REINHOLD ENVIRONMENTAL Ltd.

2015 APC Round Table
& Expo Presentation

July 13 & 14, 2015, in Atlanta, GA / Hosted by Southern Company

Ultra-Low FGD Emissions
APC Roundtable 2015

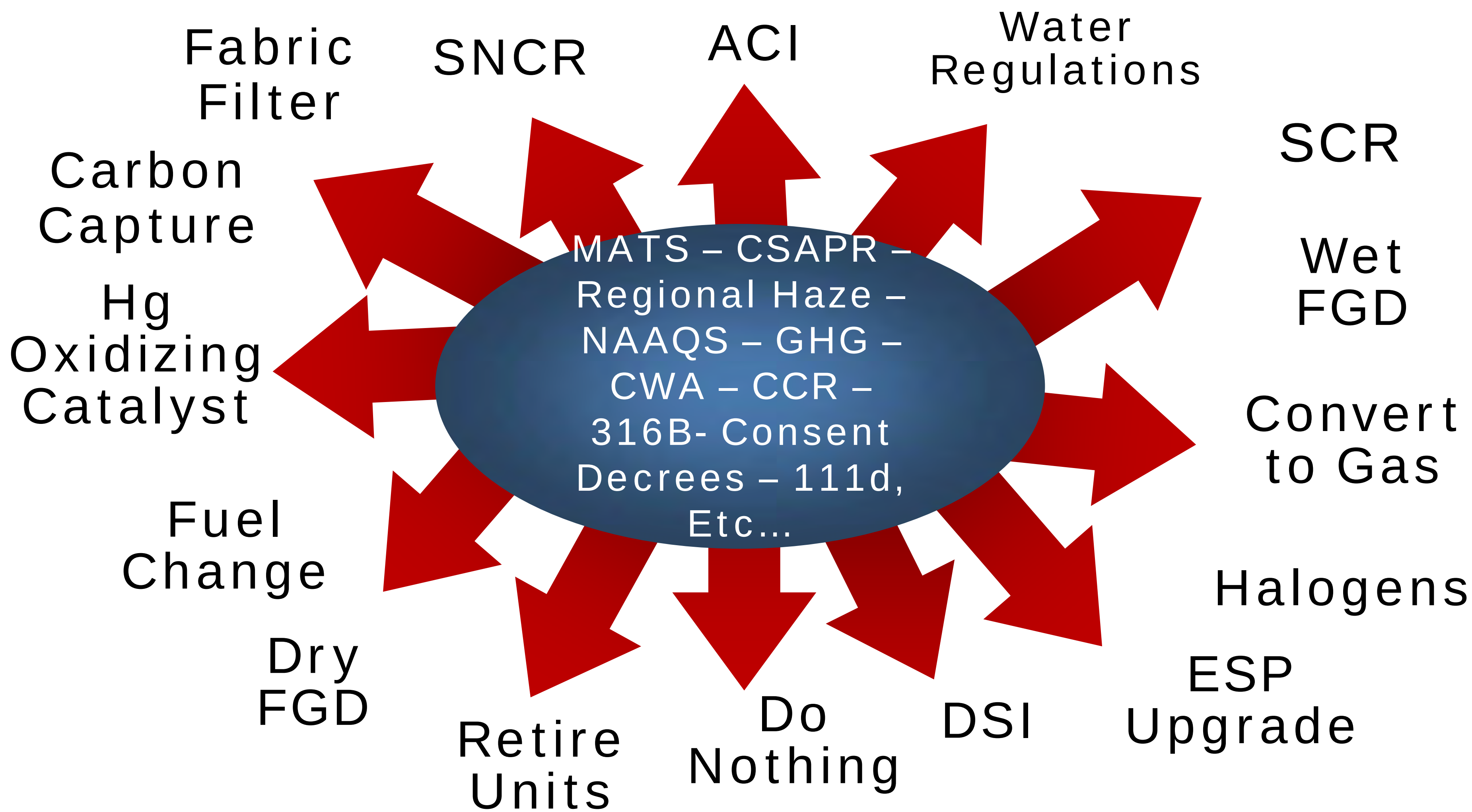
July 14th, 2015
Presented By:
Morgan French

MITSUBISHI HITACHI POWER SYSTEMS AMERICAS, INC.

US Coal Market Place

- 1,249 Coal Units in Operation as of January 2015
  - 329,552 MW Operating Nameplate Capacity
- 966 Coal Units in Operation past 2023
  - 272,643 MW Operating Nameplate Capacity
- 472 Coal Units are treated by an FGD system
  - 187,547 MW Operating Nameplate Capacity
- Average SO2 rate .214 lbs/mmBTU
  - All FGD
- 45 Units in the United States report lower than .04 lbs/mmBTU SO2 rates
  - 39 out of 45 of those units had an FGD Installed after 2005
  - This is a clear indication of a correlation between FGD install date and performance
- 569 Plants have no FGD installed
  - 241 Have Documented SO2 Removal Ratings
  - 192 of those exceed .4 lbs/mmBTU SO2 rate
- MHPSA Long Term Analysis shows that 27 GW of FGD projects will take place by 2023
- This demand for SO2 mitigation will result in $13.8 Billion dollars in AQCS projects by 2023

AQCS Market Drivers



Continued Regulation Uncertainty is Impacting Utilities' Decisions Regarding Future Capital Investments for Emission Control Projects

Environmental Regulations Impacting US Coal Fleet

Air

- Mercury & Air Toxics (MATS)
- Interstate Transport (CAIR/CSAPR)
- Regional Haze/Visibility
- Multiple NAAQS
- New Source Review (NSR)

Climate

- NSPS- New Sources
- NSPS-Existing Sources
- BACT Permitting
- International Negotiations

Water

- 316(b)
- Effluent Limitations Guidelines
- Waters of the United States
- Total Maximum Daily Loads
- Waterbody-Specific Standards

Land & Natural Resources

- Transmission Siting and Permitting
- Avian Protection
- Endangered Species
- Vegetation Management

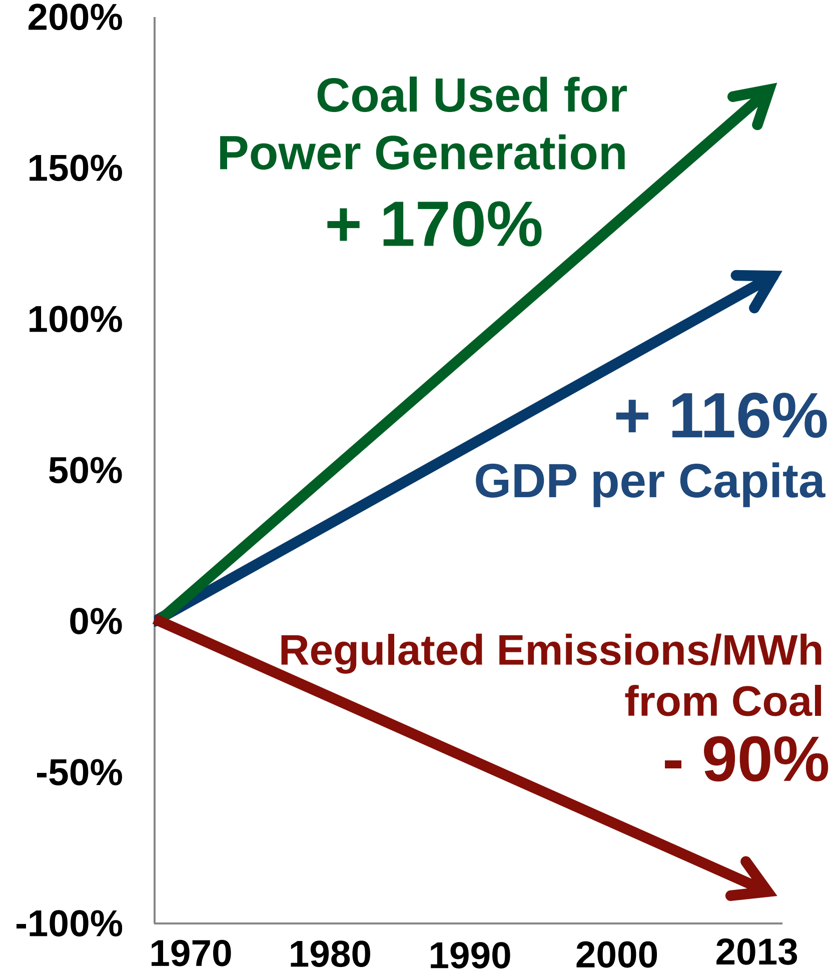
Waste & Chemical Management

- Coal Ash
- PCBs in Electrical Equipment
- HazMat Transport

EEI

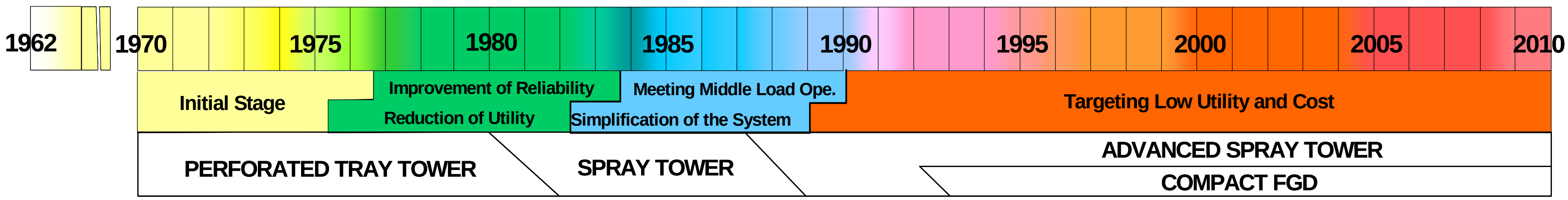
Advanced Coal Technologies: A U.S. Environmental Success Story

