Up-gradation of Boilers to Implement New Pollution Norms

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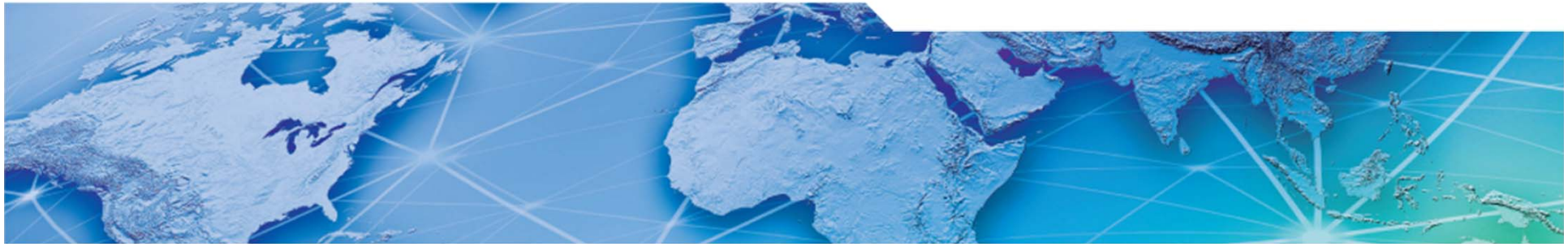


Key Regulatory Drivers: Power Plants

Pollutant	Unit*	TPPs installed before December 31, 2003 (Refer Note 1)	TPPs installed after 2003 to December 31, 2016 (Refer Note 1 & 2)	TPPs to be installed from January 1, 2017
Particulate Matter	mg/Nm^3	100	50	30
SOx	mg/Nm^3	600 (<500 MW) 200 (>=500 MW)	600 (<500 MW) 200 (>=500 MW)	100
NOx	mg/Nm^3	600	300	100

Note 1: **TPP's (Units) shall meet the limits within two years from date of the notification.**
Note 2: **Includes all the TPP's (Units) which have been accorded environmental clearance and are under construction.**

***Corresponding to 6% O_2 Dry Volume.**
NDA: Non-degraded Airshed, DA: Degraded Airshed (Poor Air Quality)

Emission Norms for Industrial Boilers are individually governed by various states.

Total Portfolio Under Emission Control

1. NOx Control
   i. Combustion Modifications
   ii. Post Combustion Measures
      a. SNCR
      b. SCR
      c. Hybrid of SCR & SNCR

2. SO_2 Control
   i. Limestone injection in the combustor of AFBC & CFBC Boilers
   ii. FGD
      a. Dry FGD
      b. Wet FGD

3. SPM Control
   i. ESP modification
      a. HFPS
      b. Hybrid Filter (ESP + Bag Filter)
   ii. Flue Gas Conditioning: SO3, NH3 and Dual injection in flue gas upstream of ESP

NOx emission Control

1. NOx Control

   i. Combustion Modifications: Up to 60% reduction potential for older units where low NOx burners / OFA were not originally provided.

   ii. Post Combustion Measures

      a. SNCR: 20 - 40% reduction potential for large PC fired units & upto 75% for small industrial units.

      b. SCR: 85 - 90% reduction potential.

      c. Hybrid of SCR & SNCR: Up to 60% reduction potential for large PC fired units.

SO_2 emission Control

1. SO_2 Control

   i. Limestone injection in AFBC & CFBC boilers: Up to 70-75% reduction potential for AFBC boilers & up to 90-95% reduction potential for CFBC boilers.

   ii. FGD

      a. Dry FGD

         - DID: Hydrated lime injection in flue gas downstream of boiler : Up to 60% reduction potential (max 75% with high grade lime).
         - RDS: Hydrated lime injection in flue gas downstream of boiler: Up to 95% reduction potential.

      b. Wet FGD using Limestone: Up to 99% reduction potential.

SPM emission Control

1. SPM Control

   i. ESP modification

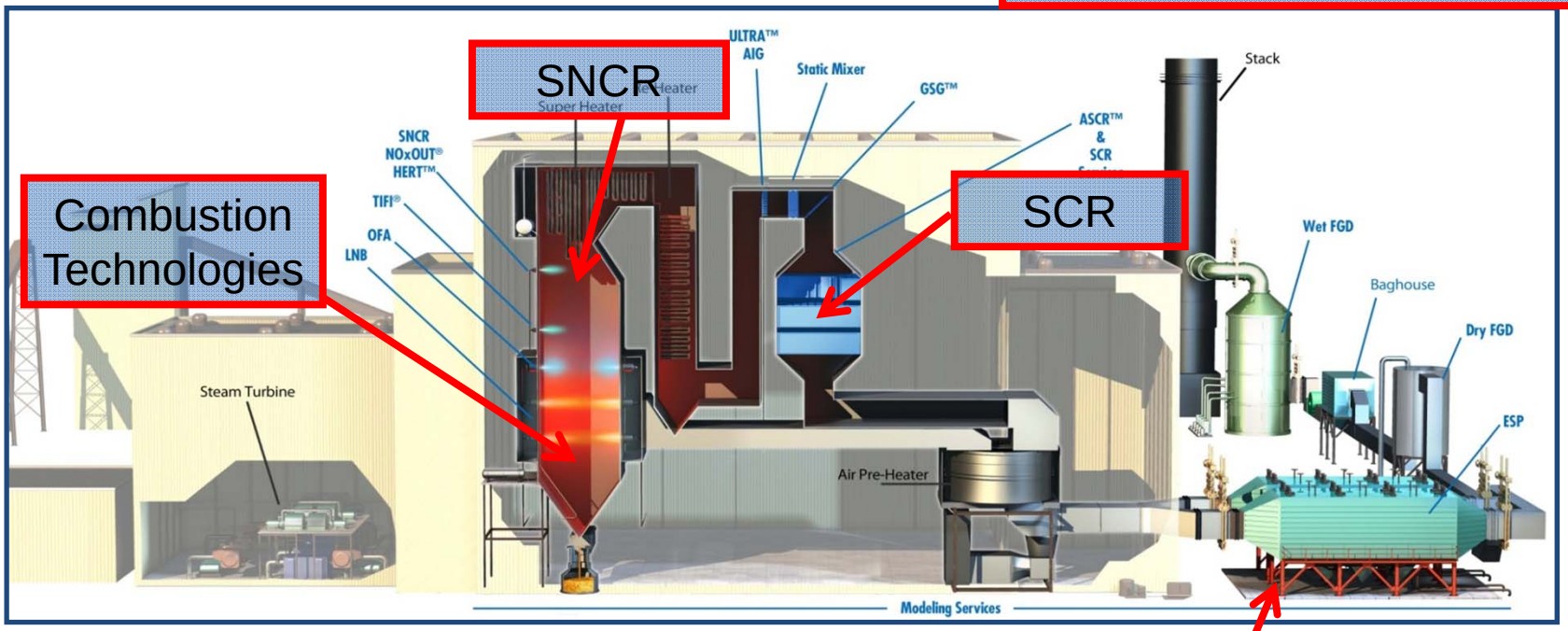
      a. HFPS: Upto 50% reduction potential depending upon existing emissions.

      b. Conversion from ESP to Hybrid Filter (ESP + Bag Filter): 80 - 90% reduction potential depending upon existing emissions from ESP

   ii. Dual Flue Gas Conditioning: SO3 + NH3 injection in flue gas upstream of ESP: : 85-90% reduction potential.

Typical Power Plant

Advanced Modeling Services – All Technologies



ESP Modification and Flue Gas Conditioning Systems

DeNOx Technologies

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Technologies to enable clean efficient energy

Primary Measure – Combustion Modifications

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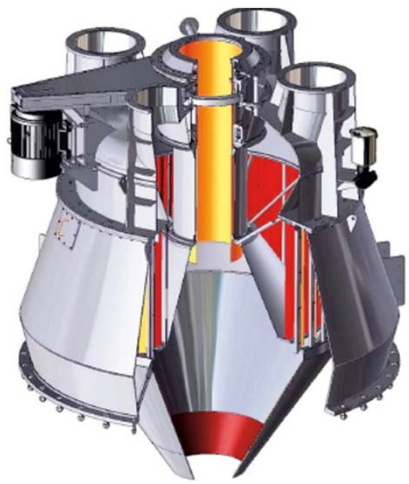
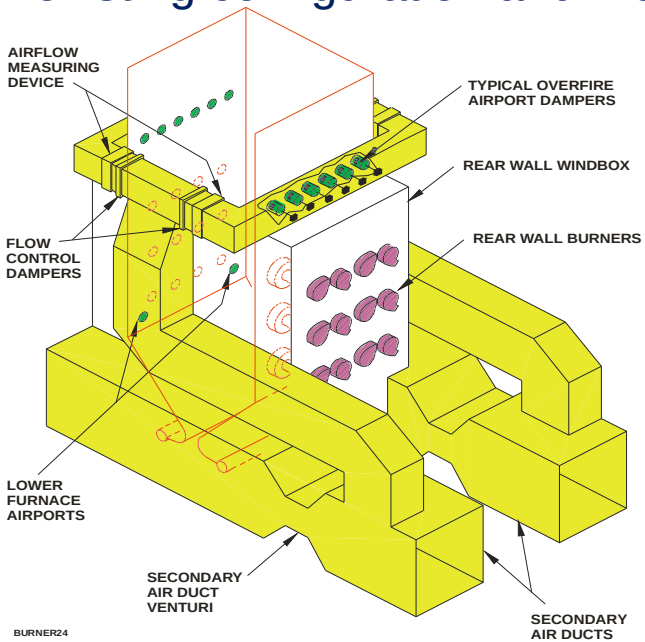
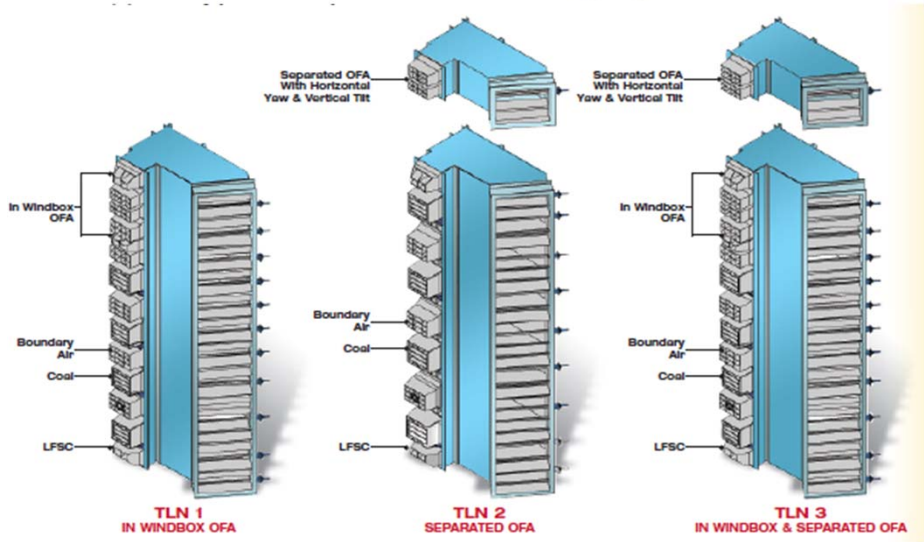
Primary Measure – Combustion Modifications

