

Confidential



***Diagnostic Study for
Optimal Environmental Measures
at Dadri TPS, NTPC***



21st February 2018

**Japan Coal Energy Center
Kyuden International Corporation**

As for Interim reporting

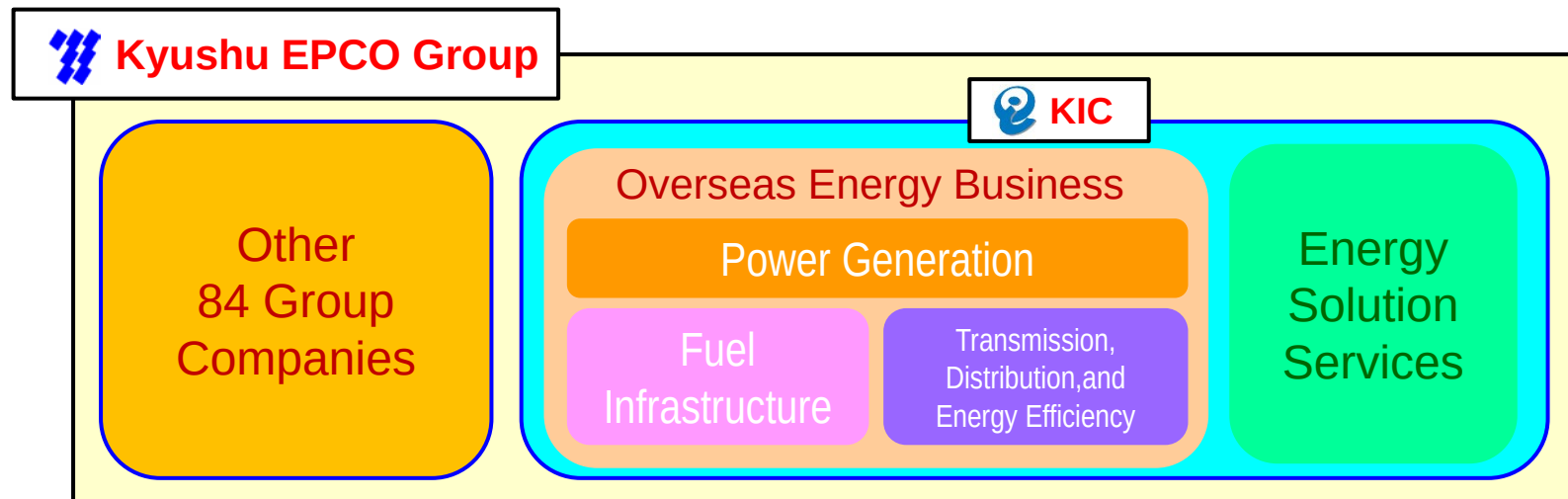
Agenda:

- I. Company profile of KIC & Kyushu EPCO***
- II. Purpose of site survey***
- III. Site survey schedule & member introduction***
- IV. AQCS' configuration of the typical systems***
- V. Introduction of Kyushu EPCO' AQCS system***
- VI. Interim proposal of AQCS introduction for Dadri PS***

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Kyuden International Corporation (KIC) is

We are one of the Kyushu Electric Power Company groups, which is in charge of International business development, and we apply our advanced technical capabilities and considerable experience in order to connect Kyushu with Asia, as well as the world.

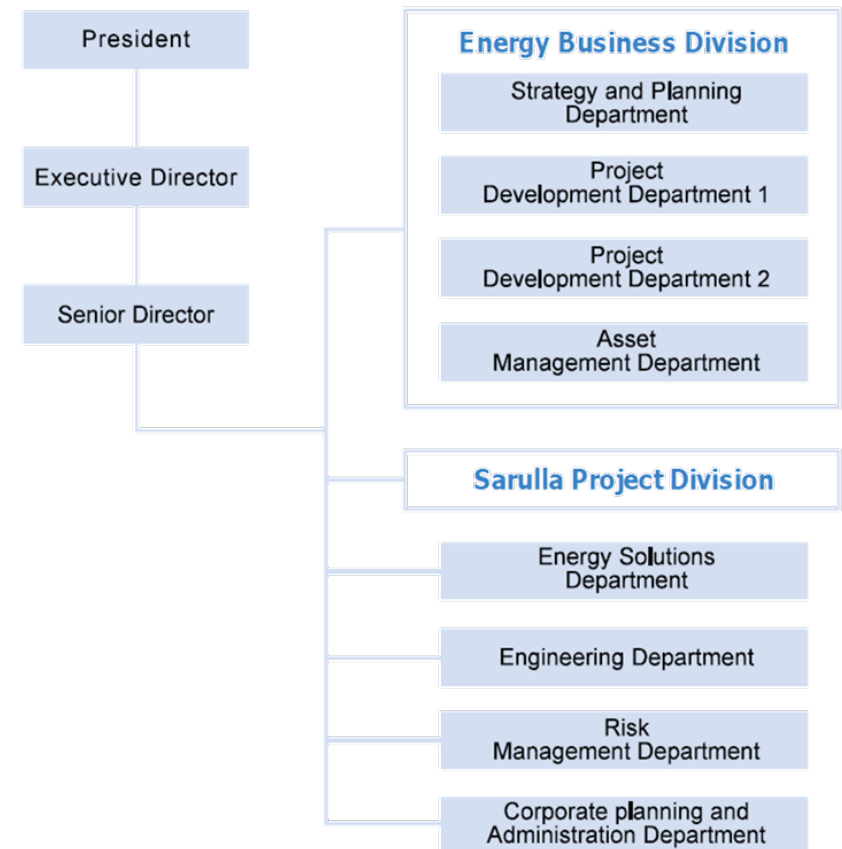


KIC Company Profile

Corporate Information

Company Name	Kyuden International Corporation
Address	1-82, Watanabe-Dori 2chome, Chuo-ku, Fukuoka, 810-0004
Representative	Makoto Kakebayashi, President
Incorporated Date	August 2, 1999
Paid-in Capital	JPY 23,150,000,000
Capital Contribution Ratio	Kyushu Electric Power Co., Inc. 100%
Principal Business	Overseas energy business Energy Solution Services

