MITSUBISHI HITACHI
POWER SYSTEMS

MHPS's State of Art AQCS Technologies for Indian Power Plants

MITSUBISHI HITACHI POWER SYSTEMS, LTD.

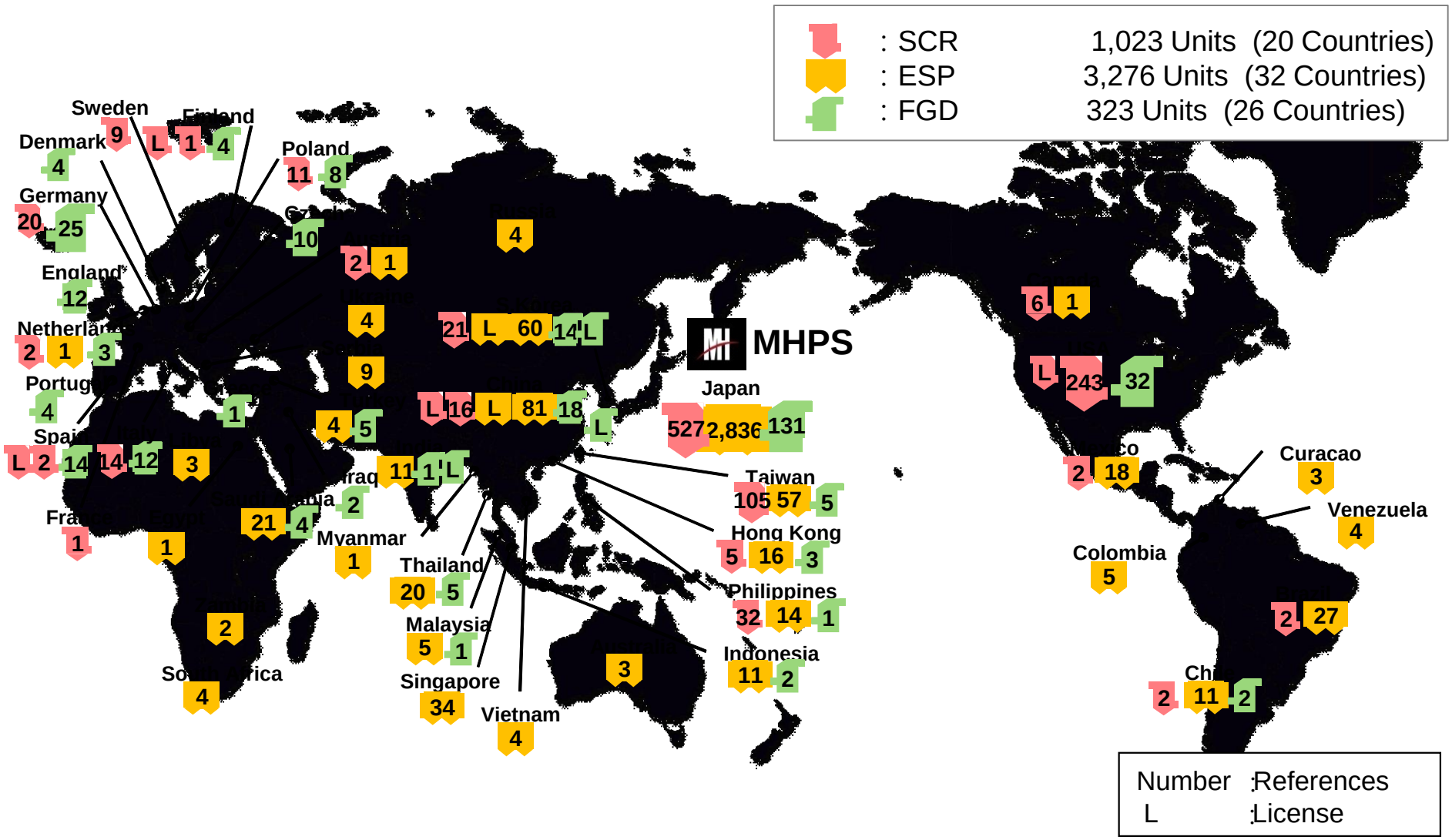
New Environmental Regulation announced on 7th Dec 2015

	TPP installed before 31 December 2003		TPP installed after January 2004 up to 31st December 2016		New install from 1st January 2017
Capacity	Smaller than 500MW	500MW & Above 500MW	Smaller than 500MW	500MW & Above 500MW	Any Size
Particulate	100mg/Nm^3		50mg/Nm^3		30mg/Nm^3
SO2	600mg/Nm^3	200mg/Nm^3	600mg/Nm^3	200mg/Nm^3	100mg/Nm^3
NOx	600mg/Nm^3		300mg/Nm^3		100mg/Nm^3
Mercury	-	0.03 mg/Nm^3	0.03 mg/Nm^3		0.03mg/Nm^3

- The new regulation may require application of state of art technologies
- MHPS has enough experience to comply with severe requirements in Japan, and MHPS can supply reliable technologies to meet Indian regulation.

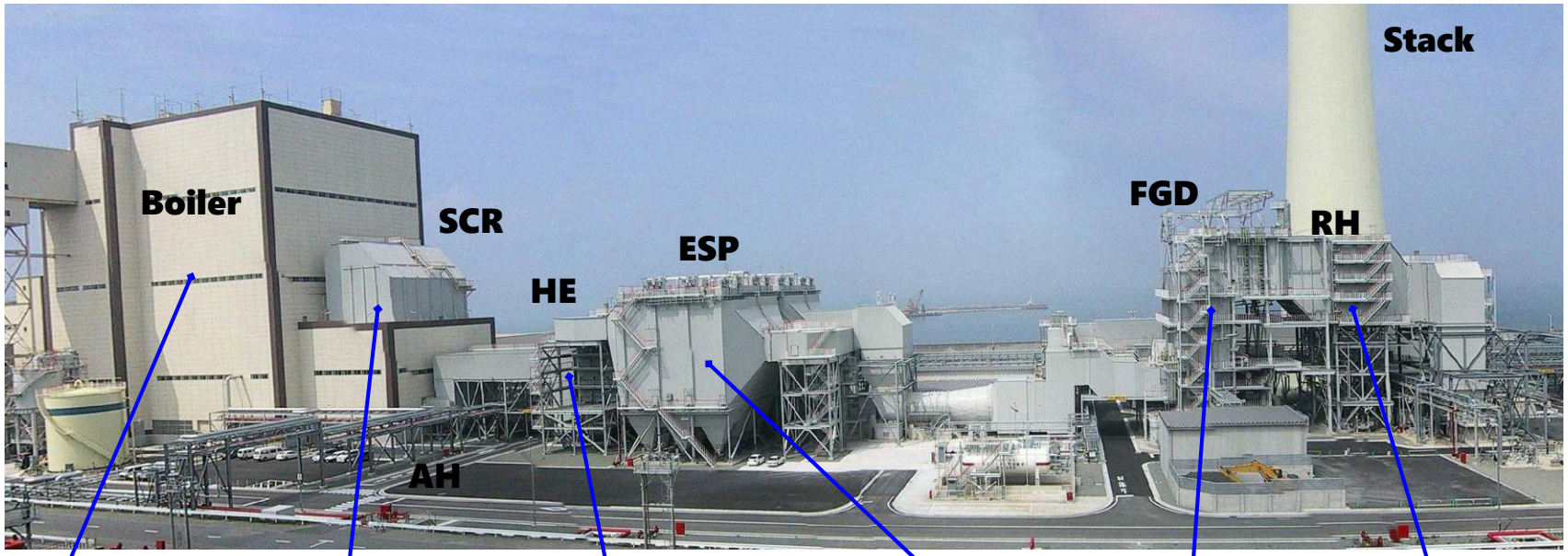
AQCS Worldwide Experiences (ESP and FGD)

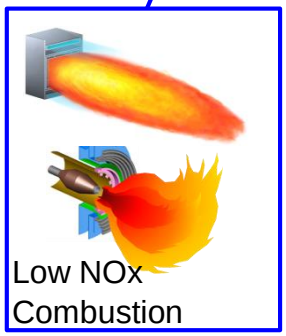
MHPS Delivered AQCS units all over the world

