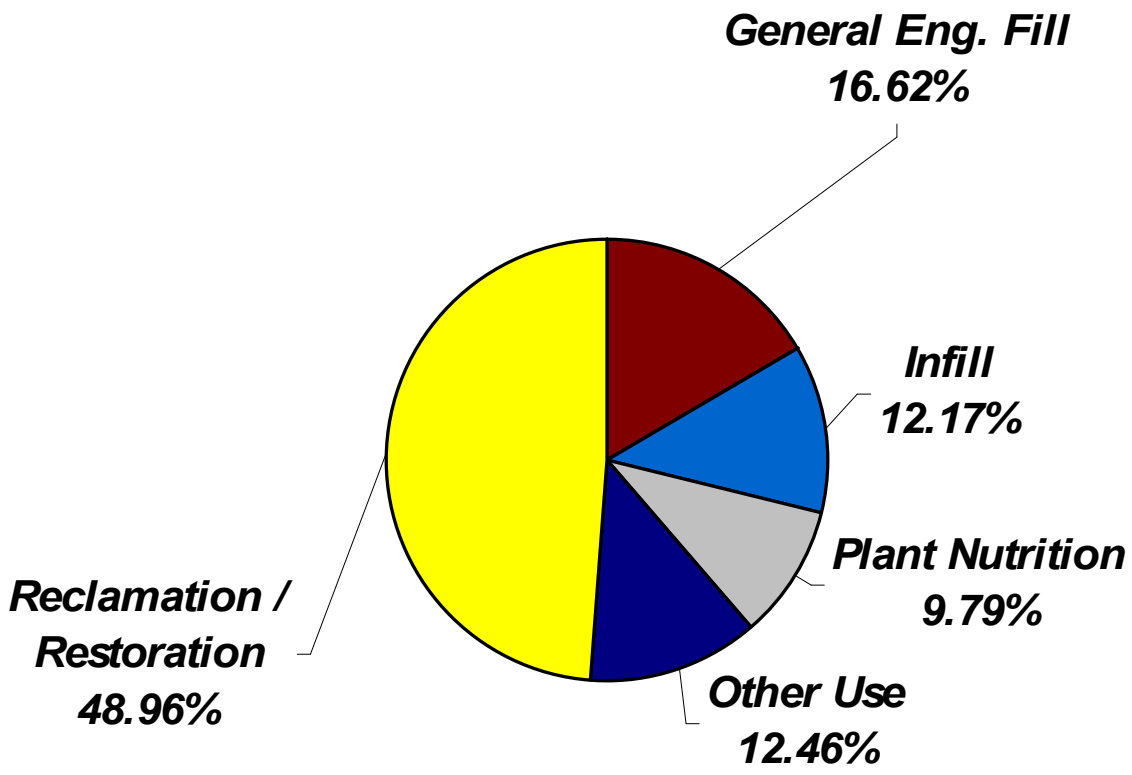


Source – American Coal Ash Association 2005 Coal Combustion Product (CCP) Production and Use Survey, www.ACAA-USA.org

SDA By-Product Utilization - Europe

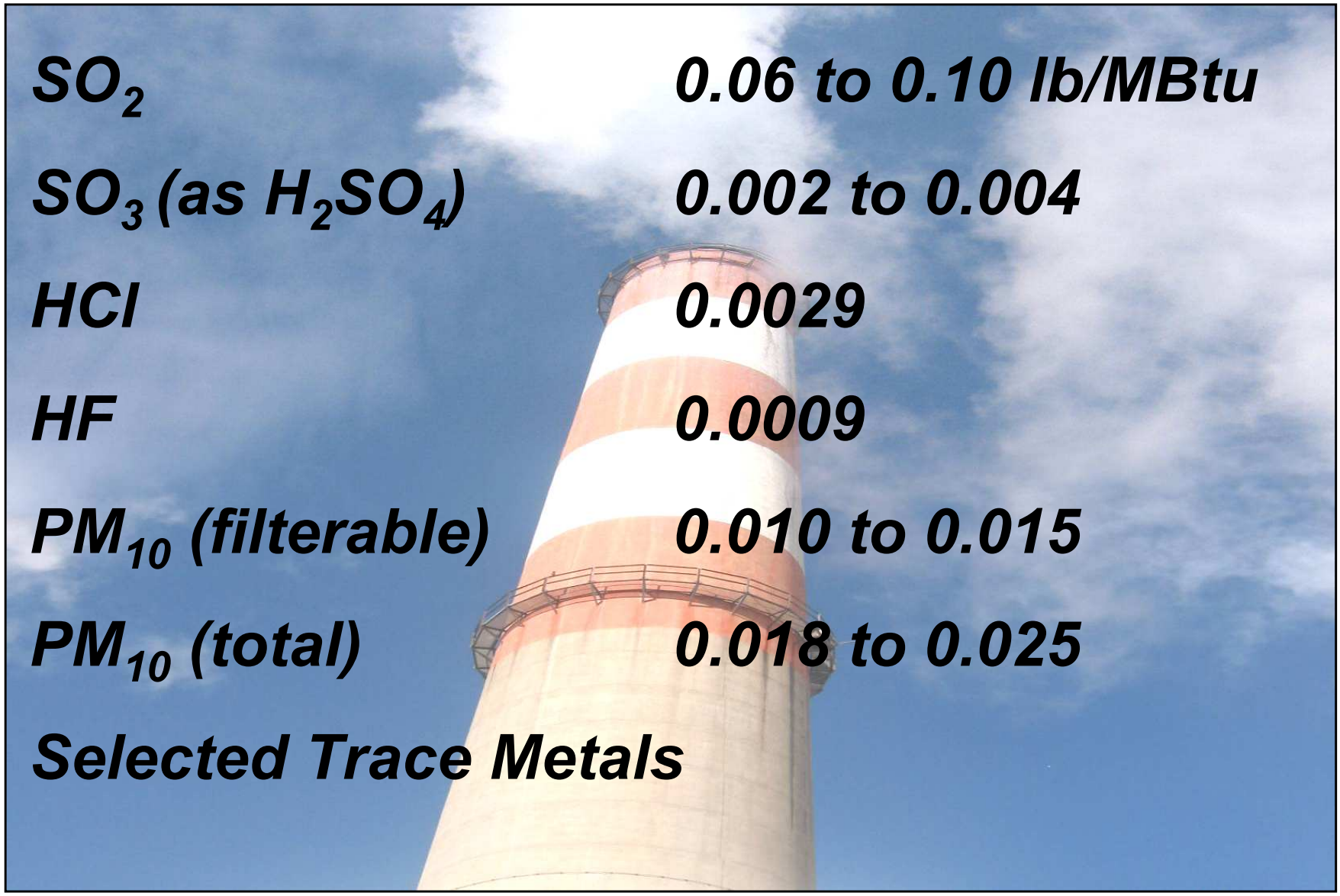
371,542 tons put to beneficial use out of 464,152 tons generated (80.0%)

SDA By-Product Solids Use (2004)



Source – European Coal Combustion Products Association, www.ecoba.com

Typical SDA Emission Requirements



SO_2	0.06 to 0.10 lb/MBtu
SO_3 (as H_2SO_4)	0.002 to 0.004
HCl	0.0029
HF	0.0009
PM_{10} (filterable)	0.010 to 0.015
PM_{10} (total)	0.018 to 0.025
Selected Trace Metals	

Thank You

Kevin Redinger
Technical Consultant