Organization Chart



KIC's Track Records

Our Track Records

Implementing consultancy projects in countries and territories that require our technology and skills, in addition to expanding our energy business focusing on Asia, whose markets have high growth potential.

Overseas Energy Business [Power Generation]

Inner Mongolia IPP (wind)
Capacity 50 MW Equity Ownership 15 MW
[China]

Tuxpan II & V IPP (gas)
Capacity 495 MW x 2 Equity Ownership 248 MW x 2
[Mexico]

Phu My III IPP (gas)
Capacity 744 MW Equity Ownership 199 MW
[Vietnam]

Hsin Tao Power IPP (gas)
Capacity 600 MW Equity Ownership 199 MW
[Taiwan]

Ilijan IPP (gas)
Capacity 1,200 MW Equity Ownership 96 MW
[Philippines]

Sarulla IPP (geothermal)
Capacity 320 MW Equity Ownership 80 MW
Operating Capacity 105 MW Equity Ownership 26 MW
Under construction Capacity 215 MW Equity Ownership 54 MW
[Indonesia]

Senoko Energy Pte. Ltd. (gas & oil)
Capacity 3,300 MW Equity Ownership 495 MW
[Singapore]

Overseas Power Generation
Equity Ownership:

1,526 MW
(Capacity: 6,989 MW)

Solution Project Records

19 countries and regions
68 projects

Overseas Energy Solution Services

Note: From April 1, 2017, Kyuden International succeeds and promotes the overseas energy solution services of the Kyushu Electric Power Group as its center of this enterprise. (Examples below are Kyushu Electric Power's projects in recent years.)

Study for Formulation of Renewable Energy Introduction in Island of Youth — [Cuba]

Information Collection and Verification Survey for Renewable Energy Introduction and Grid Stabilization — [Cabo Verde]

Project of Power System Master Plan for Geothermal Development — [Rwanda]

Information Collection and Verification Survey for Olkaria Power Station Operation and Maintenance — [Kenya]

Information Collection and Verification Survey for Ukraine Energy Sector — [Ukraine]

Feasibility Study on Replacement of Badarpur Power Station — [India]

Pre-survey for the Project of PV System Development in Ebeye Island — [Marshall]

Study on Energy Saving Promotion for Textile Industry — [China]

Training of Safety Management for China Southern Power Grid — [China]

Vision for 2030:

5,000 MW

Overseas Energy Business (power generation)
Energy Solution Services

A world map with a light blue background. The landmasses are outlined in black. Japan is highlighted in red, and the surrounding waters in the Pacific are highlighted in light blue. The text "Kyushu EPCO company profile" is overlaid on the map.

Kyushu EPCO company profile

Cooperation MOU

		Company	Date concluded
	Korea	Korea Electric Power Corporation	January,1969
		Korea Power Exchange	March,2005
	China	Sichuan Electric Power Test & Research Institute	April,1991
		Shandong Electric Power Corporation / State Grid Corporation of China	April,1992
		China Huadian Corporation	June,2005
	Taiwan	Taiwan Power Company	April,2003
	Singapore	Tuas Power Ltd.	October,2003
	The Philippines	National Power Corporation	October,2000
	Thailand	Provincial Electricity Authority	February,2000
	Vietnam	Electricity of Vietnam	June,2001
	India	<i>National Thermal Power Corporation</i>	<i>February,2007</i>
	U.K	Scottish Power Ltd.	August,1993
	France	Electricite de France	October,1996
		Reseau de Transport d'Electricite	September,2002