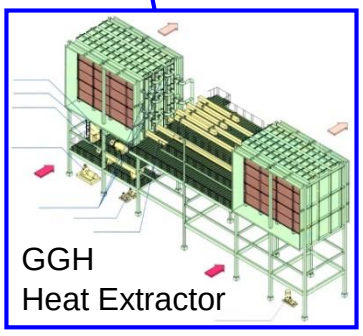


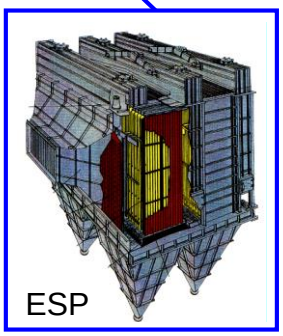
※2015年現在

Air Quality Control System (AQCS) for Coal Fired Plant







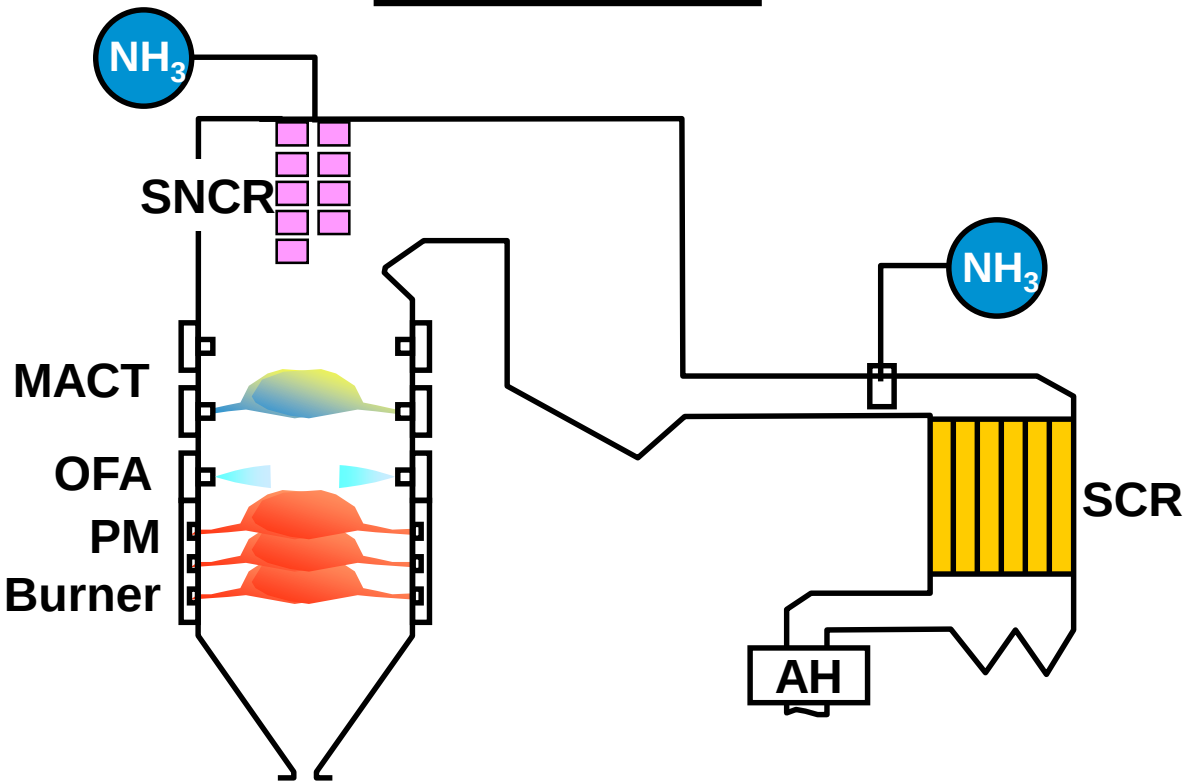


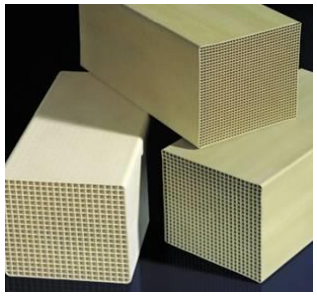
One-stop AQCS solution by MHPS

Latest MHPS SCR Technology

NOx control technologies

- NOx Control Technology
  - Combustion Technology
    - OFA (Over Fire Air)
    - Gas Reciculation
    - Low NOx PM Burner (Pollution Minimum)
    - In-Furnace NOx Removal System (MACT)
  - Post-Combustion Technology
    - Selective Catalytic Reduction (SCR)
    - Selective Non-Catalytic Reduction(SNCR)





Honeycomb Catalyst

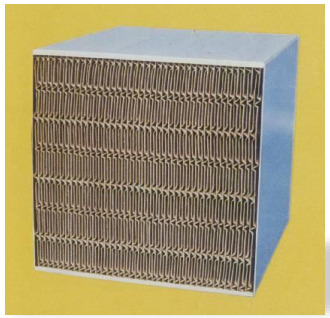
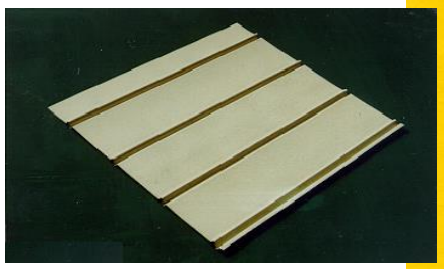


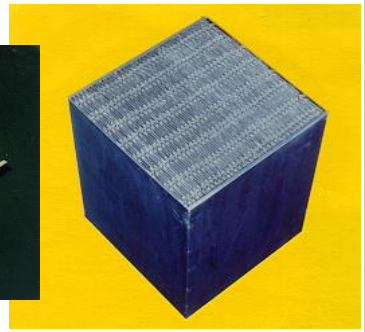
Plate Catalyst

MHPS SCR Features

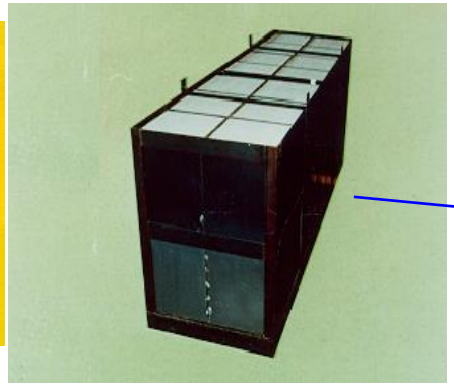
Harmful NOx is decomposed into harmless N_2 and H_2O by catalytic action