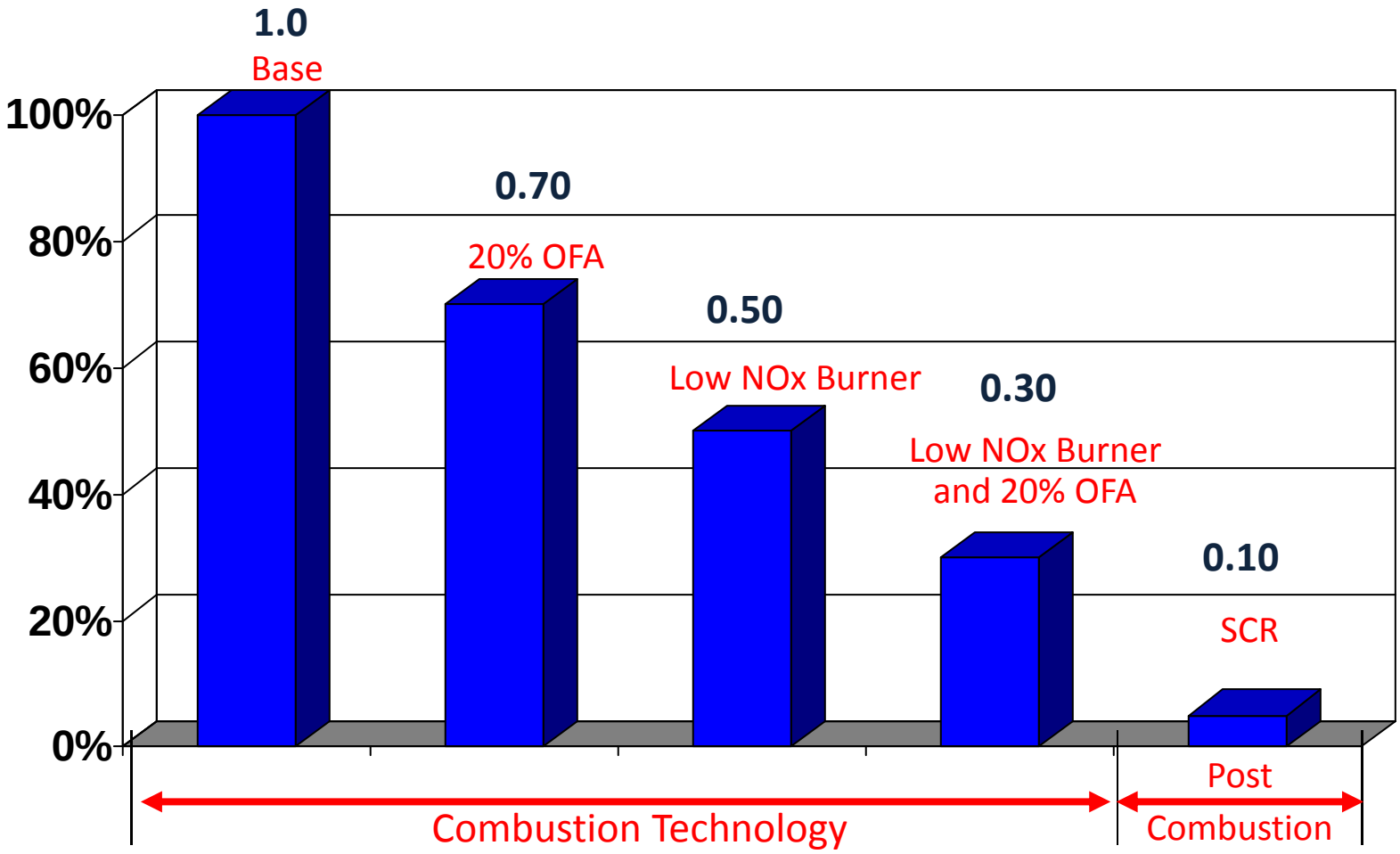
1. Low NOx Burner – For T-Fired and Wall Fired units
2. OFA (Over Fire Air) - For T-Fired and Wall Fired units
3. Mill Modification for Pulverized Coal Fineness Improvement
4. Low Capex, Negligible Opex
5. 4 – 8 weeks shut down required depending on existing configuration and modification required.







Primary Measure – Combustion Modifications



Selective Non Catalytic Reduction (SNCR) Technology

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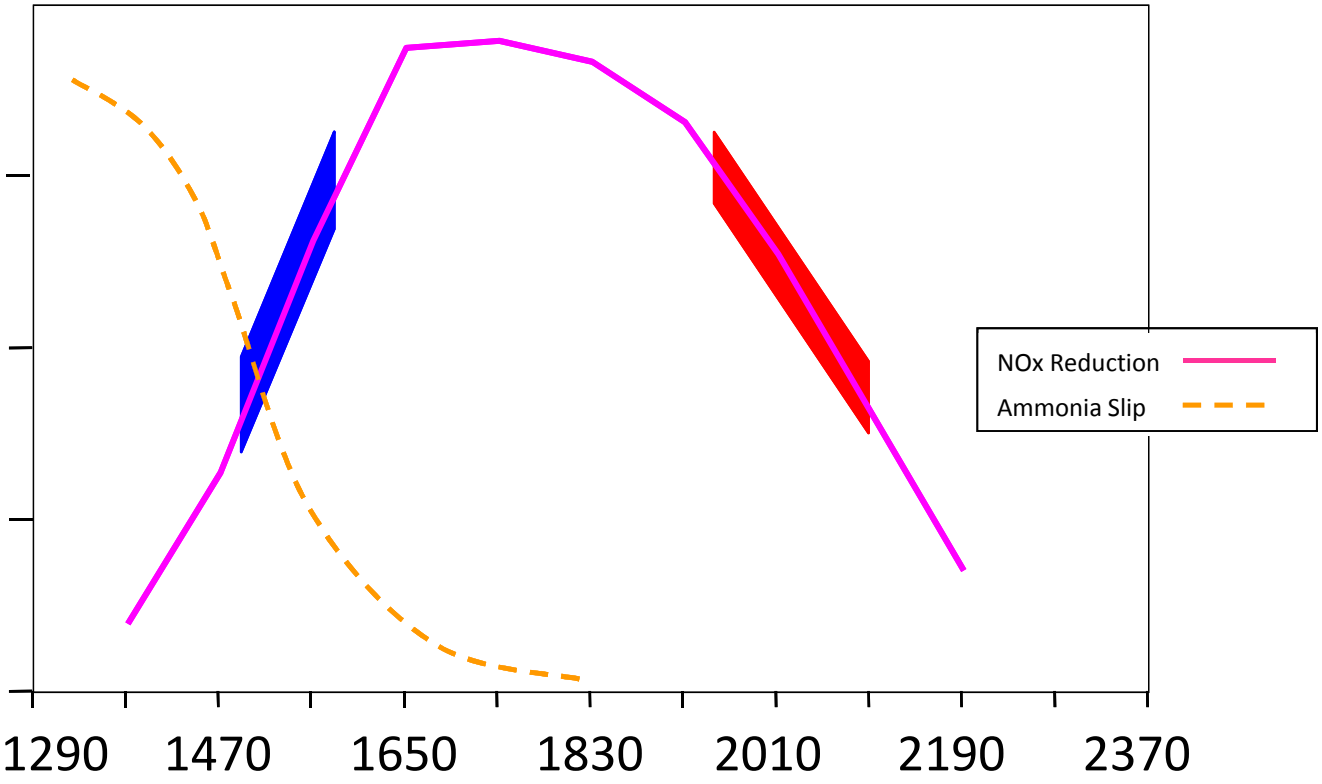
SNCR "Right Side of Slope" Injection

Low Temperature Issues

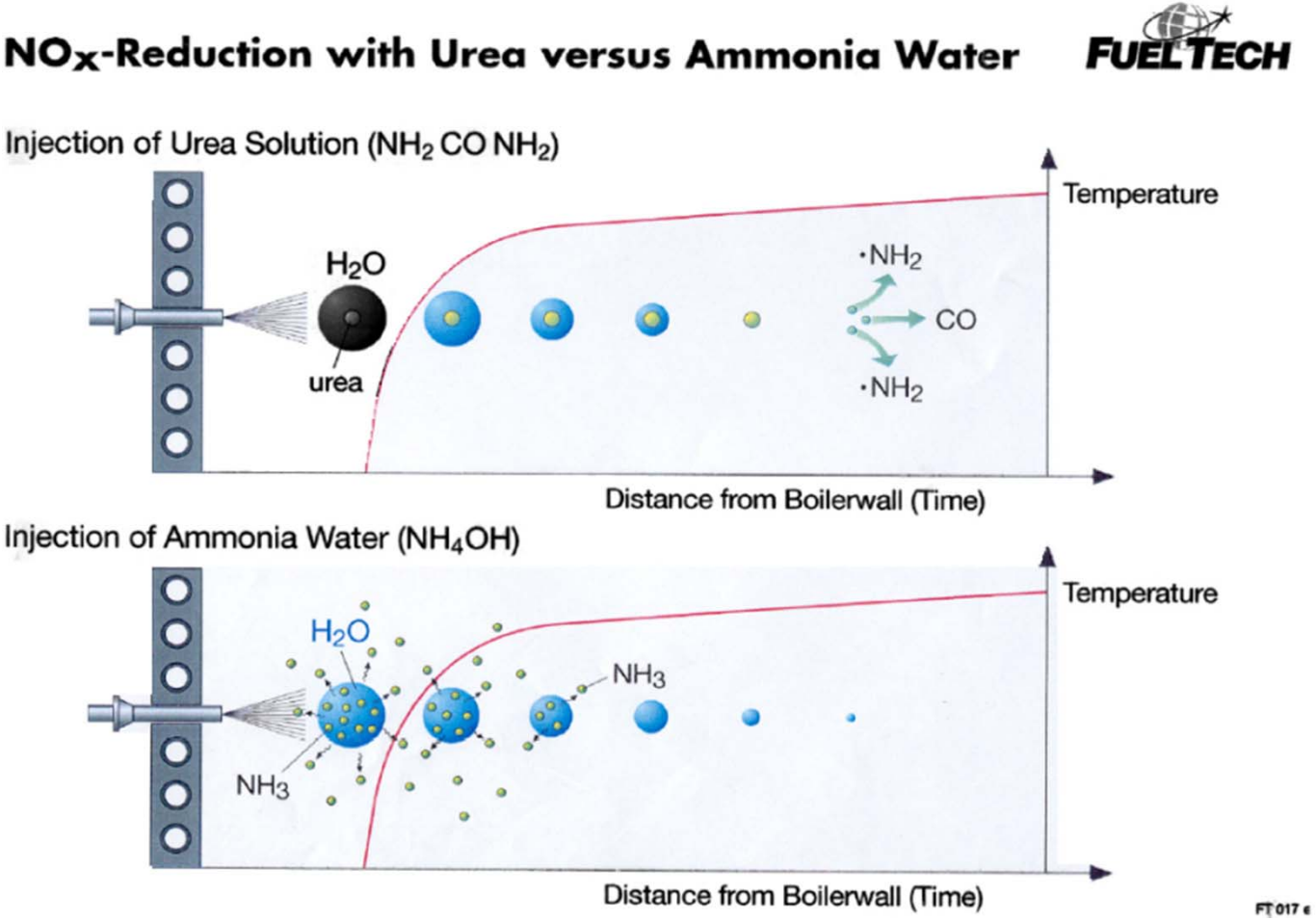
- Slow Droplet Evaporation
- Slow Kinetics
- Low OH Concentration
- Ammonia Slip Increase

High Temperature Issues

- Rapid Droplet Evaporation
- Fast Kinetics
- Increased OH Concentration
- Urea Oxidation to NOx



SNCR – Why Urea



Urea droplets formed by FTI injectors are characterized in test facilities using laser Doppler techniques.