Emissions Rate Declines 90% Since 1970 As Coal Use Rises 170%

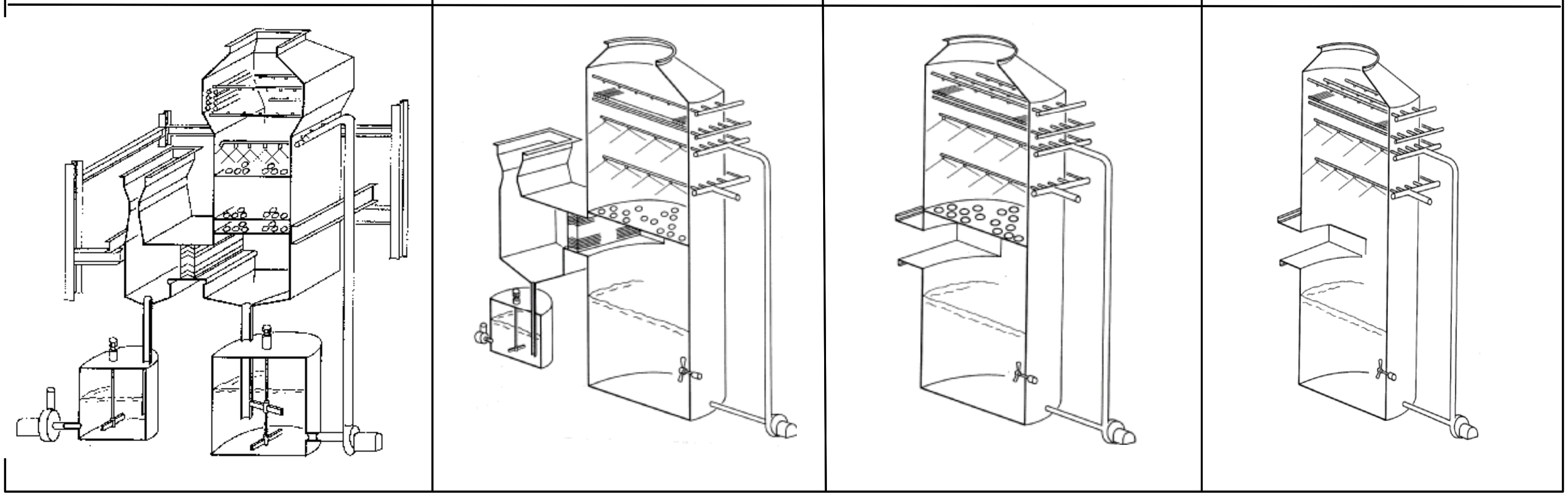


Source: U.S. Energy Information Administration (EIA) 2014 Annual Energy Outlook, 2013; EIA Annual Energy Review, 2012; U.S. Department of Agriculture, 2013; U.S. National Energy Technology Laboratory, 2012; U.S. Environmental Protection Agency, "Clean Air Markets," 2013.

40 Years of FGD Experience



TRAY TOWER	SPRAY TOWER	ADVANCED SPRAY TOWER	
		Second Generation	Third Generation

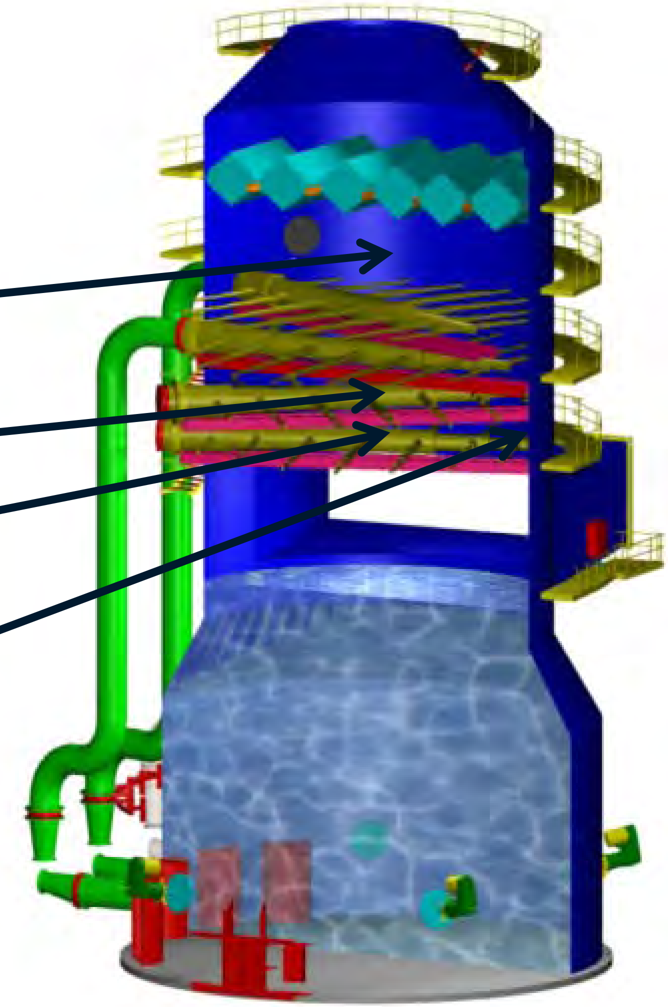


Streamlined design for high efficiency and low power consumption

Wet FGD Systems –
Market Leading Design Features

Wet FGD Design Features:

- High Velocity Design reduces absorber size
- High Spray Flux Minimizes Velocity Variation
- High Spray Flux Maximizes Gas-Liquid Contact
- Higher Spray Density Near Absorber Wall Increases Spray Coverage and Eliminates Sneakage

