

# Introduction of MHPS & Air Quality Control Systems



January 2017  
AQCS Business Dept.

**MITSUBISHI HITACHI POWER SYSTEMS, LTD.**

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2. MHPS AQCS
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  - 3-1. AQCS Retrofit
  - 3-2. SCR Catalyst for High Dust Application
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# 1. Company Profile

## 2. MHPS AQCS

### 3. Application in India

#### 3-1. AQCS Retrofit

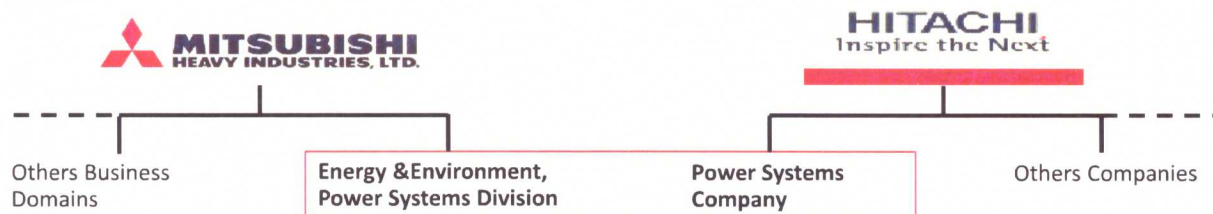
#### 3-2. SCR Catalyst for High Dust Application

#### 3-3. Existing AQCS Upgrading

## 4. High Efficiency System

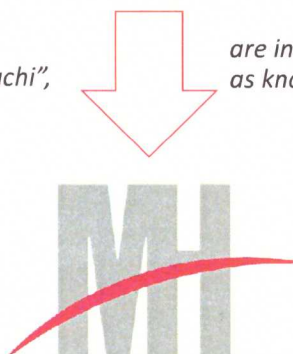
## 5. Summary

# 1. Company Profile: History of MHPS



Thermal Power Generation systems of "Mitsubishi Heavy Industries" and "Hitachi",

are integrated on February 1, 2014 as known of



## MITSUBISHI HITACHI POWER SYSTEMS

Capital: 1 Bil USD

Employees: app.22,000 (incl. 7,600 outside Japan)

# 1. Company Profile: Product Portfolio

Gas Turbine Combined (GTCC) Power Plant

Gas Turbines

Boiler & Turbine Generation Plants

Environmental Equipment (SCR/ESP/FGD)

Boilers

Steam Turbines

Integrated coal Gasification Combined Cycle (IGCC) Power Plants

Geothermal Power Plants

Generators

Power Generating Plant Peripheral Equipment

Plant Control Systems

Fans

Fuel Cells (SOFC)

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# 1. Company Profile: AQCS Related Overseas Bases

MHPS Europe (UK)

MHPS Europe (Germany)

FMH\*

MHPS Korea

MHPS Canada

MHPS America Energy and Environment

MHPS America

MHPS India

L&T MHPS JV

MHPS HQ Yokohama

MHPS-ES\*\* HQ Yokohama

CBC

\*FMH: Zhejiang Feida MHPS High Efficiency Flue Gas Cleaning Systems Eng'g

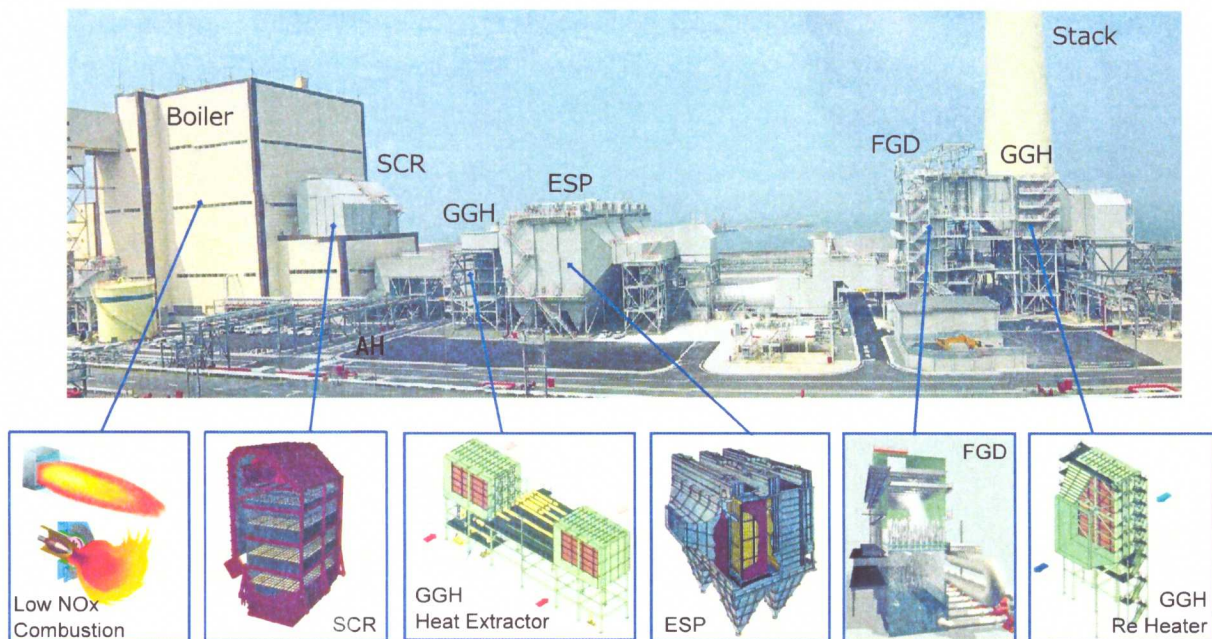
\*\* MHPS-ES: Mitsubishi Hitachi Power Systems Environmental Solutions, Ltd. (From Oct.2015)

50 Group Companies Overseas

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## 2. MHPS AQCS: Configuration for Coal Fired Plant



One-stop AQCS Solution Provided by MHPS

## 2. MHPS AQCS: Product Portfolio

MHPS covers wide ranged AQCS products to offer systems which match the needs of customers.

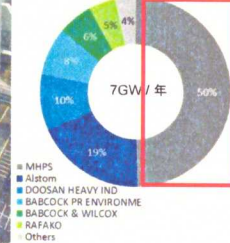
### Flue Gas Denitrification (SCR)



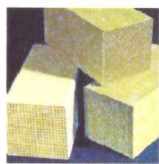
### Flue Gas Desulfurization(FGD)



Market Share in Wet Coal Method  
(2012-2014) [excl. China]  
(Source: McCov Power Report)



### Electrostatic Precipitators (ESP)



Honeycomb Catalyst

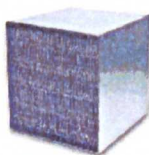
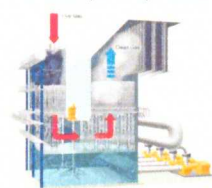
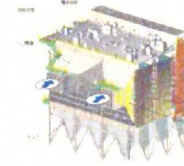


Plate Catalyst

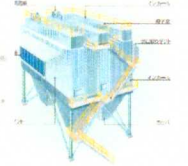
### Double Contact Flow Scrubber(DCFS) Tower



