Summary Report

CEA-JCOAL cooperation in FY 2017

December 2018

Japan Coal Energy Center (JCOAL)

Contents

1 . Summary of the Activities in FY 2017

1 . 1 Overview of the CEA-JCOAL Cooperation in FY2017

CEA and JCOAL embarked on their cooperation officially as of April 30, 2010, when they signed the first Memorandum of Understanding (MOU) on Japan-India Cooperation for Pre-primary Study of Efficiency and Environmental Improvement of Coal Fired Power Stations. As the title indicates, Japan-India Cooperation for Project on Efficiency and Environmental Improvement for Sustainable, Stable and Low-carbon Supply of Electricity, now known as CEA-JCOAL Cooperation, is expected by the both governments to play the central role in facilitating and accelerating high-efficiency and environmentally compliant coal power generation in India. The Cooperation always comes up as one of those high on the agenda of the India-Japan Energy Dialogue accordingly.

During 5 years of cooperation, 8 units out of 7 power stations owned by both NTPC and state utilities have been diagnosed and benefited through the joint activities and the proposals by Japanese experts. The effect of this cooperation has been enhanced by associated activities with focus on sharing of knowledge and experiences as well as capacity building such as an annual workshop; CEA-JCOAL Workshop, and also CCT Transfer Program, that is, a program for officers and engineers of key institutions and utilities, of knowledge and technology exchange through observation of facilities and intensive discussions between experts and specialists, all of which have expedited to establish a great bilateral network.

The past decade saw a lot of progress in formulation and implementation of energy-related policy and policy instruments by the Government of India.

India has been initiating a set of national programs for efficiency enhancement of existing power stations through R&M/LE of existing thermal power stations as well as for high-efficiency in parallel with new and cleaner coal power development through UMPPs (Ultra Mega Power Projects), etc.

The Government has been keenly initiating increase of coal production to enhance supply sustainability. “24 x 7 Power for all”, the national policy initiative for power supply for people through massive increase of generation capacity is also worth of note.

In the meantime, the New Environmental Norms came into place as early as December 2015, by which people and the Government of India showed their strong will in pursuit of sustainable economic development without sacrificing environment.

Also, MEEP (Moving-electrode electrostatic precipitator), one of the most potential Japanese Clean Coal Technology (CCT) for power plant that had been promoted under the Cooperation, was awarded for R&M of two units of Rihand STPS, NTPC. The aforementioned introduction of MEEP that had commenced its operation in mid-2016, came to be the center of attention by the power sector stakeholders in India, in the midst of growing argument on how the New Environmental Norms (New Norms) introduced in December 2016 are to be addressed.

It is well recognized that the power sector in India is experiencing a paradigm shift with the introduction of the new environmental norms; Having been well focused on the environmental aspect of coal fired power generation for years, CEA-JCOAL Cooperation remains expected to firmly address the needs and requirements; including but not limited to environmental issues in the power sector in India.

Table 1-1 New Environmental Norms

Date of Installation	Capacity (MW)	SO_2 (mg/Nm^3)	PM (mg/Nm3)	NO_x (mg/Nm^3)
Installed before Dec 31, 2003	> 500	200	100	600
	< 500	600		
Installed from January 1, 2004 to Dec 31, 2016	> 500	200	50	300
	< 500	600		
Installed after January 1, 2017	> 500	100	30	100

While enhanced environmental requirements through new norms have been supposedly welcomed by manufacturers, utilities would have received it differently. Well before the new norms came into place, they had been making their strenuous efforts in financial management under the situation where FSA and PPA are not interrelated each other. It is clear that the requirements by the New Norms may require additional financial burden to those utilities. The central government is required to take the foregoing situation into consideration in the expected policy implementation.

Activities have been deliberated, selected and performed under the Cooperation to support the foregoing policy efforts by the Central Government both in the upstream (coal) and the downstream (coal fired power) of the coal value chain. Below quoted are the four major activities in FY2017.

1.2 O&M Study at DSTPS, DVC

This project has been executed with the aim of refining the thermal efficiency management of existing coal-fired plants in India, by considering the feasibility of introducing a real-time unit performance-management system using IoT to target 500 MW subcritical units.

The Government of India plans to install 175 GW in cumulative renewable energy capacity by 2022, including 100 and 60 GW from solar and wind sources respectively. Low-load and load-following operation will be required, even with coal-fired power, which has been positioned as a base load power source, since solar and wind power output are particularly dependent on solar radiation and wind conditions. The background of this project is the need to improve deterioration in thermal efficiency.

After consideration of management methods which would help refine performance management to maintain and improve performance of the target units, the following were found desirable

1. To determine performance deterioration in real time by recognizing tendencies and age deterioration status on a daily, weekly, monthly and yearly basis,
2. To use highly accurate performance test data
3. To apply a method which manages deviation from performance reference values using the heat balance model.

Using the big data the power plants when applying these management methods allows us to provide a performance-management system service utilizing IoT from Japan as a new business, which is the stand-out feature.

With the recommendation of the Ministry of Power (MOP) and the Central Electricity Authority (CEA), the 500MW sub-critical unit at Durgapur Steel Thermal Power Station (hereinafter referred to as “DSTPS”) owned by Damodar Valley Corporation (hereinafter, “DVC”) were selected as subjects of the study conducted, via analysis of the power plant operational data, to determine causes of the decline in thermal efficiency, improve the operation method and propose measures enabling to thermal efficiency to be maintained/improved by modifying equipment.

Table 1-2 DSTPS equipment summary

Name of Electric Power Company	Damodar Valley Corporation
Name of Power Station	Durgapur Steel Thermal Power Station
Power Station Total Output	1,000MW（500MW X 2 units）
Performance Testing Target Unit	1
Start of Operations	May 2012
Main Fuel	Coal (Bituminous, Sub-Bituminous varieties）
Standard Output	500MW
Minimum Output (Coal Only)	300MW
Generator	Made by BHEL
Turbine	Made by BHEL

Boiler	Made by BHEL

Figure 1-1 Full view of the power plant and boiler building

As a DCS (Distribution Control System) is introduced in DSTPS, almost all operational data necessary for this thermal efficiency survey were conserved. The data storage period is one year or more and even hourly data were available for the units of measure. Unit 1, the survey target of thermal efficiency analysis, underwent large-scale equipment modification during the period July to August this year and its performance was substantially improved, resulting in an anomaly in data before and after modification. Accordingly, the operational data for one month was used in the analysis, starting from the large-scale modification finish.

In December 2017, the survey team visited the DSTPS to collect operational data and conduct feedback from the plant staff and also carried out a walkthrough of the entire power plant.

Fig. 1-2 DSTPS staff and JCOAL team

Summary of the site survey were listed below.

・The condenser has about a 20% margin against the design performance and shows no performance degradation at present.

・Conversely, only one unit of circulating water pumps was stopped during the high vacuuMoPeration in the winter season, which indicates room for improvement.

・The condenser is cleaned with a ball, brush and acid and actions to maintain efficiency are conducted.

・The boiler has been subject to three tube leaks on the economizer and super heater this year.

・It was explained that while the boiler is cleaned by operating the soot blower manual, relatively little molten ash had accumulated within the boiler at the time of overhaul.

・With regard to the turbine, a temperature difference emerges between the upper and lower casing at low-load (60%) operation and any further increase in this temperature difference is controlled by opening the casing drain valve (connected to the condenser), which is supposed to be open only when the unit starts up, to release the stagnating steam. According to the maker, this might be due to incorrectly positioned heat insulators.

・The purchased coals with calorific values varying from 2000 to 4000kcal/kg and ash content from 30 to 70％. Domestic coals are supplied from four coal mines and the mine which produces the coal on which the design is based is the most distant and has the lowest purchase quantity, despite being of high quality. This coal seems to be a low-sulphur variety, with a high ash melting point.

・All the coals are transported by train. The capacity of the coal storage area is 280,000 m^3 and the daily coal consumption is 14,000 t.

The on-site walkthrough brought up some comments to be noted in terms of safety management of the unit. The walkthrough brought home to use the extent to which the DSTPS prioritizes safety during unit operation above all, through posters posted in many places within the facilities for the purpose, for example, to raise awareness on safety management of the unit operation. Some recommendations related to safety management are presented here for further improvement on the matter. Conscientious practice of safety management according to those recommendations would lead to decrease unplanned shutdowns and power restrained operations, contributing to improve the unit efficiency.