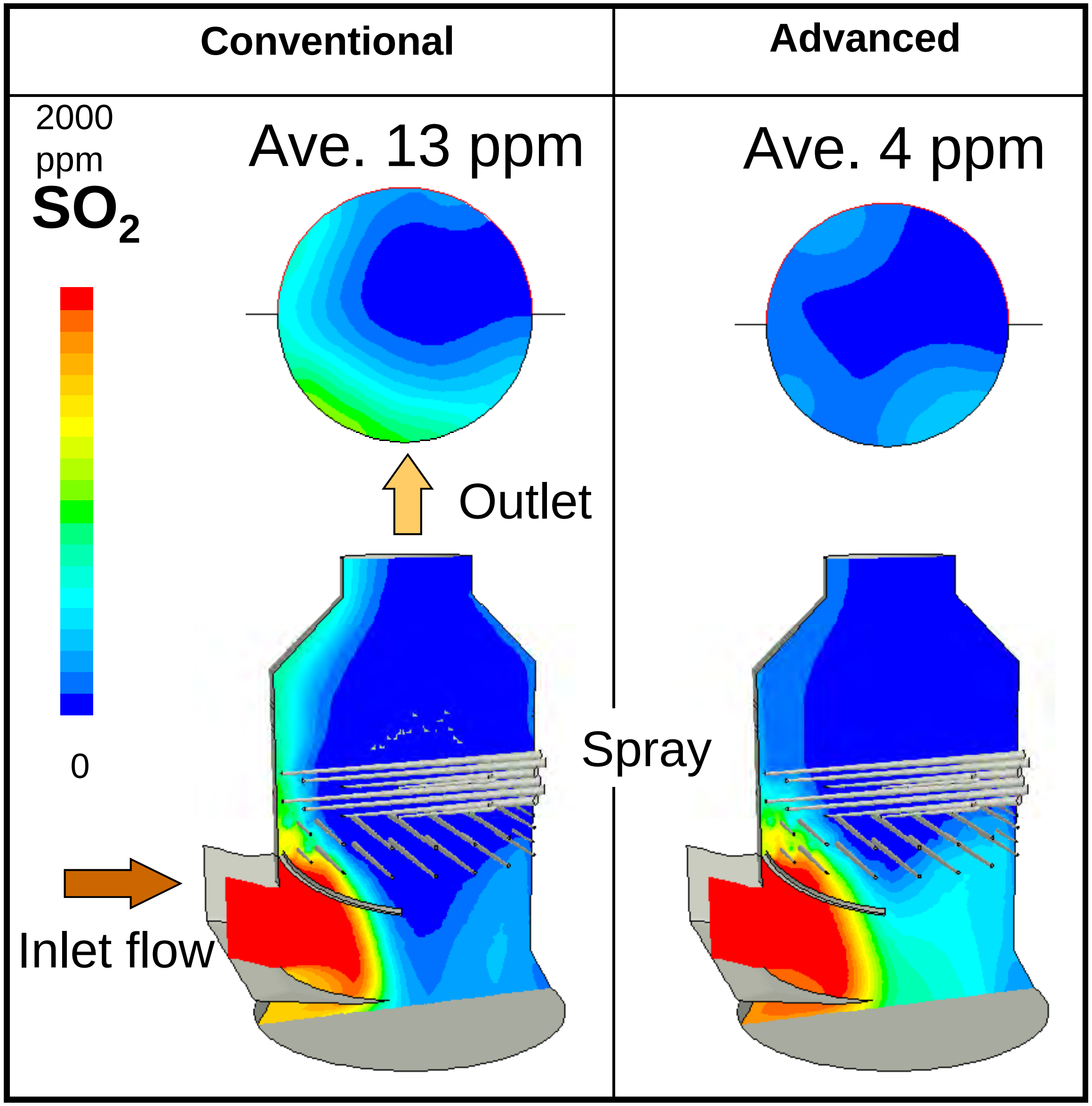


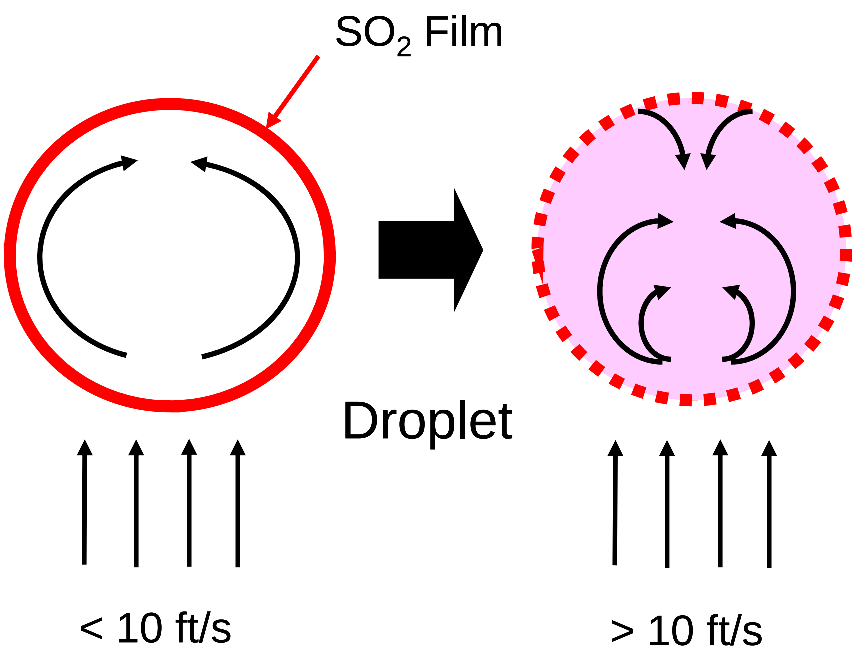
Streamlined design for high efficiency and low power consumption

Single Stage Wet FGD to Enable SO_2 Capture

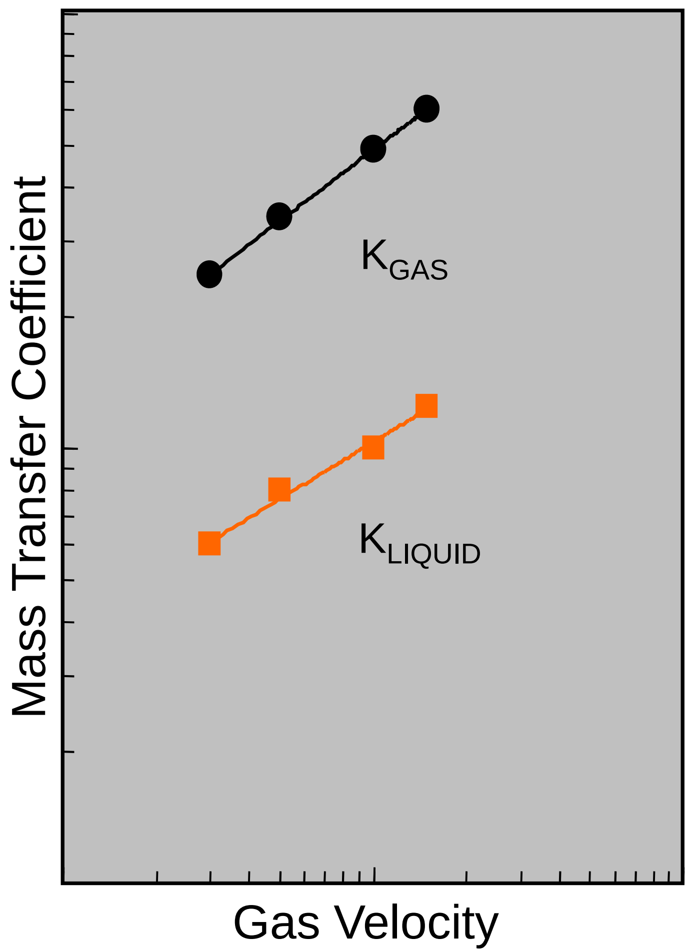
Requirement for flue gas
"single digit " SO_2
(less than 10ppm)

- CFD guided design with ANSWER (In-house 3-D software)
- Modification of spray arrangement
- Conditions
  650MWe plant
  Flow rate : 2 Mm3N/h
  inlet SO_2 : 2000 ppm





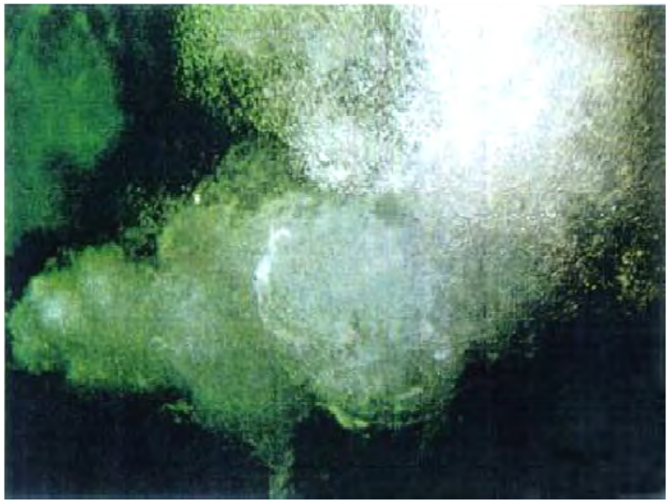
Enhanced Surface Mixing
Increases Pollutant Removal



Efficient removal of pollutants and compact scrubber size

Reaction Tank Design

- In-Situ Forced Oxidation Employs Side-Entering Agitators and Air Lances
- Reaction Tank Solids Residence Time Ensures Good Crystal Growth.



- High Solids For Enhanced SO_2 Removal and Better Dewatering

Wet FGD Experience

- 75 Worldwide Installations (Open Spray Tower)
- 30,500 MW
- All Common Utility Fuels
- Inlet SO_2 Concentrations from 500 to 4,000 ppm
- Absorber Capacities to 1,050 MW
- Absorber Sizes to 69 ft
- All Common Absorber Materials
- 30 Years of Commercial Grade Gypsum

Ameren Sioux
2 x 535 MWe

Ameren Coffeen
389 MWe and 617 MWe

The Ameren Coffeen Wet FGD was recognized as the cleanest SO_2 Coal Plant in the US in 2013

- Dynegy Duck Creek - FGD
- Dynegy Coffeen FGD
- Ameren Sioux- FGD
- Minnesota Power Boswell – SCR and FGD
- KCP&L LaCygne – SCR and FGD – 2015 Start-up

DUCK CREEK UNIT 1

PROJECT BACKGROUND

Basic Design Criteria – Duck Creek

• Absorber MW	465
• Coal Type	Bituminous
• Sulfur Content (%)	3.41
• Inlet SO_2 Conc (ppmd – 3% O_2)	3,325
• Inlet SO_3 Conc (ppmd – 3% O_2)	15 – 23
• Inlet Dust (lb/106 Btu)	0.109
• Gas Flow Rate (acfm)	1,485,900
• Inlet Temp. (deg. F)	305

RESULTS OF PERFORMANCE TESTS AT DUCK CREEK

Parameter	Guarantee	Test Result
• Particulate Emissions	≤ 0.015 lb/MMBtu	0.0045 lb/MMBtu
• SO_2 Removal	≥ 99% Removal	99.83% Removal
• SO_2 Emissions	≤ 0.064 lb/MMBtu	0.0038 lb/MMBtu
• SO_3 Removal	≥ 60% Removal	72.1% Removal
• Mercury Removal	≥ 90 % Removal of Oxidized Mercury	99.0% Removal