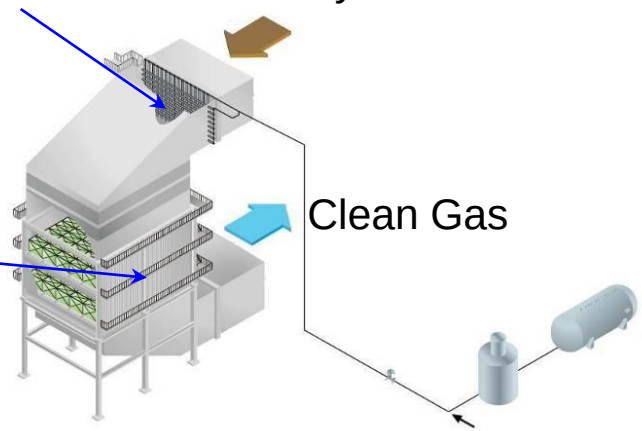
Catalyst



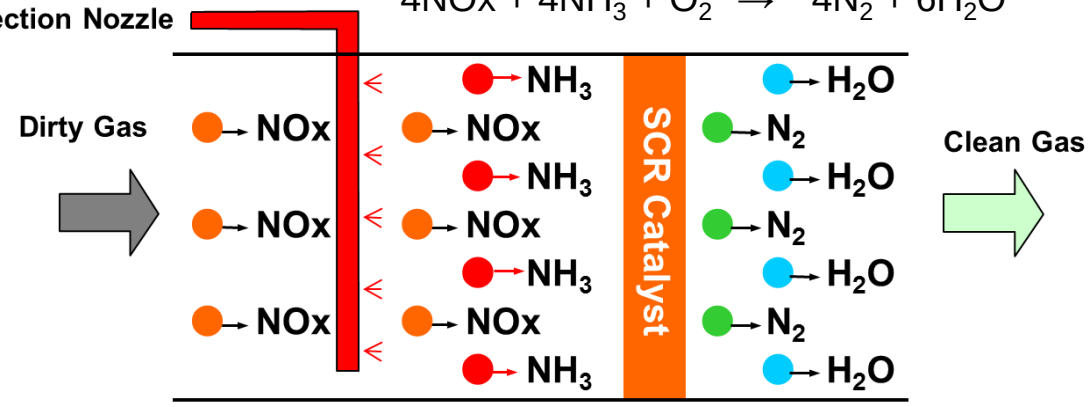
Catalyst Unit
500 x 500 x 500 mm



Catalyst Block



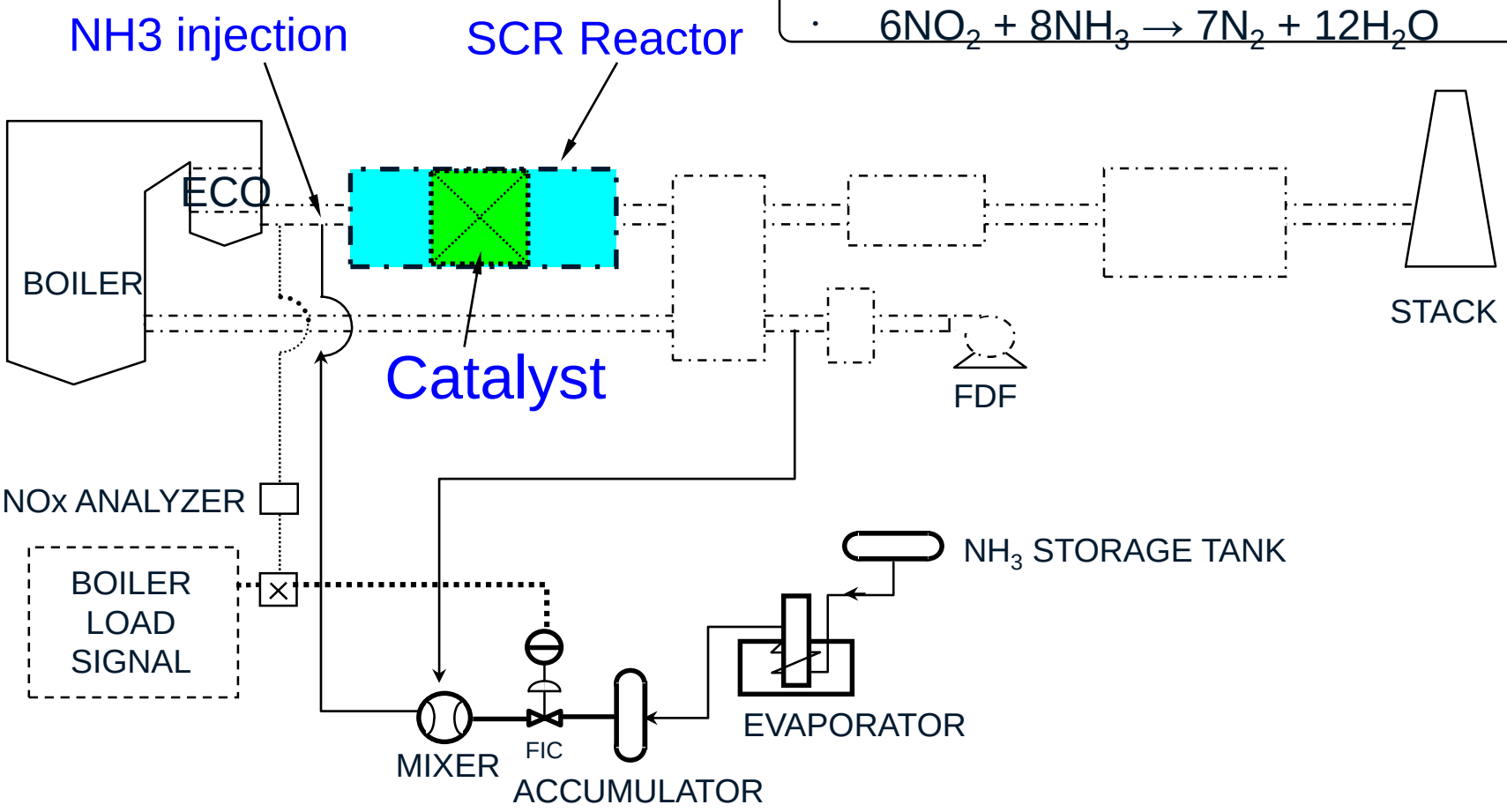
$$4NOx + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$



Typical System Configuration & Main Reaction

REACTION FORMULA

- $4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$
- $NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$
- $6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$

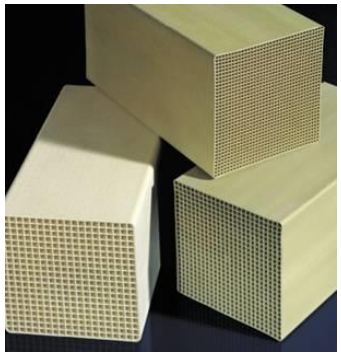


NH3 Storage & Supply

- In-house ‘Knowledge’ and ‘Expertise’ built over 45+ years.
  - Understand complete “Power Island”
  - Understand gas path management
  - Catalyst selection
  - Catalyst management plan
  - Proven track record (*1,023 units*)

- Pioneers and patent holders for SCR systems and catalyst technology.
  - (Plate & Honeycomb type)

SCR General
~ SCR Catalyst Type ~



Honeycomb Catalyst

Honeycomb/Plate cover all applications.

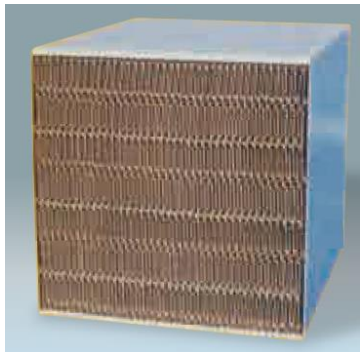
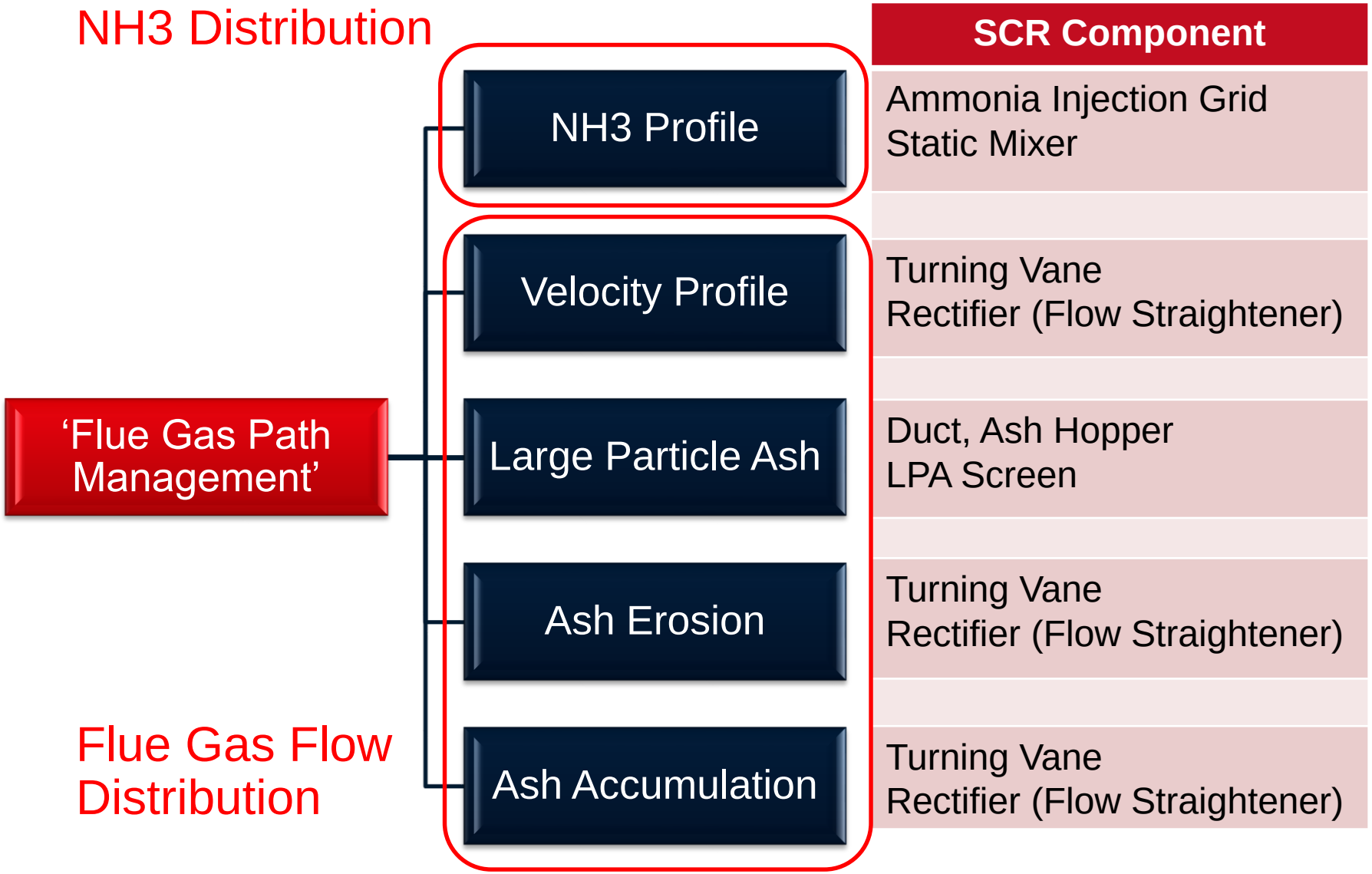


Plate Catalyst

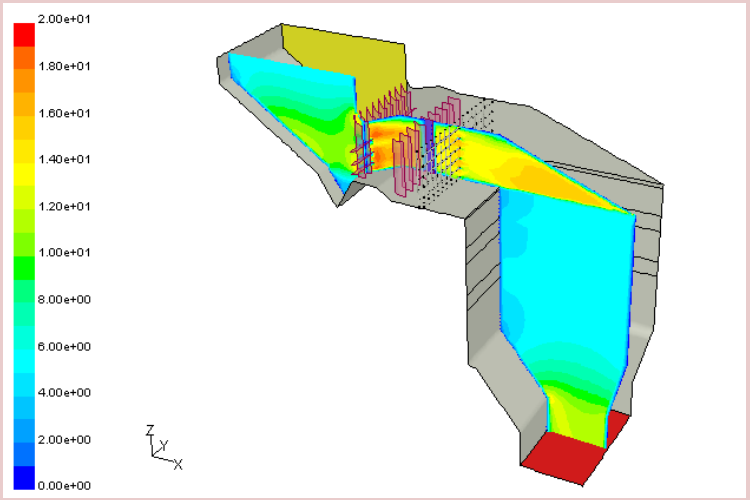
Coal	Low Dust	High Dust
		(High hydraulic diameter)
Gas	High DeNOx	Low DeNOx
Oil	High DeNOx, Less SO_2 Oxidation	Low DeNOx

Best selection of catalyst provides benefit on plant operation and maintenance costs.