### Spray Tower

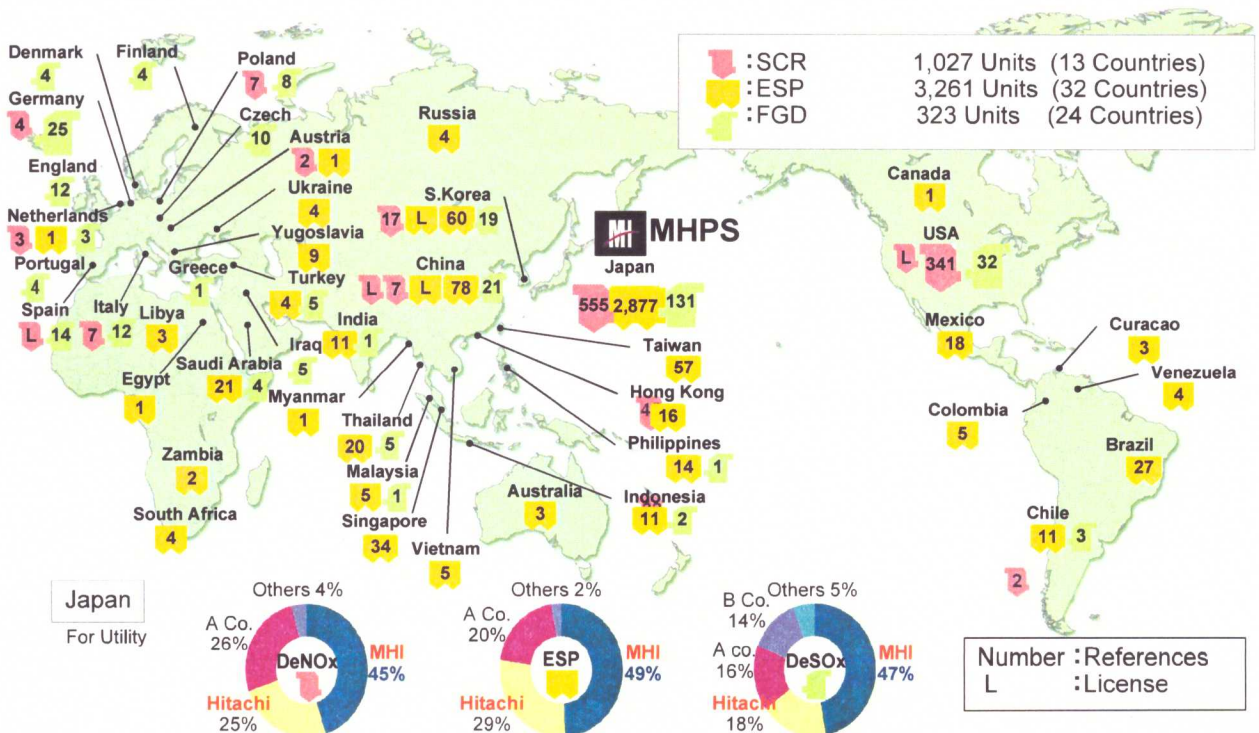


Moving Electrode



Conventional

## 2. MHPS AQCS: Supply Records



## 2. MHPS AQCS: FGD Competitiveness

**MHPS Ranked the WORLD NO.1 in 2014 and 2015 two years**



SHARE OF ORDERED CAPACITY, 12M'14		
TECHNOLOGY OWNER	12M'14	
	MW <sub>e</sub>	(%)
1 MITSUBISHI HITACHI PR. SYS (MHPS)	6,040	28.2%
ALSTOM POWER	5,805	27.1%
SUYUAN	2,000	9.3%
ANDRITZ ENERGY & ENV	1,675	7.8%
5 HAMON GROUP	1,330	6.2%
BEIJING GUODIAN	1,320	6.2%
MARSULEN ENVIRO TECH	1,025	4.8%
VALMET	665	3.1%
BABCOCK & WILCOX	550	2.6%
10 AMEC FOSTER WHEELER	510	2.4%
KEPPEL SEGHERS	180	0.8%
OUTOTEC	90	0.4%
CHONGQING SANFA COVANTA	75	0.4%
HITACHI ZOSEN INOVA	69	0.3%
15 RAFAKO	40	0.2%
EVERBRIGHT INTERNATIONAL	25	0.1%
TOTAL MARKET	21,398	100.0%

G5: 12M'15 CAP. SHARE		
TECH OWNER	12M'15	
	MW <sub>e</sub>	%
1 MHPS	5,770	37.6%
ALSTOM	4,875	31.8%
DOOSAN	1,955	12.8%
DUCON	1,200	7.8%
5 FORMOSA	565	3.7%
AMEC FW	430	2.8%
B&W	338	2.2%
VALMET	170	1.1%
OUTOTEC	40	0.3%
10 SAXLUND	27	0.2%
PENSOTTI	10	0.1%
TOTAL	15,330	100.0%

*5 MW<sub>e</sub> and up. Source: McCoy surveys.*

## 2. MHPS AQCS: FGD Competitiveness in S.E.Asia

### Frost & Sullivan Honors Mitsubishi Hitachi Power Systems With The Southeast Asia Air Quality Control System Integrator of the Year Award

BANGKOK - April 7, 2016 (Frost & Sullivan) - Frost & Sullivan recently honored Mitsubishi Hitachi Power Systems Ltd (M-PS) with the 2015 Frost & Sullivan Southeast Asia Air Quality Control System Integrator of the Year award.

The award was presented to M-PS at the 2015 Frost & Sullivan Thailand Excellence Awards ceremony on April 7 at the Dusit Thani hotel in Bangkok.

Mr. Malin Leung, Regional Manager, Energy & Environment Practice, Asia Pacific at Frost & Sullivan said that M-PS is a leader in terms of growth rates in the challenging Southeast Asia air quality control systems (AQCS) market.

He stated that in 2014, the company's growth in market share and revenue is higher than the rest of the market leader. "This outstanding performance is a testament of its holistic focus on providing complete AQCS solutions such as flue gas desulfurization (FGD), selective catalytic reduction (SCR), gas-gas heater (GGH), and a wet electrostatic precipitator (ESP)," Mr. Leung said.

He also said that M-PS also gained customer trust and confidence especially in the flue gas desulfurization (FGD) segment. In this segment, the company managed to secure 100 percent project wins in terms of seawater FGD sub-segment in 2014, a rare feat in the competitive market.

"We are honored and delighted to receive this prestigious award from Frost & Sullivan, a leading growth consulting firm," said M-PS General Manager of AQCS Business Department, Mr. Kenzou Ozaki.

He added that the award validates M-PS' commitment in delivering quality products and services to its clients. "We will continue to focus on meeting all our customer's requirements, and helping them grow with our service and products," he said.

About Mitsubishi Hitachi Power Systems Ltd

Mitsubishi Hitachi Power Systems Ltd (MHPS), headquartered in Yokohama, Japan, is a joint venture formed in February 2014 by Mitsubishi Heavy Industries Ltd. and Hitachi Ltd. Integrating their operations in thermal power generation systems and other related businesses, M-PS today ranks among the world's leading suppliers of equipment and services to the power generation market, backed by 100 billion per 31,000 million at the rate of 100 yen=US\$1 in capital and approximately 20,000 employees worldwide. The company's products include DTCO (gas turbine combined-cycle) and IGCC (integrated coal gasification combined-cycle) power plants, conventional gas/coal-fired (thermal) power plants, boilers, generators, gas and steam turbines, geothermal power plants, power plant peripheral equipment and solid oxide fuel cells (SOFC). For more information, please visit the company's website at: <http://www.mhps.com/en/index.html>

Secured **100% project wins**(\*) in tenders of **FGD** in 2014 in **S.E. Asia**.

- 1) Malaysia 1000MWx1
- 2) Indonesia 1000MWx2
- 3) Philippines 400MWx1
- 4) Vietnam 660MWx2 (First Refusal Right)



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### 3-1. AQCS Retrofit: ESP Outline

	TPP installed before 2003.12.31		TPP installed after 2003.12.31 up to 2016.12.31		New install from 2017.1.1
	Smaller than 500MW	500MW & Above 500MW	Smaller than 500MW	500MW & Above 500MW	
MW	Smaller than 500MW	500MW & Above 500MW	Smaller than 500MW	500MW & Above 500MW	Any Size
Dust	100mg/Nm <sup>3</sup>		50mg/Nm <sup>3</sup>		30mg/Nm <sup>3</sup>
SOx	600mg/Nm <sup>3</sup>	200mg/Nm <sup>3</sup>	600mg/Nm <sup>3</sup>	200mg/Nm <sup>3</sup>	100mg/Nm <sup>3</sup>
NOx	600mg/Nm <sup>3</sup>		300mg/Nm <sup>3</sup>		100mg/Nm <sup>3</sup>
Mercury	-	0.03mg/Nm <sup>3</sup>	0.03mg/Nm <sup>3</sup>		0.03mg/Nm <sup>3</sup>

The new regulation may require investment to Air Quality Control Systems.

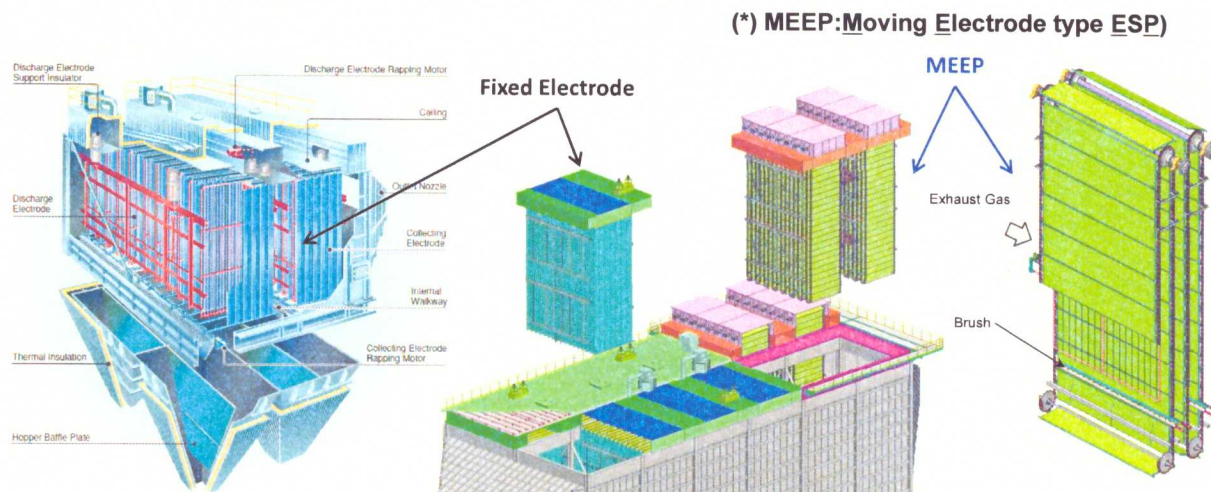
New TPP Tenders started including AQCS

**Challenge for AQCS Retrofit to Existing/Under Construction TPPs**

### 3-1. ESP Retrofit: ESP Outline

MHPS has supplied **over 3,200 units** of dry and wet ESP worldwide.  
 Feature and highlights of our ESPs are:

- ✓ **High dust reduction efficiencies** to meet the required emissions by MEEP(\*)
- ✓ **Superior cost value** as a result of compact design, easy maintenance and energy savings.
- ✓ **High durability** due to well-designed robust structure.  
 38 Reference for coal fired boiler since after 1981



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### 3-1. ESP Retrofit: MEEP Reference in India, Rihand TPP

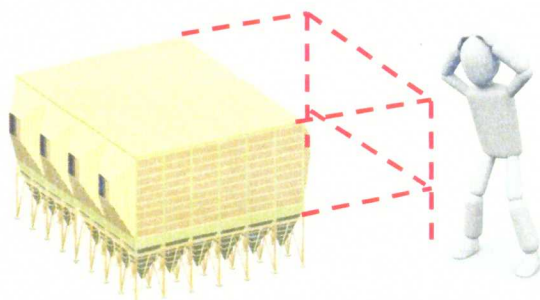
#### NTPC Rihand ESP Upgrading Project

- NTPC Rihand Power Station 2x500MW
- Upgrading by Moving Electrode (MEEP)

Reduce dust emission  
 from 500mg/Nm<sup>3</sup> to 50mg/Nm<sup>3</sup>

Applied for Indian high ash coal

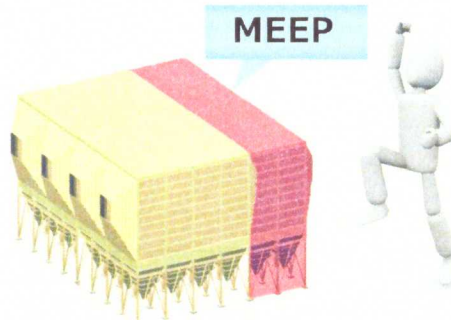
**No Space for existing ESP Expansion!**



Newly Installed MEEP at Rihand Power Station



**By MHPS MEEP technology,  
 dust removal efficiency increased  
 within the original space!**



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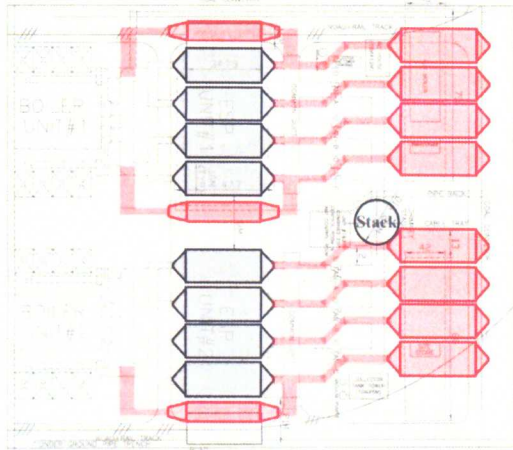
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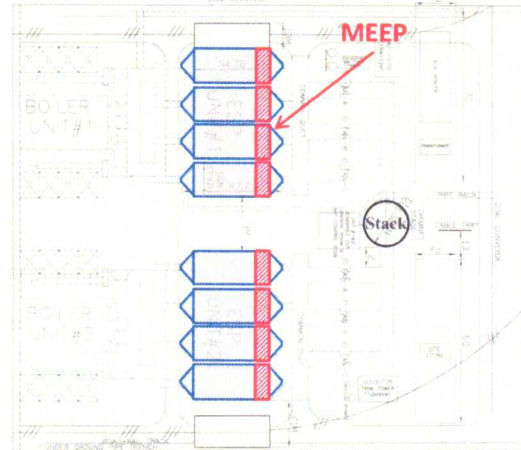
### 3-1. ESP Retrofit: MEEP Reference in India, Rihand TPP



Conventional technology requires huge space to install additional ESP!

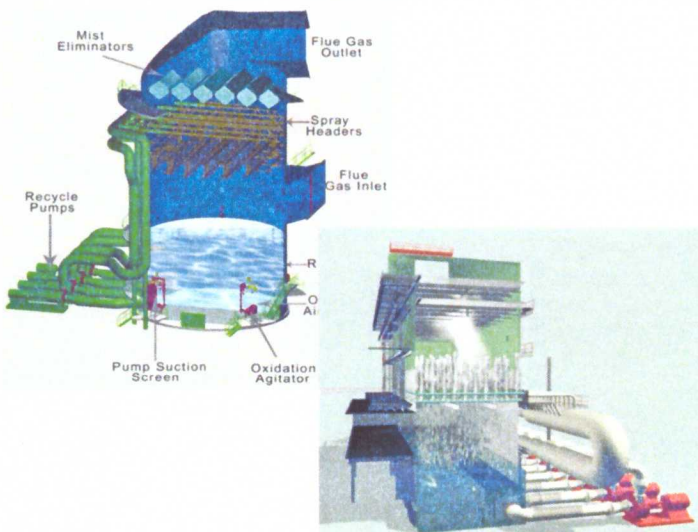


Dust removal efficiency Improved within the original space by MEEP!

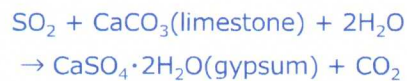
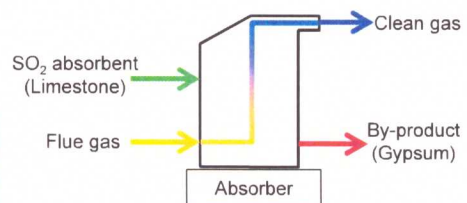


### 3-1. FGD Retrofit: FGD Outline

#### FGD Absorber



#### Chemical Reaction in Absorber



#### Features

More than 95% SO<sub>2</sub> removal efficiency is achievable.  
Efficient and highly reliable system.

#### Two Major FGD Process

1. Limestone Gypsum Process
2. Seawater Process

### 3-1. FGD Retrofit: Reference Project

#### FGD Retrofit Project Outline

Plant : Poland

Fuel : Coal

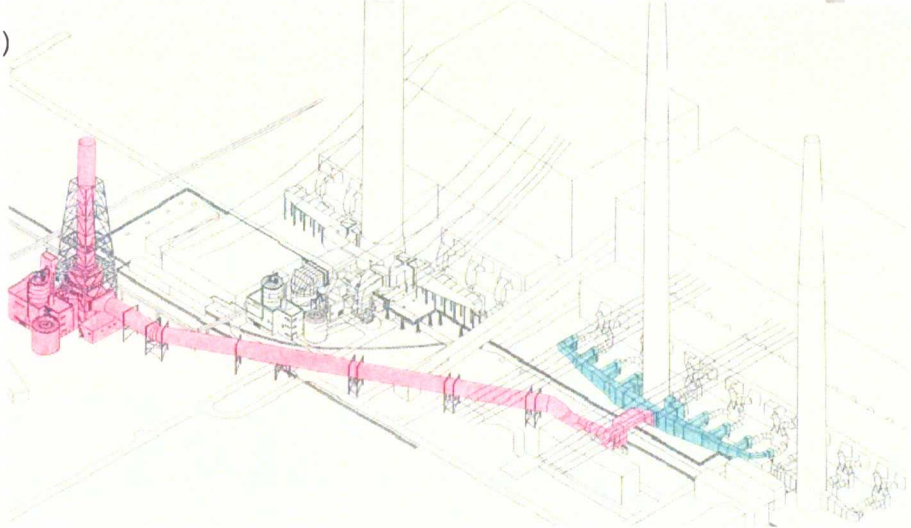
Plant Power : 800MW

Inlet SO<sub>2</sub> : 1,120ppm(d)

DeSOx: 93.75%

Start up : 2006

- ✓ No available area nearby the existing stack
- ✓ Newly installed single FGD treating flue gas from 4 boilers
- ✓ Stack is integrated to the FGD absorber tower.



