

# OUTCOME REPORT

Under  
CEA – JCOAL Cooperation  
Clean Coal Technology Training program

14<sup>th</sup> Oct 2019 to 22<sup>nd</sup> Oct 2019  
JAPAN

## Table of Contents

S.No.	Chapter	Page
1.	Introduction	1
2.	List of Delegation	2
3.	Schedule of visits Undertaken in Japan	2
4.	Kick off Meeting with JCOAL	3
5.	Isogo Thermal Power Station of J-Power	3
	5.1.Introduction	3
	5.2.Observations of the team	4
6.	Toshiba Head Office on 16.10.19 at Kawasaki	5
	6.1.Introduction	5
	6.2.Observations of the team	6
7.	NEDO visit on 16.10.19 at Kawasaki	6
8.	Hibikinada Biomass Coal-fired TPS on 17.10.19 at Kitakyushu	7
	8.1.Introduction	7
	8.2.Observations of the team	7
9.	Reihoku Coal-fired TPS on 18.10.19 at Kumamoto	8
	9.1.Introduction	8
	9.2.Observations of the team	9
10.	MHPS Head Office on 21.10.19 at Yokohama	10
	10.1.Introduction	10
	10.2.Observations of the team	11
11.	Data Analysis Centre of JERA on 21.10.19 at Yokohama	12
12.	Wrap Up Meeting	12
13.	Findings and Conclusion	13
	List of Plant Pictures taken during Site visits to Hibikinada and Reihoku	16-20

## 1. Introduction

Japan and India signed a Memorandum of Understanding (MoU) in April 2010 on a bilateral cooperation pursuing efficiency and environmental improvement of coal fired power stations in India. Central Electricity Authority of India (CEA) and Japan Coal Energy Center (JCOAL) were given mandates to implement the Cooperation i.e. CEA-JCOAL Cooperation through diagnostic activities and other means such as knowledge and technology exchange program, annual/ad-hoc workshops and meetings, etc.

The power sector in India especially the Coal Fired thermal power stations are facing challenges to comply with the new environment norms notified in December 2015. Japan has more than 30 years of experience in De-NO<sub>x</sub> & De-SO<sub>x</sub> of flue gas from thermal power station and also has the manufacturing capabilities of these equipment. Japan has also experience in replacement of old inefficient plants with new efficient environment friendly supercritical units at Isogo TPS and Reihoku TPS.

Under CEA-JCOAL Cooperation, 8 (eight) units out of 7 (seven) power stations have been diagnosed involving 4 (Four) State/Central utilities including NTPC. Also, MEEP (Moving-electrode electrostatic precipitator) was awarded for R&M of two units of a power plant (Rihand STPS) in India.

The on-going cooperation between CEA and JCOAL is expected to expedite support for efficient and environmentally - compliant coal power generation by extending the scope of activities to new development while addressing the relevant needs of the existing power stations remains the mainstay of the Cooperation.

Under MoU between CEA-JCOAL, Clean Coal Technology (CCT) Training Program in FY2019 for Project on *“Efficiency and Environmental Improvement for Sustainable, Stable and Low-carbon Supply of Electricity”* was organized by Japan Coal Energy Center (JCOAL) from 14<sup>th</sup> Oct to 22<sup>nd</sup> Oct, 2019 in Japan. JCOAL acts as the secretariat and coordinator of the entire program under the supervision of New Energy and Industrial Technology Development Organization (NEDO), Japan.

The aforementioned CCT Training Program to Japan’s state of the art power plants and manufacturing facilities was attended by participants from MoP, CEA and central & state power utilities.

## 2. List of Delegation

S.No	Name	Organization	Designation
1	Annepu Suresh	CEA	Director (TPPD)
2	Bitan Sekhar Ray	CEA	Assistant Director (TPRM)
3	Rohit Yadav	CEA	Assistant Director (TPRM)
4	Manoj Kumar	CEA	Assistant Director (UMPP)
5	Praveen Kumar	MoP	Under Secretary (IC)
6	Anil Kumar Sharma	NTPC	GM (Operation), VSTPS
7	Ghosh Sanjoy Kumar	DVC	Deputy Chief Engineer (Mechanical)
8	Sanjay Kumar Verma	UPRVUNL	Superintending Engineer
9	Narendra Kumar	KPCL	Chief Engineer (Operation), Bellary Thermal Power station (BTPS)
10	Abhishek Sinha	OPGCL	Deputy Manager, Operations
11	Vitthal Shioramji Khatare	MSPGCL	Chief Engineer, Projects and Planning Department
12	Sachin Agarwal	NTPC	Addl. General Manager (C&I)