Dynegy Coffeen 1 & 2

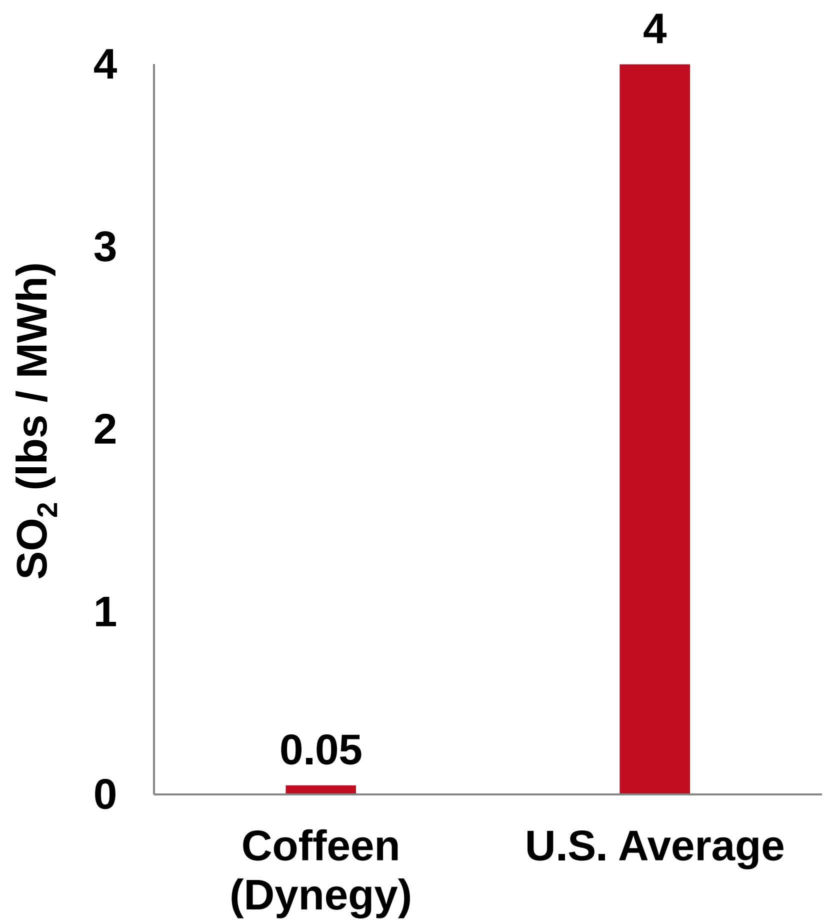
Parameter	Guarantee	Test Result
Particulate Emissions	≤ 0.015 lb/MMBtu	0.0047 lb/MMBtu
SO_2 Removal	≥ 99% Removal	99.95% Removal
SO_3 Removal	≥ 60% Removal	67.45% Removal
Mercury Removal	≥ 90% Removal of Oxidized Mercury	84.35% Removal (Note)

2013 Top 5 Cleanest Coal Plants - SO_2

Power Plant	Holding Company	State	Operating Capacity (MW)	SO_2 (lbs/MWh)
Coffeen	Dynegy, Inc.	IL	915	0.05
Iatan	Great Plains Energy	MO	1,586	0.05
South Oak Creek	Wisconsin Energy Corporation	WI	976	0.06
James H. Miller, Jr.	Southern Co.	AL	2,675	0.08
Virginia City Hybrid Energy Center	Dominion Resources, Inc.	VA	614	0.08
U.S. Average				**4.00**

Dynegy's Coffeen Plant: Lowest SO_2 Emission Rate of Major U.S. Coal Plants

Coffeen's SO_2 Emissions Rate 99% Less Than U.S. Average



Coffeen Plant

A 915-megawatt, generating plant in Montgomery County, IL

Scrubber supplied by Mitsubishi Hitachi Power Systems

SIOUX UNITS 1 & 2

PROJECT BACKGROUND

Basic Design Criteria – Sioux 1 & 2

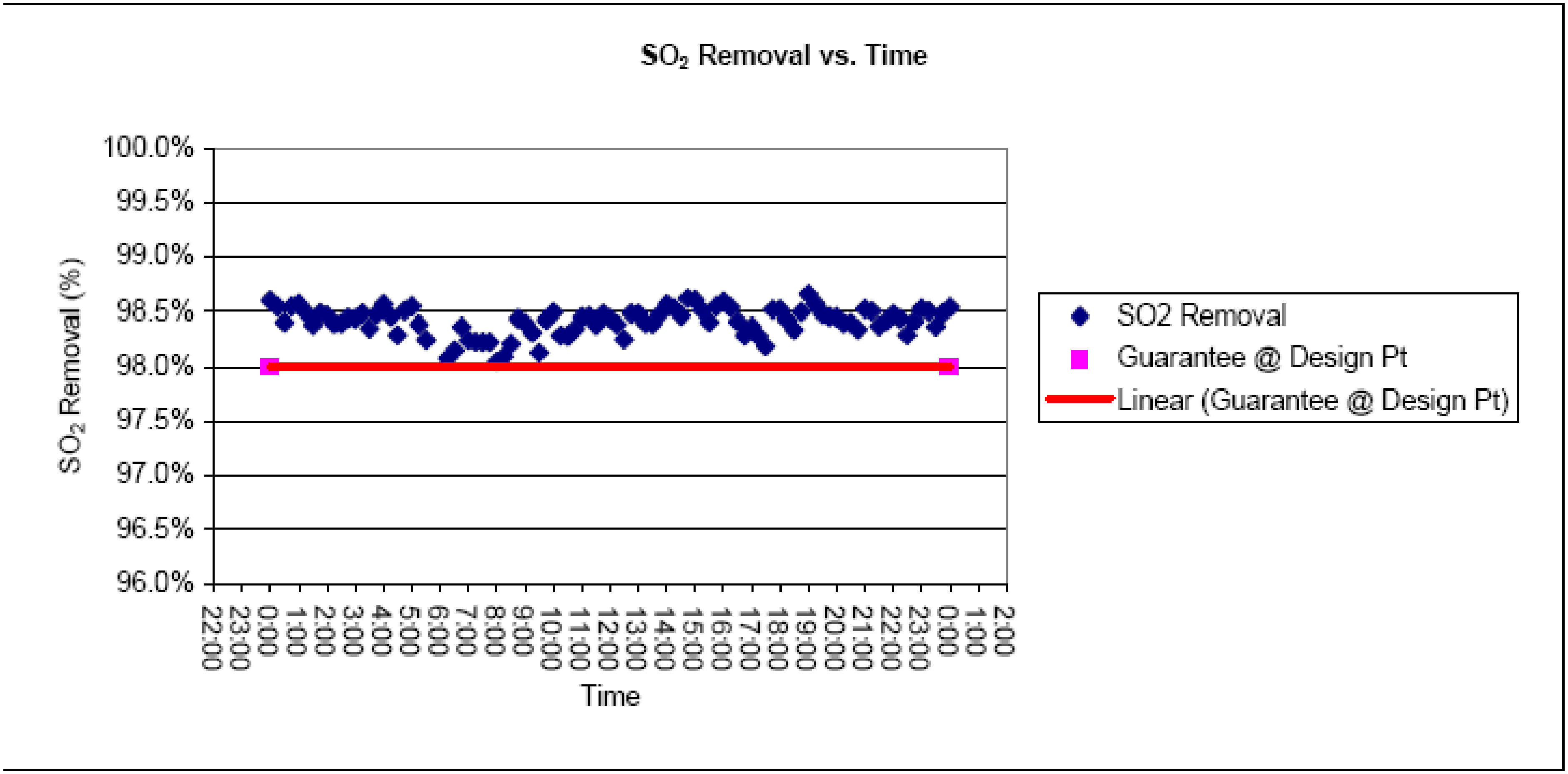
• Absorber MW	535
• Coal Type	Bituminous/PRB
• Sulfur Content (%)	2.15
• Inlet SO_2 Conc (ppmd – 3% O_2)	2,048
• Inlet SO_3 Conc (ppmd – 3% O_2)	14 – 17
• Inlet Dust (lb/106 Btu)	0.07
• Gas Flow Rate (acfm)	1,915,000
• Inlet Temp. (deg. F)	340

RESULTS OF PERFORMANCE TESTS AT SIOUX

Parameter	Guarantee	Test Result
Particulate Emissions	≤ 0.015 lb/MMBtu	0.0062 lb/MMBtu
SO_2 Removal	≥ 99% Removal	99.65% Removal
SO_2 Emissions	≤ 0.04 lb/MMBtu	0.005 lb/MMBtu
SO_3 Removal	≥ 60% Removal	72.25% Removal
Mercury Removal	≥ 90% Removal of Oxidized Mercury	98.7% Removal

Boswell – Cohasset, MN

Boswell FGD Performance



KCP&L LaCygne

Now operational, our newest installation at KCP&L La Cygne is meeting all emission guarantees

High Flux, Variable Density Spray Arrangement

- High Spray Flux Minimizes Velocity Variation
- High Spray Flux Maximizes Gas-Liquid Contact
- Higher Nozzle Density Near Absorber Wall Increases Spray Coverage and Eliminates Sneakage
- Progressive Flux Density Moves Gas Away From the Absorber Wall Toward the Center