Fig 1-3 Additional safety management comments for DSTPS

The present project was conducted through the following two approaches, which would lead to the overall thermal efficiency of each unit in the thermal power equipment being maintained/improved:

(1) Thermal efficiency maintenance/improvement of the plant alone

(2) Improvement of overall thermal efficiency of the power generation equipment

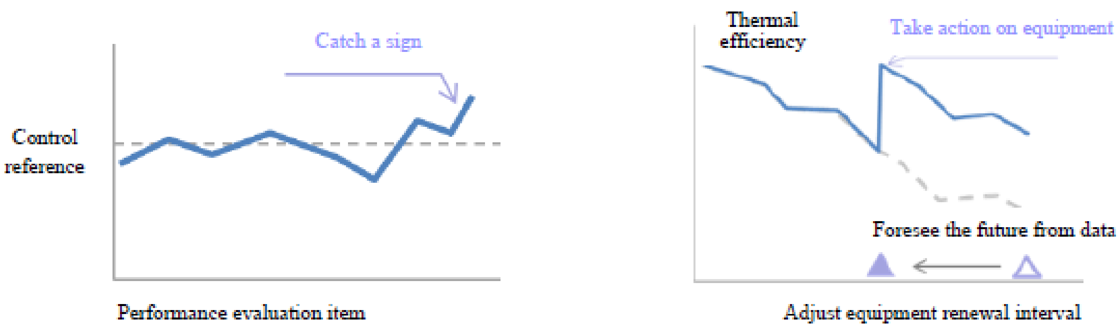


Fig-1-4 Image of early detection of anomalies by comparing operating conditions and reference values

Fig-1-5 Image of thermal efficiency maintenance/improvement

As stated in 1.2, data are well conserved in DSTPS and almost all operational data (about 1,600 data, hourly data for one month) and documents (test certificates, equipment specifications, repair records and plan, various drawings, design heat balance chart, performance curves, structural drawings, etc.) necessary for analysing thermal efficiency were available.
The operational data period is one month from 25 Oct. to 24 Nov. During this period, the rated output of 500MW was attained for only three days and hovered at around 350MW on other days.

It emerged that the unit loses its efficiency, despite being just less than 5% of the design value at the construction phase. The factors behind the decline were analysed by individual equipment as follows:
Boiler efficiency was maintained at the design value. However, the air leakage ratio of the air heater (hereinafter, “AH”) was high, causing the AH temperature efficiency ratio to decline and it emerged that such decrease, despite having minimal influence, was responsible for the drop in efficiency.
As for turbine efficiency, a decline in performance from the design value was observed. Following detailed performance diagnosis by individual equipment, a performance decrease due to age-related degradation emerged on the intermediate pressure turbine and the high-pressure heater. The prime reason behind the decline in efficiency of the unit turned out to be the decline in efficiency of the turbine.
Unit efficiency decreases gradually from the operation start-up. To date, it has declined by about 0.7% compared to the design value. Individually analysed efficiencies constituting unit efficiency, i.e. turbine and boiler efficiencies, showed that the latter had remained at or exceeded the design value from the operation start while the former had dropped considerably.
The turbine is found to be responsible for the actual decline in unit performance. The performance of individual pieces of equipment was analysed to determine the factors in the turbine equipment impacting on said performance. Compared to the result of the most recent performance test, the analysis showed that the internal efficiency of the high-pressure turbine remained at the design value while that of the intermediate pressure turbine declined by about 2% of the performance test result.
Based on the above, it is inferred that the factors impacting on turbine performance stem from the intermediate pressure turbine. Furthermore, the data accuracy of the result and the data-collecting position of the 2013 Performance Guarantee Test should be verified, since some data show extremely low values compared to design values, making the test results themselves problematic.

Finally, four main recommendation was proposed;

(1) Proposal to improve intermediate turbine performance (replacement of first stage nozzle, etc.)

It emerged that the intermediate turbine internal efficiency had decreased by about 2% compared to the design value. The likely cause of this decrease and consequent recommendation proposal for points to be checked and items to be repaired at the next periodic inspection (2019) are described in the detail report.

(2) Proposal to improve high pressure heater performance (Water-jet washing of No. 6 heater tubes)

Given the increased deviation observed in terms of TD and DC values since operation commenced, which indicate high-pressure heater performance, a decline in performance is likely. A recommendation proposal for points to be checked at the next periodic inspection (planned for 2019), based on the likely causes of this deviation and consequent items to be repaired are described in the detailed report.

(3) Proposal to improve air-heater performance (installation of sensor drive)

Although the temperature efficiency and air leakage ratio of air heater showed improvement in the 2017 periodic inspection, the air leakage ratio may increase again over time in future. The leakage observed in this survey did not impact in terms of triggering a decrease in boiler efficiency, but it was thought that a leak may lead to a decrease in boiler efficiency depending on the circumstances of any deterioration in performance. Therefore, it was considered effective to install a sensor which detects an increase in the air leakage ratio.

(4) Proposal to improve condenser performance

For turbine equipment, one of the key parameters governing whether thermal efficiency declines or remains constant is the condenser vacuum degree, which varies depending on various factors such as turbine steam cooling temperature, atmospheric temperature/humidity, combustion condition of the boiler, etc. Conversely, given the narrow effective range of condenser vacuum allowing optimal unit performance, it is not possible to efficiently control the condenser vacuum by indirect means.

If the remedial actions as proposed in above list are carried out, the amount of change in thermal efficiency (absolute value), reduction in fuel consumption and annual fuel cost reduction would be estimated as follows:

Table 1-3 Impact in terms of improved thermal efficiency and reduced fuel cost of the unit

Equipment	Recommendation	Expected value of restored performance	Change in thermal efficiency of the unit (%pt)	Reduction in CO_2 emission (t-CO2/year)	Reduction in fuel consumption (t/year)	Fuel cost reduction (103 INR/year)
Intermediate pressure turbine	Efficiency recovery by first stage nozzle replacement, etc.	Recovery of intermediate pressure turbine inner efficiency by 1.0%	0.17	▲13,499	▲10,032	▲30,096
High pressure heater	Heat exchange performance recovery by jet cleaning of tubes	Recovery of TD and DC values up to the values at Performance guarantee test	0.05	▲3,983	▲2,890	▲8,670
Air Preheater	Reduction in air leakage ratio by installing SDS	15% annual average leakage → 10% (design value) will be maintained.	0.03	▲2,391	▲1,960	▲5,881
Condenser	Optimal vacuum maintenance by installing vacuum regulating valve	0.02% pt. efficiency decrease due to excessive vacuum in winter season will be avoided.	0.02	▲1,595	▲90	▲270
Total			0.27	▲21,468	▲14,972	▲44,917

Note 1. The annual utilization ratio of the unit is estimated as 70%.

Note 2. The gross calorific value (GCV) of the design coal, 3300 kcal/kg, was used as the calorific value for the coal fuel.

Note 3. 3000 INR/t (result of hearing) was used as the coal fuel unit price.

Note 4. The above stated CO_2 reduction effect differs slightly from that stated in Chapter 5 because of the difference in the way fractions are treated.

Table 1-4 Impact in terms of ROI of the unit

	①	②	③=①/(②/2)	④			⑤=(③+④)/②
Facility	Fuel Cost Merit	Effective duration	Fuel Cost Merit (per effective duration)	Repair expenses and investment expense	Construction period	Working artificial number	Total Cost Merit
	(10^3 INR/year)	(year)	(10^3 INR)	(10^3 INR)	(days)	(Number)	(10^3 INR/year)
IP Turbine	▲ 30,096	5	▲75,240	60,000	80		▲3,048
HP Heater (4 Unit)	▲ 8,670	5	▲21,675	2,000	5	16 (4 × 4units)	▲3,935
Air Preheater	▲ 5,881	20	▲117,620	100,000	50		▲881
Condenser	▲ 270	20	▲5,400	5,000	50		▲21
Total	▲ 44,917		▲220,117	167,000			▲7,885

Note 1. Repair expenses : Convert actual price in Japanese yen to INR (1INR=2yen)

Note 2. Effective duration : It means a period during which the unit performance drops to the performance before recovery

Note 3. For the merit evaluation, we do not consider losses of power sale equipment due to suspension of work

Note 4. HP Heater for 4 units = 5A,5B,6A,6B Heater

In developing a means of calculating greenhouse-gas emission reductions in this project, we adopted an approach of calculating the theoretical efficiency of measures to be introduced by using the heat balance model, which was then corrected based on performance tests conducted before and after introducing the measures. According to the assumption, annual CO2 emission reductions at the units were estimated as 21,300 tons. Moreover, when the target unit continues to generate electricity, there is no room for photovoltaic power generation to supply power to the grid under specific electricity demand. However, reducing the amount of electricity generated by the target unit does free up scope for photovoltaic power generation. Given the scope to generate photovoltaic power by changing the target unit operation, it is possible to regard the amount of CO2 reduction resulting from photovoltaic power generation as a contribution of the target unit. Calculating this contribution, the CO2 emission reductions were estimated as 35,500 tons (56,800 tons in total). We also discussed the potential of materializing the benefits for each entity, partner country government and companies, Japanese companies and financial institutions, by quantifying the international contribution amount.

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

(1) Unit overview

Unit No.1 of the Dadri Power Station has been in operation for 25 years or longer. However, NTPC is in a position to set an example for other power companies and the Dadri Power Station is regarded as a model power plan among its power stations.

The Dadri Power Station is located in Uttar Pradesh in the northern part of India. It is about 50 km to the east of the capital city New Delhi.