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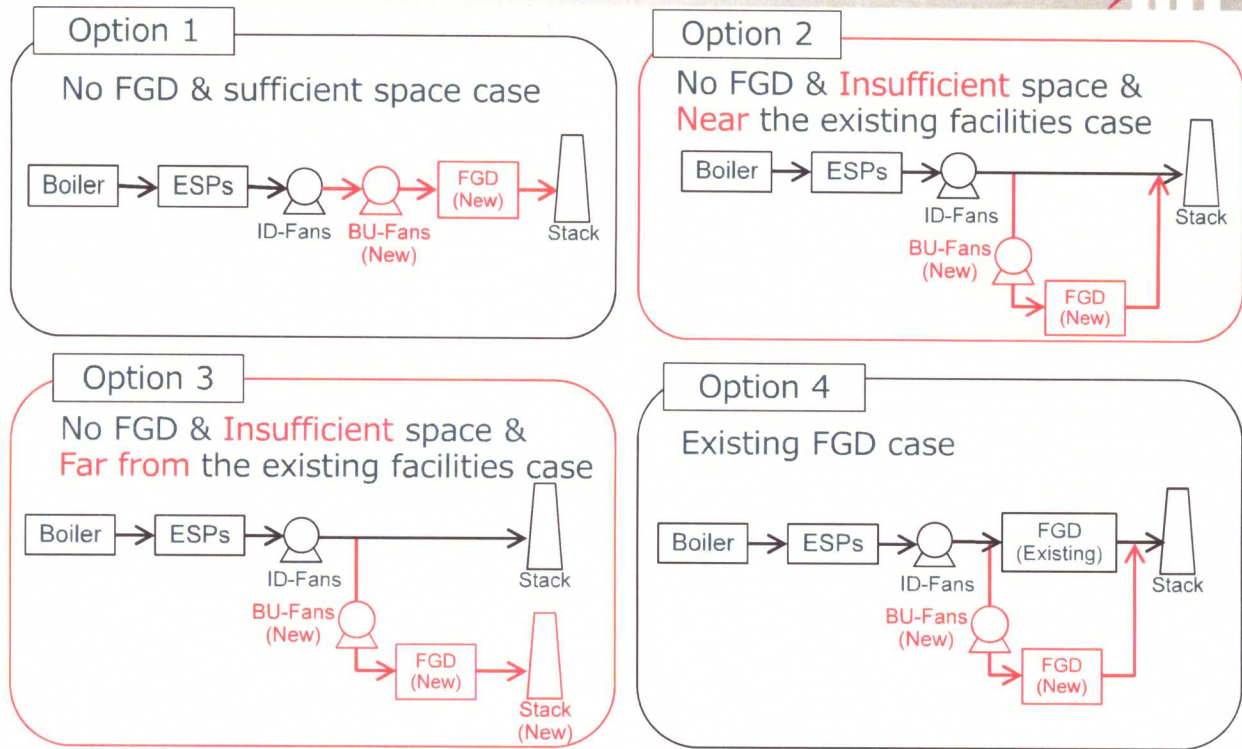
### 3-1. FGD Retrofit: Normal Practice in AQCS Industry

#### Majority of MHPS FGD reference is Retrofit

	Total N of units	Retrofitted Units	Retrofit Ratio
USA	32	26	81%
Europe	102	72	71%
Japan	131	70	53%
China	18	6	33%
Korea	14	4	29%
Others	26	0	-
Total	323	178	55%

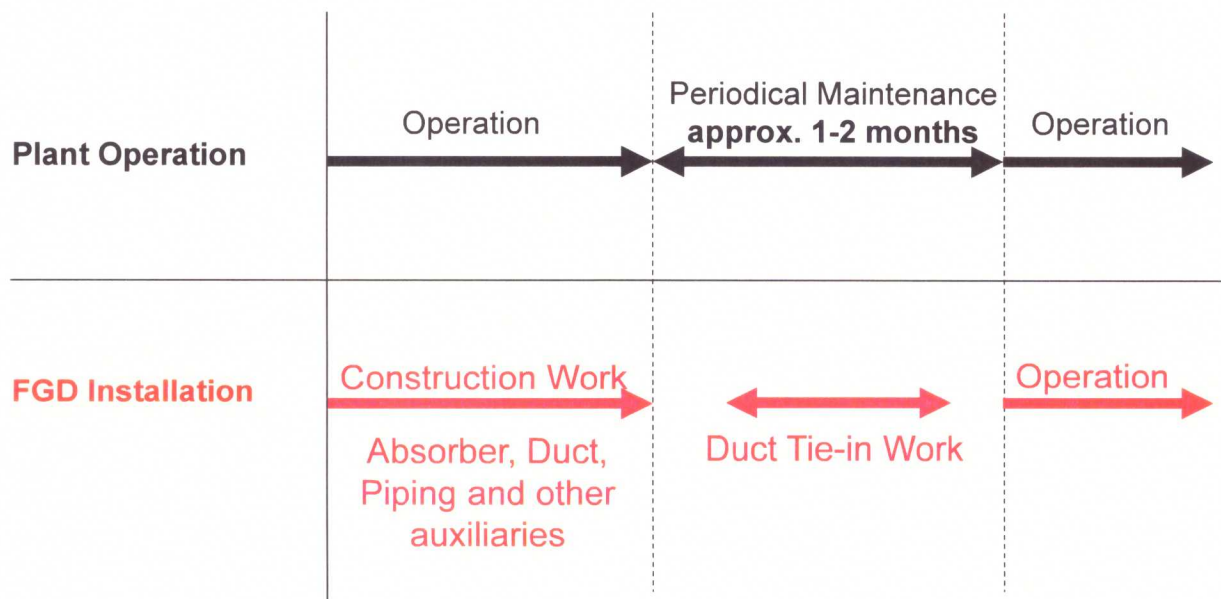
**FGD retrofit has been required in many countries as emission regulation established after the power plant operation.**

### 3-1. FGD Retrofit: Various Applications



Most of retrofit units are categorized to Option 2 or Option 3.

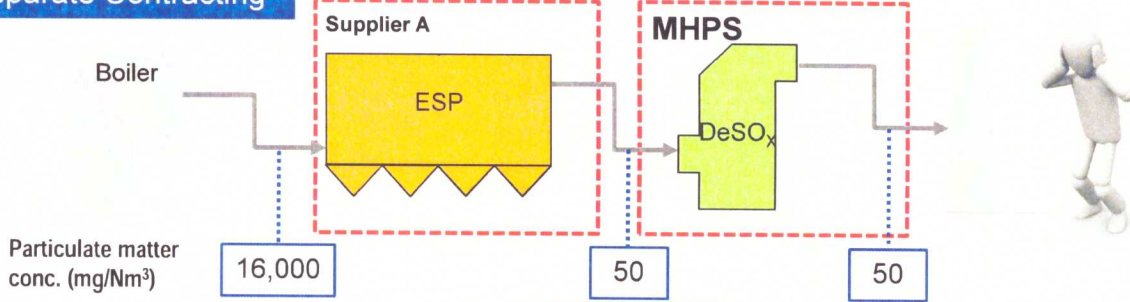
### 3-1. FGD Retrofit: Typical Installation Schedule



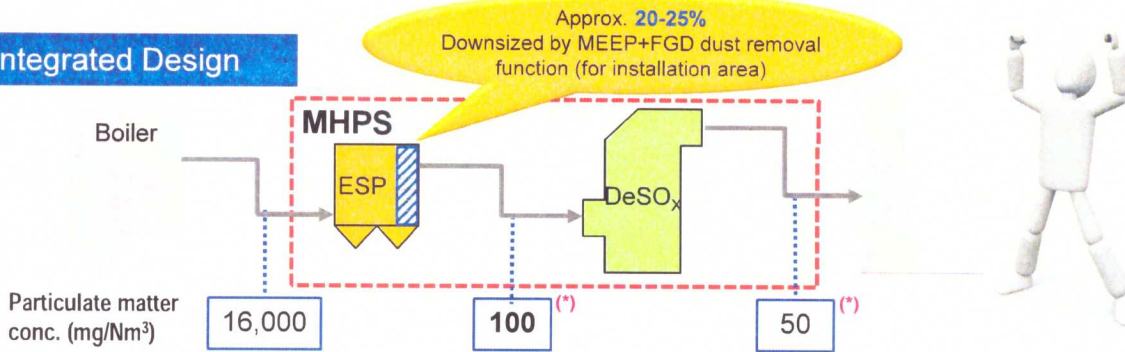
- FGD installation can separately proceed during boiler operation.
- Duct tie-in work to the existing duct could be done within maintenance period.