## 3. Schedule of visits Undertaken in Japan

One Biomass Coal-fired and one Coal fired thermal power station and four manufacturing facilities were visited by the participants during the seven days stay in Japan. A brief itinerary is given as below:

- i. Kick off meeting with JCOAL on 14.10.19 at 1015 hrs at Tokyo
- ii. A presentation on Isogo Thermal Power Station of J-Power on 14.10.19 at 1400 hrs at Tokyo
- iii. Visit to Toshiba Head Office on 16.10.19 from 0830 hrs to 1030 hrs at Kawasaki
- iv. Visit to NEDO on 16.10.19 from 1045 hrs to 1215 hrs at Kawasaki
- v. Visit to Hibikinada Biomass Co-fired TPS on 17.10.19 from 0930 hrs to 1200 hrs at Kitakyushu

- vi. Visit to Reihoku Coal fired TPS of Kyushu EPCO on 18.10.19 from 1300 hrs to 1600 hrs at Kumamoto
- vii. Visit to MHPS Head Office on 21.10.19 from 0900 hrs to 1045 hrs at Yokohama
- viii. Visit to Data Analysis Centre of JERA on 21.10.19 from 0900 hrs to 1045 hrs at Yokohama
- ix. Wrap-Up Meeting on 21.10.2019 at 1500 hrs at TKP Shimbashi Conference Center, Tokyo.

#### **4. Kick off Meeting with JCOAL**

Twelve members of visiting team met the President and other members of JCOAL at JCOAL office, Tokyo and shared the expectations from the CCT Training program. Mr. Osamu Tsukamoto, President, JCOAL welcomed the visiting team to Japan. He extended all support and co-operation for successful study tour. The JCOAL team explained the program module to participants.

#### **5. Isogo Thermal Power Station of J-Power**

##### **5.1. Introduction**

A presentation was given on Isogo TPS which is operated and owned by J-Power. The team could not visit the plant due to safety reasons in the aftermath of Typhoon Hagibis in Japan. It is the only coal-fired power plant located in Tokyo Bay area and is constructed over 12 hectares of land. Isogo TPS is an example of Coal Fired Power Plant operating in a city and its emissions are lowest in the world.

It has a tower type ultra-super critical plant consisting of two units each of 600MW constructed in 2002 and 2009 respectively. Efficiency of the plant is 45%. The new units are replacement of old 2x265MW (constructed in 1967 and 1969).

The plant uses activated carbon for Flue Gas desulfurization. The activated carbon adsorbs the SO<sub>x</sub> which is extracted during the regeneration process of activated carbon. The SO<sub>x</sub> is expelled from activated as highly concentrated sulphuric acid.

The ash generated at Isogo TPS is fully utilized. The stack height is 200m, despite the low emissions. It has been informed that the surrounding area is

an industrial area and to prevent any over concentration of pollutants due to cumulative accumulation from industries, the height has been kept above the normal requirement. Cooling water discharge temperature differential is 7 degree centigrade.

Emissions of Isogo TPS	Unit 1	Unit 2	Old Units 1 & 2
SPM (mg/Nm <sup>3</sup> )	10	20	50
NO <sub>x</sub> (ppm)	20	13	159
SO <sub>x</sub> (ppm)	20	10	60

J-power is an electric power development Company producing power in both home and overseas market. It has about 100 stations in Japan which include various type of power sources such as thermal, hydro, wind, biomass, geothermal. It also operates 2400 km of transmission lines. It has 61 Hydro power station, 22 Wind power station, 11 Thermal power station, 1 Geothermal and 2 others.