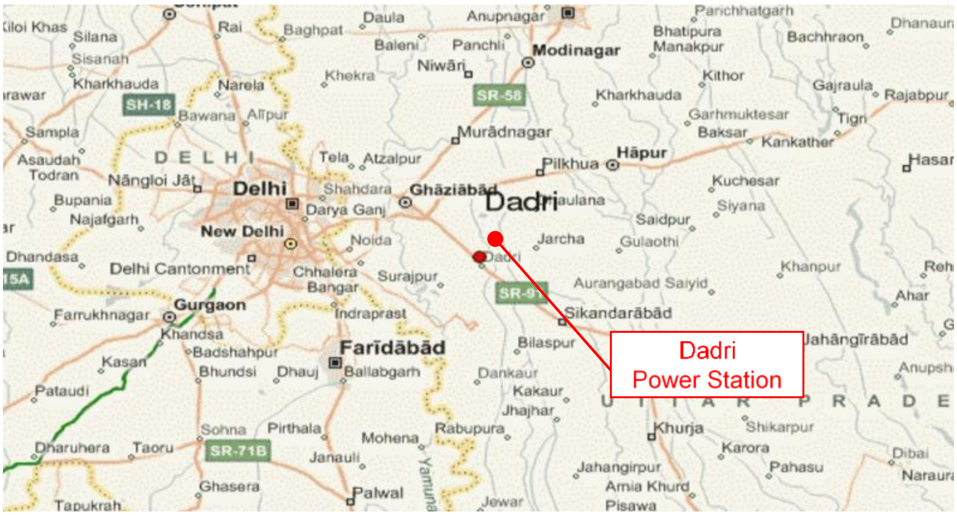


Figure 1.6 Location of the power station

The coal-fired thermal power generation facilities are a total of 6 units: 4 210MW units (Stage 1) operated since the first half of 1990s and 2 490MW ones (Stage 2) operated since 2010.

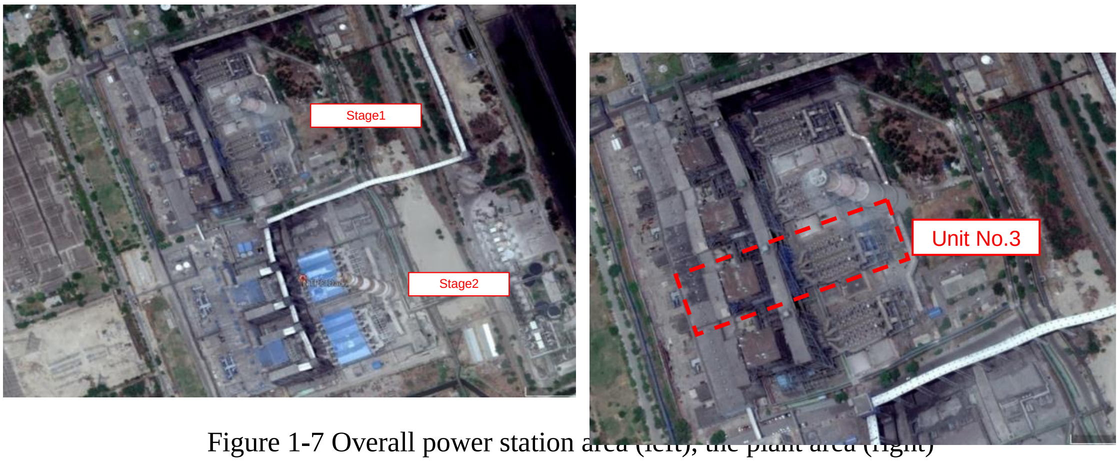


Figure 1-7 Overall power station area (left), the plant area (right)

Table 1-8 List of all units of Dadri TPS

Item		Stage-1			Stage-2		
		Unit No.1	Unit No.2	Unit No.3	Unit No.4	Unit No.5	Unit No.6
Year of starting operation		1991	1992	1993	1994	2010	2010
Rated output [MW]		210	210	210	210	490	490
Annual power generation capacity [GWh] *1		993.4	567.1	902.6	1,072.4	-	-
Facility utilization factor [%] *1		54.1	31.3	49.2	61.9	-	-
Manufacturer	Boiler	BHEL	BHEL	BHEL	BHEL	BHEL	BHEL
	Turbine	BHEL	BHEL	BHEL	BHEL	BHEL	BHEL
	Generator	BHEL	BHEL	BHEL	BHEL	BHEL	BHEL
Vapor pressure [kg/cm2]	Main vapor	154	154	154	154	-	-
	Reheat vapor	38.8	38.8	38.8	38.8	-	-
Vapor temperature [deg.C]	Main vapor	540	540	540	540	540	540
	Reheat vapor	540	540	540	540	568	568
Boiler efficiency [%] *2		86.5	86.6	86.6	87.1	-	-
Turbine heat efficiency [kcal/kwh] *2		2,077	2,061	2,077	2,045	-	-
Unit heat efficiency [kcal/kwh] *2		2,402	2,382	2,398	2,347	-	-
Environment Facility	Electrostatic Precipitator	Yes	Yes	Yes	Yes	Yes	Yes
	Flue gas desulfurization equipment	No	No	No	No	No	No
	Flue gas denitration equipment	No	No	No	No	No	No
Chimney height [m]		225			225		
Exhaust regulation [mg/Nm3]*3	Dust	150	150	150	150	100	100
	SO_2	N/A	N/A	N/A	N/A	N/A	N/A
	NO_x	N/A	N/A	N/A	N/A	N/A	N/A

*1: Data of January to December 2017 *2: Data of January 2018 *3: Former exhaust regulation value (up to November 2015)

(2) Site Survey

To check conditions at NTPC/Dadri Power Station Unit No. 3, the Study Team conducted hearings with responsible staff at Dadri Power Station, investigated the site, and viewed and collected data including maintenance and operation records, drawings, etc. The Team conducted feasibility study work with emphasis on considerations for compliance with the new emission regulations, cost, environmental equipment installation space, operability and maintainability of the environmental equipment, and the type of coal being used.

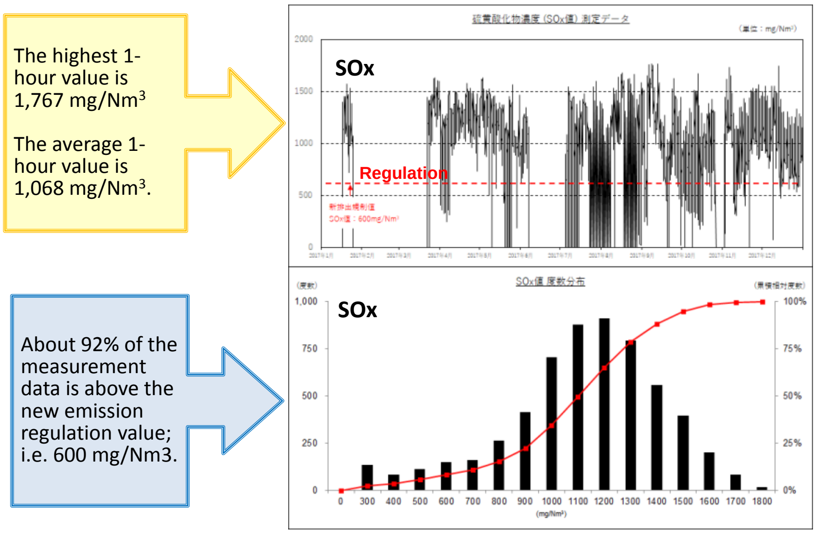


Figure 1-8 Current SOx emission at Dadri TPS

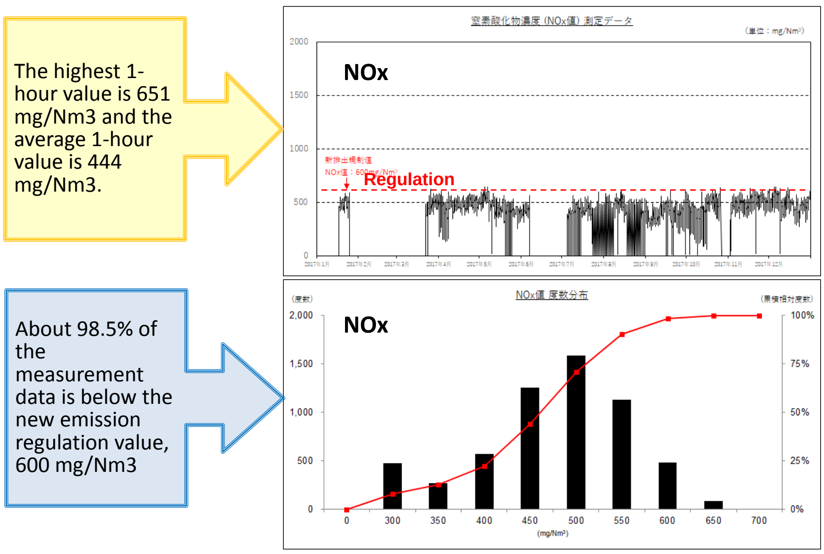


Figure 1-9 Current NOx emission at Dadri TPS

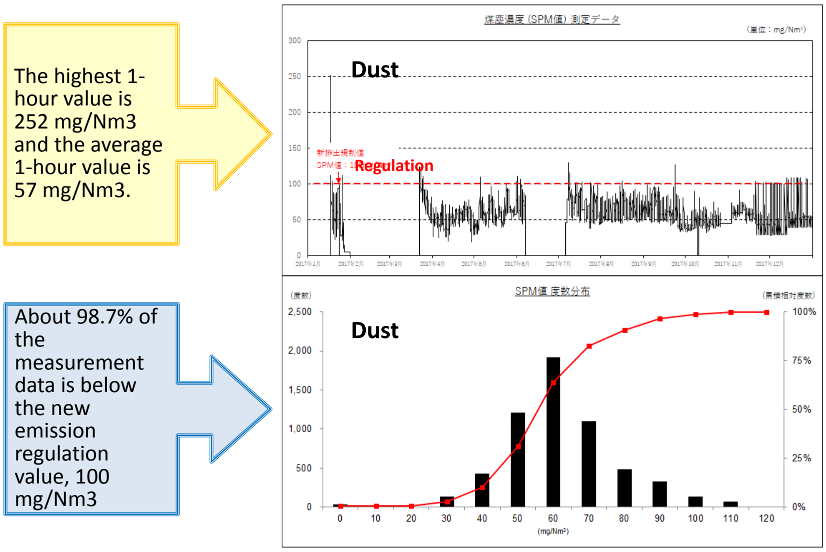


Figure 1-10 Current PM emission at Dadri TPS

According to the current emission level of SOx, NOx and PM, it was found that De-SOx and enhancement of ESP were required as environmental compliances.