Flue Gas Path Management



SCR for High Ash Coal
~ Catalyst Erosion and Plugging Mitigation ~

CFD Analysis	Cold Flow Model Test
	

- Understand flue gas profile.
- Minimize gas angle entering SCR catalyst.
- Minimize velocity maldistribution at catalyst inlet.
- LPA (Large Particle Ash) simulation by CFD.

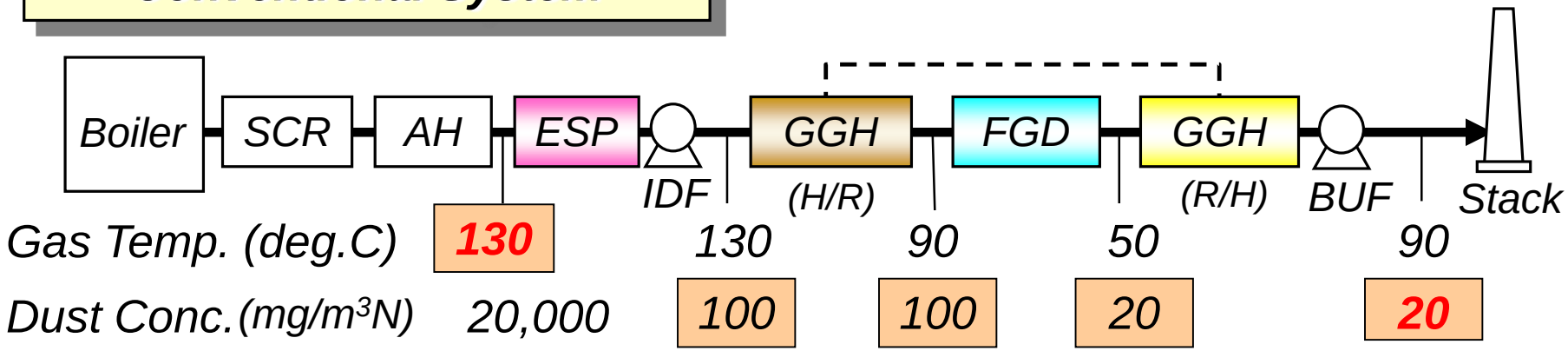
✓ In-house capability of CFD analysis and cold flow model test.

✓ Minimize gas angle and velocity maldistribution by guide vane and rectifier (MHPS patented technology).

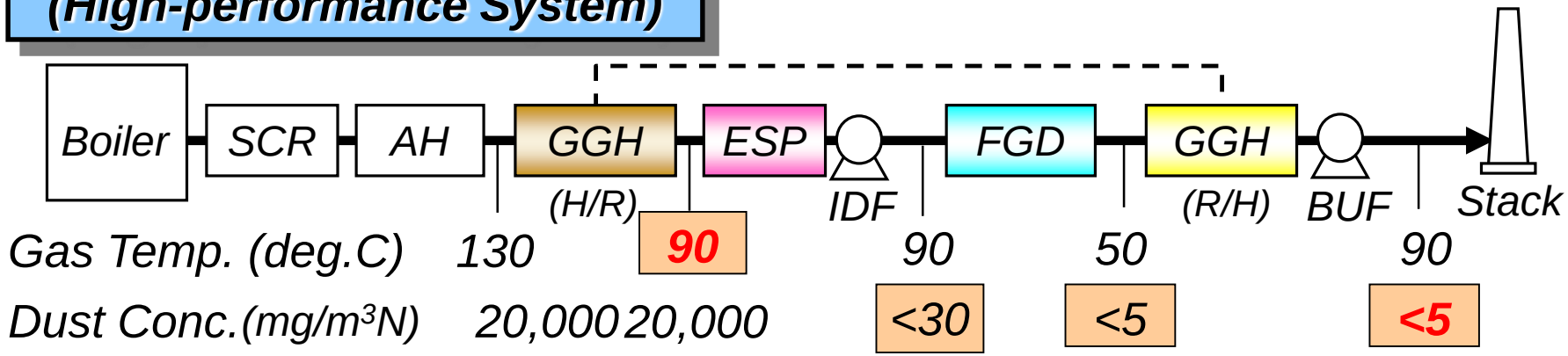
Latest MHPS Technology to Remove Particulate Matter

High-performance PM Removal System

Conventional System



Low-Low Temp. ESP System (High-performance System)

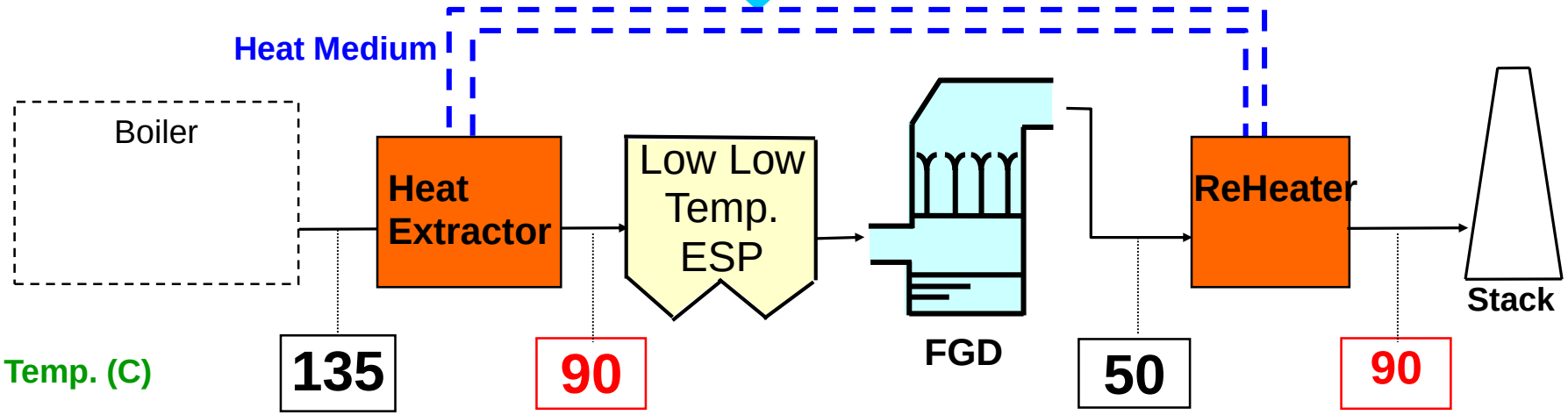


SCR: Selective Catalytic Reduction A/H: Air Heater GGH: Gas-Gas Heat Exchanger
DESP: Dry Electrostatic Precipitator FGD: Flue Gas Desulfurization