Exchange Program with NTPC

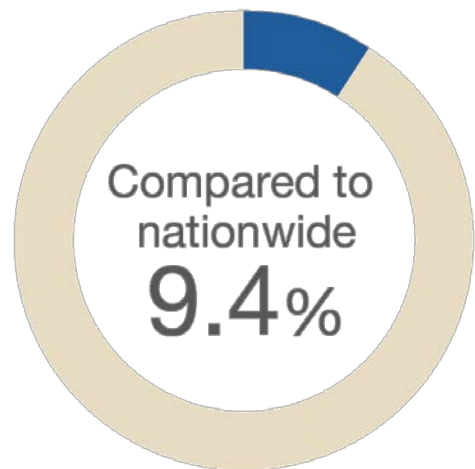
In Feb. 2007

The signing ceremony for MOU of Cooperation NTPC & Kyushu EPCO

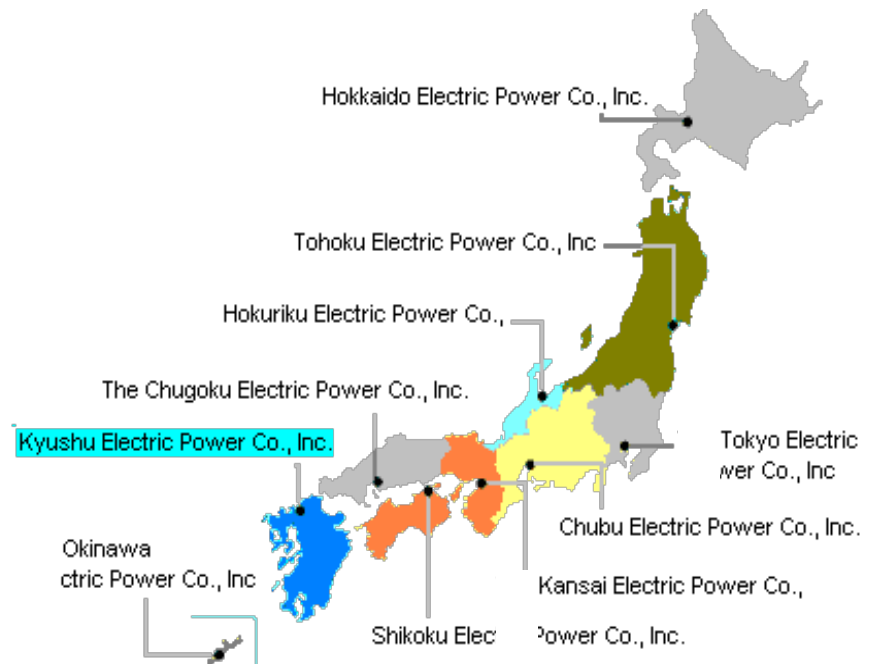


Kyushu EPCO Company profile

Kyushu Electric Power's Sales as a Ratio of the Entire Electricity Business (fiscal 2015)



Reference: Report on Total Electric Power Demand for Fiscal 2015 (Agency for Natural Resources and Energy)



Establishment	May 1, 1951
Paid-in Capital	237.3 billion yen
Number of Shareholders	158,823
Operating revenues	1705.5 billion yen (Nonconsolidated)
Total assets	4321.4 billion yen
Number of Employees	13,132

Source: KEPCO
Source: KEPCO

(As of March, 2016)

Kyushu EPCO Power Supply Facility

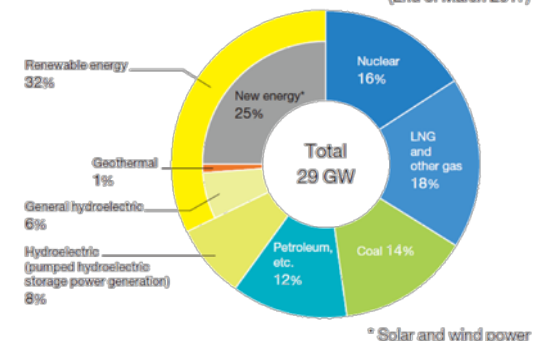
- Power Generation Facilities

Nuclear	4,699 MW	2 stations
Thermal	9,805 MW	8 stations
Hydro	3,584 MW	143 stations
Geothermal	208 MW	6 stations
Photovoltaic	3 MW	1 station
Wind	3 MW	2 stations
Internal combustion	399 MW	34 stations
Subtotal	18,701 MW	196 stations
Facilities with purchase agreement	9,335 MW	
Total	28,036 MW	

- Power Network Facilities

Substations	72,599 MVA
Length of transmission lines	10,773 km
Length of distribution lines	140,352 km

● Composition of capacity for all facilities (GW)
(Including power purchased from other companies)
(End of March 2017)