### 3-1: AQCS Retrofit: Integrated design FGD+FGD

#### Separate Contracting



#### Integrated Design



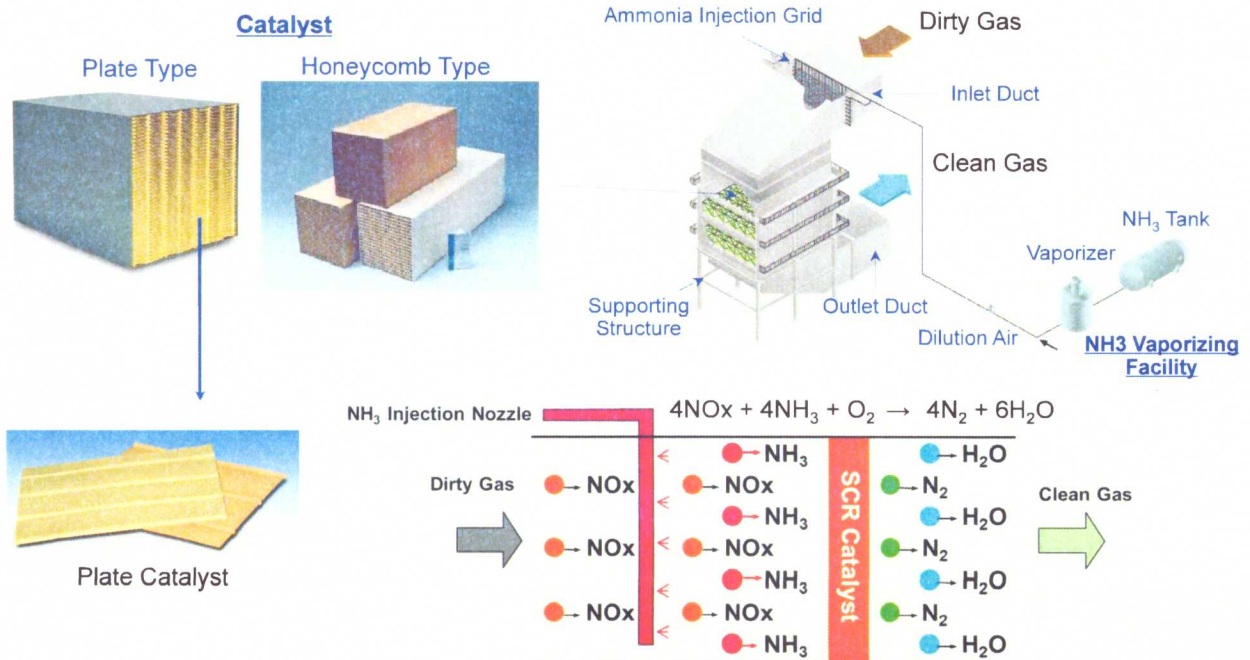
(\*) AQCS system dust removal efficiency depends on coal type and dust particulate distribution. Considering dust removal performance at DeSO<sub>x</sub>, ESP can be downsized.

Overall system purchasing achieve ...

- Installation cost and space decrease 10-20%.
- Prevention of trouble at the interfaces

### 3-1. SCR Retrofit: SCR Outline

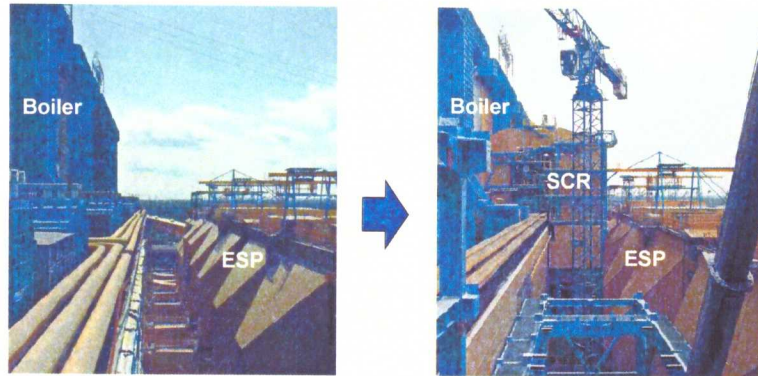
Harmful NO<sub>x</sub> is decomposed into harmless N<sub>2</sub> and H<sub>2</sub>O by catalytic action



### 3-1. SCR Retrofit: Reference Project

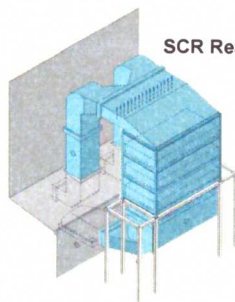
#### Project Outline

Plant : Poland  
 Fuel : Coal  
 Plant Power : 220MW x 2  
 DeNOx Efficiency: 80 %  
 Slip NH<sub>3</sub>: 2 ppm  
 Start up: U2 Oct. 2015  
 U1 Mar. 2016

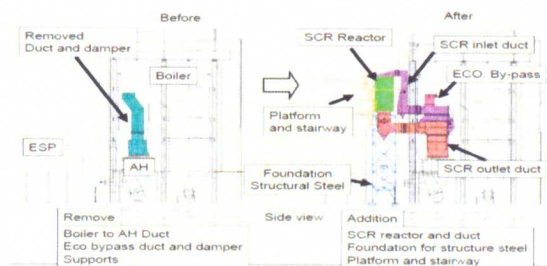


Before installation

After Installation



SCR Reactor

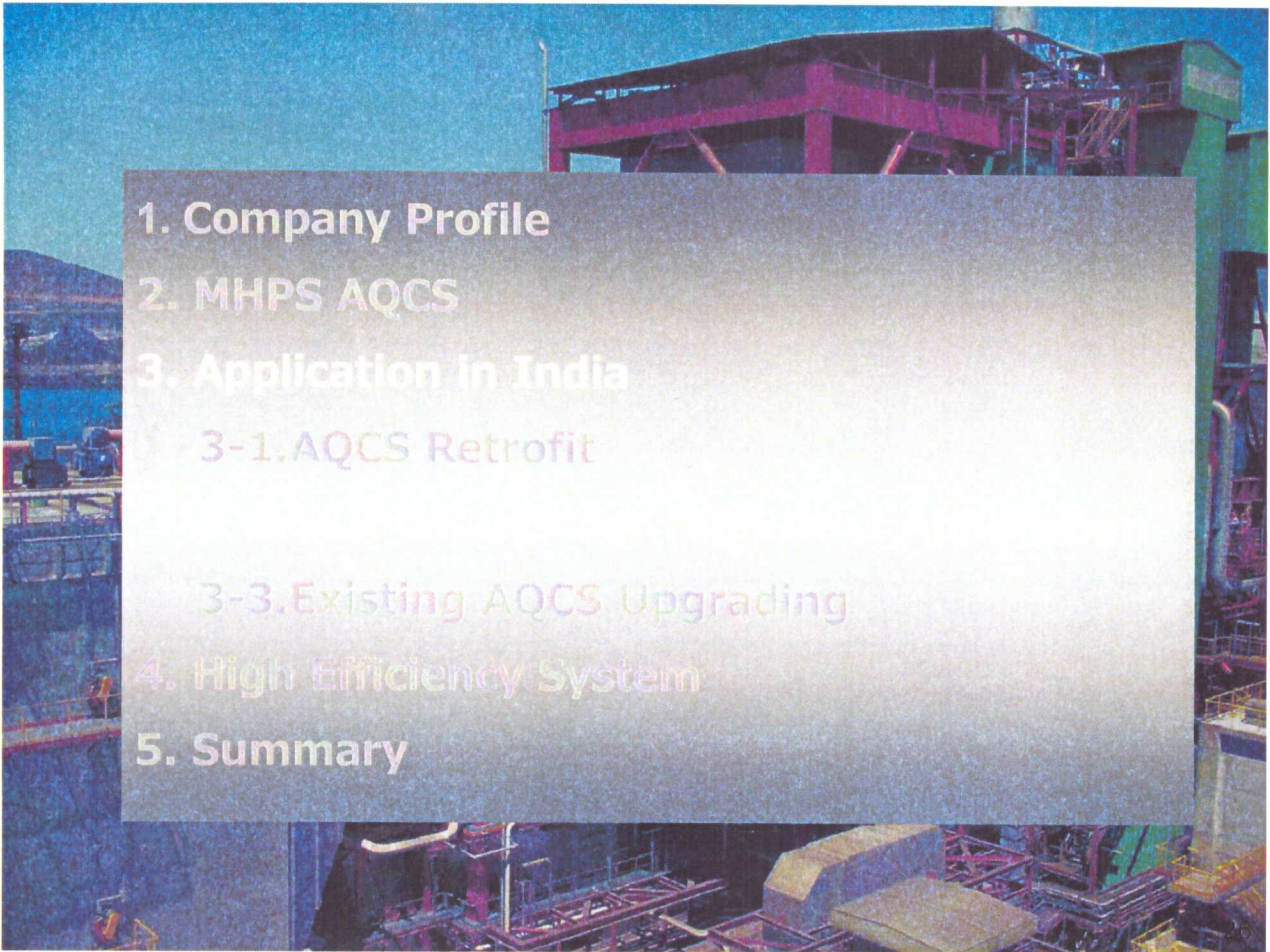


### 3-1. SCR Retrofit: Normal Practice in AQCS Industry

About half of MHPS SCR reference is Retrofit

	Total N of units	Retrofit Units	Retrofit Ratio
USA	21	13	62%
Europe	24	16	67%
Japan	85	21	25%
China	32	9	28%
Korea	12	12	100%
Taiwan	42	22	52%
Others	6	4	67%
Total	222	97	44%

SCR retrofit has been required in many countries as emission regulation established after the power plant operation.