High Efficiency SO3 and PM removal Technology

Gaseous SO_3 10 ppm → <1 ppm

Particulate Matter 20,000mg/m³N → ≦5mg/m³N

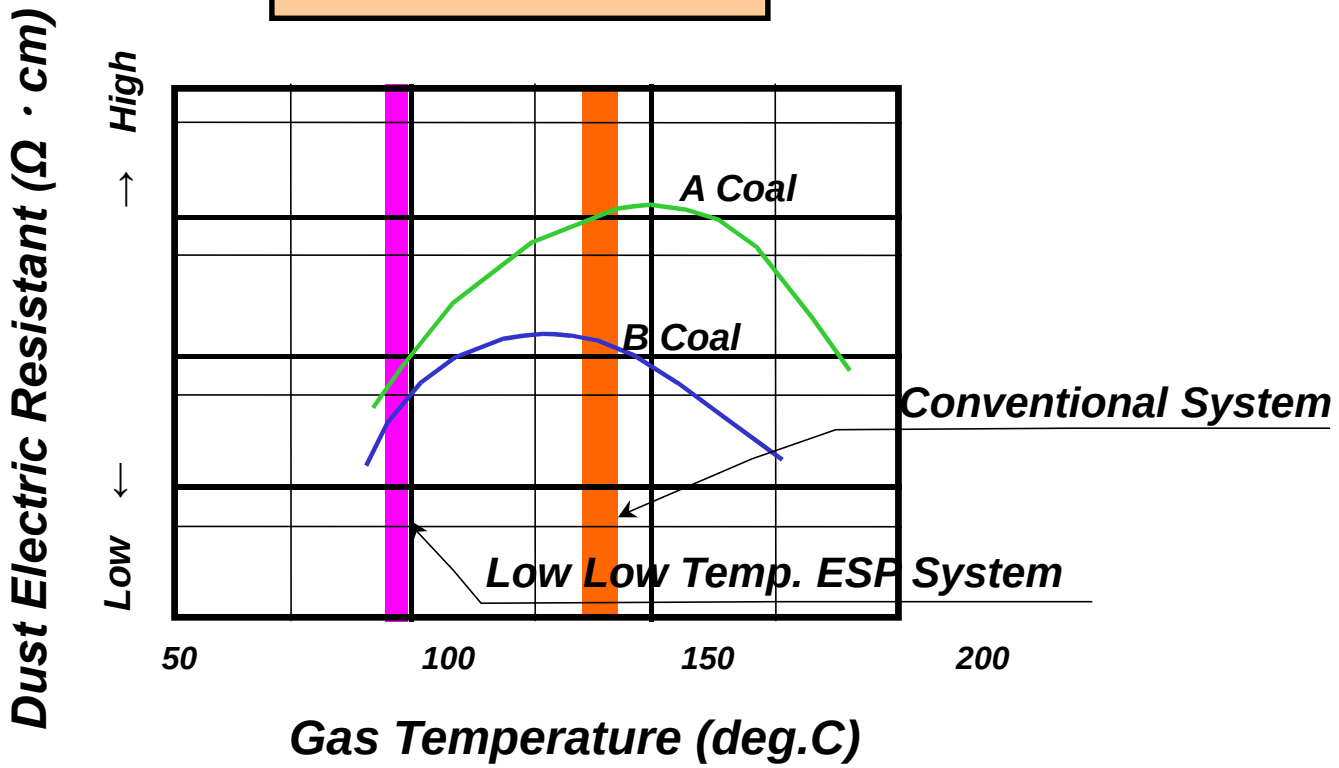


1. SO_3 removal : SO_3 gas is condensed on fly ash
2. Opacity reduction : No plume caused by SO_3 mist at stack
3. High PM removal performance at ESP : Gas temperature reduction
4. Water consumption saving at FGD : Gas temperature reduction

Effect of Gas Temperature on PM Removal

Decrease of ESP Inlet Gas Temp. → *Decrease of Dust Electric Resistant* → *Improve of ESP Performance*