Selective Catalytic Reduction (SCR) Technology

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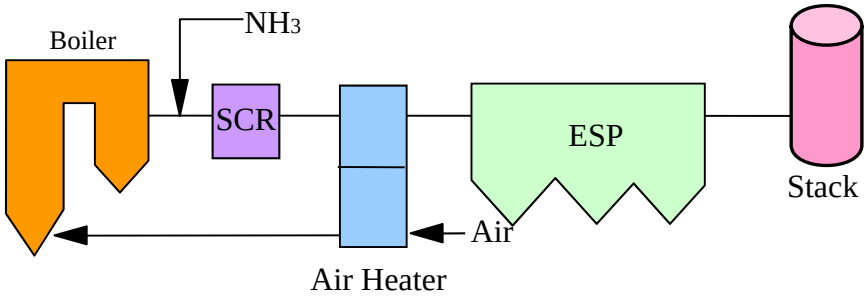
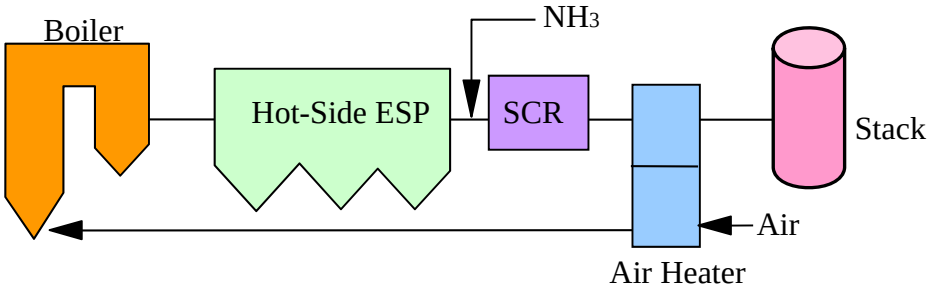
SCR Arrangements

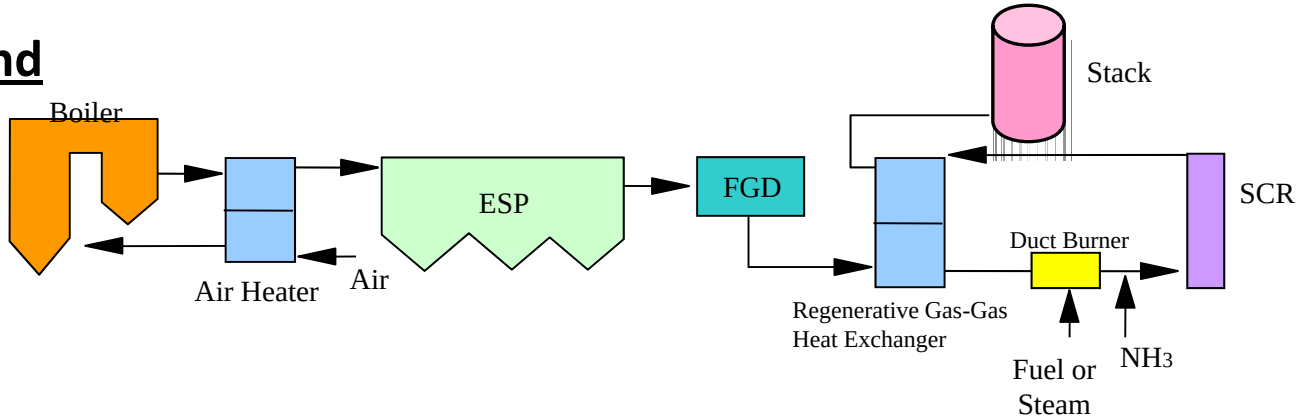
High Dust



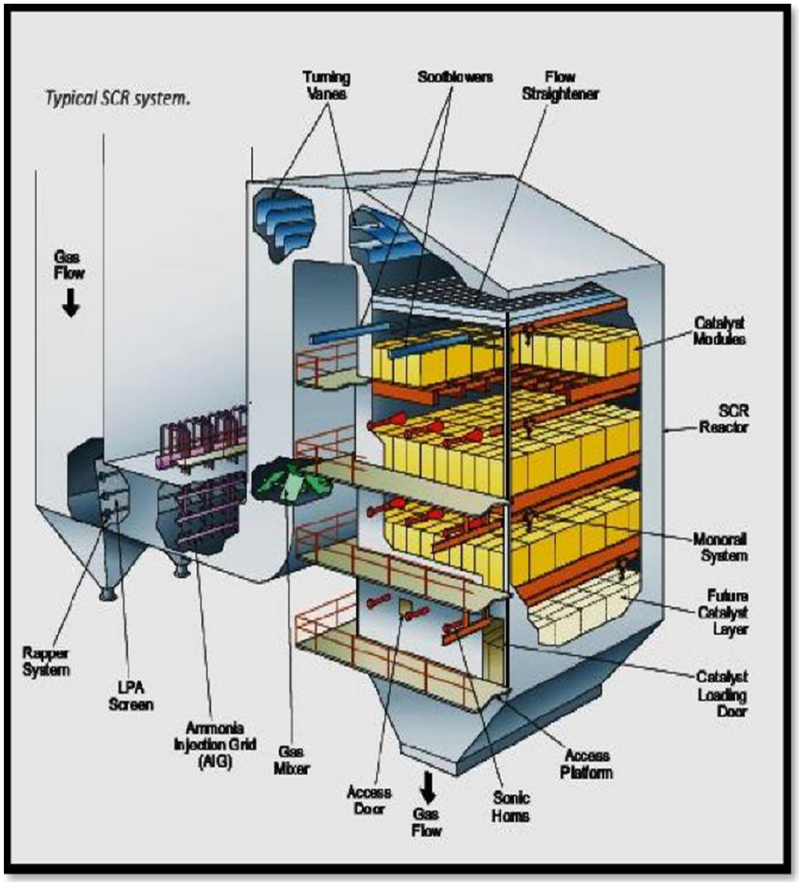
Low Dust

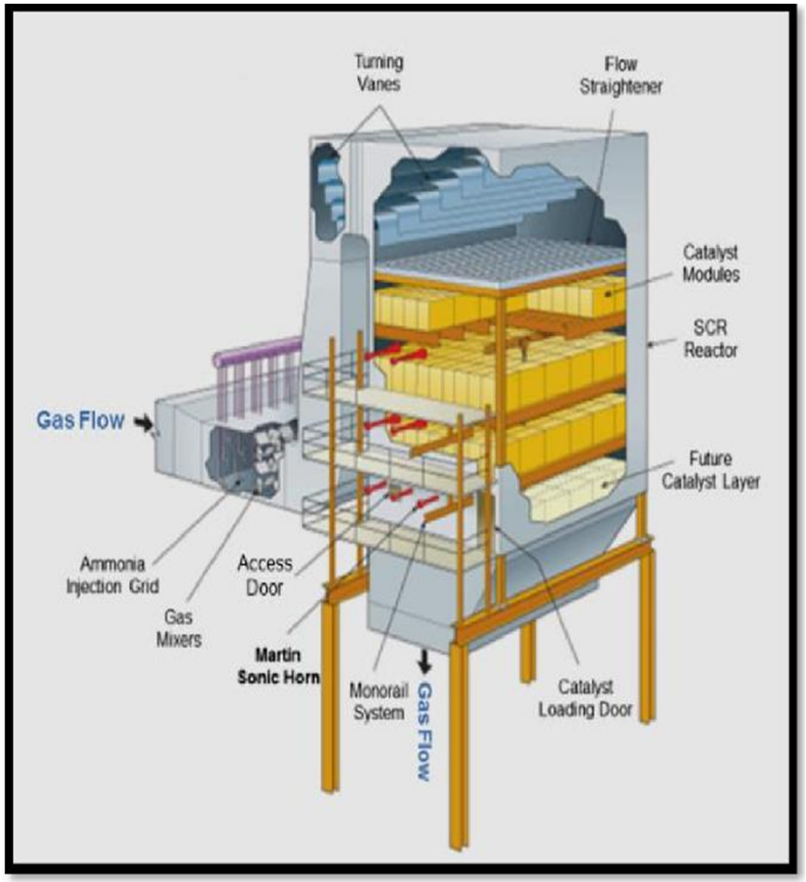


Tail End



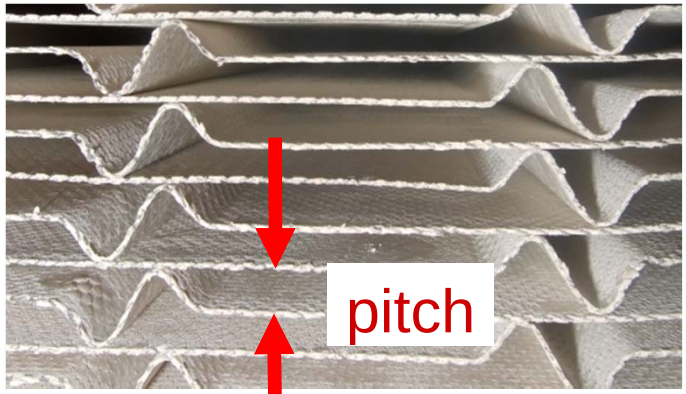
SCR Reactors

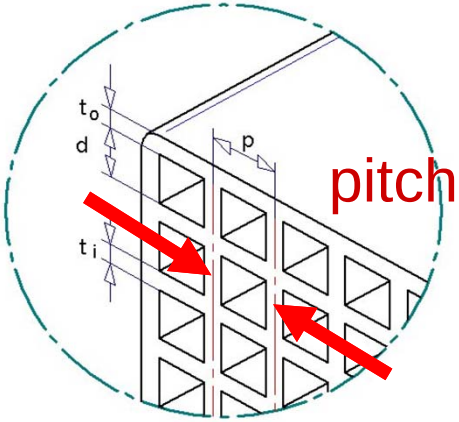




- *Higher Capex & Moderate Opex.*
- *Relatively longer installation time.*
- *SCR may not be necessary for retrofit units in view of relaxed emission norms.*