Possible performance issues

- Nozzle Pluggage
  - Deposit build up
  - Fouling
- Improper grinding of the limestone
- Inlet Pluggage (low load)
- Solids Level
- pH

2020

- Integral Chimneys for Tight Site Retrofits
  - Compact Absorber for Small Unit Retrofits

2015

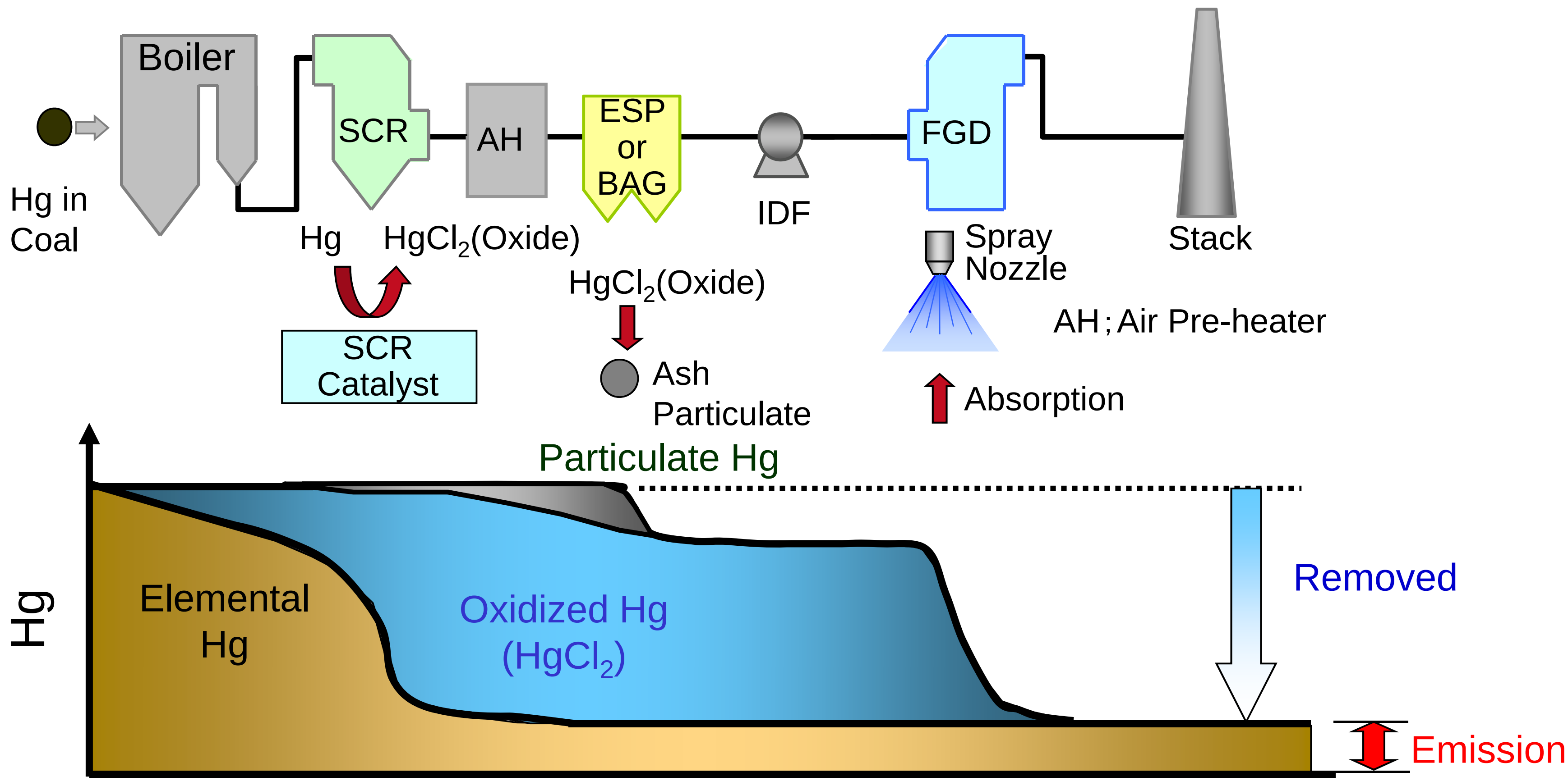
- Mercury Capture
  - SCR Co-Benefit

2010

- Advanced Venturi Scrubber

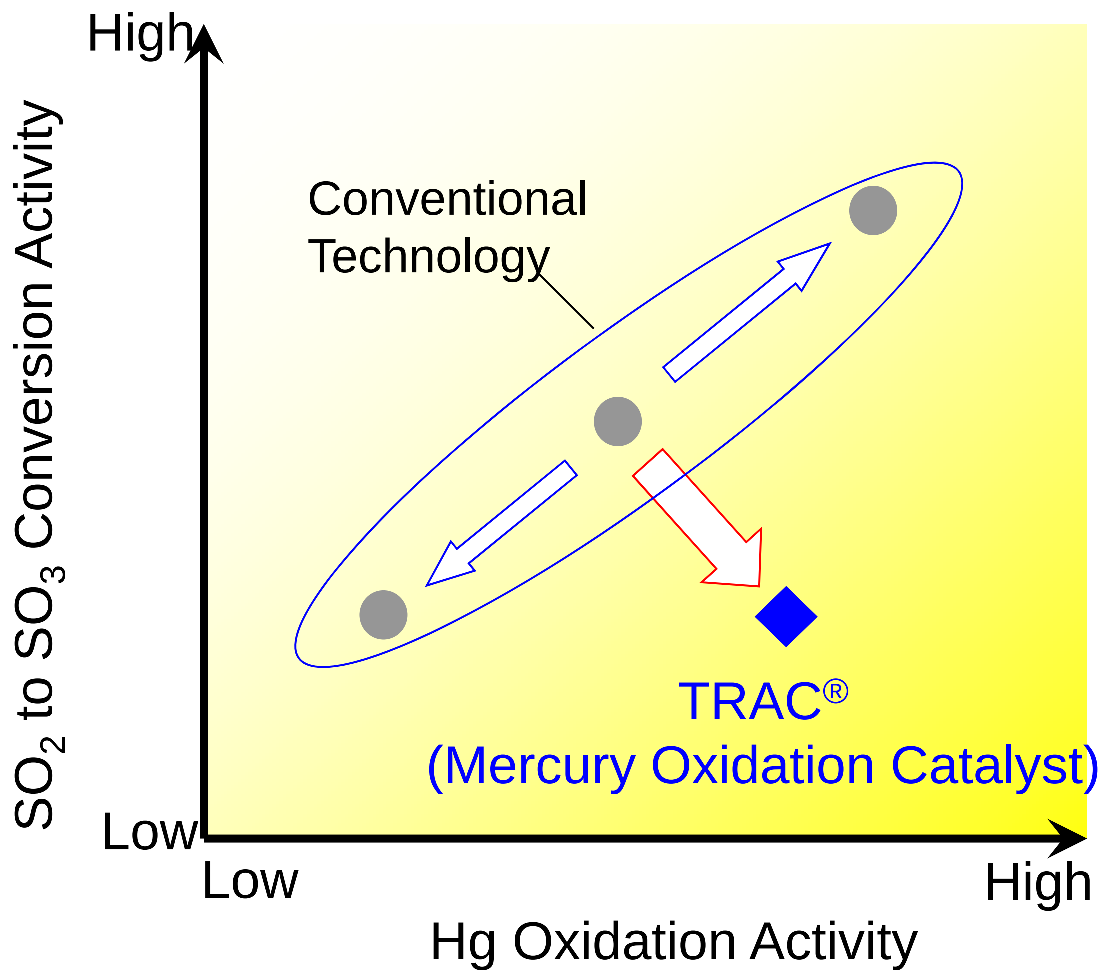