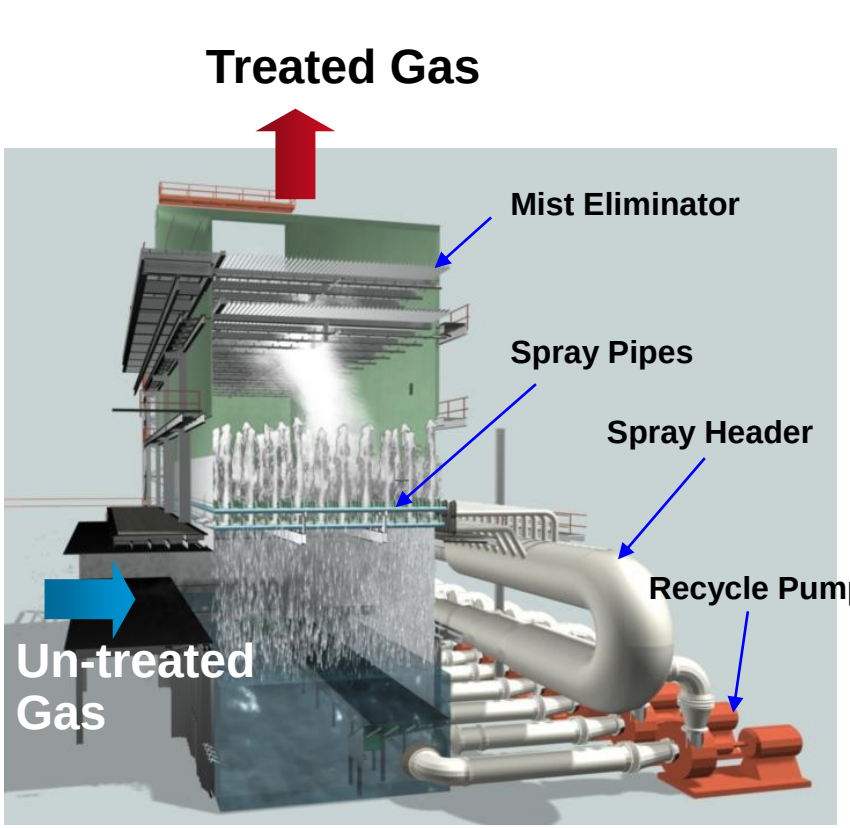
Decrease of Gas Volume →



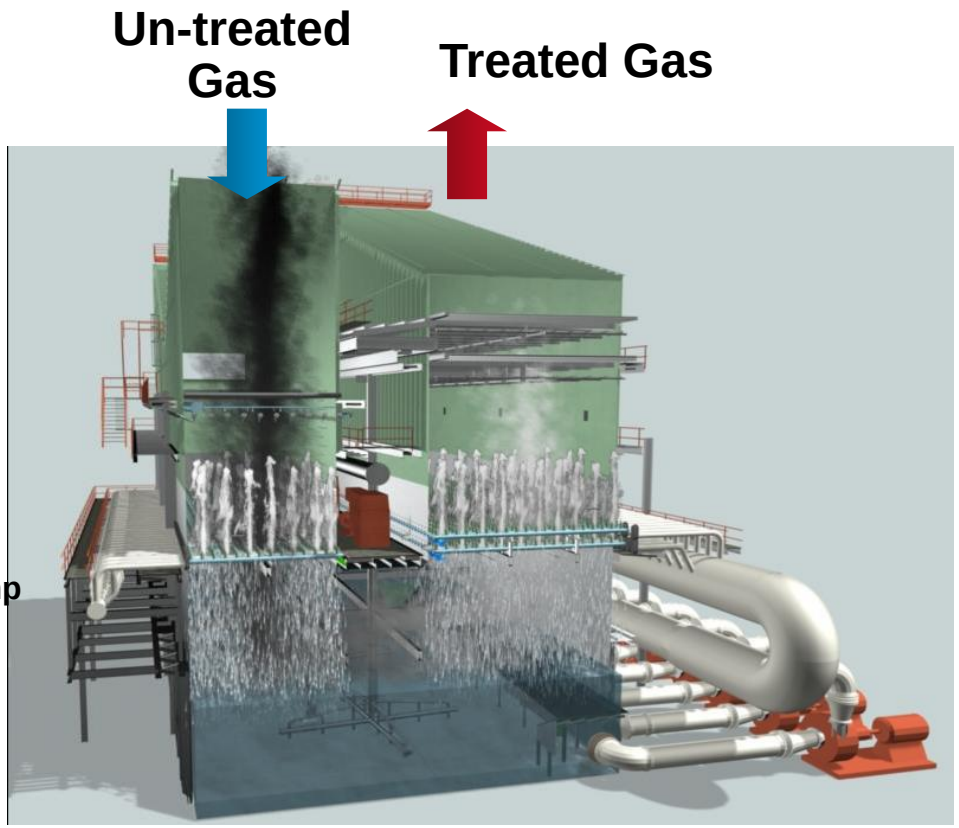
Latest MHPS FGD Technology

Wet Limestone-Gypsum process ; DCFS-type Absorber

DCFS ; Double Contact Flow Scrubber



Single Tower DCFS

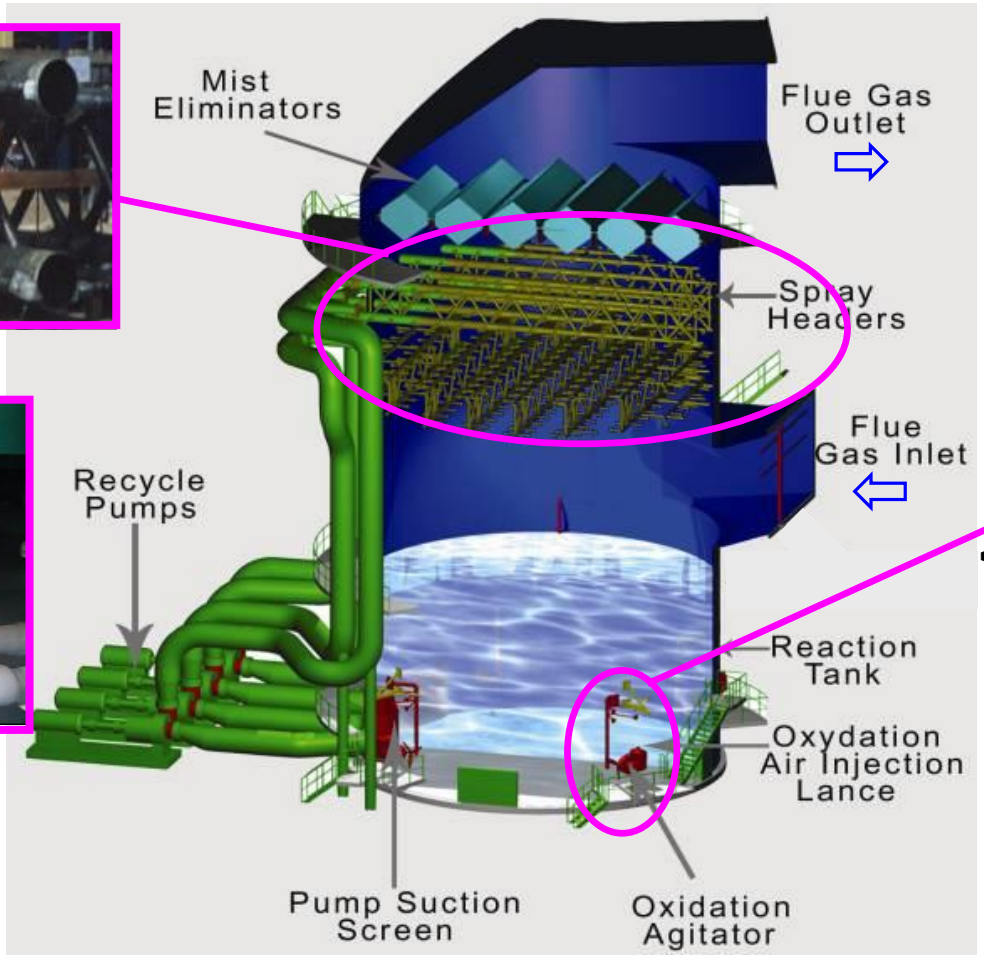


Twin Tower DCFS

Wet Limestone-Gypsum process ; Open Spray-type Absorber

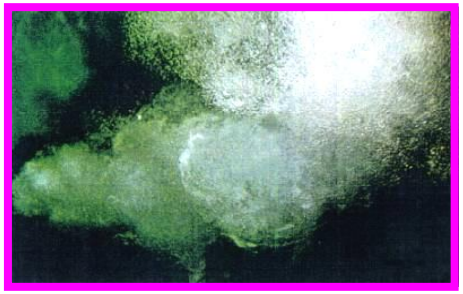
<Spray Header>

<Spray Nozzles>



<Oxidation Agitator>

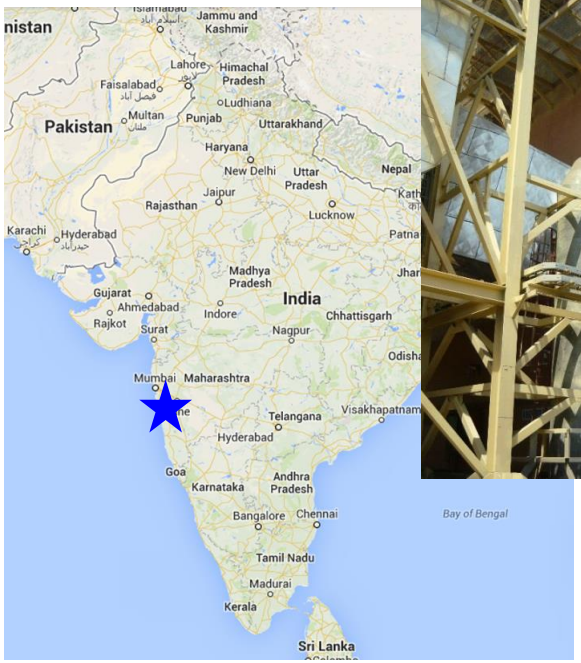
<Air Dispersion>



FGD : Technical Collaboration in India

Seawater FGD reference

Client : Tata Power Company Limited.
Plant : Trombay #8, India
Fuel : Coal
Capacity : 250 MW x 67%
Efficiency : 91 %
Start-up : 2009
Build by BHEL (MHPS as subcontractor)



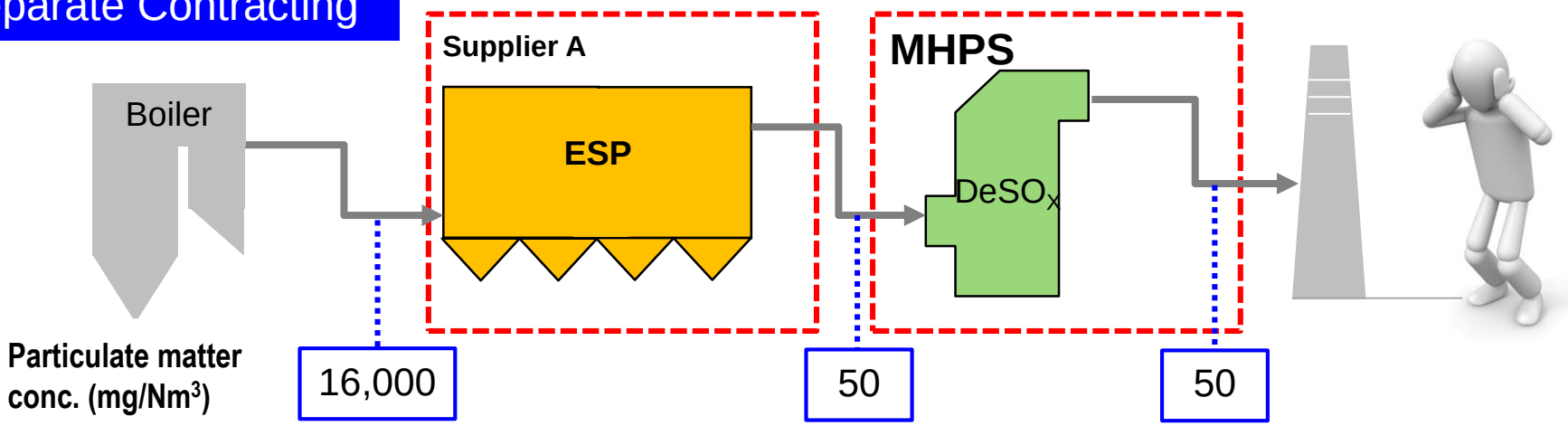
FGD License Agreement with BHEL
Agreed in April 2013

MHPS BHEL

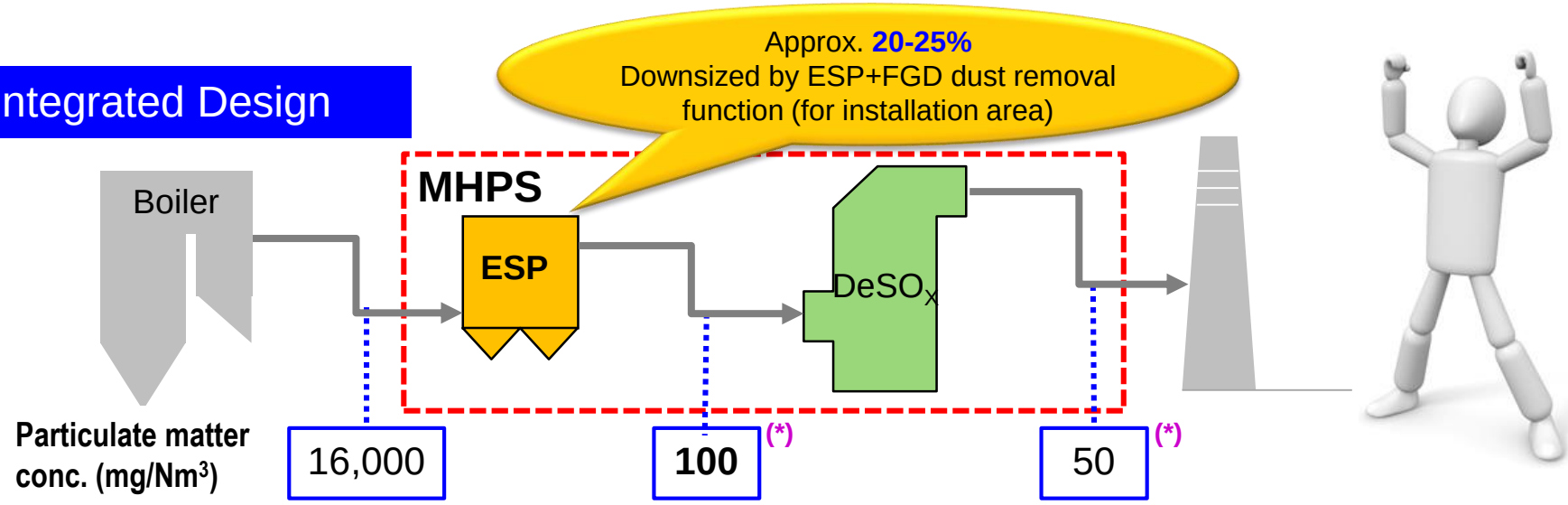
Signing Ceremony in Feb., 2013

Advantage of integrated design: ESP Downsizing

Separate Contracting



Integrated Design



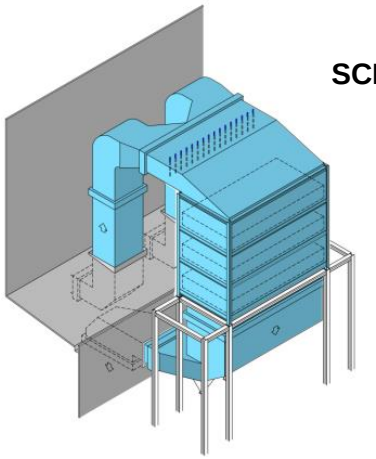
(*) AQCS system dust removal efficiency depends on coal type and dust particulate distribution. Considering dust removal performance at DeSOx, ESP can be downsized.