Comparison Plate – Honeycomb Catalyst





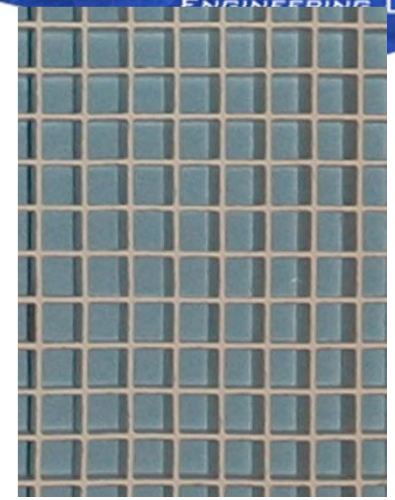


Plate Type Structure

- Flexible Plates With Notches to Maintain Pitch
- Large Rectangular Openings
- High Void Fraction (>85%)
- Pitch: ~5 to 7 mm

Honeycomb Structure

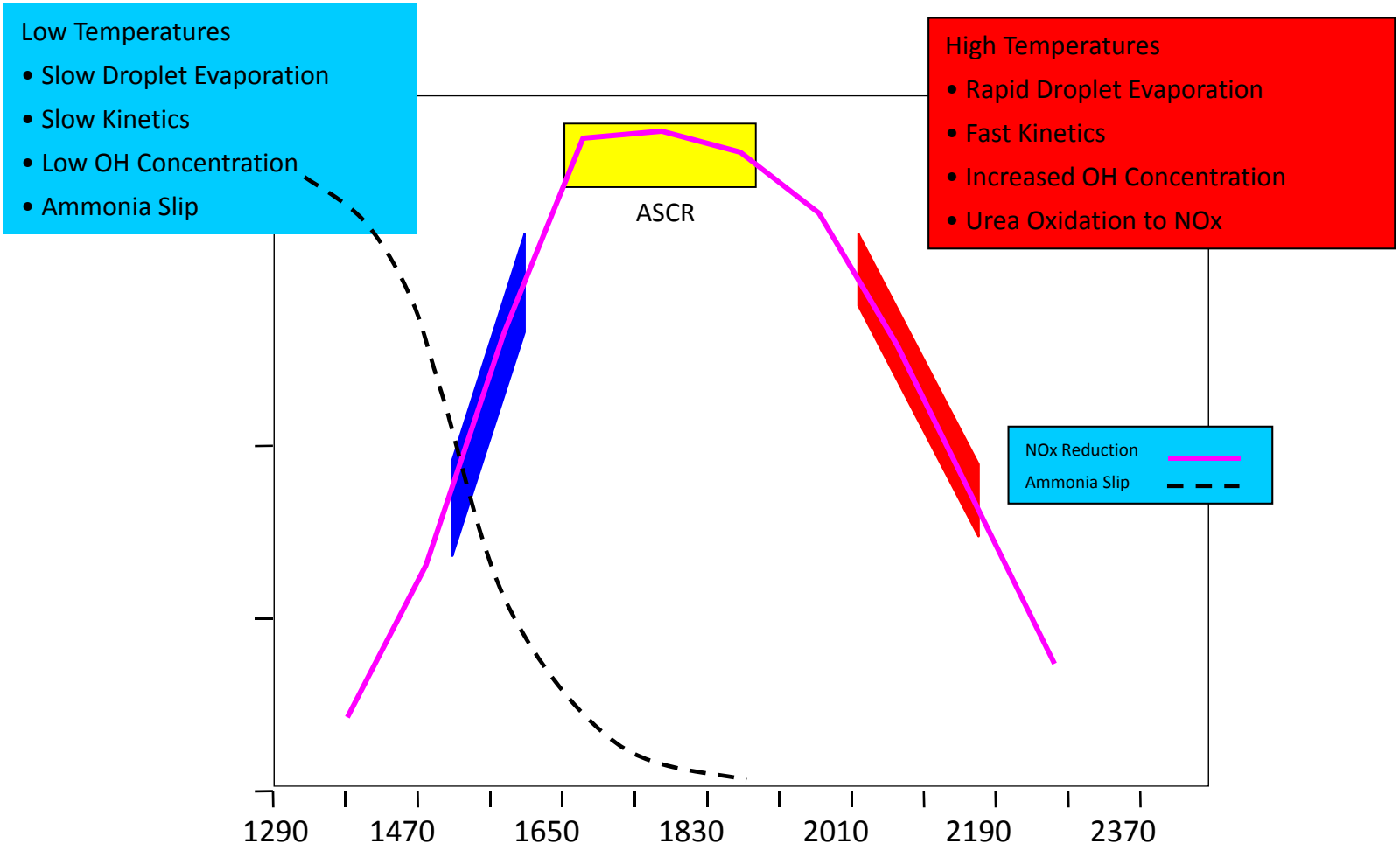
- Rigid Structure
- Square Openings/Increased Surface Area
- Void Fraction >75%
- Pitch: 7 to 10 mm (for coal-fired applications)

Plate type catalyst with conservative pitching is recommended for High Ash Indian Coal

ASCR Technology Presentation

NOx Reduction Technology

Optimized SNCR/ASCR



- *Moderate Capex & Opex*
- *Relatively high shut down time as compared to SNCR.*

China Light & Power – Castle Peak "B"

Project Overview

- Project to reduce NO_x emissions and increase operating efficiency in an existing coal fired power generating facility in Hong Kong

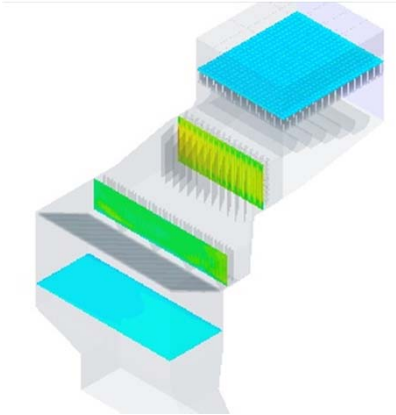
Fuel Type	Bituminous coals
Boiler Type and Size	4 x 685 MW tangential-fired boiler

Problems and Challenges

- Complicated duct run that involved numerous sharp turns
- Limited space for Ammonia Injection Grid (AIG) and mixing devices.
- Limited space for reactor requires very high velocity through the catalyst, increasing chance of erosion failure and requiring extremely even and vertical gas flow.
- System needed to be designed to handle a range of coals with variable ash loading, sulfur content and NO_x baselines

Fuel Tech Solution / Approach

- Utilized CFD modeling to predict gas flows, operating temperatures, velocities and other critical variables
- Single layer SCR installed in the existing ductwork, and an AIG was installed and located in the cavity of the economizer
- Patented Graduated Straightening Grid was used to provide optimally distributed and uniform gas velocities into the catalyst



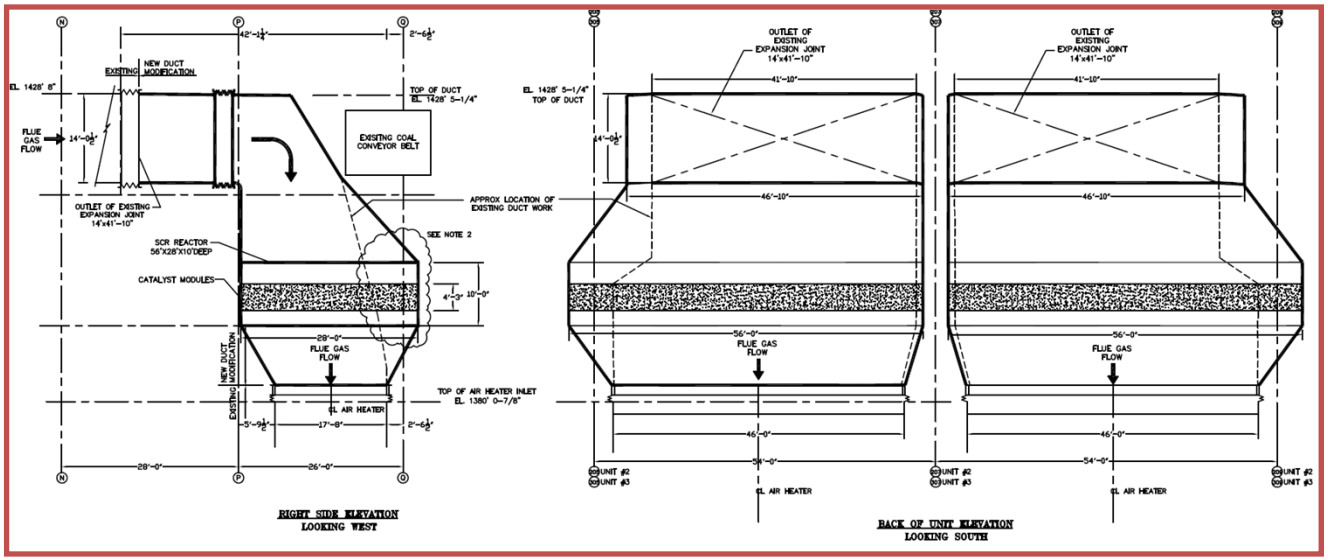
Computational and Experimental Fluid Dynamics Models

Results

- Single layer of catalyst provides ~8,000 hours of catalyst lifetime
- NOx removal efficiency varying from 40% at the beginning and 30% at the end of life
- Reactor is designed for 7.5 m/s catalyst face velocity

Next step – ASCR feasibility

- Evaluate Ductwork and Spacing between Economizer Outlet to Air Heater Inlet
- Evaluate Operating and Ash Conditions
- Space Available for Single Layer of High Performance Catalyst



DeSOx Technologies

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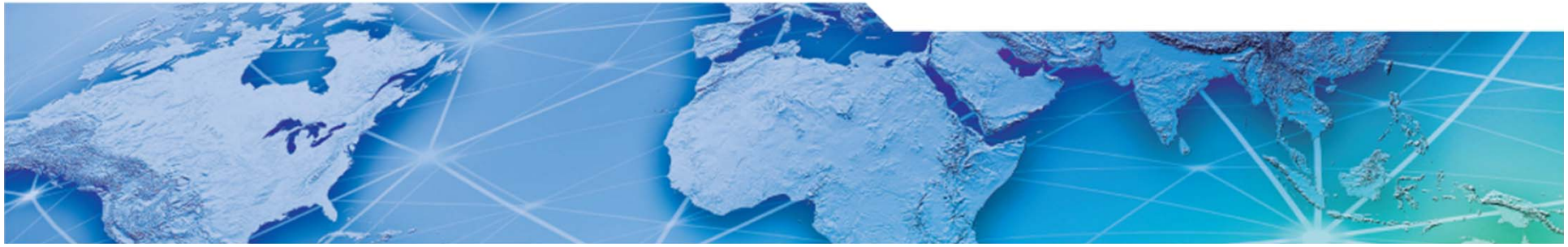