Integral Chimneys for Tight Sites

Process of Hg Removal by SCR + FGD



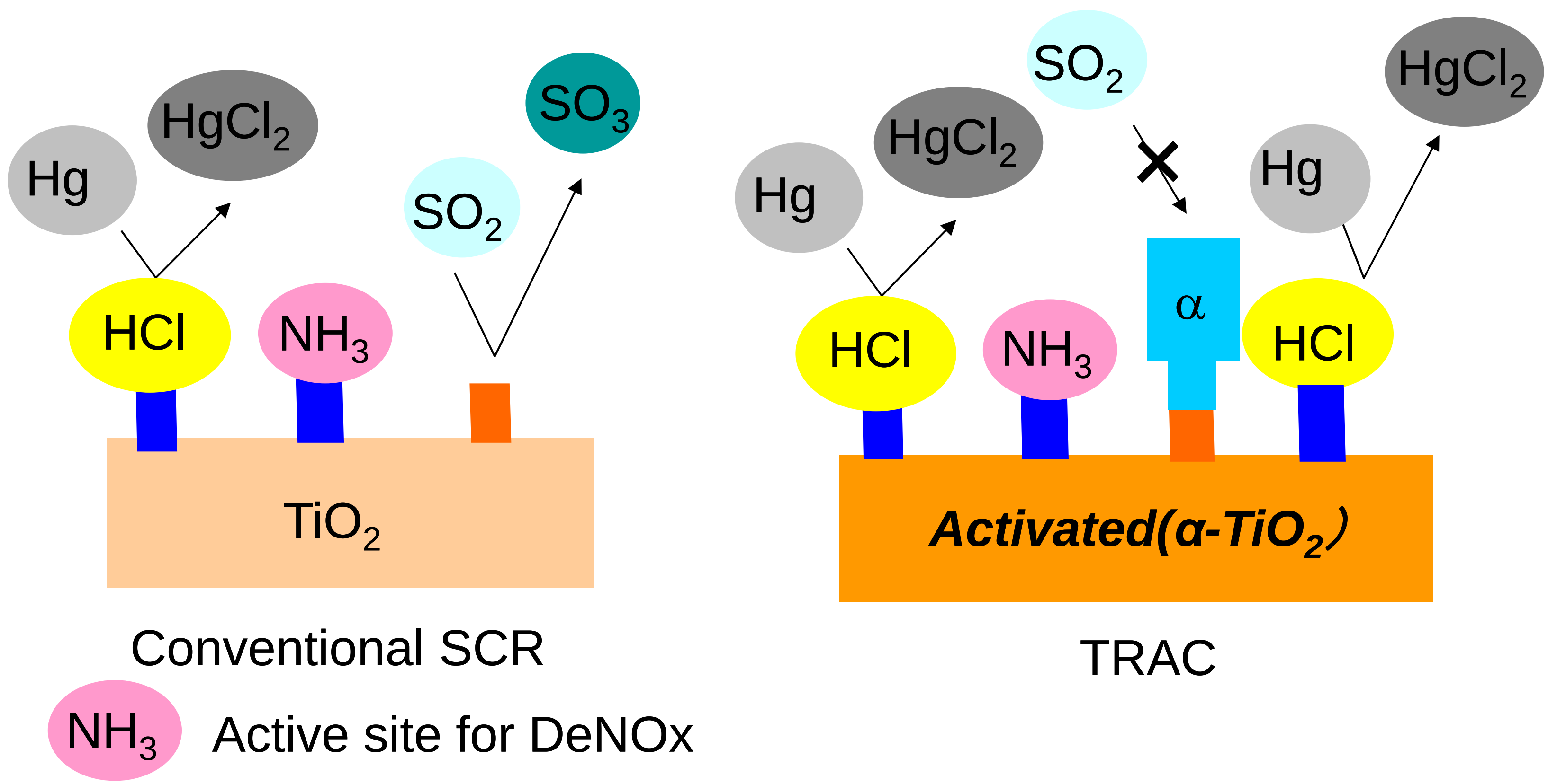
SCR Catalyst is a key component for mercury oxidation

TRAC® - Mercury Oxidation Catalyst



TRAC® Has Higher Hg Oxidation & Maintains Low SO_2 Conversion

TRAC® Reaction Model



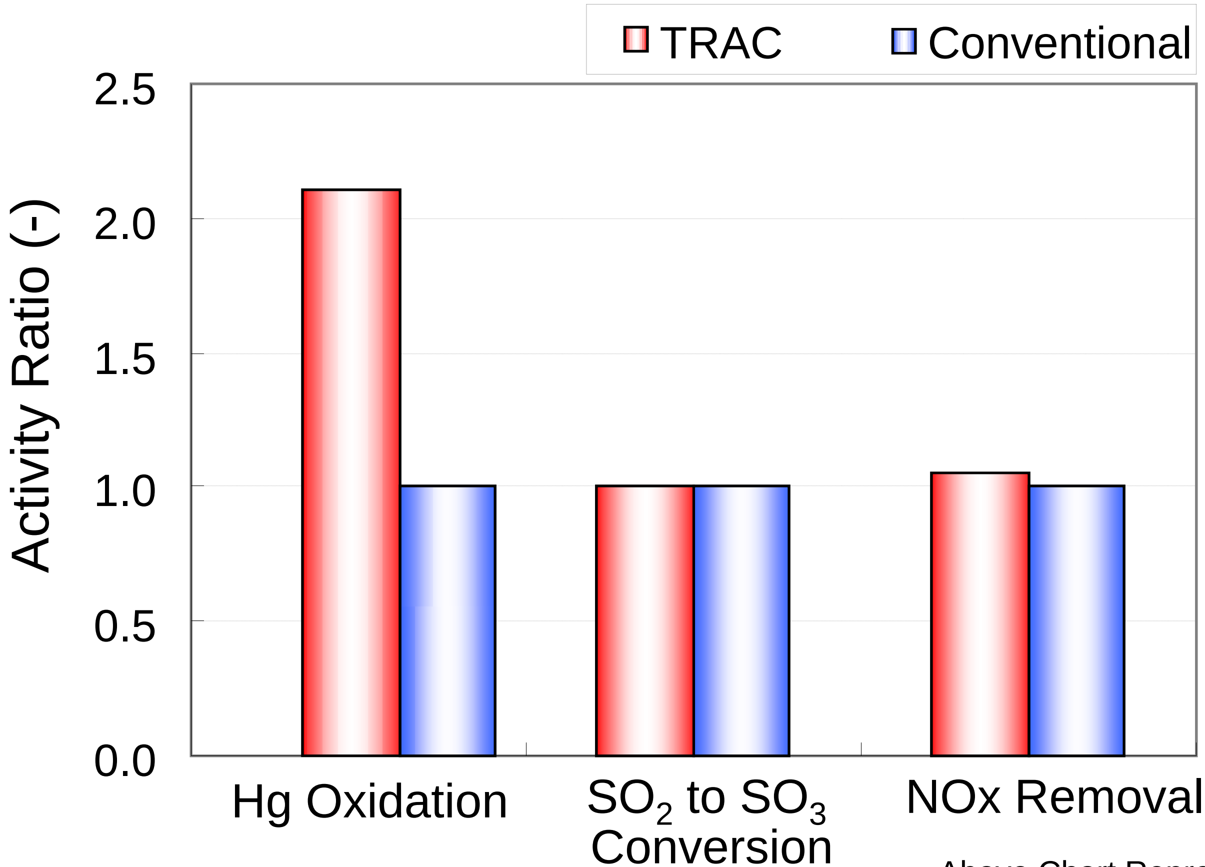
α Component Can Inhibit SO_2 Conversion Rate and Enhance Hg Oxidation Performance.