Overall system purchasing achieve …
- Installation cost and space decrease 10-20%.
- Prevention of trouble at the interfaces

Retrofit to Existing Boilers（SCR）

SCR Retrofit Project Outline

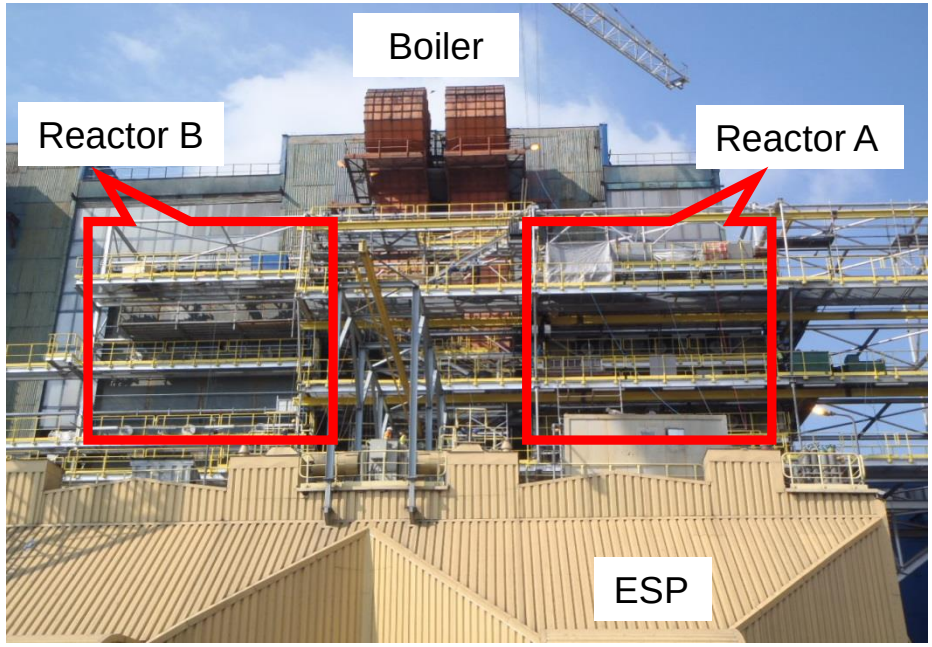
Plant ： Poland
Fuel ： Coal
Plant Power : 220MW x 2
DeNOx: 80 %
Slip MH3: 2 ppm
Start up: U2 Oct. 2015
U1 Mar. 2016



SCR Reactor

Before installation

After Installation



Retrofit to Existing Boilers（ FGD ）

FGD Retrofit Project Outline

Plant ： Poland

Fuel ： Coal

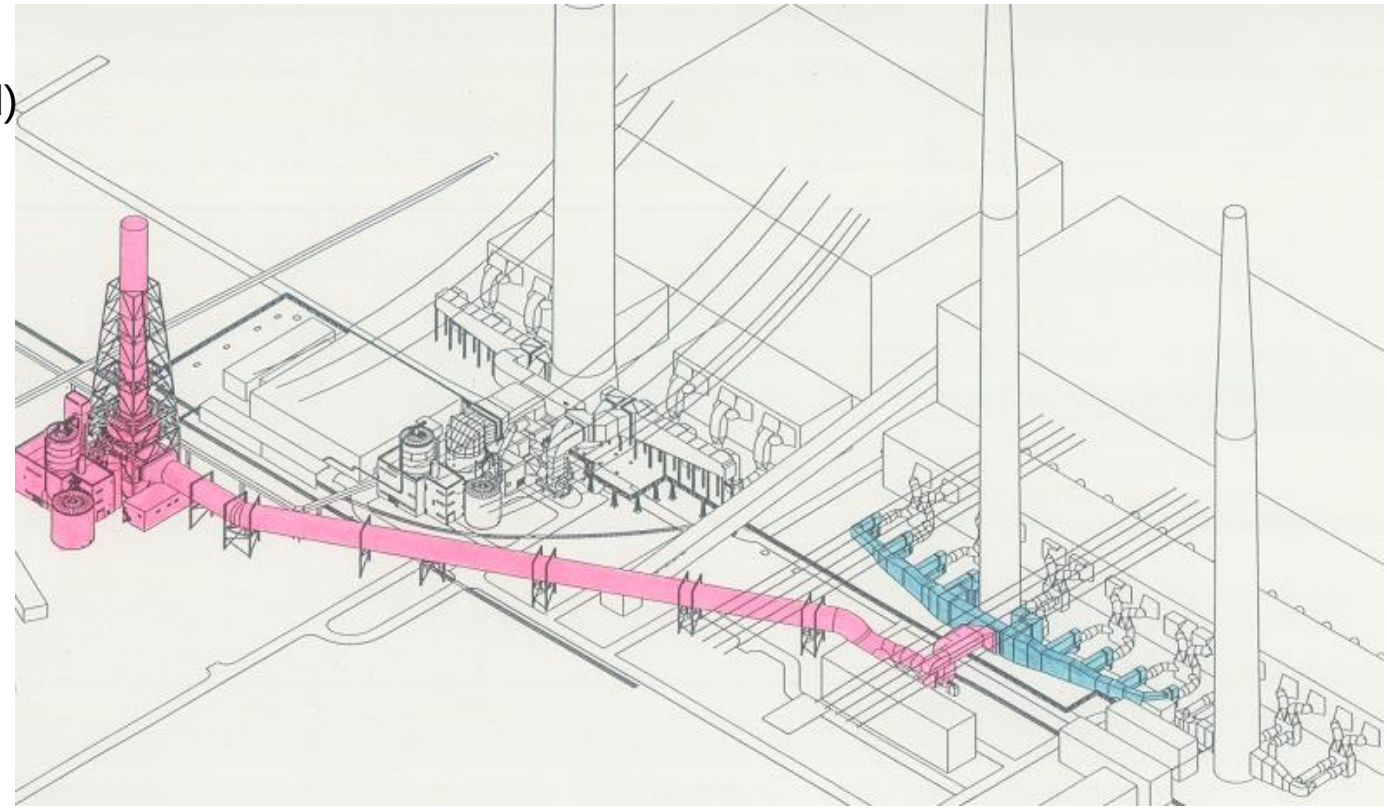
Plant Power : 800MW

Inlet SO_2 : 1,120ppm(d)

DeSOx: 93.75%

Start up : 2006

Newly installed single FGD treating flue gas from 4 boilers



MHPS technology to capture Mercury in AQCS

Mercury Capturing in AQCS

Form of vapor phase mercury (Speciation)

Elemental Mercury - Hg^0

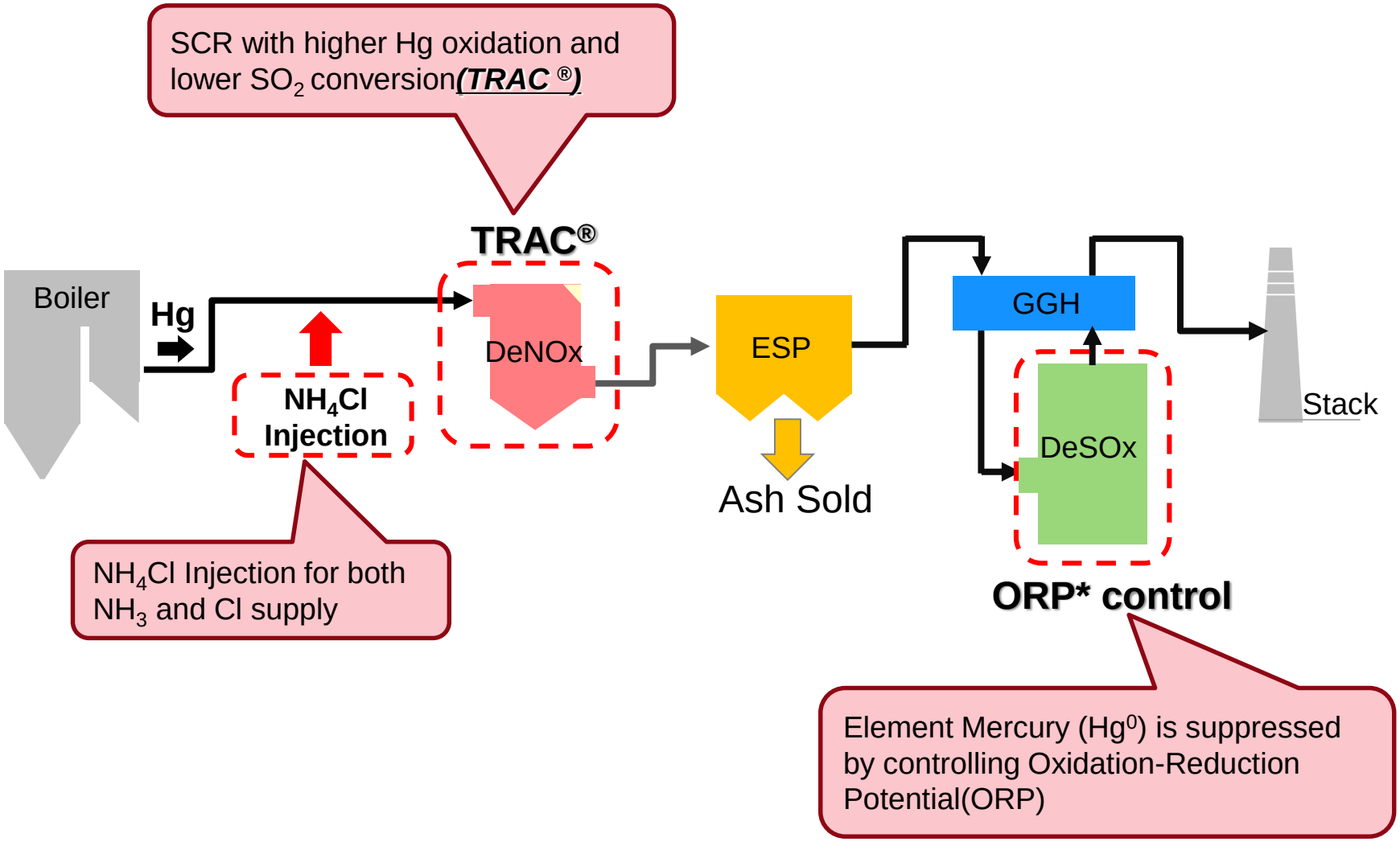
Oxidized Mercury - Hg^{++}

The form of mercury in the flue gas is critical to performance of emissions control systems.