DeSOx Technologies – AFBC/CFBC Boilers

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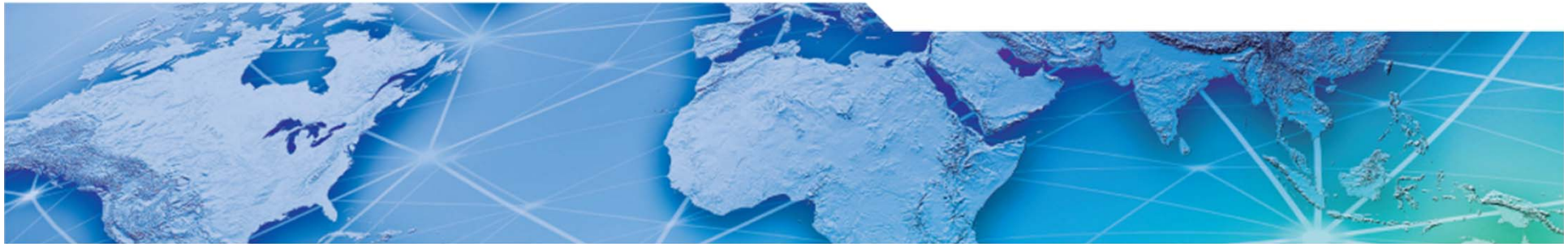


Lime Stone Feed System

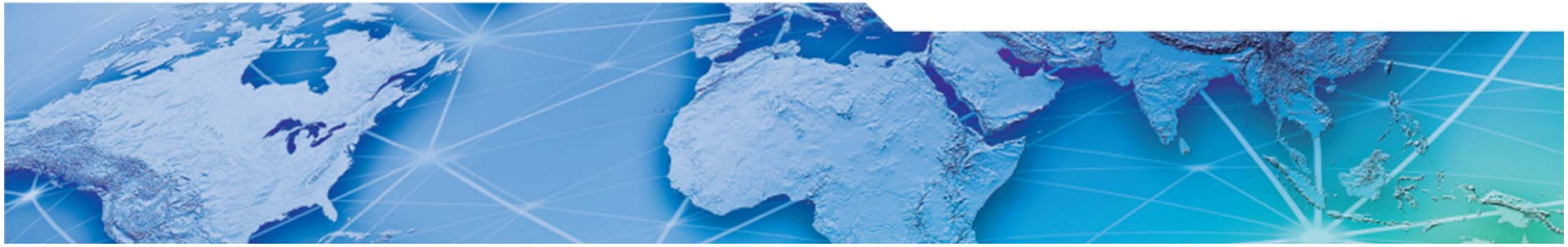
Crushed Limestone is fed either pneumatically or mechanically into the CFB and AFBC boiler.

- The pneumatic system feeds the Limestone directly into the furnace through furnace openings.
- In the mechanical system, the Limestone is fed along with fuel through fuel feeders into the furnace.

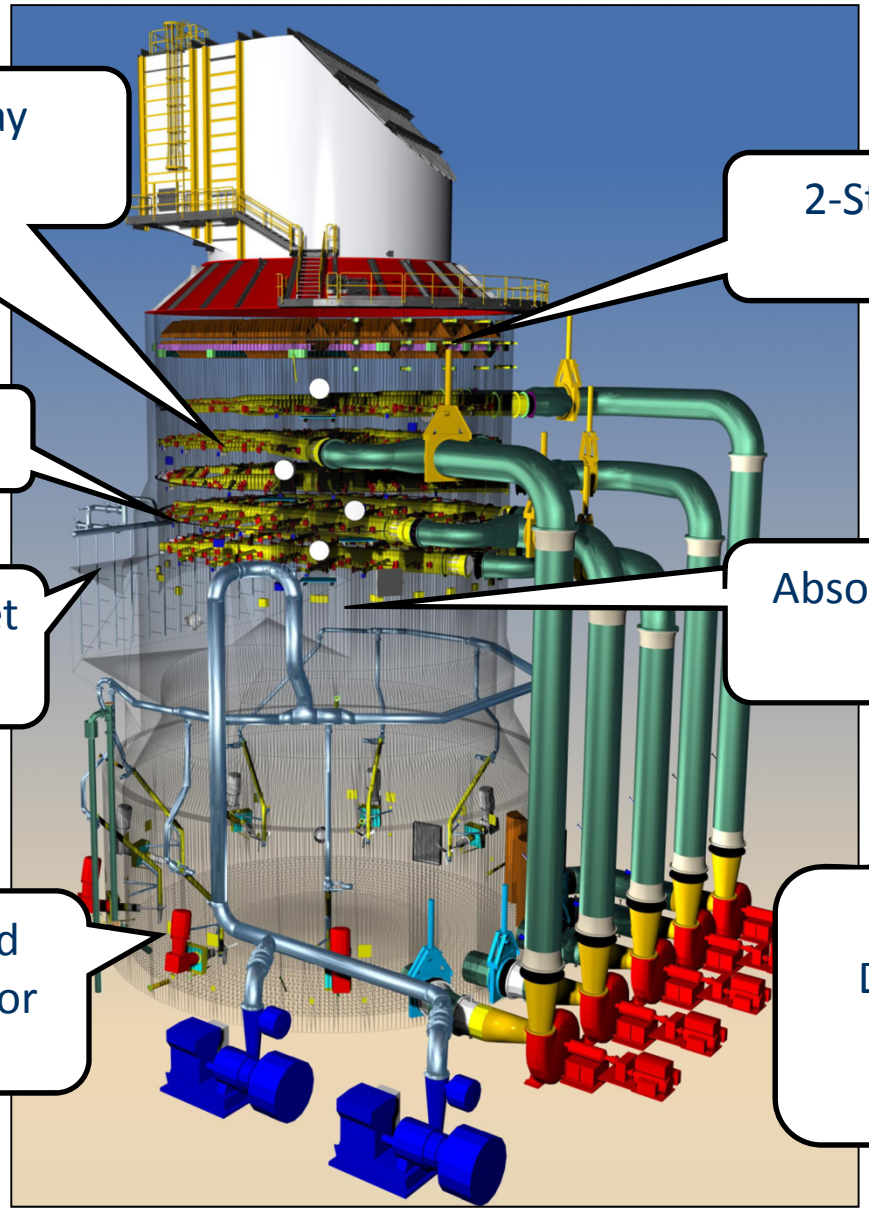
System Requirement for Lime Stone Feeding

- Limestone Preparation – To ensure required particle size.
- Conveying System from preparation plant upto Lime Stone Storage Bunker.
- Lime Stone Storage Bunker near Boiler.
- Conveying system from Bunker to Furnace, as applicable.
- Opening in Furnace
- SOx analyzers (part of CEMS)
- Control Logics – to be incorporated in existing DCS

Wet Flue Gas Desulphurization Technology



Wet Limestone based FGD



Bi-Directional Spray Nozzles

2-Stage Internal Mist Eliminator

Wall Ring

Absorber Inlet and Inlet Awning

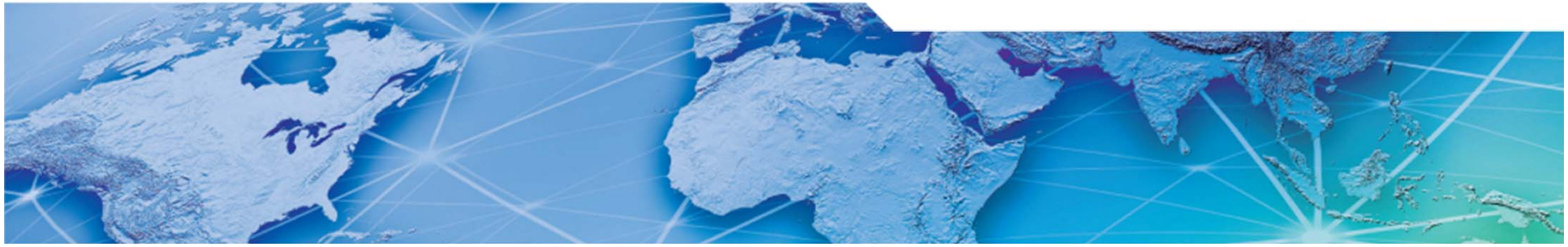
Absorber Design Greater Than 500 MW

Reaction Tank forced oxidation with agitator

Experience with Designing Systems to Treat Flue Gas from Multiple Units

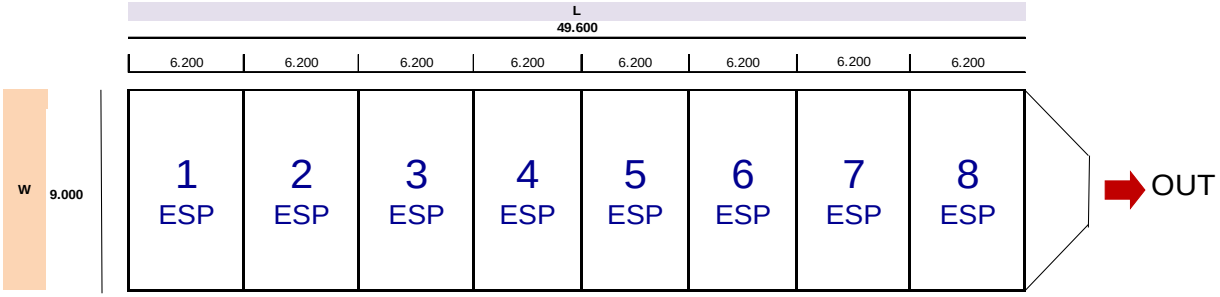
Dry Injection Desulphurisation (DID) Technology

Isgec Redecam Enviro Solutions



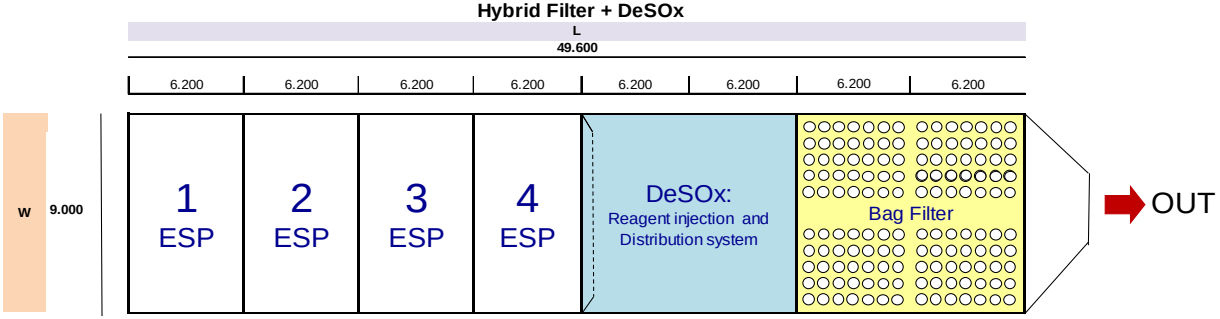
Case Study 1 – 2x210 MW PC Boilers

Existing ESP



Field Inlet Dust	70.000	21.000	6.300	2.520	1.134	737	479	335	255	Outlet Dust
Recovered Dust (mg/Nm3)	49.000	14.700	3.780	1.386	397	258	144	80	(mg/Nm3)	
Recovered Dust (kg/hr)	**13.046**	**3.914**	**1.006**	**369**	**106**	**69**	**38**	**21**	**(kg/hr)**	
Field Efficiency	70%	70%	60%	55%	35%	35%	30%	24%		

Hybrid Filter + DeSOx



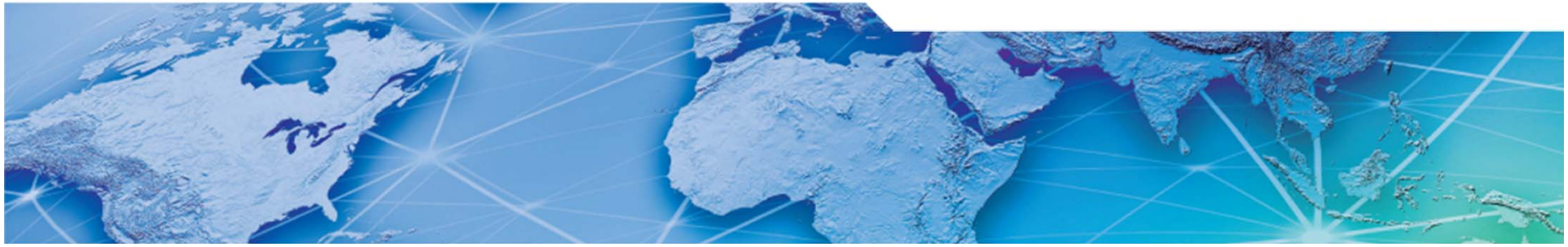
Field Inlet Dust	70.000	21.000	6.300	2.520	1.134	7.894	10	Outlet Dust
Recovered Dust (mg/Nm3)	49.000	14.700	3.780	1.386	-6.760	7.884	(mg/Nm3)	
Recovered Dust (kg/hr)	**13.046**	**3.914**	**1.006**	**369**	**-1.800**	**2.099**	**(kg/hr)**	
Field / BF Efficiency	70%	70%	60%	55%		99,87%		

(*) Ca(OH)2 Injection (worst case).