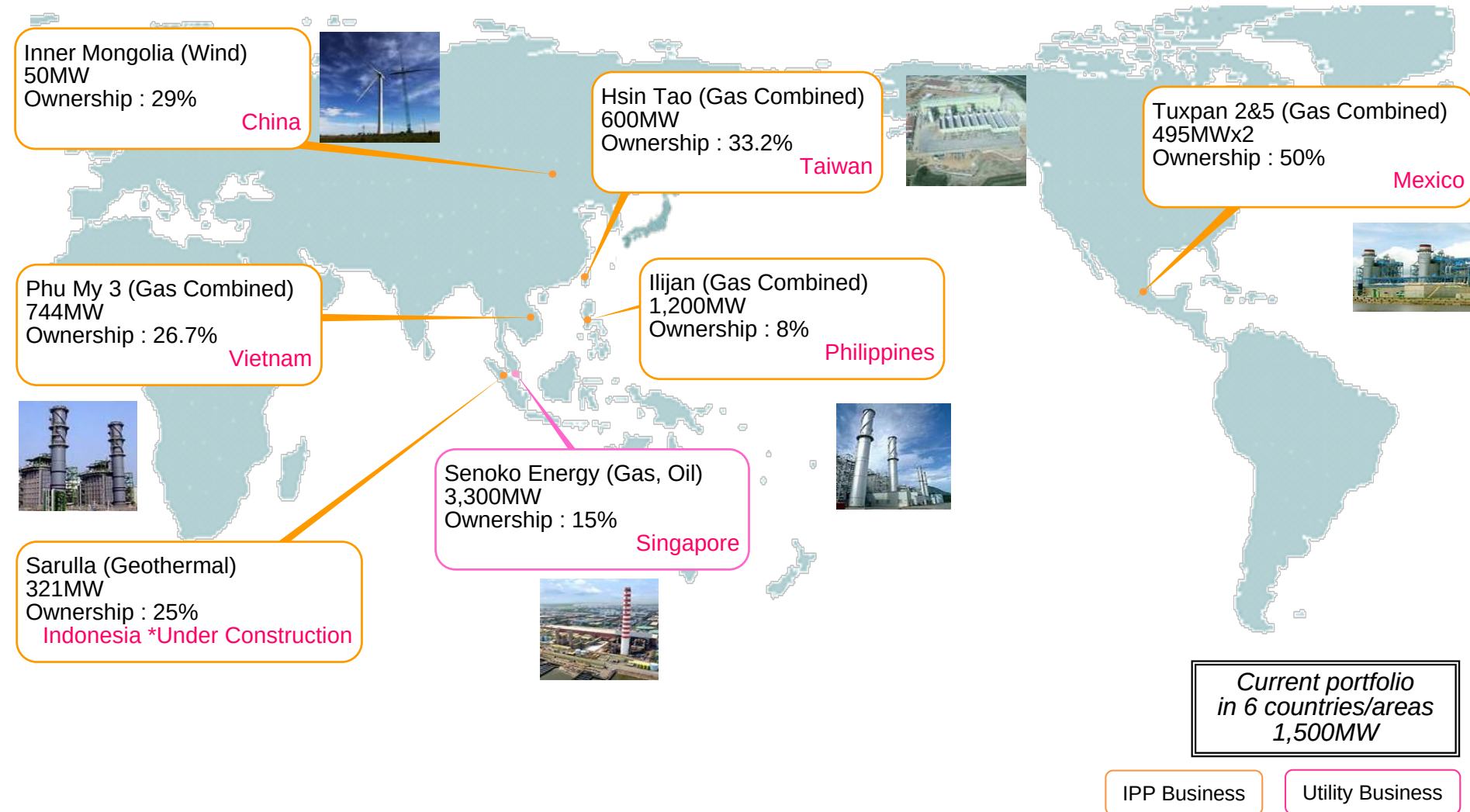


Kyushu's Coal Fired Power Units

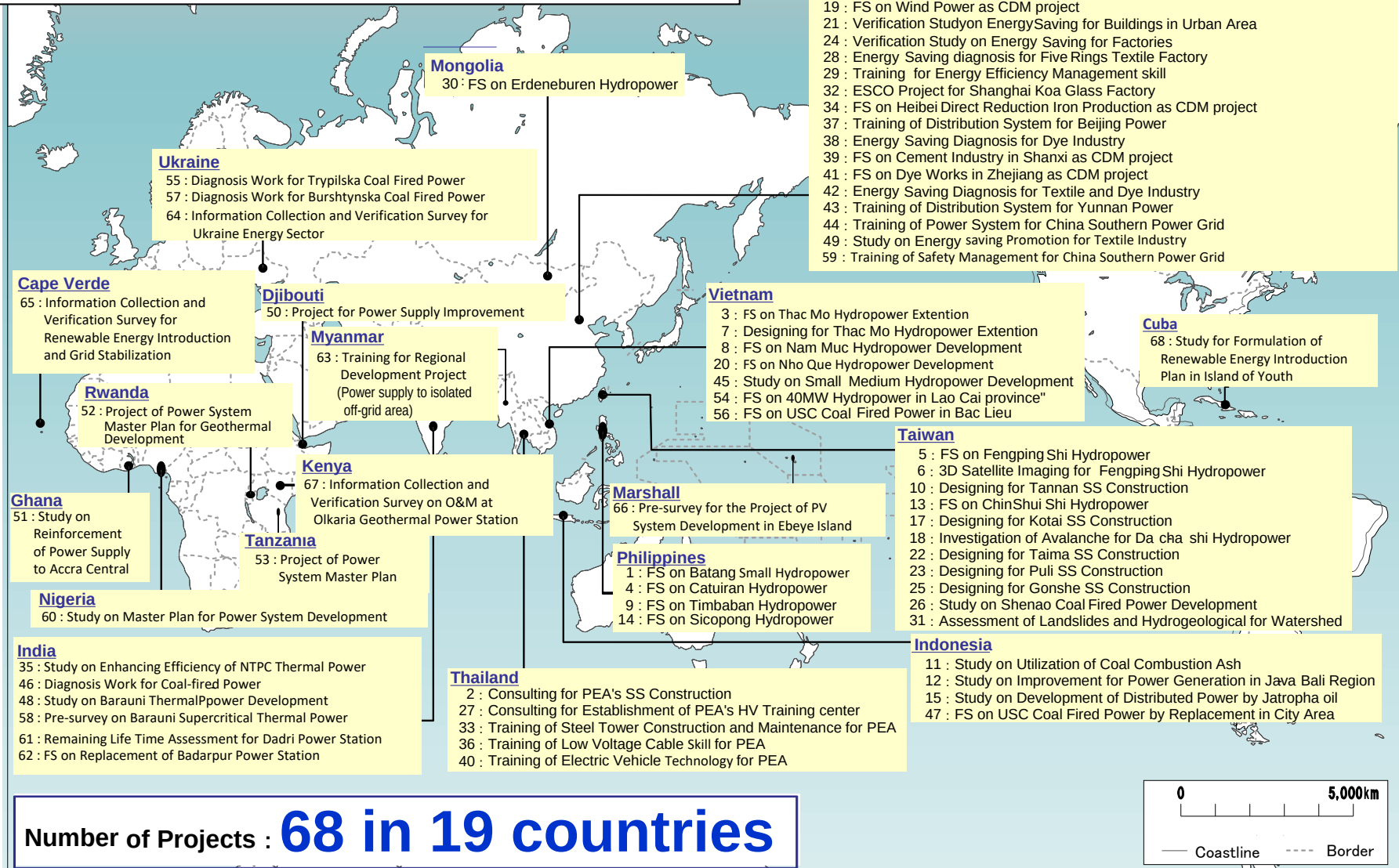
	Matsuura No.1	Reihoku No.1	Reihoku No.2	Matsuura #2
Output	700MW	700MW	700MW	1,000MW
Type	Super Critical	Super Critical	Ultra Super Critical	Ultra Super Critical
Steam Condition	24.1MPa 538/566 degC.	24.1MPa 566/566degC.	24.1MPa 593/593degC.	Under construction
Thermal Efficiency (HHV, Gross)	40.7%	42.1%	42.8%	
OEM	Boiler : MHI ST : Hitachi Gen : Hitachi	Boiler : IHI ST : Toshiba Gen : Toshiba	Boiler : MHI ST : Toshiba Gen : Toshiba	
Operation Commenced	1989	1995	2003	
				2020 (expected)