- **Elemental Mercury: Hard to remove from flue gas**
- **Oxidized Mercury: Easier to remove from flue gas (downstream ESP, FGD)**

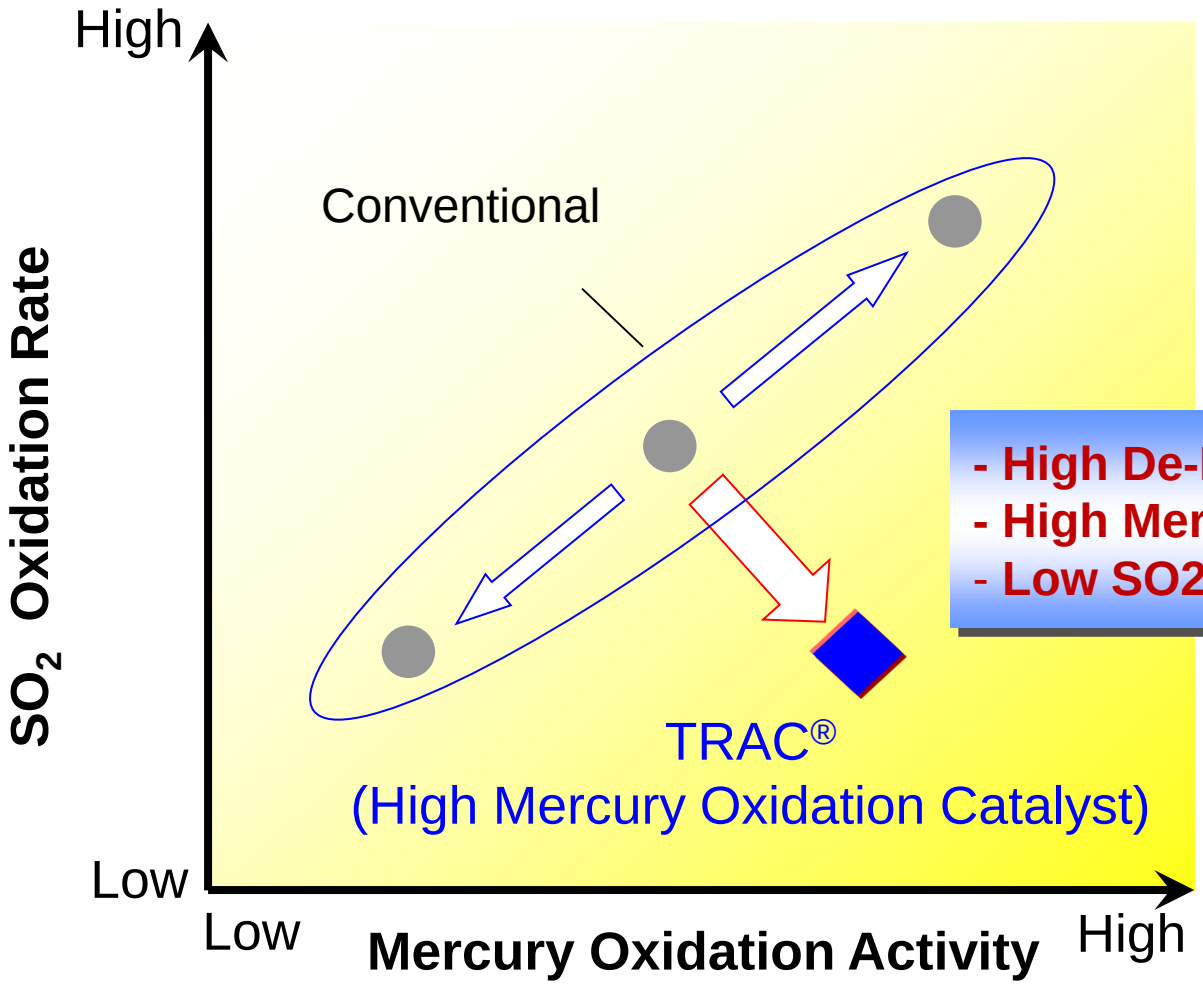
To achieve higher Hg removal, Hg oxidation is indispensable.

Mercury Removal Technology
~ Hg removal in TRAC® with NH_4Cl Injection~



***ORP: Oxidation-Reduction Potential**

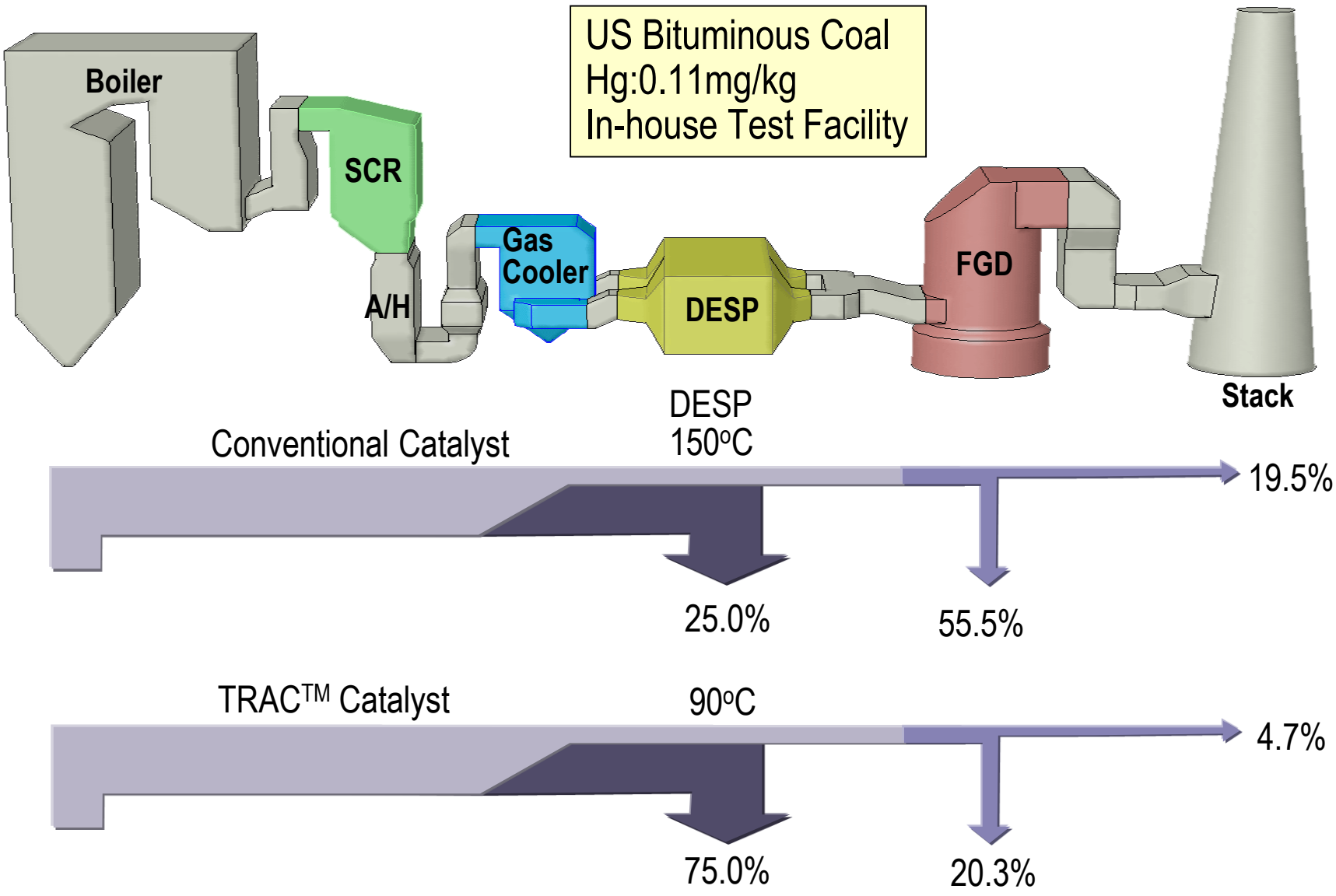
Mercury Removal Technology
~ TRAC® Catalyst ~



- High De-NOx Activity
- High Mercury Oxidation Activity
- Low SO2 Oxidation Rate

TRAC® = Triple Action Catalyst

Effects of TRAC™ and Gas Cooler on Hg Removal



MITSUBISHI HITACHI
POWER SYSTEMS