- *Low Capex & Higher Opex as compared to Wet FGD technology.*
- *Best suited for units where space is a constraint.*
- *No need for wet stack*
- *SO3 can be controlled efficiently.*

Redecam Dry Scrubber (RDS) Technology

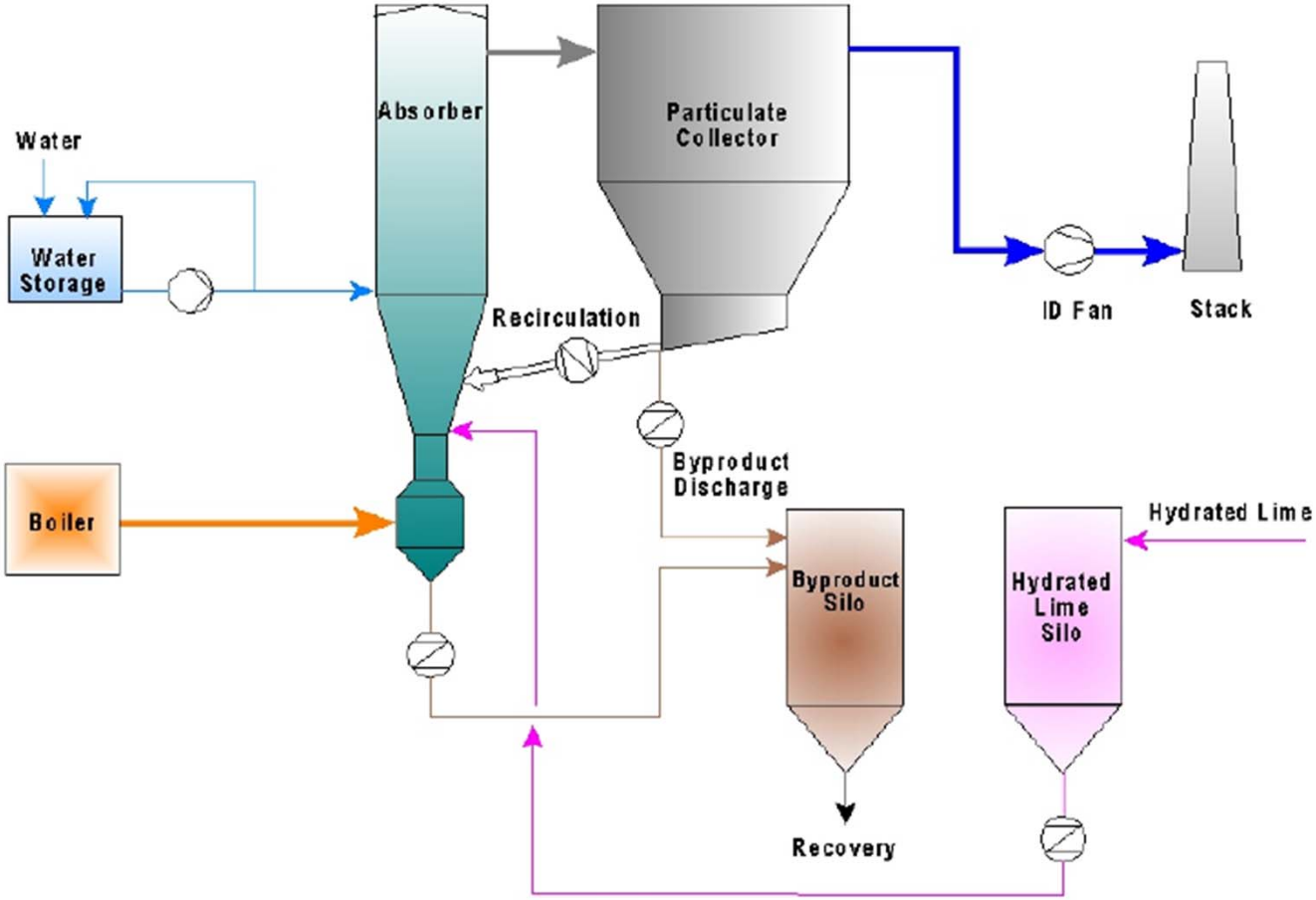
Isgec Redecam Enviro Solutions



Redecam Dry Scrubber (RDS)

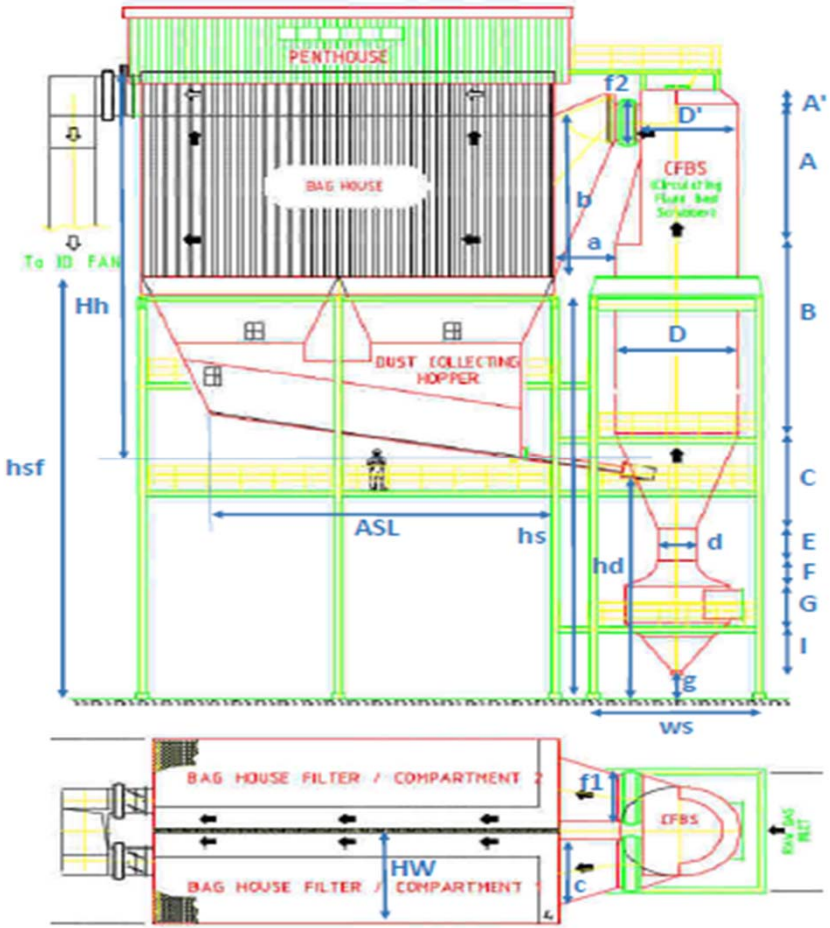
MAIN FEATURES

- Circulating fluidized bed principle
- Separate water spraying
- Low fineness hydrated lime
- Molar ratio Ca/S 1.3 to 1.5

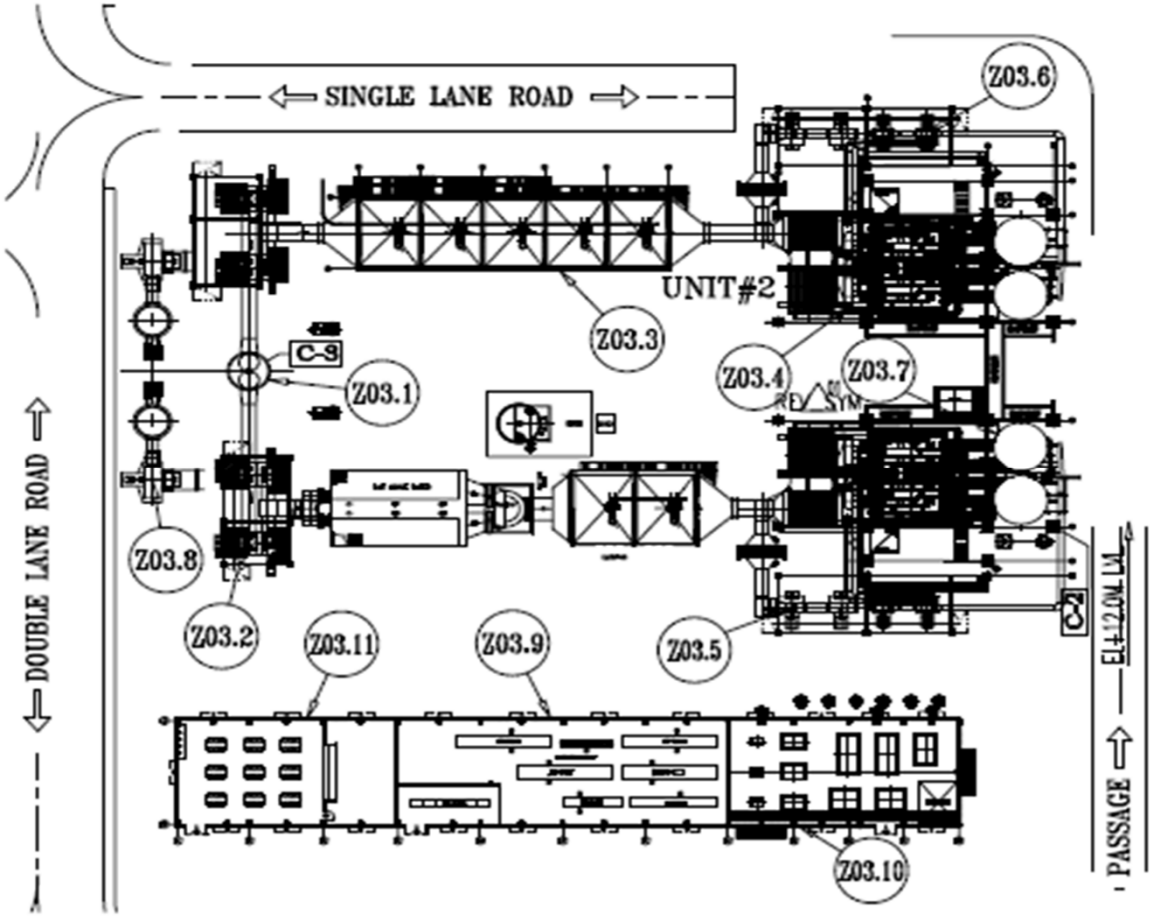


RDS: Major Components

1. REACTOR
2. REAGENT INJECTION SYSTEM
3. WATER INJECTION SYSTEM
4. BAG FILTER
5. DUST RECIRCULATION SYSTEM
6. DUST EVACUATION SYSTEM
7. FLUE GAS DUCTING
8. COMPRESSED AIR SYSTEM