(3) Comparison of the cases and Recommendation

In consideration of the current flue gas condition and space constraints, 6 cases; i.e. 1) dry flue gas treatment (ISOGO-type), 2) simple FGD installation, 3) case 2+MEEP, 4) Integrated FGD system+MEEP (variation of case 3), 5) case 3+GGH, 6) case 5+SCR were identified.

Table 1-9 Case-1 and -2

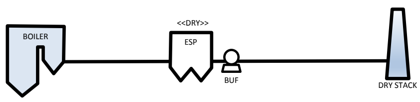
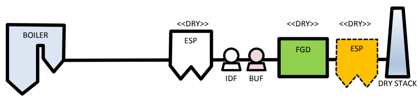
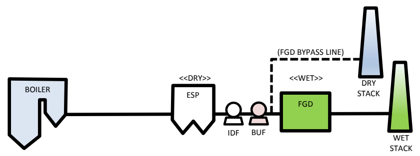
Case	Type	Layout	Advantages	Disadvantages
	Current			
1	Dry flue gas treatment (Isogo Type)		-Smaller space required compared to Wet-type -No water required	-ESP at downstream -Initial cost required is twice of that of Wet-type; running cost x1.7 -Number of supplier limited
2	FGD (Single)		-Gypsum obtained as byproduct	-Waste water treatment required -Gypsum quality may deteriorate -Stack lining required

Table 1-10 Case-3 and -4

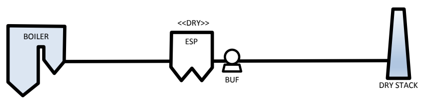
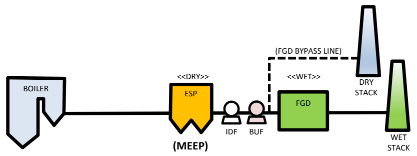
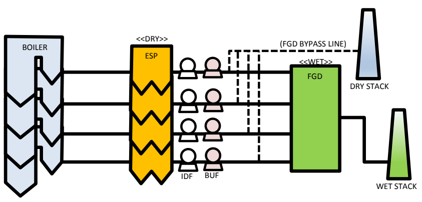
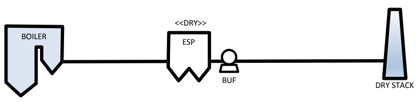
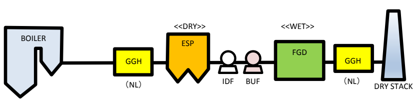
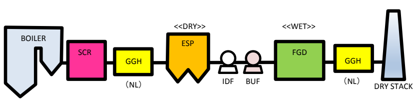
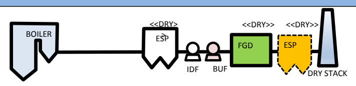
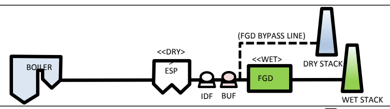
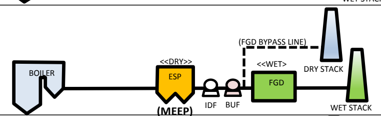
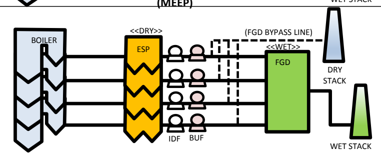
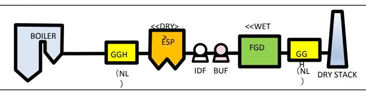
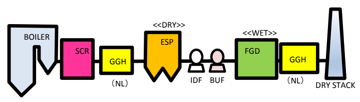
Case	Type	Layout	Advantages	Disadvantages
	Current			
3	Case 2＋MEEP		-Gypsum obtained as byproduct -Better ESP performance than Case 2	-Waste water treatment required -Additional cost for MEEP -Stack lining required
4	Integration of Case 3＋MEEP		-Gypsum obtained as byproduct -Space and cost advantage than Case 2, -Better ESP performance than Case 2	-Waste water treatment required -Additional cost for MEEP -Stack lining required -All 4 units to be shutdown during FGD maintenance

Table 1-11 Case-5 and -6

Case	Type	Layout	Advantages	Disadvantages
	Current			
5	Case 3＋GGH＋MEEP		-Gypsum obtained as byproduct -Better ESP performance -No stack lining required	-Space for GGH required –Higher initial cost in addition to Case 3
6	Case 5＋SCR (Typical in Japan)		-Gypsum obtained as byproduct -High quality of emission level -Well comply with the three norms; NOx, SO2, SPM	-Higher initial & running cost -Space for SCR required in addition to Case 5

In consideration of space constraints and economy, combustion improvement was recommended instead of SCR installation. 6 cases were identified through preliminary assessment of advantages and disadvantages in terms of cost, space, O&M and performance. By comparative study of the foregoing 6 cases, Case 4, a combination of MEEP and 1 larger integrated type of FGD was identified to be most suitable as environmental measures at Dadri Stage-I in the viewpoint of cost, installation space, operability, maintainability and the type of coal being used

Table 1-12 Comparison of the cases by relative score

Case	Layout	cost	space	O&M	performance	overall
1		1	4	2	4	11
2		5	3	3	1	12
3		4	3	3	2	12
4		6	5	2	2	15
5		3	2	3	3	11
6		2	1	3	5	11

(5) Summary of the study

- ✓ Diagnostic study for optimal environmental measures at NTPC Dadri TPS was conducted in February 2018, under CEA-JCOAL cooperation as part of India-Japan cooperation under the Electricity Working Group of the bilateral Energy Dialogue.
- ✓ Target Units were 4x210MW, Stage-I, for the study of the installability of environmental facilities such as FGD, SCR, ESP, etc.
- ✓ The Study Team was greatly impressed by the level and spirit of O&M at Dadri TPS.
- ✓ In consideration of the current flue gas condition and space constraints, 6 cases; i.e. 1) dry flue gas treatment (ISOGO-type), 2) simple FGD installation, 3) case 2+MEEP, 4) Integrated FGD system+MEEP (variation of case 3), 5) case 3+GGH, 6) case 5+SCR were identified.
- ✓ While the regulated value is currently well achieved for NOx emission, in the near future SCR may come as part of the environmental measures to be taken, looking at the international environmental standards and overall direction of regulatory enhancement.
- ✓ Replacement of 4x210MW to 800MW USC was not feasible due to space constraints.

1.4 Mini-workshops with potential state utilities

(1) Purpose and framework of the Mini-Workshop

The Mini-Workshop with GSECL and APGENCO each selected as a potential utility involved a team of Japanese private sector players lead by Japan Coal Energy Center (JCOAL) constitutes a part of follow-up activities under the Cooperation. The Workshop was intended to provide all participating parties with an occasion to have frank exchanges of knowledge, experience, information, views and ideas about relevant issues in the power sector with focus on environmental compliance through R&M, replacement as well as greenfield new power development utilizing power sector CCTs.

The Mini-workshop was tailored for each utility incorporating the preliminary requirement by CEA to provide with information on Japanese CCTs not only for R&M but also for replacement and/or new development.

This event as aforesaid was held as part of the activities under the CEA-JCOAL Cooperation. While CEA was not able to participate in the event due to its own engagements, the full and firm support by CEA to the event and post-event activities had been committed. JCOAL undertook the entire organization of the event. Any officer or plant engineer of the utility was eligible and recommended to participate in discussions at the event.

The main presentations at either Mini-workshop are as below-quoted:

JCOAL: Overview and updates of Japan’s endeavors in working for efficiency and environmental improvement of coal fired power generation in India

Toshiba: On-line Performance and Diagnostic Monitoring of Toshiba Steam Turbines

MHPS: Air Quality Control System (AQCS) for high-efficiency.

JGC C&C: De-NOx Catalyst for High Ash flue gas treatment

(2) Overview of the Mini-workshop

1) GSECL

The major attendance of Mini-workshop with GSECL was as shown below:

Mr. S.P. Jain, Chief Engineer (P2P)

Mr. A.C. Patel, Chief Engineer (Generation)

Mr. B.A. Gandhi, Executive Engineer

Mr. N.G. Metha, Addl. Chief Engineer

In total 17 delegates of GSECL attended the Mini-workshop.