## 5.2. Observations of the team

The scheduled visit to Isogo TPS was cancelled due to the recent Typhoon in Japan. Alternatively, an interaction meeting was arranged with the representatives of Isogo TPS. During the discussions, the following emerged:

- i. Isogo TPS is a coastal TPS. Coal is imported from Australia & Indonesia.
- ii. Isogo TPS is a replacement project of former TPS.
- iii. Former Isogo TPS was based on subcritical technology comprising two units of 265 MW each.
- iv. The new plant is based on ultra-supercritical technology with two 600 MW units. The gross plant efficiency is 45% and the steam parameters are as below:  
 $U - 1 = MST = 600^{\circ}c \quad RST = 610^{\circ}c$   
 $U - 2 = MST = 600^{\circ}c \quad RST = 620^{\circ}c$
- v. The total plant area is 30 acres. The replacement units are built on the same location of existing units. During the replacement period, one unit was always operational.
- vi. The vessels are of self-unloading carrier type with coal unloading on the MGR belt. Unloaded Coal is stored in silos. The power plant keeps a stock for 30days where in 10days stock is stored in Coal silos at the site while 20days stock is stored in other locations. Crushing and washing of Coal is done at the source and such coal is received at the plant.

- vii. Plant is based on model of **Build, Scrap and Build Construction** Procedure. To maintain the required power supply capacity during the construction of a new generating facility, first unit of 600MW was built while operating the old generating facility of 530 MW. After the new No. 1 Unit was commissioned, the old generating facility was decommissioned and demolished. The new no. 2 Unit was commissioned on the site. The extra space was made available by reducing the outdoor Coal yard by building an indoor coal silo.
- viii. Coal is stored in closed type silo for saving space. The belt conveyer which carries the coal has air flowing type belt in sealed pipes. This helps prevent coal dust dispersion and reduces noise and vibration.
- ix. To make optimum use of available space, a tower type boiler is installed.
- x. The following environmental protection measures were taken in the Thermal Power Station:
  - a. Intake of cold sea water from bottom of the sea and water discharge on sea surface. The water temperature is constantly measured.
  - b. Adoption of USC for steam cuts CO<sub>2</sub> emission.
  - c. Using 2-stage combustion method and low-NO<sub>x</sub> burners are effective in reducing NO<sub>x</sub> emissions.
  - d. Indoor coal/ash silos and air flowed belt conveyers are used for storing and handling coal and ash.
  - e. At ISOGO Station entire amount of coal ash is used.
- xi. The plant boasts of a world class environmental performance. The Sox & Nox emissions are 0.01 & 0.06 gm/kWh, respectively. Dry type De-  
SO<sub>x</sub> based on activated coke feed is used and the water consumption is 1/100 of the wet-type process.
- xii. The SO<sub>x</sub>, NO<sub>x</sub>, Dust emissions:

Pollutants	Environmental Agreement regulated value Unit-1	Environmental Agreement regulated value Unit-2	Operating results
SO <sub>x</sub> ,	20 ppm	10 ppm	1-6 ppm
NO <sub>x</sub>	20 ppm	13 ppm	10-15 ppm
Dust	10 mg/Nm <sup>3</sup>	5 mg/Nm <sup>3</sup>	1-3 mg/Nm <sup>3</sup>

## 6. Toshiba Head Office on 16.10.19 at Kawasaki

### 6.1. Introduction

Toshiba is a leading company in super-critical (SC) and ultra-super-critical (USC) technology. They have decades of experience as a power plant equipment manufacturer and have supplied equipment for more than 118GW.

Toshiba is also on the leading edge of technology in designing and manufacturing a wide range of equipment of power plants from steam turbines to C&I systems. This factory is the base of the energy apparatus production of Toshiba. Main products are nuclear plant component, generator, turbine and various energy apparatuses.

## **6.2. Observations of the team**

Toshiba informed the delegation that they have setup a fully integrated manufacturing plant at Chennai. It gave a presentation of the various facilities available at this factory. The company also gave an overview of the digital transformation solutions in the energy field. Smart use of renewable energy, virtual power plant, plant maintenance using digital twin and efficient sophisticated maintenance are the solutions presently available under digital transformation. Toshiba representatives informed that they are currently working on technologies like Energy storage and Hydrogen energy.

Toshiba also explained about its digital platforms for Energy industry which provides solution to power industries. The platform provides solutions to coal management, optimized load distribution, maintenance planning, fuel optimization, abnormality detection, equipment diagnosis, plant modernization etc.