### 3-2. SCR Catalyst : Catalyst Manufacturing Facility

#### Japan



MHPS Akitsu Factory

Operation start: 1987  
Location: Hiroshima, Japan

#### China



Mitsubishi-Hitachi (Hangzhou)  
Environmental Equipment Co.,Ltd.  
(100% Subsidiary)

Operation start: 2012  
Location: Hangzhou, China

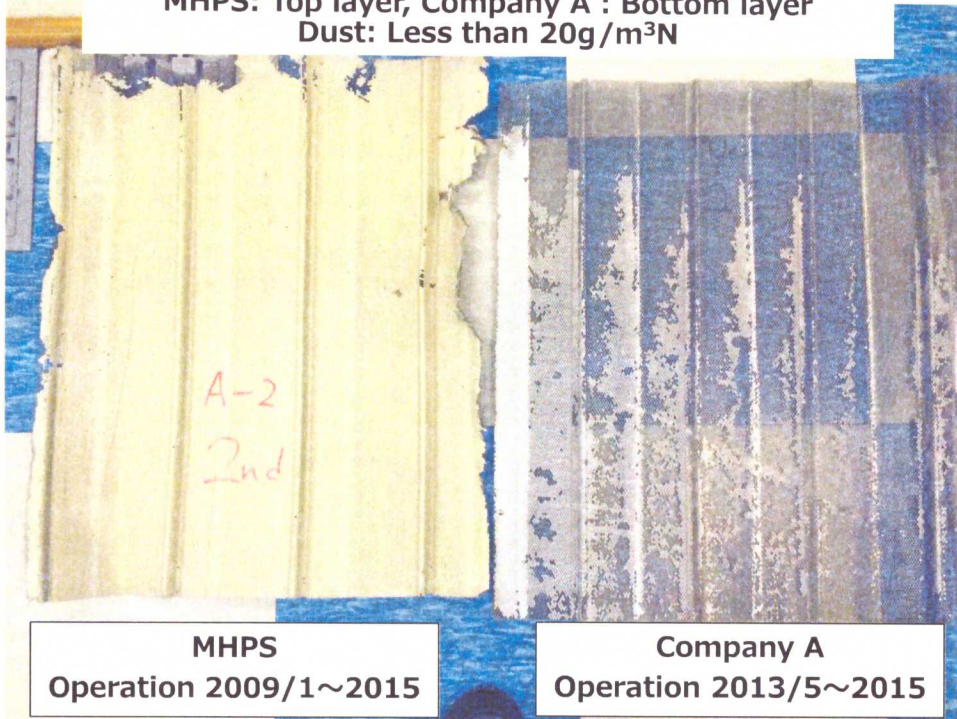
#### India



Under Feasibility Study

### 3-2. SCR Catalyst: Catalyst Erosion Problem at Same Plant

Same SCR reactor  
MHPS: Top layer, Company A : Bottom layer  
Dust: Less than 20g/m<sup>3</sup>N



### 3-2. SCR Catalyst: Catalyst Erosion Problem in China



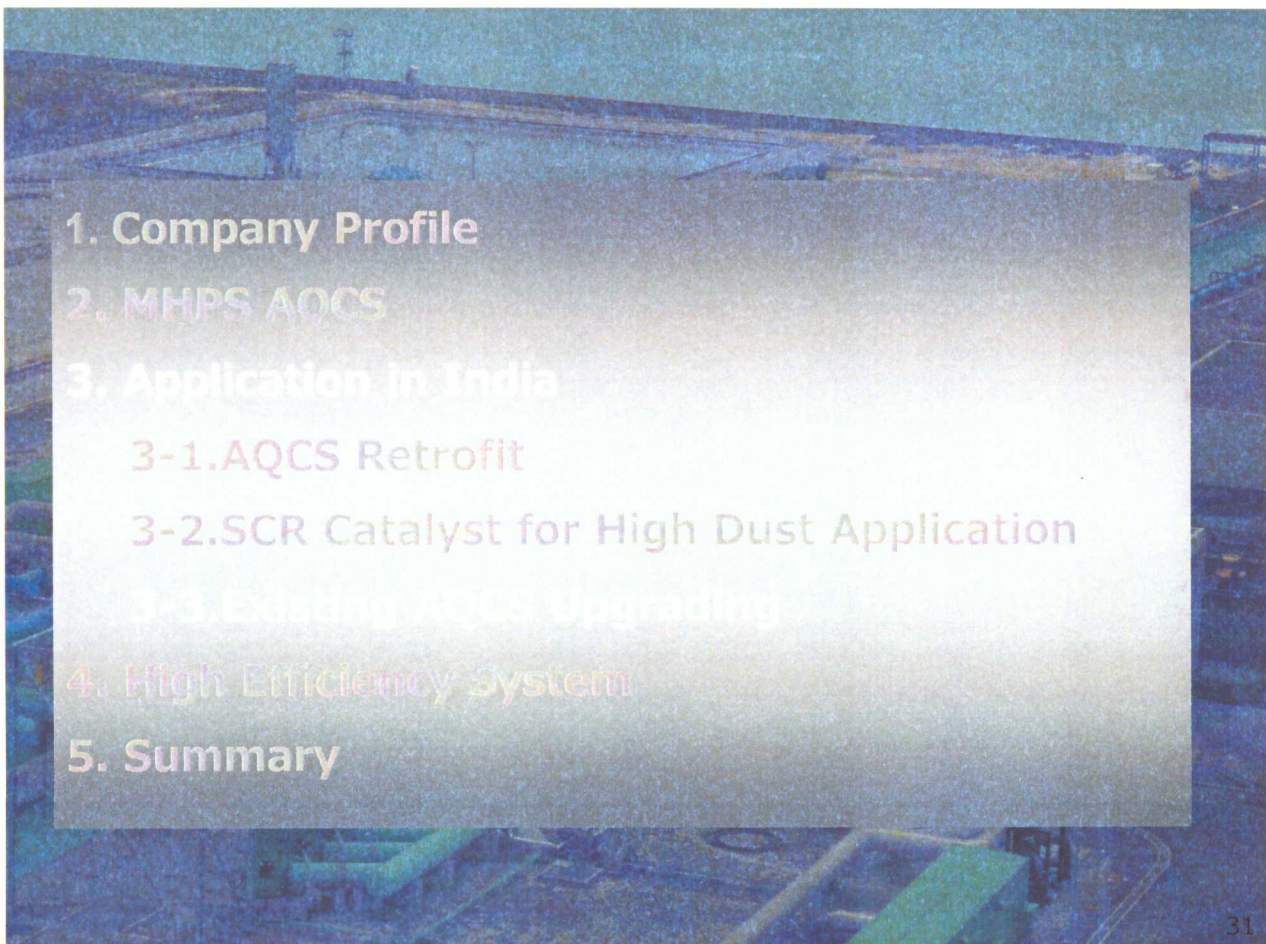
Company B: Operation 2012/6~2014/5

## 3-2. SCR Catalyst: MHPS Reference of High Dust Coal

No.	Project	Capacity	Dust conc. g/m <sup>3</sup> N	Operation
1	石景山 Unit 1-4	200MW x 4	46.6	2008
2	南京下关Unit 1,2	660MW x 2	41.0	2011
3	林州Unit 1,2	350MW x 2	43.6	2011
4	蒲圻Unit 1,2,3,4	1000MWx2 +300MWx2	41.2	2012
5	珞璜Unit 5,6	600MW x 2	53.7	2012
6	张家口Unit3,5,6,7,8	300MW x 5	68.9	2012/2013
7	塔山Unit 1,2	600MW x 2	55.0	2013
8	唐山陡河Unit 3,4,6,7,8	250MWx2 +200MWx3	57.5	2013
9	康巴什Unit 1,2	350MW x 2	64.3	2013
10	河津Unit 1,2	350MW x 1	48.2	2013
11	蒲州Unit 1,2	300MW x 2	46.7	2013
12	滇东Unit 1-4	600MW x 4	50.0	2013/2014
13	中石化金陵Unit 1-4	220 t/h x4	43.5	2013-2014
14	渠东Unit 1,2	300MW x 2	40.0	2013
15	牡丹江Unit 9	300MW x 1	50.6	2013
16	珞璜Unit 1-4	360MW x 4	53.8	2013
17	汉新Unit 3	300MW x 1	40.0	2013
18	扬州第二Unit 2	630MW x 1	41.0	2013
19	佳木斯Unit 1	300MW x 1	48.2	2013
20	半山Unit 5	130MW x 1	41.4	2013

No.	Project	Capacity	Dust conc. g/m <sup>3</sup> N	Operation
21	宿州Unit 1, 2	630MW x 2	51.7	2013-14
22	常州亚太Unit 1	220t/h x1	43.1	2013
23	宜兴Unit 1,2	260 t/h x2	40.0	2013
24	哈尔滨热电Unit 7	300MW x 1	58.7	2013
25	滇东雨汪Unit 1	600MW x 1	57.3	2013
26	姚孟Unit 3,4	300MW x 2	60.0	2013-14
27	丰城Unit5	600MW x 1	41.4	2014
28	灵武Unit 2	660MW x 1	50.9	2014
29	蒲城Unit 3, 4	360MW x 2	53.3	2014
30	铁岭Unit 1, 4	300MW x 2	47.9	2014
31	南阳Unit1,2	12.5MW x 2	53.5	2014
32	邹县Unit7	1000MW x 1	48.5	2014
33	涟源Unit1, 2 Lyangyuan	300MW x 2	70.8	2014
34	曲阜Unit1, 2	220MW x 2	56.5	2014
35	佳木斯Unit2	300MW x 1	48.2	2014
36	哈尔滨热电Unit8	300MW x 1	58.7	2014
37	牡丹江Unit8	300MW x 1	52.6	2014
38	宁北Unit1, 2	13.5MW x 2	52.9	2014, 2015
39	唐湖Unit1, 2	13.5MW x 2	53.6	2014, 2015

Above 50g/m<sup>3</sup>N: 20 Projects  
Above 60g/m<sup>3</sup>N: 4 Projects





### 3-3. Existing AQCS Upgrading: Global Regulation Trend

**CLEAR TREND** toward more and more stringent emission regulation  
The AQCS is required to be upgraded to comply with the new regulation.