Figure 1-13 Mini-workshop with GSECL

When welcoming the delegates, JCOAL appreciated the cooperation forwarded by the utility as well as CEA, followed by the introduction of the short history of bilateral cooperation and the brief purpose of the mini workshop.

Chief Engineer (P2P) of GSECL in its opening address touched on the commitment to the Paris Agreement and the globally rising environmental awareness as well as the establishment of new regulations. It was emphasized that environmental response has become an urgent issue for GSECL as a state utility. In addition, load fluctuation management that is required along with the introduction of large amounts of renewable energy was also mentioned as one of the major issues.

In summary, anticipation to the Japanese team was expressed for sharing technical knowledge and experiences, to deal with the foregoing issues and to advance optimuMoPeration and maintenance management.

Subsequently, MHPS, Toshiba and JGC followed the technology introduction and suggestions in line with the issues of the Indian power sector.

<Main questions and concerns>

In Q & A concerning MHPS technology, there was a question centering on the technology of MEEP which the electric companies' interests are generally high.

As for Toshiba's IoT technology, a proposal was made according to the situation of each plant, and attention was high on the aspect that improvements including economics can be expected for overall operation and maintenance management.

Regarding the dry desulphurization technology of JGC, although concern was high because the use of water was also referred to as "zero drainage" under the new regulations, it was also in the middle of the demonstration project and it is requested that we exchange information at any time from now on Met.

(3) Mini-workshop with APGENCO (February 1 10: 30-15: 00)

The major attendance of Mini-workshop with APGENCO was as shown below:

Mr. K. Gangadhara Rao, SE (Generation-I)

Mr. Rajayya, Divisional Engineer

Mr. Venkata Reddy, Chief Engineer, Dr. NTTPS TPS

In total 33 delegates of APGENCO attended the Mini-workshop.

Figure 1-14 Mini-workshop with APGENCO

When welcoming the delegates, JCOAL appreciated the cooperation forwarded by the utility as well as CEA, followed by the introduction of the short history of bilateral cooperation and the brief purpose of the mini workshop.

Next, Representative of APGENCO, SE (Generation-I) delivered his address. He emphasized environmental measures and response to load fluctuations caused by the massive introduction of renewable power as the most important tasks for state utilities. He further mentioned that cost as well as the applicability of technology is the most crucial. While receiving opinions on technical information from teams from Japan and exchanging opinions, he decided to consider appropriate regulatory compliance and optimal operation and maintenance management strategies for the future.

Subsequently, MHPS, Toshiba and JGC followed the technology introduction and suggestions in line with the issues of the Indian electricity sector.

<Main questions and concerns>

In Q & A concerning MHPS technology, there was a question about the details and cost of MEEP technology, which is generally high in interest of electric power companies. Regarding MEEP, there was also interest in saving space and creating new / additional installations according to newly established / existing situations.

About Toshiba's IoT technology, proposals were made according to the situation of each plant, and interest was indicated by saying that improvements including economy can be expected for overall operation and maintenance management, but as a priority There was an impression that it was

environmental response.
Regarding the dry desulfurization technology of JGC, since the use of water is also referred to as "zero drainage" under the new regulation, the interest was high and there were many questions. Remarks that I want you to exchange information at any time from the future were also from executives who attended the meeting.

Summary
It was observed through the discussions that both GSECL and APGENCO respectively have been pursuing measures to address the New Environmental Norms. They were also enthusiastically trying to identify the optimal approach to cope with the issue of possible fluctuations by the expected massive introduction of renewable power.
Each specialist of JCOAL Team came up with an excellent choice of technologies to address the foregoing major issues. They would be pleased to continuously interact with each utility.

The Mini-workshop was intended to enhance both knowledge and technology for the state utility and learning of the current issues, situation and of the Indian power sector with focus on state utilities. The Mini-workshop was anticipated to play a catalytic role in facilitating a direct dialogue between state power plants as client candidates and technology-holding companies in Japan as the CEA-JCOAL Cooperation ultimately is intended for efficiency and environmental improvement for sustainable power supply through implementation of actual projects.

1.5 CEA-JCOAL Workshop

CEA and JCOAL first held their joint workshop in FY2011 as the bilateral forum to discuss relevant issues to be addressed, the Workshop on November 11, 2017 marked the seventh year of the event that is now well recognized as one of the important annual events in the power sector in India.
The event in FY2017 tried to pursue possibilities for low carbon economy on every point of coal value chain in addition to facilitating implementation actions for New Environmental Norms through presentations and discussions on the on-going efforts and good practices as well as available technologies in India and Japan.

Figure 1-15 Lighting ceremony at CEA-JCOAL Workshop

Chairperson, CEA (in the middle)

Main dignitaries and speakers:

Mr. R.K. Verma, Chairperson, CEA

Mr. Aniruddha Kumar, Joint Secretary, Thermal, MoP

Mr. B.C. Mallick, Chief Engineer (TPRM), CEA

Mr. Narendra Singh, Chief Engineer (TPE&CC), CEA

Mr. Bhai Lal, Chief Engineer (HERM), CEA

Mr. Sukumar, Chief Engineer (TCD)

Mr. Rajeev Kumar, Director, TPRM, CEA

Mr. A.K. Sinha, Executive Director (Engg.), NTPC

Mr. P.K. Mohapatra, Executive Director (Tech.), NTPC

Mr. R.K. Chauhan, GM (R&M Engg.), NTPC

Mr. V. Ramesh, AGM, (R&M Engg.), NTPC

Mr. O. Tsukamoto, President, JCOAL

Mr. Sano, Director, Environment Department, NEDO

<Opening Session>

Figure 1-16 Opening session

Joint Secretary (Thermal), MoP (the speaker)

President of JCOAL appealed to the need for stable coal supply and comprehensive and holistic environmental initiatives, introduced the history of Japanese environmental policies and regulations and the current state of high-efficiency thermal power generation technology, It is said that Japan's knowledge and technology are useful for a series of tasks such as maintaining efficiency at a level, efficient utilization of land, urgent issues in the environment related to SOx, NOx, dust, water treatment, ash treatment, etc. , Continuing from last year, claimed that efforts across the entire call value chain are important and urgent.

Joint Secretary (Thermal), MoP mentioned that power demand in India is steadily growing and the fact is that India is rather lagging behind other countries in terms of GDP and electricity consumption per capita. Then it is emphasized that coal fired power remains as the main pillar of electricity to bolster the steady growth-at least over the coming 20 - 30 years. In the meantime, India is endowed with a great potential in renewable energy, which is basically intermittent and require measures to avoid fluctuation at the grid especially in case of the expected massive introduction. In summary, renewable energy is important as it strongly supports India’s efforts to comply with the commitment to the Paris Agreement, in introducing it attention and measures are required to minimize unnecessary losses and inconveniences. Finally, appreciation to the cooperation forwarded by JCOAL and relevant parties so far as well as high expectation to further cooperation with focus on both environment and flexibility issues was expressed.

Director of Environment Department, NEDO expressed his hopes for Japan's USC technology and environmental technologies such as desulfurization and denitrification, through mutually beneficial cooperation between the two countries, to express their expectations for the potential contribution to the Indian electricity sector, and also on the organization and efforts of NEDO Introduced.

ED (Engg.), NTPC touched on the importance of coal-fired power which accounts for about 60% of electricity supply. With NTPC 18 GW is under construction while 44 GW is in operation. NTPC deems that environmental measures to address the New Environmental Norms is extremely important for both existing and new construction. Furthermore, in view of the current state of the electric power sector, 1) emission reduction response, 2) environmental equipment test at the power plant, 3) system load adjustment, 4) whether to abolish obsolete existing facilities or to effectively replace the site The decision and the selection of the four points are listed as issues.

Chairperson, CEA asserts that coal-fired power is a factor supporting 80% of electricity on the basis of the amount of electricity generated and it will remain the main pillar for the time being. Regarding coal fired power, along with compliance with environmental regulations, the issue of flexibilization that is required accompanying the introduction of renewable energy is recognized as a major issue, and in this workshop, in addition to environmental regulation compliance, load adjustment, and other urgent It is very reliable that various subjects of the topic are listed as topics. Given the long-standing friendship between India and Japan, cooperation relations, and the cultural similarities between the two countries, Japan's cooperation with high technology and knowledge on the tasks currently faced by the electric power sector, an appropriate balance between the environment and development.

<Session I>

In the beginning, the CEA announced the direction of bilateral cooperation and the future prospects of the power sector. Subsequently, JCOAL reported on the status of various initiatives this fiscal year, and outlined the outlines and results of environmental tests with particularly high Indian coal among the activities that have been carried out so far.

In addition, the manager of the CEA Environment Division explained the status of compliance with environmental regulations and future prospects based on information such as the number of targeted / in-service facilities.

Figure 1-16 Session 1

Questions and answers were mainly made on the following issues:

-In light of the fact that the energy elasticity value tends to decline, the demand forecast may come different from the one shown.

-Why is PLF coming down? → Relationship with Renewable Energy Large Scale Introduction

-Where can we absorb capital expenditure costs for environmental response?

<Session II>

Figure 1-17 Session 2, presentation by MHPS

At the outset, MHPS introduces SCR, FGD technology and introduction examples.

Subsequently, NTPC explained the efforts for compliance with environmental regulations in detail based on company statistical materials.