Relative Performance of TRAC®

1st High Mercury Oxidation

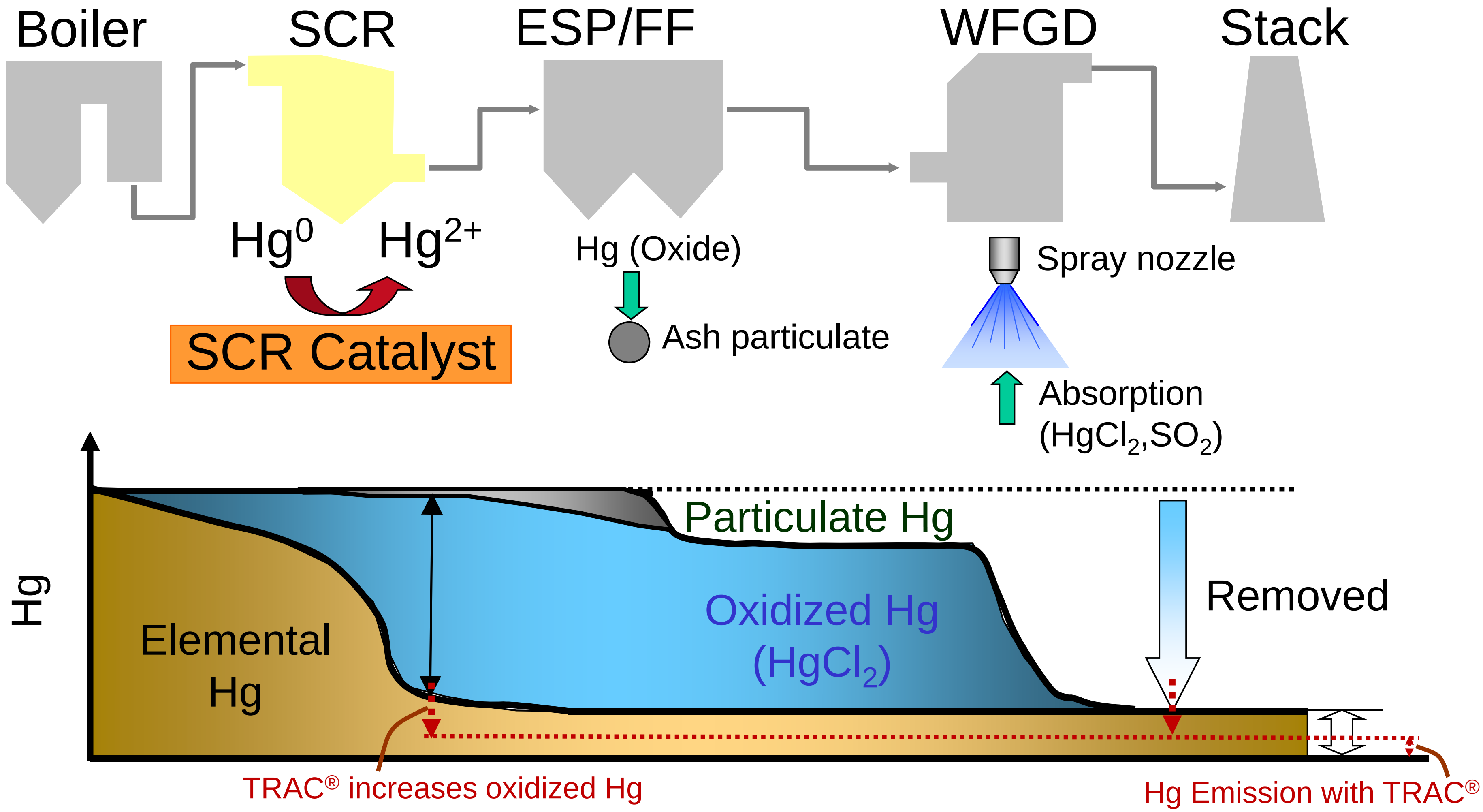
2nd High DeNOx Performance

3rd Low SO_2 to SO_3 Conversion



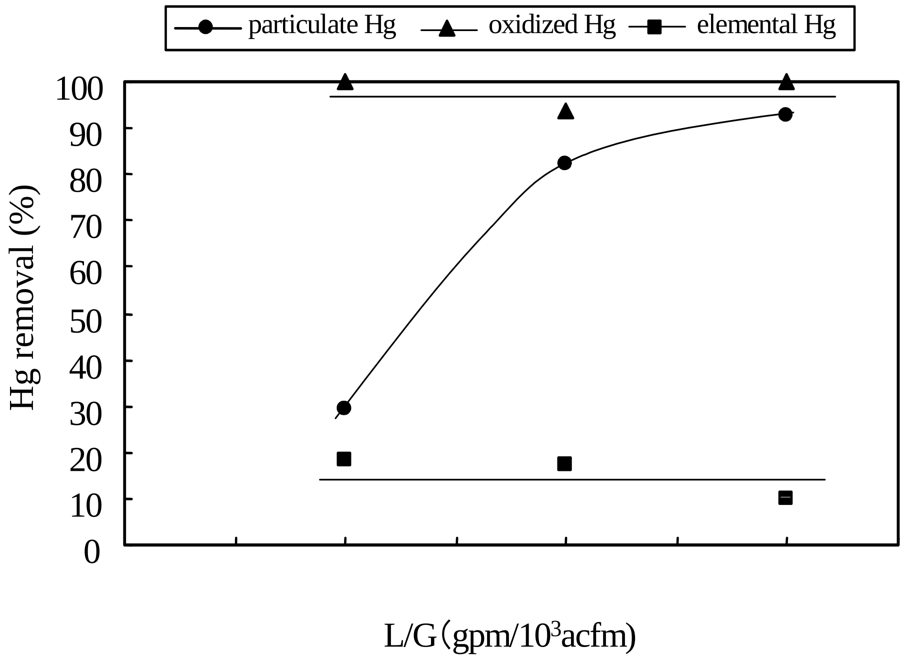
Above Chart Represents Typical Results

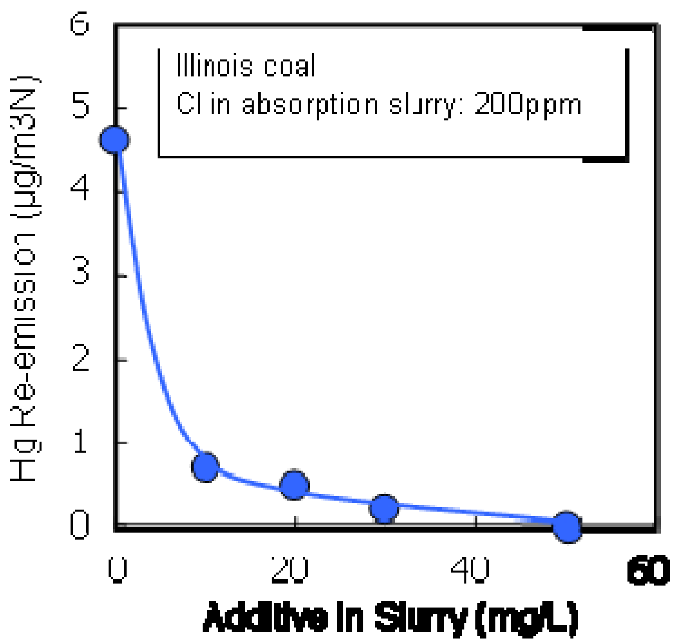
SCR + FGD Co-Benefit with TRAC® Catalyst



SCR catalyst is a key component for mercury oxidation

Mercury Removal Across Wet FGD





Oxidized and particulate mercury is effectively removed in WFGD
Effective additives are being developed for controlling re-emissions

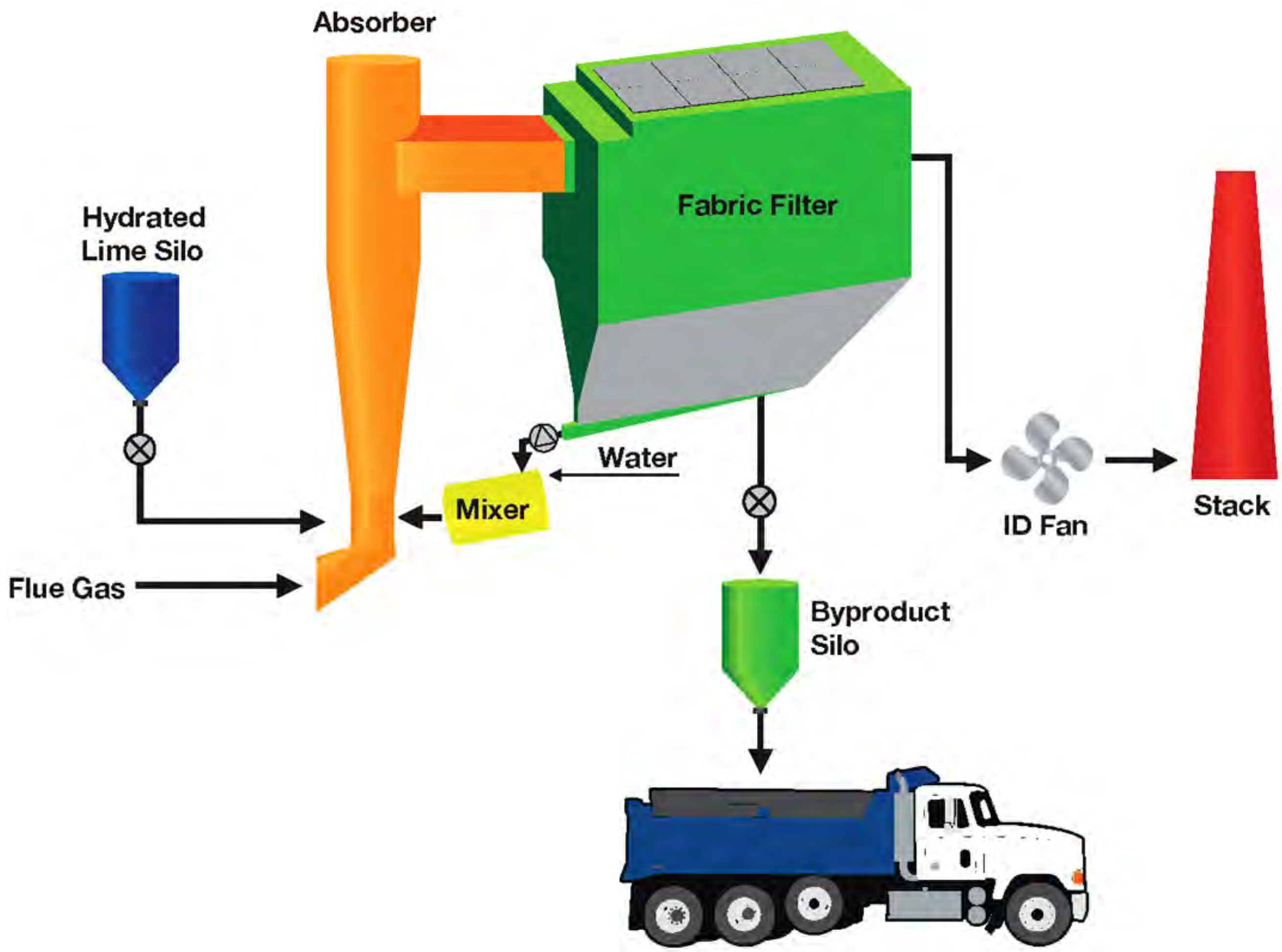
Origin of the EAD™ Scrubber

EAD Pilot Plant (1986, Gardanne, France)