Kyuden International Activities

Overview of Overseas IPP Assets



Overseas Consulting Services



(As of Sep 30, 2017)

USC Coal-Fired Power Station Development - India

Country	Bihar, the Republic of India
Project name	Study of the Preparation for Construction of Barauni Supercritical Coal-fired Thermal Power Station in Bihar, the Republic of India
Content	Construction feasibility study necessary for the coal-fired thermal power station to be built as an yen loan project (1) Selection of power generation facility specifications (2) Examination of ancillary facilities needed for the power generation facilities (environmental facility, coal storage yard, etc.) (3) Examination of the facility foundation structure based on the topography and geology data (4) Study on the coal fuel procurement status and railway transportation (5) Project cost calculation and economic & financial evaluation
Period	Feb 2015 - Nov 2015



Framework (JICA Project)



Control Room (Existing plant)



New site for construction

Kyushu EPCO

- Project manager
- Sub-manager
- Plant construction planning
- Civil engineering
- Economic/financial analysis

WEST JEC

- Project Implementation planning, etc.

J-Power

- Maintenance system, etc.

Kyuden Int'l

- Fuel procurement plan

ERM Japan

- Environmental and social consideration

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India is fully committed to save the environment from harmful emissions from various sources like industries, power stations, vehicles etc.

In its continuing efforts to safeguard the environment and reduce emissions from power sector, India has taken the initiatives as per the INDCs (Intended Nationally Determined Contributions) submitted in COP21.

Further, to reduce other harmful emissions from Thermal Power Stations, Ministry of Environment, Forest and Climate Change (MoEF & CC) has issued new and more stringent environmental norms in December 2015 regarding emission of SPM, SO_x, NO_x and Mercury.

Capacity (MW)	PM (mg/Nm ³)			SO ₂ (mg/Nm ³)			NO _x (mg/Nm ³)			Mercury (mg/Nm ³)		
	-2003	2003- 2016	2017-	-2003	2003- 2016	2017-	-2003	2003- 2016	2017-	-2003	2003- 2016	2017-
Unit < 500	100	50	30	600	600	100	600	300	100	—	0.03	0.03
Unit > 500				200	200					0.03		

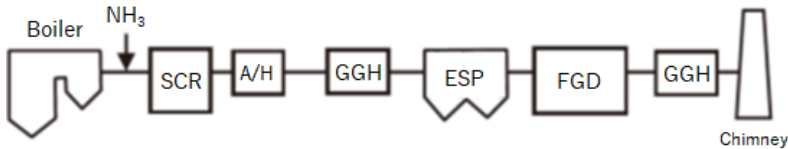
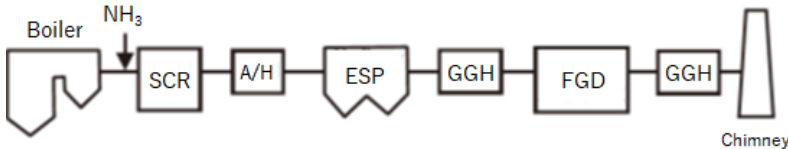
In Japan, for the purpose of safeguarding public health and securing living environment from air pollution, “The National Air Pollution Control Act” has been issued in 1968.

The National Air Pollution Control Act stipulates emissions standards (further-more, local government applies more stringent requirements) for each type of emitted or scattered air pollutants in accordance with type and size of factory / business-facility. Each business entity emitting/scattering air pollutants shall comply with applicable national laws and local regulations.

Kyushu EPCO has introduced optimal environmental equipment to power stations in compliance with national laws and local regulations. The regulations which Kyushu EPCO shall comply is as below.

Coal Fired Power Station	PM	SO _x	NO _x
Reihoku Unit 2 (Jun / 2003~)	30mg/Nm ³	228mg/Nm ³	123mg/Nm ³
Matsuura Unit 2 (Under construction)	10mg/Nm ³	120mg/Nm ³	74mg/Nm ³
Reihoku Unit 1 (Dec / 1995~)	40mg/Nm ³	286mg/Nm ³	123mg/Nm ³
Matsuura Unit 1 (Jun / 1989~)	40mg/Nm ³	286mg/Nm ³	123mg/Nm ³

Efficiency and Environmental improvement in Kyushu EPCO

Power Station	Process flow diagram	Actual emission parameter		
		PM	SO _x	NO _x
Reihoku Unit 2				
Matsuura Unit 2				
Reihoku Unit 1				
Matsuura Unit 1				

Purpose of the site survey

The objective of the Diagnostic Study at Dadri TPS is to identify optimal environmental measures in view of the requirements by the New Environmental Norms.