Also, APGENCO, which was positioned as an excellent state among state power and chosen as a leaf collecting power presenter by CEA, explained about its efforts. In the presentation, as a major factor that environmental response does not necessarily proceed smoothly, I emphasized space constraints in introducing environmental facilities.

Horiba Ltd., Chugai and Technos both participated for the first time in this workshop, and presented on details of measurement techniques and measurement methods of high concern in India.

Questions and answers were about the usefulness of non-leak type GGH, the influence on water usage when each environmental equipment is installed, the necessity of water treatment, the rate of depreciation when using catalyst, the contents of performance guarantee, technical applicability, etc. It was quite impressing that individual participants were seriously considering for the introduction of environmental technology and were well aware of relevant issues so that many participated in the discussions with their own views and insights.

<Session III>

In the third session, KUDEN International, which is responsible for the international business of the Kyushu Electric Power Group, is able to replace coal-fired power plants with consideration for the environment from the viewpoint of a holistic approach to power plant operation management based on maintenance and safety management of power plants In addition, in the second half Mitsui Miike Machinery appealed to the usefulness of the silo which is increasingly interested in India from the viewpoint of environmental response in the latter half and the effective utilization of land and silo equipment and technology from Japan.

Figure 1-18 Session 3, presentation by Toshiba

Next, Toshiba announced optimization of power plant operation management using IoT.

Questions and answers have focused on cost, space and applicability to Indian coal, as silos are hardly introduced in India. On the other hand, concerning IoT, participants' attention gathered in that they can be customized for each plant, and there were questions regarding whether remote control is sufficiently possible or not.

<Session IV>

JICA introduced a scheme (PSIF) that does not go through the central government that can respond flexibly according to the needs of the project, in addition to the support scheme through the central government, suitable for wide-ranging initiatives such as master plans. He emphasized that JICA's strengths include the ability to combine efforts with human resources development.

From the viewpoint of reducing emissions, the PFC said it is preparing support focused on renewable energy and energy efficiency improvement.

Figure 1-19 Session 4

<Summary>

The enthusiastic exchange of views during the question and answer sessions no doubt provided the participating dignitaries, speakers and participants with insights and ideas for technology application and implementation. In addition, there came a request from a major utility to some of the presenters and their companies to respectively make detailed presentations, which indicates that the workshop well played a catalytic role.

1.6 CCT Training Program

CCT Training Program under CEA-JCOAL Cooperation was first conducted in FY2013. Since then, it is a regular part of the Cooperation. The main objective of CCT Training Program is to be conducive to the government policy and implementation by utilities toward efficiency and environmental compliance enhancement that is crucial to sustainable power supply.

The Program offers a set of observations to relevant facilities with a good variety of visited facilities-from subcritical, USC to IGCC. Visits in FY2017 were in 1 batch; participants were updated about various applicable technologies and equipment as well as O&M techniques. Exchanges and discussions were planned both during observations as well as the kick-off/wrap-up meetings with JCOAL, METI, NEDO and relevant stakeholders, all of which were crucial to enhance the effect of the overall training program.

Figure 1-20 Facilities visited by the delegation under CCT Training Program in FY2016

(1) Schedule

Entire period: From November 29 to December 7, 2017

Period of stay in Japan: November 30 to December 77 (morning), 2017

(2) Features of the visited facilities

Features of the visited facilities are shown in the list below:

Visited facility	Salient features
J-POWER's Isogo Power Plant	With its state-of-the-art USC technology and best practices, Isogo is deemed to be one of the world-best coal fired power stations State-of-the-art technology; history of "Built-scrap-and-built" method applied upon replacement of the two old units for new ones. MEEP (Moving Electrode Type ESP) has been installed at Unit 2.
Toshiba Keihin Works	One of the major plant of Toshiba, Keihin Works has been

	active in the international power market for thermal turbines and other relevant machineries.
MHPS Kure/Akitsu Works	This plant manufacturing boilers is also deemed to be a center for producing environmental equipment. Akitsu Works is where Environmental Study was conducted under CEA-JCOAL Cooperation in FY2014.
J-POWER's Takehara Power Plant	Well-maintained power plant with old and new units mixed; A "Build-dismantle-and-build" process involving a 48-years unit and a 41 year, both subcritical, to be one USC unit going on with the target COD in 2020.
Horiba Factory	Participants will observe extensive range of technology from stack gas analysis to the waste water treatment at Horiba, one of the leading companies in the field of environmental technology for power plant.
Chugai Technos Research Technology Center	Chugai Technos is a company that provides a wide range of environmental solutions and measurement services. Their Research Technology Center in Hiroshima will show the participants environmental technology and techniques as well as how environmental measurements may be conducted

(3) Participants

In total 10 delegates visited Japan under CCT Training Program in FY2016, as shown in the below-quoted lists.

No.	Name	Institution /organization	Designation
1	BIKASH CHANDRA MALLICK	CEA	Chief Engineer (TPRM)
2	MOHAMMAD AFZAL	CEA	Director (FM)
3	PRABHJOT SINGH SAHI	CEA	Assistant Director (TPRM)
4	SANJEEV KUMAR KASSI	MoP	Director (Thermal)
5	SUMAN MAJUMDAR	MoP	Under Secretary (State Thermal)
6	PRASHANT KASHYAP	NTPC	General Manager (O&M, NTPC Barh)
7	TARUN KUMAR	DVC	Deputy Chief Engineer (Mech)
8	SHASHIKANT SONPURE	CSPGCL	Executive Engineer (CT)
9	ARVIND KUMAR SINGH	UPRVUNL	Chief Engineer (Obra TPS)
10	PRADEEP DUNGDUNG	TVNL	Electrical Superintendent Engineer

Figure 1-21 Photos of the site visits and meetings

(4) Summary of discussions at key meetings

Participants engaged in key meetings such as Kick-off Meeting and Wrap-up Meeting as well as individual meetings during observation visit to relevant plant.

Below-quoted is main issues of concern/interest of the participants and the summary of discussions at the wrap-up meeting.

< Main issues of concern/interest>

- The thermal capacity of India is 194 GW (total equipment capacity: about 281 GW in 2015) and coal occupies 76%. Since 2015, we are strengthening dust, SOx and NOx compliance, and I would like to visit plants related to these. We plan to introduce FGD (desulfurizer) and SCR (denitrification device) by 2022. As the capacity of sunlight and wind power generation increases, there is a command (dispatch) to lower the burden on the thermal power plants, and although it is compatible, the influence on facilities and efficiency is concerned. Hydropower and gas fired power corresponding to normal load fluctuations are not sufficient quantitatively, and coal fired power must also be dealt with. Regarding this point, the request has been made to carry out flexibilization studies to address issues at the equipment end.
- In India, interest in IGCC is also high as environmentally friendly high efficiency power generation. IGCC technology in Japan.
- Japan's support for coal-fired lamp rate (increasing load factor) accompanying the introduction of renewable energy, problems of flexibility, problems of high emissions (dust, SOx, NOx) due to load fluctuation, low load operation etc. Is required.
- The New Environmental Norms has enhanced environmental compliance of coal fired power stations. FGD installation has been already planned. In the meantime, for NOx , things are yet to be decided. There is space restriction and concerns as well.
- Storage of coal is also a problem, now it is outdoor coal storage, calories are lowered by evaporation of volatile matter. There is also concern about environmental impact. I am thinking of mixed coal and I am also interested in Japanese technology concerning this.
- There is a waste-to-energy plant in an urban area, but technology is old, there is a problem of dioxin, considering the introduction of plasma technology.
- Blend with oil until about 30% load at startup, I want to reduce this to 10% to 15% load. If you modify the burner, you will also review the boiler design and take time and money.
- The power station where I serve as GM is made in Russia, I am interested in the possibility of applying Japanese technology. Dust collector, dust problem.
- The load of the thermal power plants is low due to the increase of PV. If there is a case in

<Summary of discussions at the Wrap-up Meeting>

The topics of wrap-up were set to the following five, but actual presentation and exchange of opinions were done without distinction.

1) Environmental measures to be taken by India power sector

2) Technical measures to be taken for grid flexibilisation

3) High efficiency and low emissions (HELE), replacement of sub-C to latest USC

4) Issues around materialization of R & M

5) Efficiency Improvement through enhancement of O & M

After METI / NEDO / JCOAL greetings, on behalf of the participants, CEA and MOP made presentations respectively.

Current status and problems of the Indian electricity sector

By Mr. B.C. Mallick, Chief Engineer (TPRM), CEA

-Power supply ratio, equipment capacity, PLF, 13th power development plan

-Responding to new environmental regulations, Phasing Plan

-Results of CEA-JCOAL Cooperation

-As future cooperation themes, replacement of existing coal-fired power to USC, environmental technology (compliant with new environmental regulations), and grid load correspondence accompanying large-scale introduction of renewable energy (power station end). Both of them are requesting examination from the beginning of the fiscal year, and we are anxious to be able to proceed positively.

Status of the Indian Electricity Sector and Invitation Participation Report

By Sanjeev Kumar Kassi, Director (Thermal), MoP

-Between 2010 and 2017, the role of private sector expansion (17% → 44.40% on equipment capacity basis).