Country	India		Japan	US		China			EU			
	N	E		N	E	Standard		Key Regions	Current IED		Draft BREF	
Category	N	E	N/Exist	N	E	N	E	N/E	N	E	N	Exist
SO <sub>2</sub> /SO <sub>x</sub> [mg/Nm <sup>3</sup> ]	100	200	115 (12)	144	288	100	200	50	150	200	10~75	10~130
NO <sub>x</sub> [mg/Nm <sup>3</sup> ]	100	300	70 (60)	50	50	100	100	100	150	200	65~85	65~150
Dust [mg/Nm <sup>3</sup> ]	30	50	5 (5)	12	39	30	30	20	10	20	2~8	2~5
Est. Year	2015		1970	1990		2015			2010		2017 (Planned)	

N: New Built, E: Existing, Japan: Most stringent case  
IED: Industrial Emission Directive 2010/75/US  
BREF: Best Available Reference Document

### 3-3. Existing AQCS Upgrading: Case Study in China

#### 1000MW Chinese Power Station AQCS: Before MHPS Modification

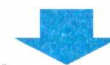


#### Client's efforts before MHPS Modification

ESP	5 sections In 2014, Modification of ESP Guaranteed ESP outlet dust: 30mg/Nm <sup>3</sup>
FGD	Limestone Slurry Process with 5 stages In 2014, added 6 <sup>th</sup> stage Guaranteed FGD outlet SO <sub>2</sub> : 30mg/Nm <sup>3</sup>
GGH	Rotating Type, 3.54% leakage

#### Emission before MHPS Modification

Dust: 14 mg/Nm<sup>3</sup>  
SO<sub>2</sub>: 330 mg/Nm<sup>3</sup>



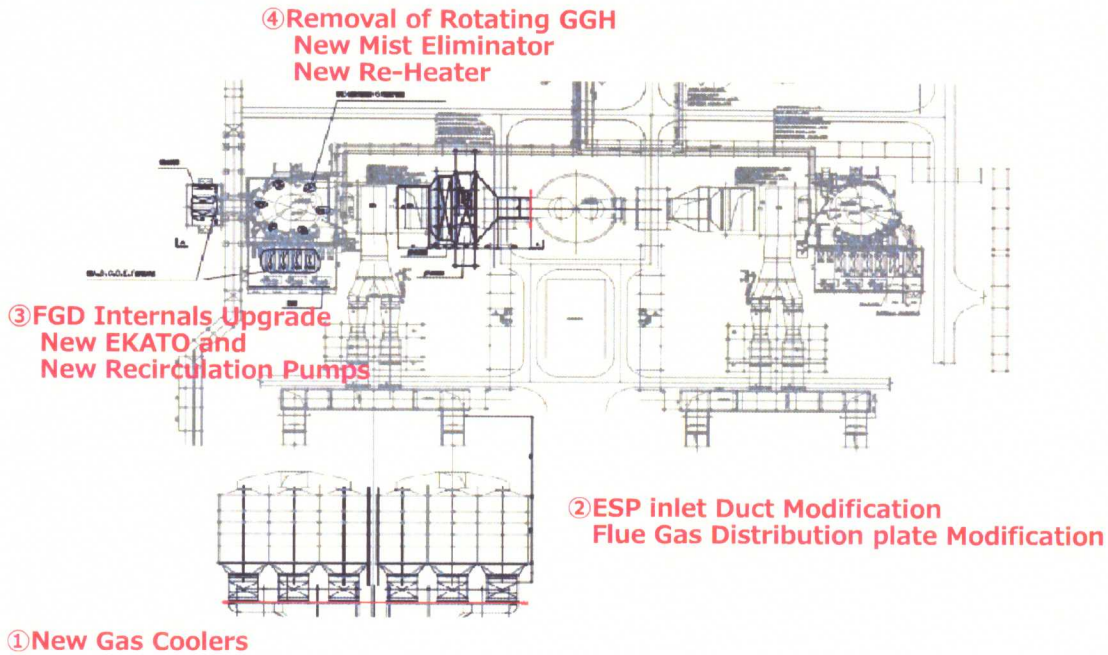
#### Client Target

Dust: 5 mg/Nm<sup>3</sup>  
SO<sub>2</sub>: 35 mg/Nm<sup>3</sup>

Client already made modifications such as ESP and 6<sup>th</sup> stage of FGD but still far from the required emission level.

### 3-3. Existing AQCS Upgrading: Case Study in China

#### Scope of AQCS Modification by MHPS



#### Comprehensive Modifications by MHPS from the Air Heater Outlet to the Stack

### 3-3. Existing AQCS Upgrading: Case Study in China

#### Scope of AQCS Modification by MHPS



FGD Outlet Before Upgrading

SO <sub>2</sub>	Mist	Dust
330mg/Nm <sup>3</sup>	86mg/Nm <sup>3</sup>	14mg/Nm <sup>3</sup>



FGD Outlet After Upgrading

SO <sub>2</sub>	Mist	Dust
≤35mg/Nm <sup>3</sup>	≤40mg/Nm <sup>3</sup>	≤5mg/Nm <sup>3</sup>

Achieving ultra low emission by Comprehensive Modification of GGH, ESP & FGD

**Dust ≤5mg/Nm<sup>3</sup> SO<sub>2</sub> ≤35mg/Nm<sup>3</sup>**

### 3-3. Existing AQCS Upgrading: Case Study in China



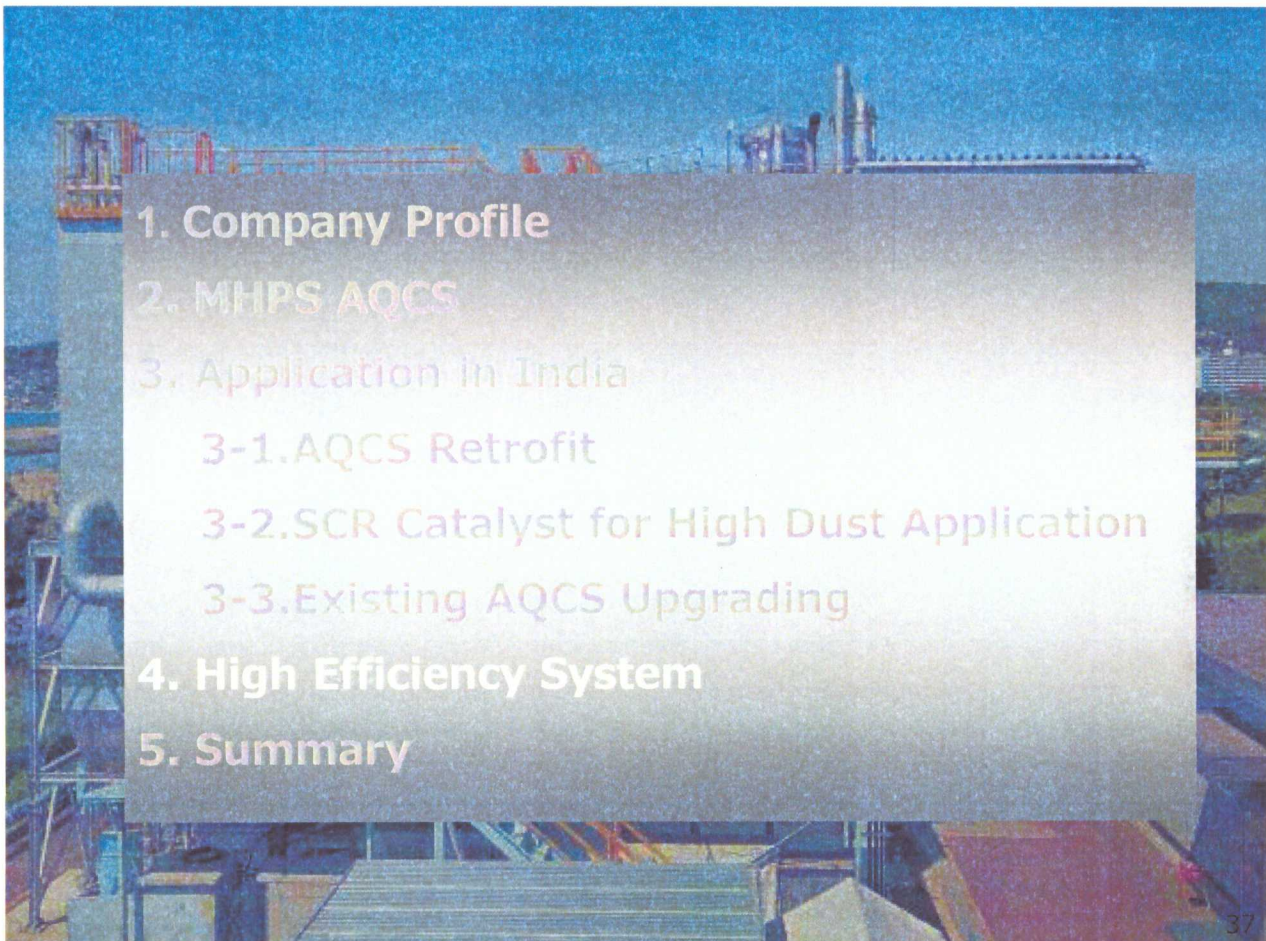
#### MHPS Modification Result

Output : 1000MW  
 Inlet Dust : 24.82g/Nm<sup>3</sup>  
 Dust Emission (Design): 5mg/Nm<sup>3</sup>  
 (Actual): 2mg/Nm<sup>3</sup>  
 SO<sub>2</sub> Emission (Design): 35mg/Nm<sup>3</sup>  
 (Actual): 10~23mg/Nm<sup>3</sup>  
 Outlet Flue Gas Temp: 80°C