Case Study: 2x20 MW AFBC Boilers



- *Suitable for higher SOx capture efficiency with respect to DID.*
- *Minimum modification in existing chimney as wet stack is not necessary.*
- *Best suited for units where wet FGD cant not be installed due to space constraint.*

Particulate Matter Emission Control Technologies

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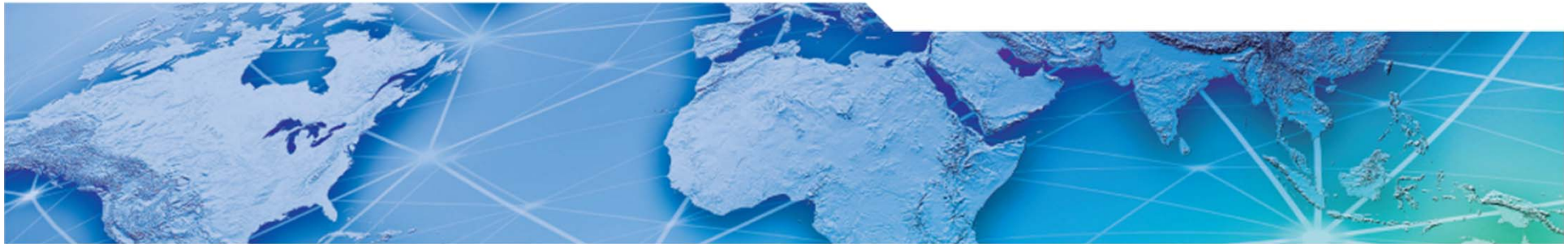

ESP Performance Improvement by Flue Gas Conditioning

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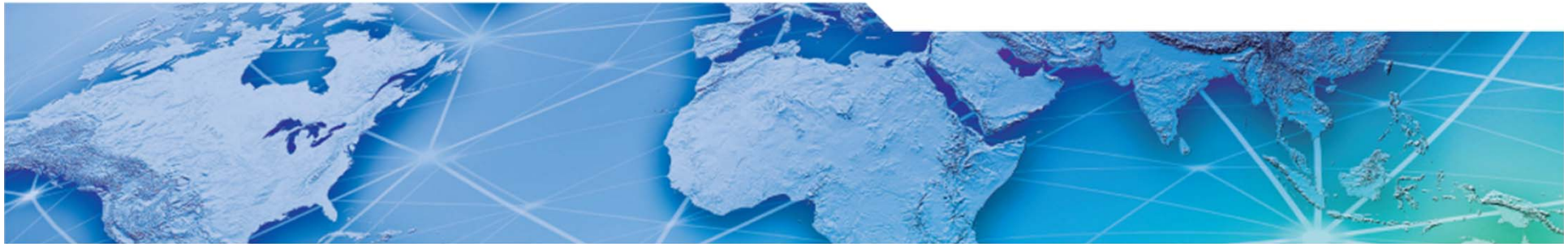
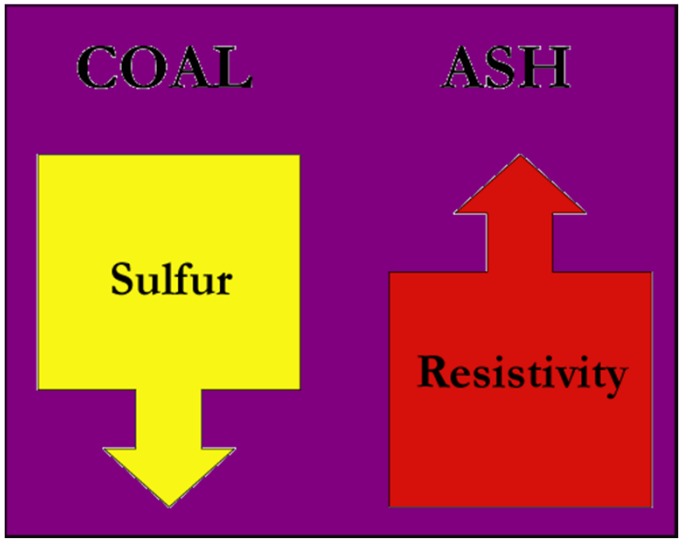


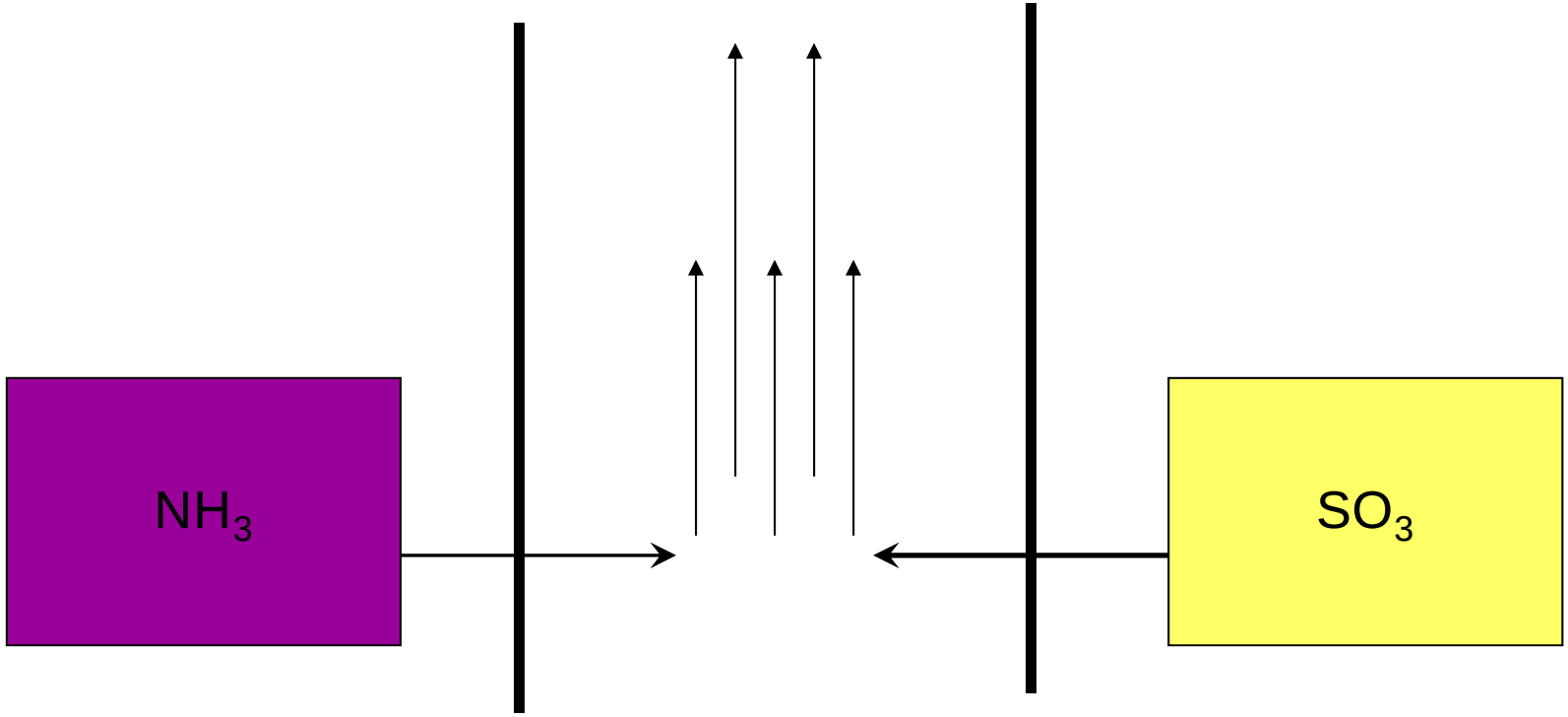
Flyash Resistivity vs. Sulfur in Coal

- Cold side ESPs are primarily affected by sulfur content of the coal being burned
- Other constituents can also play a role in affecting ESP performance (i.e. flue gas temperature, moisture in ash, % ash in coal, and carbon in fly ash)
- Injection of SO3 in to flue gas reduces ash resistivity and thereby improves capture efficiency



Dual Flue Gas Conditioning

A dual flue gas conditioning system simultaneously and independently injects two conditioning agents, SO_3 and NH_3, into the flue gas upstream of ESP.

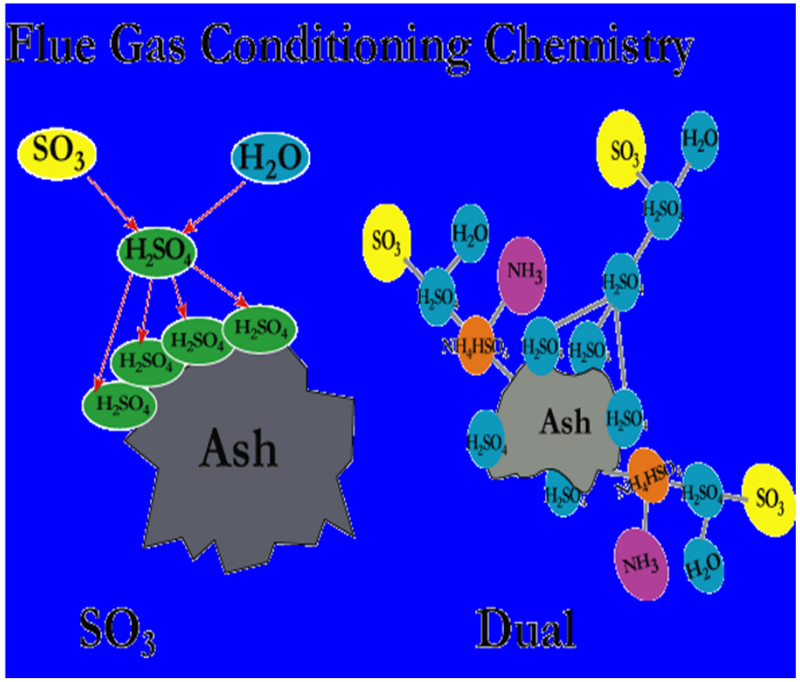


Dual Flue Gas Conditioning

Why Add NH_3 to the Flue Gas?