-Coal-fired power occupies nearly 60% on the basis of equipment capacity. Currently, about 80% on the base of electricity generation is dependent on thermal power.

-Since 2010, we strongly promoted SC. 63 units (43,000 MW) are in operation. All new establishments after 2017 are SC.

-Manufacturer's production capacity is 30,000 MW / year.

-As a challenge, India has set a goal of reducing CO_2 emissions by 33 to 35% compared with 2005 by 2030 on the Paris agreement, but this is because, in the electricity sector, 40% of non-fossil fuels must be used means.

-In addition, it is said to be an urgent issue for electric power companies, as measures to deal with the new environmental regulations are applied from January 2017 for new construction and immediately after the grace period of two years for existing facilities.

The delegates expressed their impression and appreciation as follows:

At Isogo Thermal Power and Takehara Thermal Power, it was quite meaningful to learn about the experiences-one on-going and the other achieved- replacement to USC while continuing operation and holistic power plant operation management. In addition, visiting manufacturers who are well versed in the circumstances of India and discussing with them provided excellent opportunities to deeply discuss and think about how to proceed for the actual implementation.

Also, it was really felt that Japanese technology and knowledge are quite useful in the context of India and Indian coal. In the meantime, further information is needed on the cost and application of technology to high-ash Indian coals.

1 . 7 Other knowledge sharing activities

1.7.1 Support Activity for the Feasibility Study on Dry-DeSOx System for TATA power

Environmental regulation is tightening in India as the Ministry of Environment, Forest and Climate Change (MoEF&CC) published the Environment (Protection) Amendment Rules, 2015 for thermal power plants(TPP) further to amend the Environment (Protection) Rule, 1986. In this circumstance, JGC, JGC C&C, SOJITZ and JCOAL organized a consortium and financially assisted by Japanese Ministry of Economy, Trade of Industry (METI) in order to meet the needs of flue gas treatment in the coal-fired TPP by exporting the exclusive dry DeSOx process and DeNOx process.

Table 1-13 New Emissions Norms notified on 7 December 2015

		before 31st Dec 2003		Jan 2004-Dec 2016		from Jan 2017 onward
capacity	MW	Less than 500	500 and above	Less than 500	500 and above	
SPM	mg/Nm^3	100		50		30
SO_2	mg/Nm^3	600	200	600	200	100
NOx	mg/Nm^3	600		300		100
Hg	mg/Nm^3	Not regulated	0.03	0.03		0.03

Reference data source: CEA

The main objective of the study is to confirm feasibility of introducing the dry DeSOx process and DeNOx process into coal-fired TPP in India. For this purpose, competitiveness of the dry DeSOx process and DeNOx process against conventional wet DeSOx process and DeNOx process shall be assessed from technical and commercial aspects.

Apart from the feasibility study, as a support work, JCOAL conducted an interview at TATA power and two other utilities to analyze coal and flue gas properties for understanding their environmental measures. Coal Properties from two thermal power station owned by TATA Power, 1 state utility and 1 private utility have been obtained for the survey.

Flue gas calculation was done for MPL and 1 state utility. Gas volume was calculated as excess O_2 = 6%, PM concentration is as upstream of ESP. NOx concentration is recognized to be mainly influenced by combustion condition of a boiler.

Estimated SO_2 concentration showed a good agreement with actual data. Considering the performance of ESP of both Jojobera and MPL, SPM collection level is found to be quite high.

Table 1-14 Coal property and calculated flue gas data

Items	Thermal Power Station	TATA Power Jojobera		Maithon Power Limited				State		Private	
		Actual		Design	Actual			Design	Actual	Design	Actual
					Max.	Min.	Ave.				
Source		Middling	MCL		CCL, BCCL			SECL, MCL, WCL		CCL	
CALORIFIC VALUE											
Gross air dried	Kcal/ kg	4474	3283	4671	5707	3750	4561	3731	3500	3655	3646
CHEMICAL ANALYSIS											
Total Moisture	% ar	4.05	12.50	7.11	16.72	4.1	5.95	10.8	12	11.65	12
Moisture	% ad	1.06	5.43		5.63	0.97	1.44				
Ash Content	% ad	41.72	45.15	36.19	49.72	29.52	40.71	33.76	41.2	36.66	33.52
Volatile Matter	% ad	19.03	22.87	15.92	23.71	13.56	16.51	26.61	21.56	24.4	21.4
Fixed Carbon	% ad	38.19	26.55	40.78	52.51	31.05	41.34	28.83	25.5	27.25	
ULTIMATE ANALYSIS											
Total Carbon Content	% daf			47.84	61.4	40.8	48.58	40.34	35.87	40.58	38.3
Total Hydrogen Content	% daf			2.89	3.58	2.81	3.15	2.61	2.66	2.46	3.7
Total Nitrogen Content	% daf			1	1.07	0.25	0.61	0.97	0.72	0.85	0.96
Total Sulphur Content	% daf			0.39	0.93	0.3	0.52	0.63	0.59	0.31	0.46
Oxygen Content by difference	% daf			4.58	13.41	3.91	6.07	10.8	12	6.98	
Combustible Sulphur	% daf										
Mercury in coal	% db										
Calculated data											
Flue gas (Excess O2 = 6%)	Nm3/kg-fuel	0	0	17	21	15	17	14	12	14	15
SOx	mg/Nm3			460	890	406	602	917	963	441	604
PM	g/Nm3			21	24	20	24	25	34	26	22

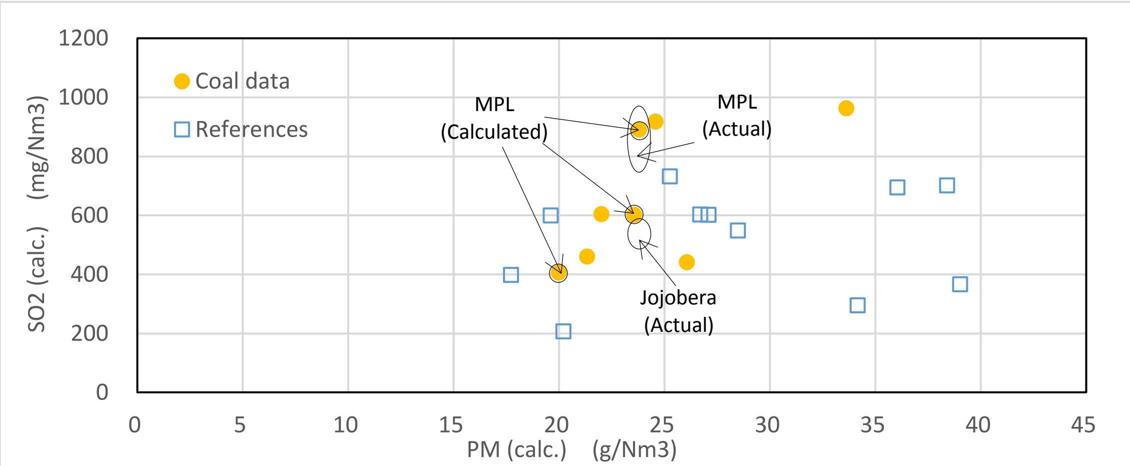


Figure 1-22 Relation between calculated value of PM and SO_2 concentration

According to the Feasibility Study of dry DeSOx and DeNOx process by JGC, JGC-C&C and

SOJITZ, this dry system has advantages compared with conventional wet-type in the folowoing condition;

> the system is installed at downstream of ESP with lower flue gas temperature condition.

> by having a common DeSOx agent production facility among neighbor TPPs and by industrializing/introducing the DeSOx agent production process using quick lime (CaO) instead of slake lime ($Ca(OH)_2$) for the raw material.

1.7.2 Additional Study for the SCR Pilot Test at Sipat STPS

New Environmental norms of NOx, SO_2, SPM and Mercury by MOEF&CC is expediting the environmental compliance by India Power Sector. While the deadline of the measures was by the end of 2017, CEA showed a phasing plan of installation of FGD and ESP for their completion by 2022 as a practical point of view. As for the measures for de-NOx, pilot plant test is required to demonstrate that commercially proven technology is available to Indian domestic coal which has high ash content. In this circumstances, NTPC is conducting the pilot test at several NTPC owned TPS with the participation from many suppliers of de-NOx technologies.

MHPS participate the de-NOx pilot test at NTPC Sipat STPS to apply their SCR testing device with high durability plate type catalyst. The pilot test conducted by MHPS was supported by the Japanese government as a bilateral cooperation in environmental improvement of India power Sector.

Additional Study for the SCR Pilot Test at Sipat STPS by JCOAL was to collect and analyze the related information such as the environmental norms, flue gas monitoring and influence of coal properties on the performance of SCR device.