机组	#5	#6	#7	#8
二氧化硫	892	687	953	954
二氧化氮	133.0	93.7	162	16.0
氮氧化物	73.3	77.0	66	43.5
粉尘	11.5	10.5	11	1.9

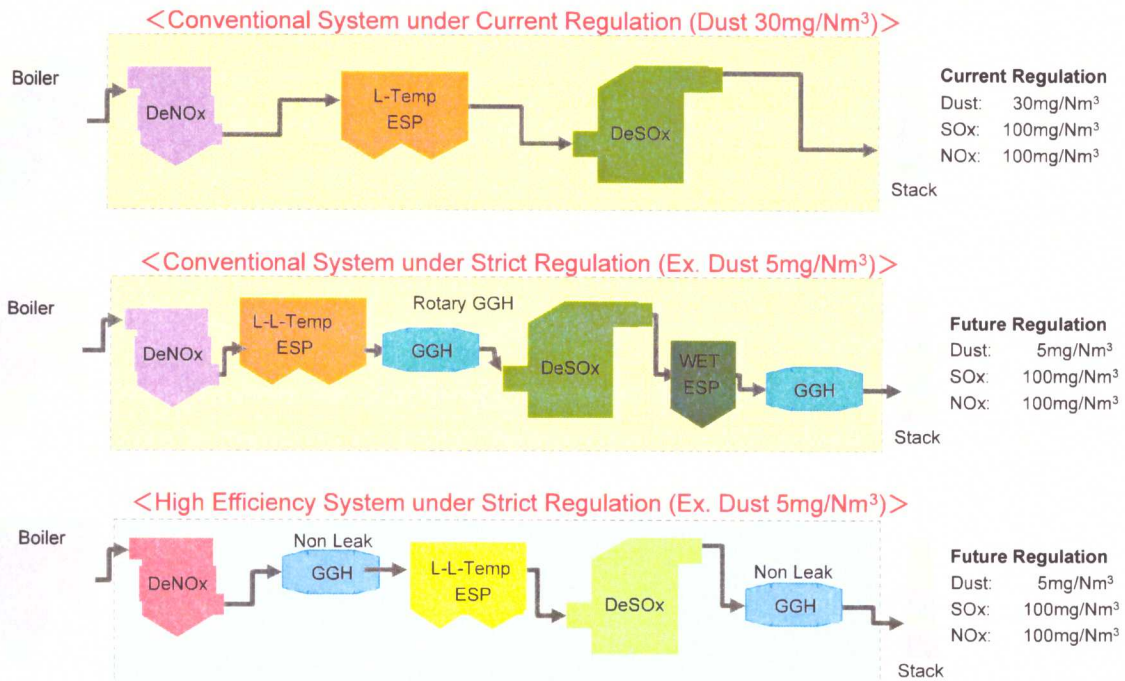
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**Achievement of ultra low emissions by the comprehensive modification from Air Heater outlet to the stack**



## 4. High Efficiency System (HES)

### HES is the advanced technology for strict dust restriction



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## 4. High Efficiency System (HES)

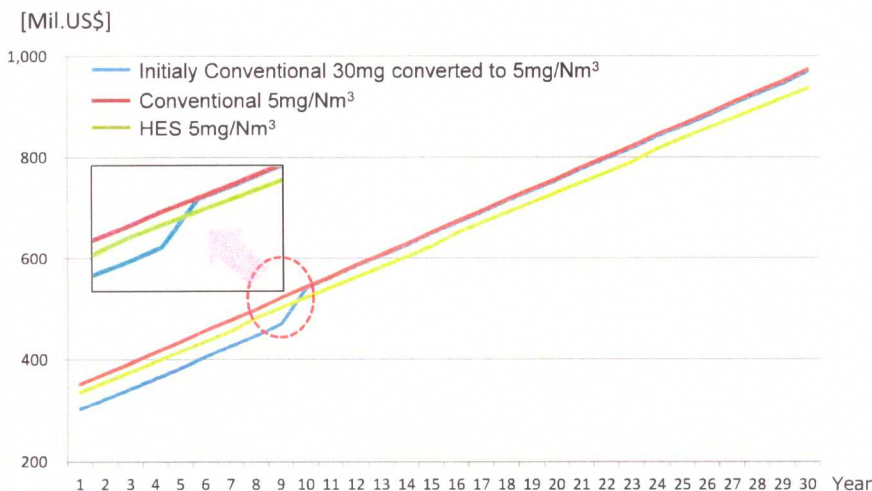
### Comparison of Life Cycle Cost (1000MW x 2 New Boiler)

Assumption: Outlet Dust is regulated to 5mg/Nm<sup>3</sup> after 10 years

Scenario: Initially the Conventional system for 30mg/Nm<sup>3</sup>, 10 Years Later: Conversion for 5mg/Nm<sup>3</sup>

HES is the most economical way under severe emission limit.

Further, Japanese Government loan can be applied under very favorable conditions e.g., 0.3% interest rate, 40 years repayment period including 10 years grace period



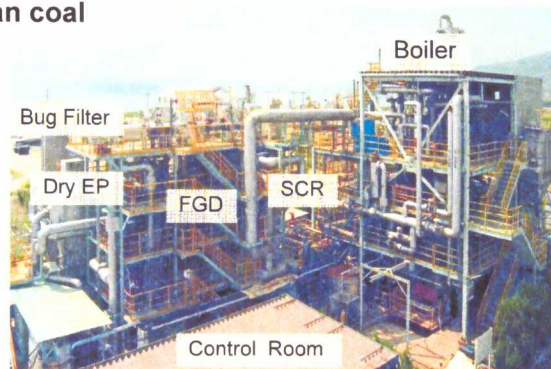
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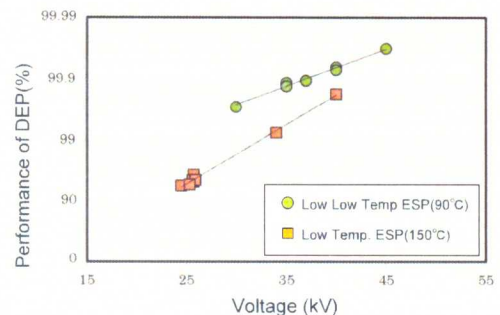
## 4. High Efficiency System (HES)

The HES has been pilot tested by using Indian coal

1. Project : HES Pilot Test with Indian Coal in Japan
2. Place : MHPS Akitsu R&D Centre
3. Term : FY2015
4. Fund : Clean Coal Fund by Japanese Government



Schedule in FY2015	1Q (Apr.-Jun.)	2Q (Jul.-Sep.)	3Q (Oct.-Dec.)	4Q (Jan.-Mar.)
1. Planning/Contract	Planning	9/4 Contract		
2. Import of Indian Coal		9/19 Import to Akitsu		
3. Preparation of Test			Test	
4. Test				Report
5. Analysis/ Reporting				



The performance of ESP was improved by reducing inlet flue gas temperature

### 1. Company Profile

### 2. MHPS AQCS

### 3. Application in India

#### 3-1. AQCS Retrofit

#### 3-2. SCR Catalyst for High Dust Application

#### 3-3. Existing AQCS Upgrading

### 4. High Efficiency System

### 5. Summary

## Summary of MHPS AQCS Business

1. MHPS's AQCS total solution covers SCR, FGD and ESP.
2. The novel AQCS technology has been developed to meet the restricted emission limit in World Bank, Japan, EU and US standards. MHPS has huge amounts of the worldwide delivery records.
3. Extensive experiences for retrofitting AQCS to the existing boilers within the limited area and the limited period.
4. Experiences of various type of coal enables us to design the most optimized Catalyst under Indian high ash condition.
5. MHPS is also aware of the importance of cost competitiveness, therefore the local supply chains would be applied for further cost reduction.