The injection of NH_3 promotes improved utilization (uptake) of the SO_3, resulting in more effective resistivity control.

DFGC will require least shut down time.



ESP Performance Improvement by HFPS Implementation

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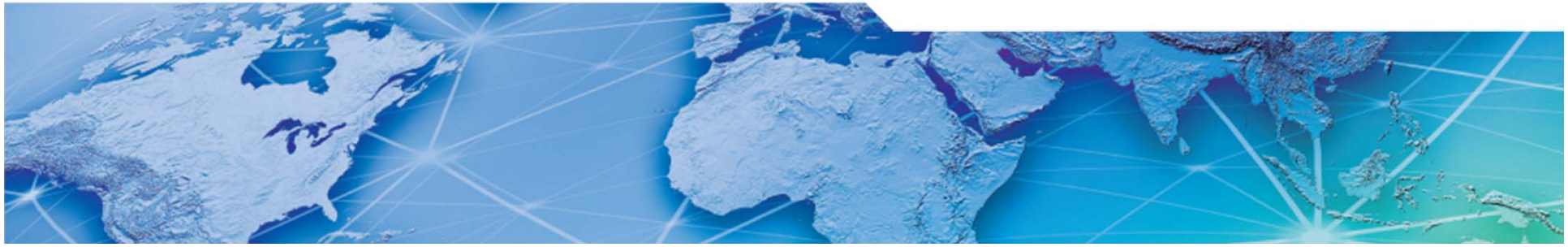

PowerPlus™ vs. TR Sets

POWERPLUS

TR SETS

- Low Capex and Opex.
- Low installation time.

FGC+HFPS – Feasibility Studies Conducted on Indian Plants

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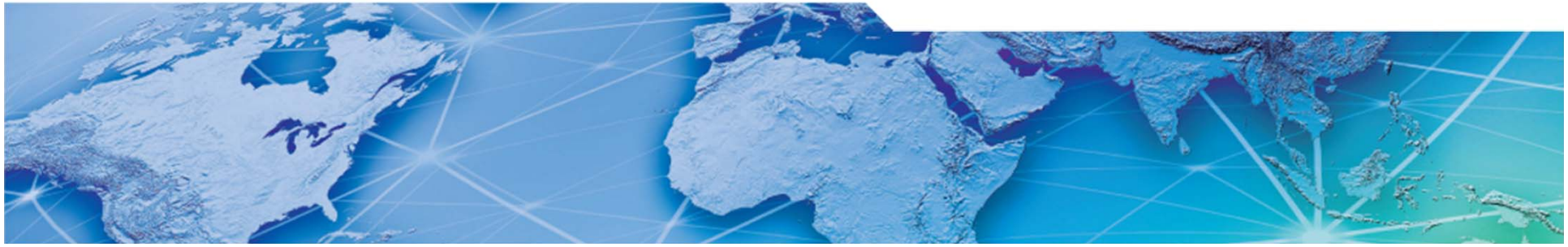
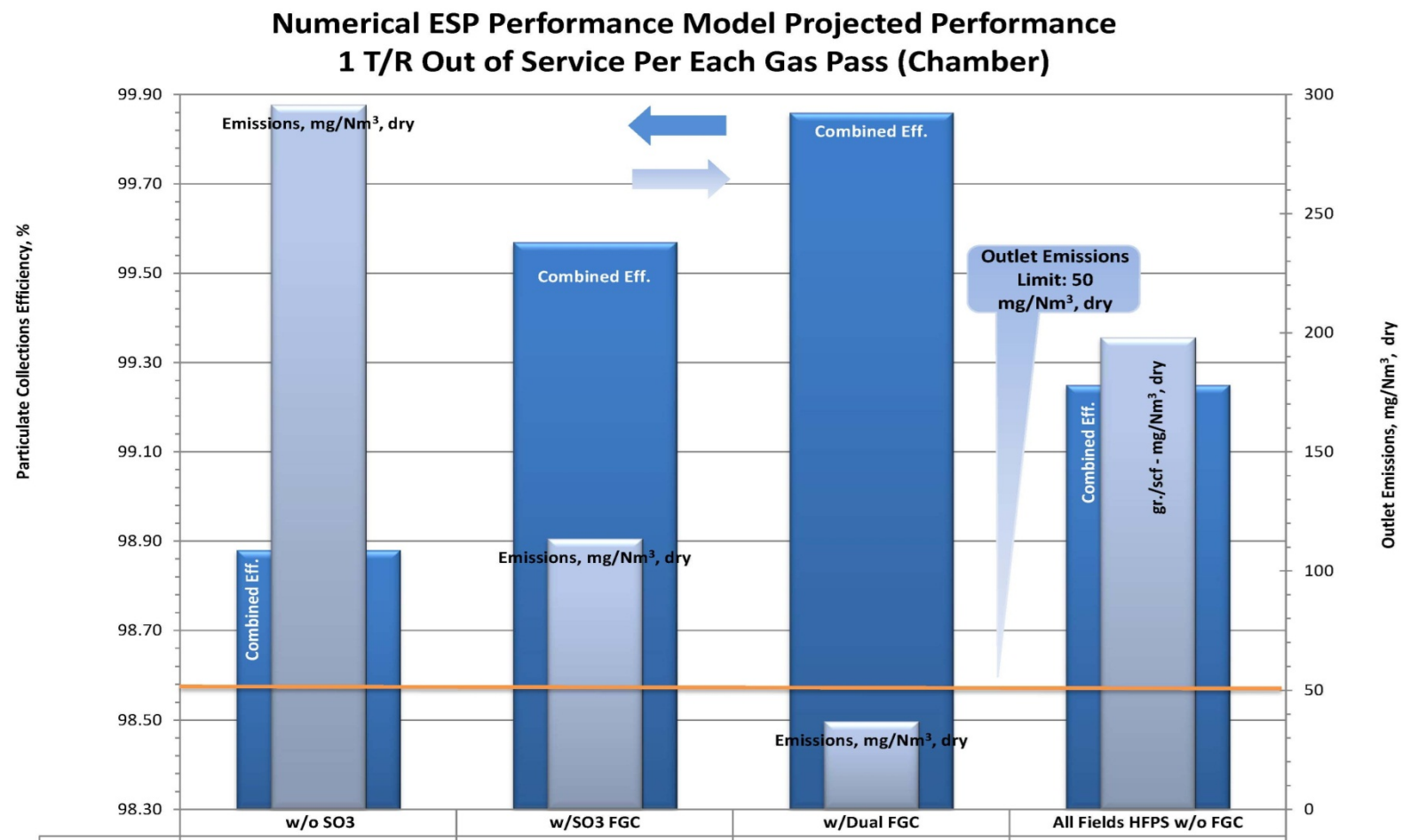
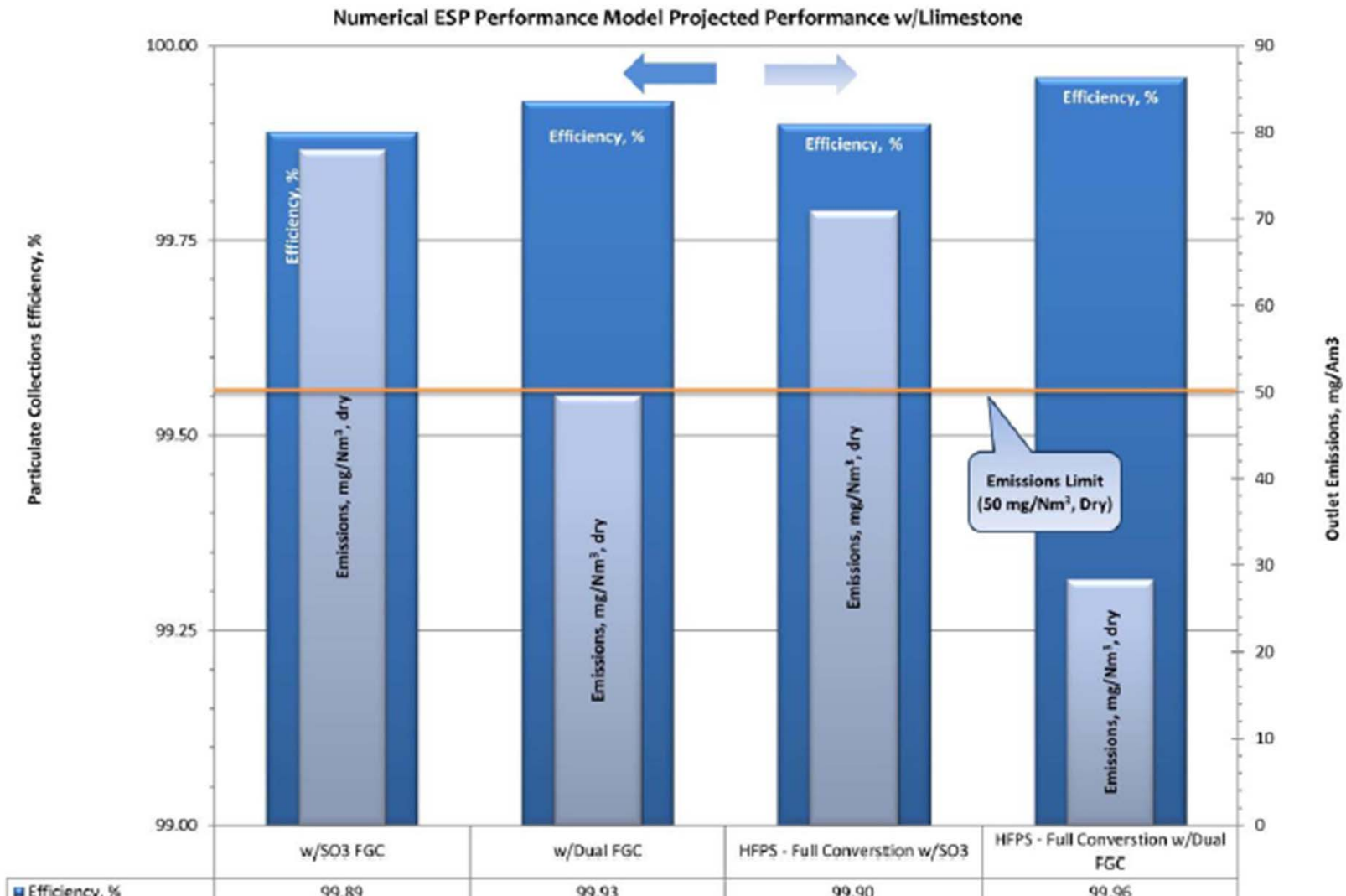


Case Study of 5x660 MW



	w/o SO3	w/SO3 FGC	w/Dual FGC	All Fields HFPS w/o FGC
Combined Eff.	98.88	99.57	99.86	99.25
mg/Nm3, dry	295.84	113.58	36.98	198.11

Case Study - 140 TPH CFB Boiler



	w/SO3 FGC	w/Dual FGC	HFPS - Full Converstion w/SO3	HFPS - Full Converstion w/Dual FGC
Efficiency, %	99.89	99.93	99.90	99.96
Emissions, mg/Nm3, dry	78.10	49.70	71	28.40

Thanks!!!!

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