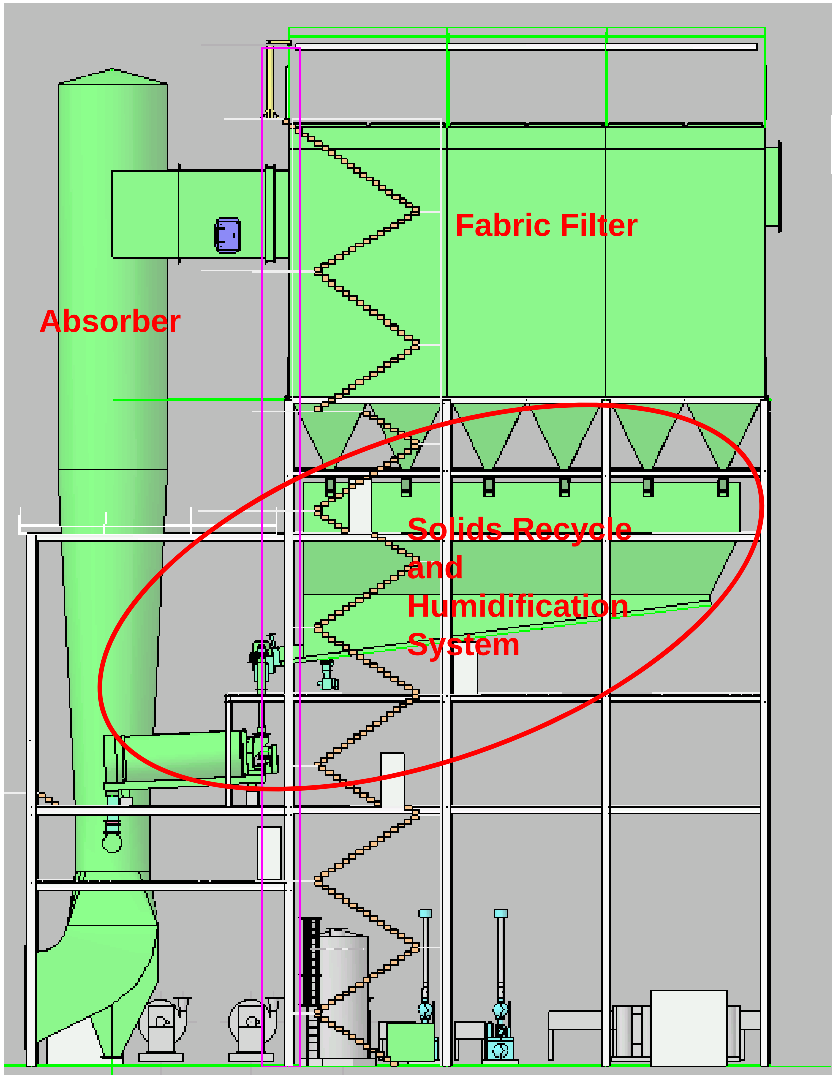
- Patented
- Developed in the 1980s
- The Original *Enhanced All Dry* Process
- External Solids Humidification
- Simple, Flexible

EAD is the original CDS Technology developed in the 1980s

EAD™ Simplified



EAD™ Basic Principle



The EAD Scrubber is a Transport (Entrained Flow) Reactor

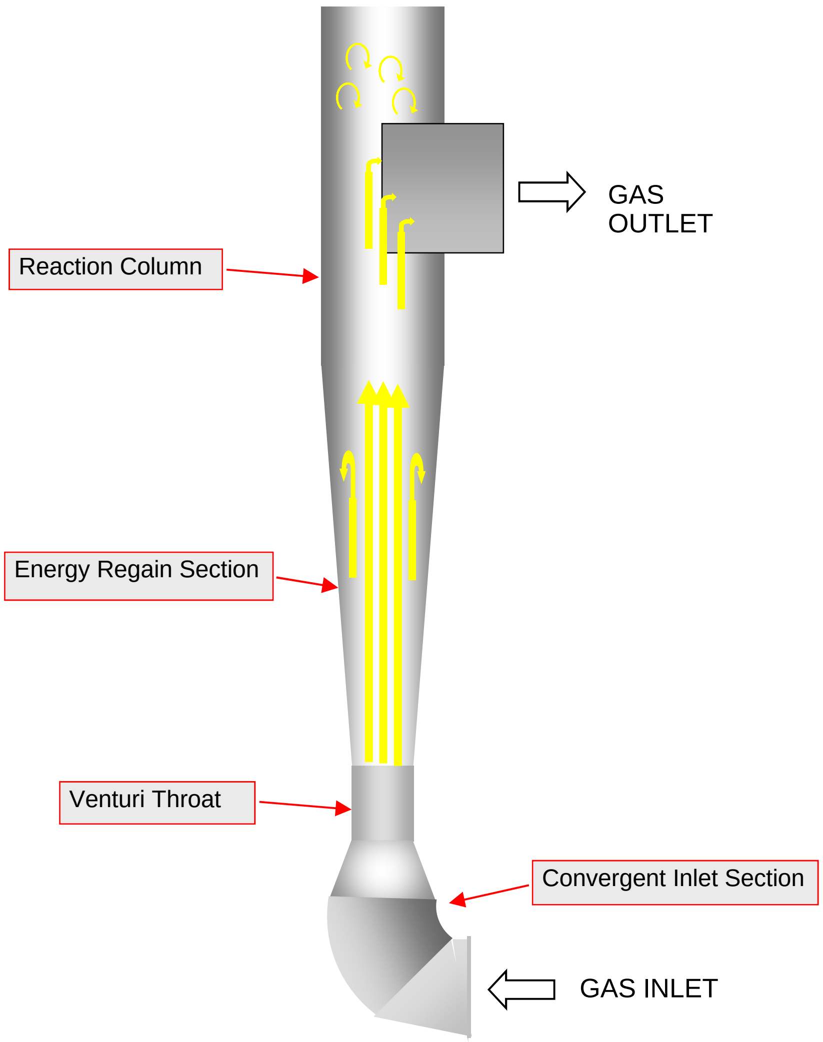
Coupled To

A Low Air-To-Cloth Ratio Fabric Filter

And

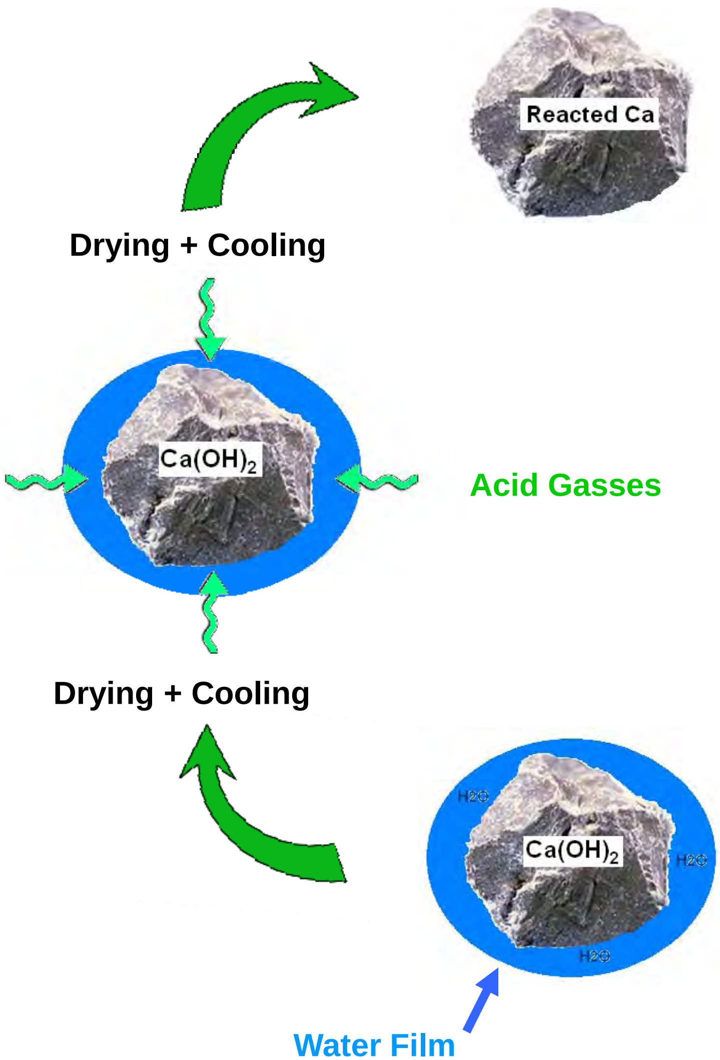
An External Solids Recycle and Humidification System.

Venturi Absorber



- Entrained flow - no fluidized bed to maintain
- Venturi nozzle – turbulence / mixing
- Very high apparent stoichiometry due to solids recycle
- Energy recovery section – low pressure drop
- No internals to plug or erode
- Lime injected independent of solids recycle for fast response
- No water injection in absorber

EAD™ Basic Principle



- Reaction takes place in an entrained flow absorber
- Water added to the surface of the recycled solids:
  - Cools the flue gases to the ideal reaction temperature
  - Lowers the hydrated lime surface temperature
  - Increases the humidity at the point of reaction
- This provides optimum conditions for reaction of the hydrated lime with acid gases.

Questions??