The purpose of the site survey is to collect required information that is to complement the data and information kindly provided by NTPC prior to the site survey.

Method of the site survey

The site survey will be conducted through:

- a. Joint discussions at Kick-off Meeting and Wrap-up Meeting*
- b. By-group interviews with relevant plant officers/engineers*
- c. Observation to the relevant area of the plant*

Points of attention

- 1) Environmental performance*
- 2) Cost*
- 3) Space for installation*
- 4) Operability and Maintainability*
- 5) Suitability for the coal used at the plant*

Site survey contents (Data collection)

Documents		Purpose of use
(1)	Plant layout drawing (with scale and equipment)	To study optimal environmental measures & improvement
(1-1)	(Additional request) Plot plan for Stage 1 (with scale and equipment name)	
(2)	Equipment drawing (EP, Flue, Chimney & Boiler exit)	To confirm the existing system
(3)	Process flow diagram (Main process & Gas emission system)	
(4)	Organization diagram of Power Station	To confirm the management organization
(5)	Power Station running performance data	To study optimal environmental measures & improvement
(6)	Unit 3 operation status	
(7)	Periodical inspection records and plan information on Unit 3 environmental equipment (EP, Flue & Chimney)	To confirm the current condition of environmental equipment
(8)	Forced outage information on Unit 3 environmental equipment (EP, Flue & Chimney)	
(9)	Renovation / Modernization records and plan information on Unit 3 environmental equipment (EP, Flue & Chimney)	
(10)	Gas emission parameter (Temperature, Oxygen, Concentration and Moisture content)	To study optimal environmental measures & improvement
(11)	Gas emission quality data at Boiler exit	
(12)	Gas emission quality data at Chimney entrance	
(13)	(Additional request) Coal characteristic data (Latest analysis data)	

Site survey contents (By-group interviews)

Officers / Engineers in charge	Points to be checked
Management	
Facilities planning	• Renovation / Modernization planning for environmental equipment and Others (Stage1&2) • Target emission value for environmental improvement (Stage1) • Available area to install new environmental equipment etc.
Operation & Performance management	• Methods of Flue-gas measurement (Automatically / Manually)
Maintenance	
Boiler	• Combustion state • Any failure or defect, malfunction etc.
Coal unloader	• Possibility of modification for installation of new environmental equipment etc.
Waste water treatment	• Treatment of waste water from Power Station • Control criteria (requirements) etc.
Electrostatic Precipitator	• Rapping (Hammering) interval of fixed electrode (Daily / Weekly) • Any failure or defect, malfunction etc.
Electrical equipment	• DCS system configuration etc.
Environmental equipment	• Target emission value for Stage1 • SO_x value escalation from Dec. 2015

Site survey contents (Site observation)

<i>Location</i>	<i>Points to be checked</i>
<i>Equipment (Boiler, EP, Chimney etc.)</i>	<i>Current condition of environmental equipment and its auxiliaries</i>
<i>Boiler exit - Chimney entrance</i>	<i>Space to install new efficiency and environmental equipment</i>
<i>Premises of power station</i>	<i>Allocation of temporary storage yard</i>
<i>Center control room</i>	<i>System configuration of monitoring system for emissions parameter</i>

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Site survey schedule

Date	Day	Time	Activities
19 th Feb.	Mon	AM	Kick-off meeting at NTPC Dadri Power Station
		PM	Interview: Session1: Facilities planning & Plant management Session2: Plant maintenance
20 th Feb.	Tue	Whole day	Site survey & Interview (if there is remaining works) ✕ KIC would like to request site survey by 2 teams.
21 st Feb.	Wed	AM	Wrap-up meeting
		PM	Interim reporting at NTPC EOC

KIC's members



Masaya Shibata
(Mechanical)



Yuzo Yoshida
(Electrical)



Kazuyoshi Nagamatsu
(Mechanical)



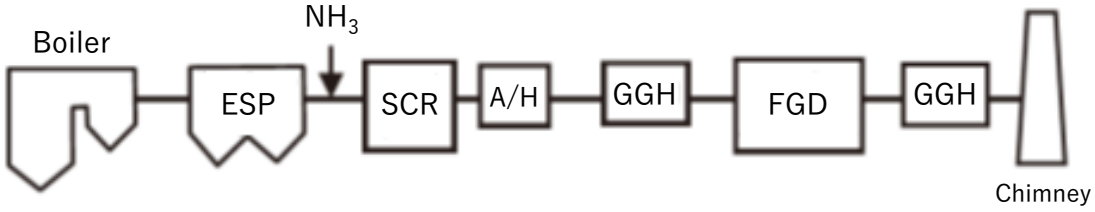
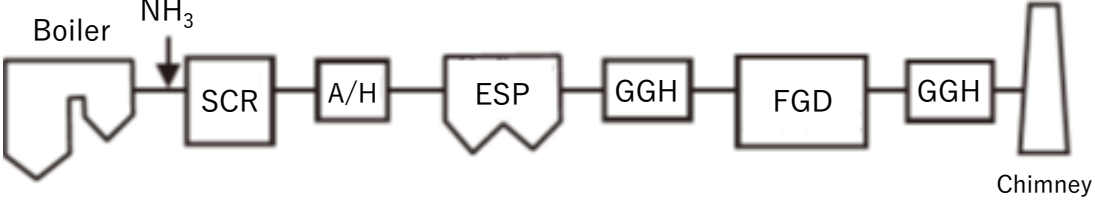
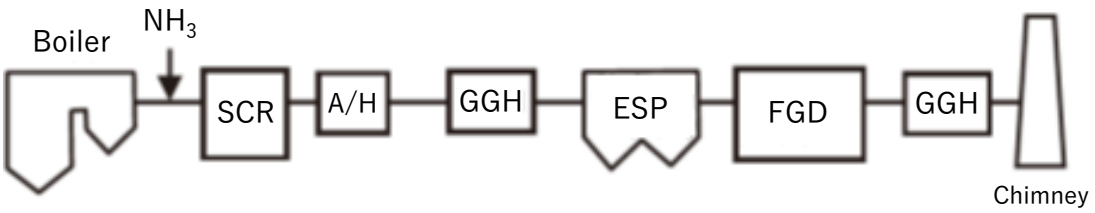
Tomohiro Hata
(Electrical)