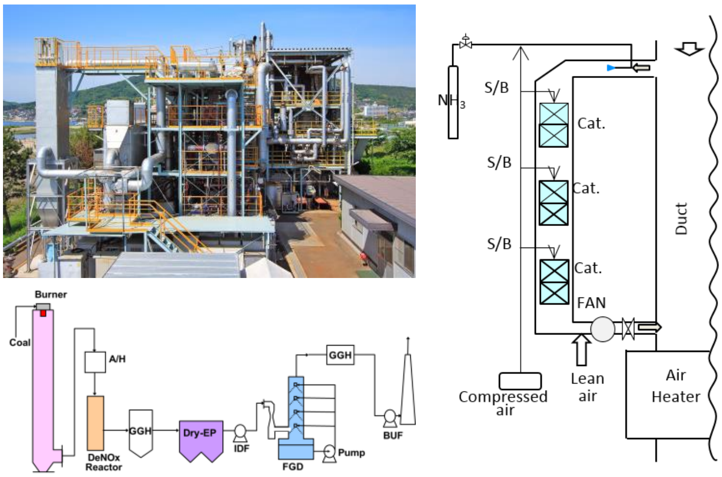


Figure 1-23 AQCS demonstration plant (left) and SCR Slip Stream testing Device at Sipat STPS (right)

Flue gas monitoring by TPS was surveyed by comparing with a portable gas analyzer (Horiba PS-300) at the GL+40m sampling point. Values between daily monitoring shown in the central control room and measurement were in good agreement. Following item was also surveyed.

- Reproducibility: drift range of indicated value was within the measurement instrument specification.
- Calibration by Standard gas: traceability and calibration frequency was not defined
- Data reporting: data was automatically stored in the cloud server, consolidated at EOC Noida.
- Emergency: In case of analyzer trouble, another offline analyzer will be used. In case of high alert of SO2 or NOx, load will be decreased.

JCOAL expert team recommended a maintenance of NOx catalyst converter and introduce high resolution type which allows precise measurement under 100mg/Nm^3 range.

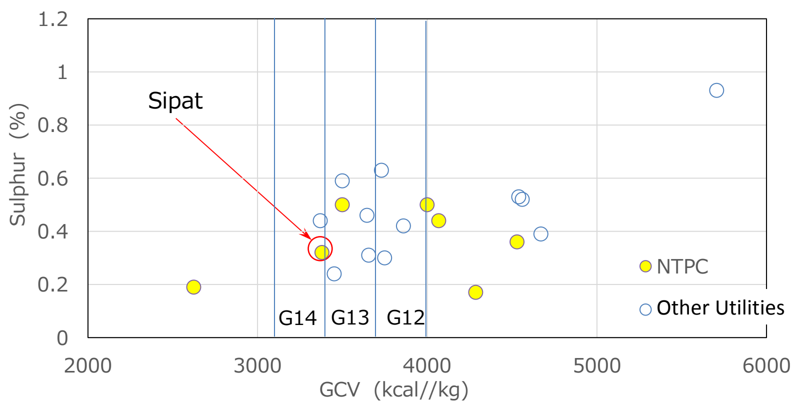


Figure 1-24 Coal property of Sipat STPS

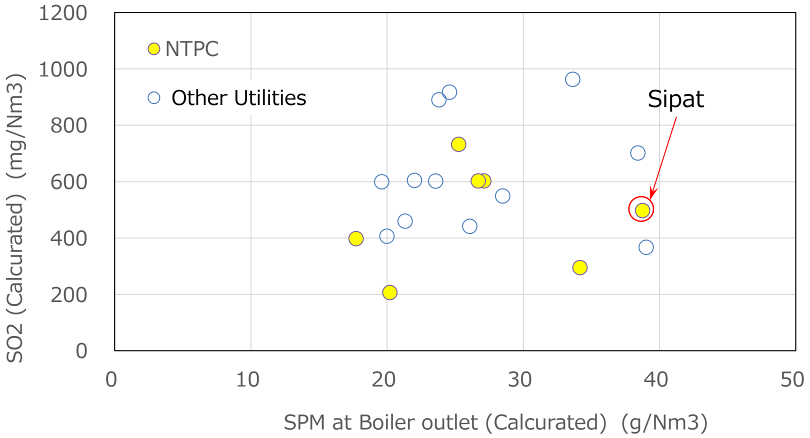


Figure 1-25 SO2 and SPM calculated from coal analysis

SO2 and SPM were calculated with 6% access air using coal elemental analysis. SO2 was estimated at around 500 mg/Nm^3, SPM at around 40g/Nm^3. Higher SPM and higher amount of SiO_2 and Al_2O_3 in coal ash might possibly affect the durability of SCR catalyst

2 . Perspectives in FY2018

Electricity and Renewable Energy Working Group of India-Japan Energy Dialogue was held on January 24, 2018.

CEA presented updates of the situation in India and desired programs for optimal power sector development. Though JCOAL was not able to attend due to the circumstances, significance and the central position of CEA-JCOAL Cooperation in the bilateral cooperation for the power sector in India was presented by NEDO representing Japanese side.

Following is a table showing the planned activities[1] under CEA-JCOAL Cooperation in FY2018 in association with the programs requested by CEA at the Working Group.

Table 2-1 Planned activities under CEA-JCOAL Cooperation in FY2018

[1] It is to be noted that some of the activities are in the pipeline and yet to be budgeted.

No.	CEA Presentation at Joint Working Group on January 24, 2018	2018 CEA-JCOAL cooperation
1	Indian Power Sector especially coal fired thermal power generating units are hard pressed to comply new environmental norms after MOEF notification of December 2015. Japan has more than 30 years of operating experience of DeNOx and DeSOx equipments and also have manufacturing capabilities of these equipment, so collaboration in air quality conroll systems to meet emission norms.	Dadri study report will be prepared and the debriefing meeting with NTPC is to be held on June 26 at NTPC. Other related information will be provided through the activities of information exchange/knowledge sharing such as CEA-JCOAL workshop.
2	Government of India has ambitious target of adding 175GW of renewable capacity addition by 2022. It will affect the operation of coalfired generation due to intermittent nature of renewable gneration. Flexible operation of coal fired thermal power station may be one of the future area of collaboration.	Specific studies at NTPC Vindhyachal and UPRVUNL Anpara B respectively are to be proposed by JCOAL for implementation in FY2018.
3	Plazma ignition technology	Outline of the envisaged cooperation is to be identified
4	Bio-Mass	Detailed discussion for identification of envisaged collaboration area is expected.
4-1	Japanese experience of co-firing of biomass with higher blending ratios.	Knowledge sharing on the requested subject is to be initiated.
4-2	Experience of conversion of pulverized furel fired plants to 100% biomass firing or 100% biomass based fuels in Japan.	Knowledge sharing on the requested subject is to be initiated. At the same time, the current status of biomass utilization, source, etc. in India power sector is required to be provided.
4-3	Technology transfer/ experience sharing in above areas.	
5	Fly ash utilization specially at pit head station and also sharing o experience on utilization of fly ash for extraction of Alumina (Al2O3) and other specific use of fly ash.	While JCOAL may prepare current utilization stuation in Japan, Japan has no experiences in fly ash utilization at pit head station as well as Alumina extraction from fly ash.
6	R&D collaboration in the field of a Clean Coal Technology Centre jointly.	Any ideas from India side to be firstly provdied.
7	Pre-feasibility study on IGCC & IGFC Technology in India taken into account the benefits, viaility, suitability of India, cost of construction, cost of power and environumental benefits, etc.	Knowledge sharing on IGCC & IGFC technology will be provided in CEA-JCOAL workshop and/or through CCT training programme as per in previous years.
8	Optimization of land use in thermal power plant construction.	Related information shall be provided based on the outcomes of the past studies; i.e. Sungrauli study and Dadri study. In the meantime, another replacement feasibility study at NTPC Talcher may not be conducted due to continuous unavailability of human resources in Japan. CEA is kindly requested to understand the situation and communicate with relevant utilities.
9	Sharing of O&M and safety related best practices	Debriefing of TEPCO O&M study at DVC Kolakta was completed. CEA and JCOAL will observe the forthcoming actions and activities at DSTPS.
10	Energy from Municipal waste.	CEA is kindly requested to provide an outline of the envisaged cooperation. Current status of municipal waste utilization in India power sector is required.

Two replacement feasibility studies (No. 1) and a flexibilization study (No. 3) have been requested by CEA in January 2017, long before the aforementioned Working Group meeting (Figure 2-1).

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केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
तापीय परियोजना नवीनीकरण एवं आधुनिकीकरण प्रभाग
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Dated: 31-01-2017

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Subject: Study on Replacement of old and inefficient units with Super Critical Units under CEA-JCOAL Cooperation.
Reference: TPRM Letter No. 2/9(JCOAL)/TPRM/CEA/2016/ 1484 dated 09-11-2016

In continuation to TPRM letter dated 09-11-2016 on the above cited subject following thermal power stations are also offered for study on replacement of old units by Super Critical Units in addition to Singrauli STPS (5x200) MW.

1. Talcher TPS (4x60 + 2x110) MW of NTPC.
2. Koradi TPS unit-5 & 7 (2x210) MW of Mahagenco.

JCOAL has conducted RLA studies at Dadri TPS unit-3 (210 MW). NTPC has requested that a similar study for developing feasibility report for R&M of Dadri TPS unit-3 may please be conducted by JCOAL.

NTPC further requested JCOAL to carry out a 'Flexibilisation study' jointly with CEA at NTPC Vindhyachal.

You are therefore, requested to consider the above studies by JCOAL under MoU between CEA and JCOAL and confirm the same along with the action plan.

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Chief Engineer

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Figure 2-1 Official request from CEA to JCOAL for three studies

Throughout FY2017, JCOAL is determined to continuously work in close cooperation with CEA with focus on materialization and implementation.