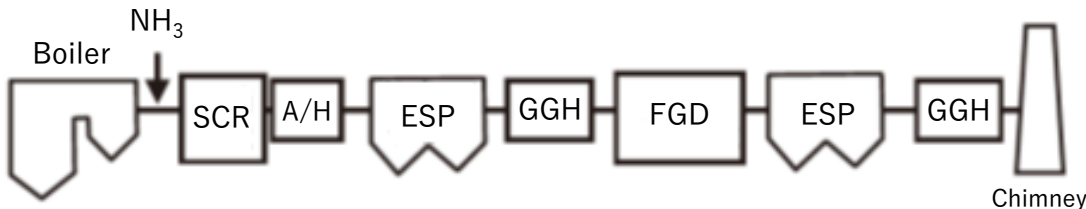
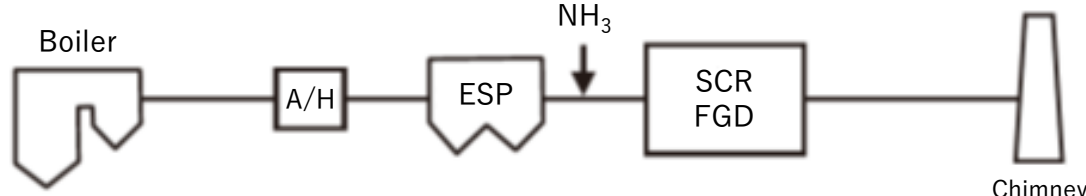
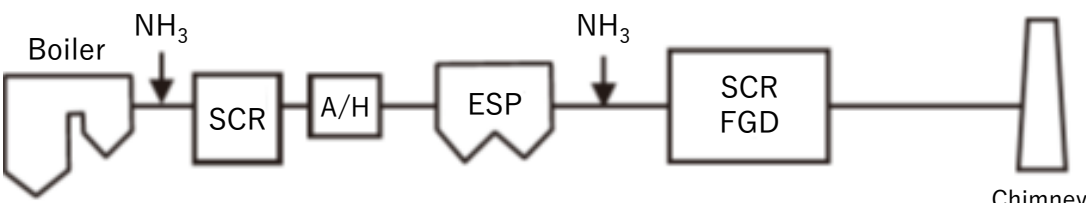
Tachibana Shunsuke
(Electrical)

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AQCS' configuration of the typical systems

Treatment System	System Configuration
Wet type FGD high-temperature ESP system (low dust system)	 The diagram shows a horizontal flow from left to right. It starts with a 'Boiler' icon, followed by an 'ESP' (Electrostatic Precipitator) icon. An arrow labeled 'NH₃' points down into the line between the ESP and the next 'SCR' (Selective Catalytic Reduction) icon. This is followed by an 'A/H' (Air Heater) icon, then a 'GGH' (Gas-Gas Heat Exchanger) icon, then an 'FGD' (Flue Gas Desulfurization) icon, then another 'GGH' icon, and finally a 'Chimney' icon.
Wet type FGD low-temperature ESP system (high dust system)	 The diagram shows a horizontal flow from left to right. It starts with a 'Boiler' icon, followed by an 'SCR' icon. An arrow labeled 'NH₃' points down into the line between the Boiler and the SCR. This is followed by an 'A/H' icon, then an 'ESP' icon, then a 'GGH' icon, then an 'FGD' icon, then another 'GGH' icon, and finally a 'Chimney' icon.
Wet type FGD low-low-temperature ESP system (high dust system)	 The diagram shows a horizontal flow from left to right. It starts with a 'Boiler' icon, followed by an 'SCR' icon. An arrow labeled 'NH₃' points down into the line between the Boiler and the SCR. This is followed by an 'A/H' icon, then a 'GGH' icon, then an 'ESP' icon, then an 'FGD' icon, then another 'GGH' icon, and finally a 'Chimney' icon.

AQCS' configuration of the typical systems

Treatment System	System Configuration
Wet type FGD wet ESP system (high dust system)	
Dry type FGD Simultaneous denitration and desulfurization treatment system (independent treatment)	
Dry type FGD Simultaneous denitration and desulfurization treatment system (install denitration equipment)	

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Outline of the Kyushu EPCO AQCS

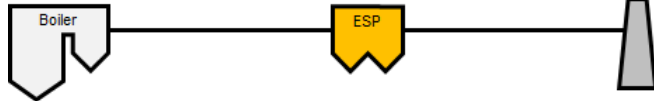
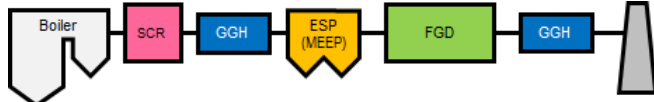
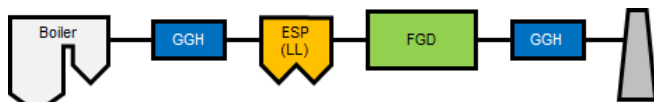
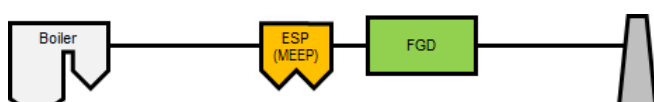
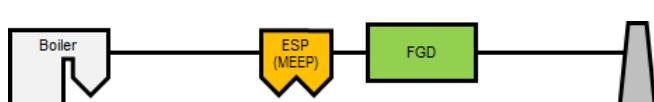
Item		Conventional system	
Power station		Reihoku Unit 1	Matsuura Unit 1
Commercial operation			
Desulfurization equipment			
GGH			
ESP			
Guaranteed performance	Dust concentration (ESP outlet)		
	Dust concentration (stack inlet)		
	Nitrogen oxide		
	Sulfur oxide		
Test results	Dust concentration (ESP outlet)		
	Dust concentration (stack inlet)		
	Nitrogen oxide		
	Sulfur oxide		
Outline drawing			

Outline of the Kyushu EPCO AQCS

Item		High efficiency system	
Power station		Matsuura Unit 2	Reihoku Unit 2
Commercial operation			
Desulfurization equipment			
GGH			
ESP			
Guaranteed performance	Dust concentration (ESP outlet)		
	Dust concentration (stack inlet)		
	Nitrogen oxide		
	Sulfur oxide		
Test results	Dust concentration (ESP outlet)		
	Dust concentration (stack inlet)		
	Nitrogen oxide		
	Sulfur oxide		
Outline drawing			

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Our interim proposal of AQCS introduction for Dadri PS

	Treatment System	System Configuration	Advantage			
			Cost	Space	Operability	Environment
Present status	—		—	—	—	—
Case1	SCR + GGH + ESP(Low-Low Temp) + FGD + GGH					
Case2	GGH + ESP(Low-Low Temp) + FGD		<i>Under study</i>			
Case3	ESP MEEP + FGD (Each unit)					
Case4	ESP MEEP + FGD (4 unit set type)					

Remarks: Need to consider below aux equipment for introducing new AQCS systems

	Boost-up fan (addition)	Make-up water system modification	Air supply system modification	Waste water treatment	Ammonia preparation system	Limestone preparation system	Gypsum recovery system	Power supply system modification	Control system modification
Case 1 SCR+GGH+ESP(Low-Low Temp) + FGD+GGH 	☐	☐	☐	☐	☐	☐	☐	☐	☐
Case 2 GGH+ESP(Low-Low Temp)+FGD 	☐	☐	☐	☐	N/A	☐	☐	☐	☐
Case 3 ESP MEEP+FGD (Each unit) 	☐	☐	☐	☐	N/A	☐	☐	☐	☐
Case 4 ESP MEEP+FGD (4 unit set type) 	☐	☐	☐	☐	N/A	☐	☐	☐	☐

Finding and further consideration through the site survey at NTPC Dadri PS

1) Environmental performance

- *SO_x: New Norm of (600mg/Nm³) is not being satisfied. Environmental equipment is required. (R&M Plan Stage1,2 2019.Dec)*
- *NO_x: New Norm of (600mg/Nm³) is being satisfied, therefore addition of environmental equipment is not required as of now.*
- *SPM new norms (100mg/Nm³) are met with current levels at (46mg/Nm³), hence R&M of ESP is not being planned.*
- *In spite of change in environment equipment, there is no need to take measures for power station renewal immediately.*
- *Against New Environmental Regulation Standard, Achievable Target Values are taken up by NTPC HQ.*
- *Dadri TPS is internally proceeding towards Zero Discharge Target by 2018 March End.*

Finding and further consideration

- *To achieve Zero Discharge, Using water after water treatment is desired/advised.*

Finding and further consideration through the site survey at NTPC Dadri PS

2) Space for installation

- *Possible space for installation of environmental equipment is as annexed*
- *Distance from Boiler Exit Pillar to ESP inlet Pillar at Unit 3, approx. 23m.*
- *Distance from ESP exit Pillar to chimney inlet duct at Unit 3, approx. 43m.*
at Unit4, approx. 45m.

Finding and further consideration

- *In case of introducing new ESP, it is necessary to consider the method of installation including carrying the panel into the ESP building and cable pulling.*
- *Furthermore, it is necessary to consider the method of crane approach to the position of installation.*

Finding and further consideration through the site survey at NTPC Dadri PS

3) Operability and Maintainability

- *Operation & maintenance of ESP is performed appropriately.*
- *In 2015, R&M for DCS integration of Stage1 All Units performed.*
- *In 2012 for stage1 Unit3&4, remote monitoring ESP Control equipment modified, in terms of operability, currently no problems.*

Remark

- *FGD compatibility with current DCS are appropriate.*

Finding and further consideration through the site survey at NTPC Dadri PS

4) Suitability for the coal used at the plant

- *Various Coal types are used, variations in coal type conditions.*
- *Washed coal is being received, Ash Content is below 34%.*

Finding and further consideration

- *Investigation of Environmental equipment corresponding to varying conditions in coal types used is required.*



Thank you!

[Contact]



Engineering Department

Kyuden International Corporation

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