## **7. NEDO visit on 16.10.19 at Kawasaki:**

NEDO is an independent administrative agency under METI. It promotes R&D as well as dissemination of industrial, energy and environmental technologies. NEDO's mission is to solve global energy and environmental problems.

The representatives of NEDO outlined its activities in New Energy such as high efficiency PV cells, Batteries and Energy System, Energy conservation, clean coal technology, environment and resource conservation. It presented its outlook on coal based power plant in future. NEDO estimates that the coal prices will stay low and stable and will continue to contribute to energy security compared with oil and LNG. The CCT activities in NEDO thrust upon development of next generation high efficient coal fired power technologies such as Integrated Coal Gasification Combined cycle (IGCC), Advanced Ultra Super Critical (A-USC) and Integrated Coal Gasification Fuel Cell Combined cycle (IGFC). NEDO is also supporting development of Biomass Co-firing, environmental technology, utilization of coal ash and Flexibility. NEDO highlighted about Japan's new initiative for carbon recycling.



The following CCT initiatives have been taken by NEDO in India so far:

- i. Demonstration test for De-Nox system in Sipat.
- ii. Feasibility study for utilization of biomass in co-firing stations
- iii. Optimization of NTPC Vindhyachal power plant using IoT
- iv. CCT Training programme for Indian government experts.

## **8. Hibikinada Biomass Coal-fired TPS on 17.10.19 at Kitakyushu**

### **8.1. Introduction**

Hibikinada Biomass Coal-fired Plant is located in Kitakyushu city. Plant is based on supercritical technology with one unit of 112 MW and it started its operations in Feb, 2019. The power plant site area is about 5 ha. The plant is designed with Biomass blend ratio 30%. The Design Thermal Efficiency of plant is about 44%.

Gypsum handling system is taken care by Yoshino Gypsum Co. Ltd.; Transaction of Ash by KMEW company and Supply of coal & Use of Coal storage yard by Nippon Coke & Engineering Co. Ltd. In this way, plant activities with plant operator are limited to only plant operation which is best example of a model policy of efficient plant operation.

### **8.2. Observations of the team**

The salient features of the plant are:

- i. Fuel is import based. Both coal and biomass are imported. Coal is imported from Australia & Indonesia while Biomass is imported from America and Vietnam. The GCV of imported biomass is impressive which in the range of 4000-4500 kcal/kg.
- ii. The power plant has a supply contract for full load for 1 year. The contract is annually renewed.
- iii. There are 3 coal mills running under full load comprising of 1 Biomass mills and 2 coal mills. It has no standby mill. It has 2+1 (standby) Boiler feed pumps and 2+1 (standby) condenser pump.
- iv. Wet FGD is installed. The regulated value of PM is 20 ppm, SO<sub>x</sub> is 80mg/m<sup>3</sup>. Purified recycled water is used instead of sea water.
- v. Bottom Ash and Fly Ash are treated as Industrial waste and the plant pays for their disposal. Some amount of fly ash is used in construction block materials made by nearby industries. Steam is supplied to such

industries which is used for compression of construction material. The cost of disposal of bottom ash is twice that of fly ash.

- vi. The following other information is known about the plant:  
 Cooling water - fresh water;  
 Gypsum 95% purity@ PH= 6-8, consumption – 500 tonne /month;  
 Bottom Ash = 200 tonne/ month; fly ash = 2000 tonne / month;  
 Coal consumption = 660 tonne/ day.  
 Plant Efficiency = 43% Heat rate = not disclosed,  
 Auxiliary consumption (House rate) = 11%  
 Tangential/ corner fired boiler is used.
- vii. The hydraulic pressure in pellet mill is less compared to Coal mill.
- viii. The following aspects have to be considered during design of a Co-generation plant for better efficiency and reduced emissions:
  - a. Heat concentration is to be worked out for different fuels.
  - b. Burner to be modified for combustion
  - c. Boiler design considering separate fuels of Biomass & Coal

## 9. Reihoku Coal-fired TPS on 18.10.19 at Kumamoto

### 9.1. Introduction

Reihoku Coal-fired TPS is operated by Kyushu Electric Power Company. The total installed capacity of plant is 1400 MW with two units each of 700 MW. Unit No.1 & 2 was commissioned in 1995 & 2003 respectively. The power plant is located at Kumamoto in Amakusa Archipelago bordering with Uzen-Amakusa National Park. The site of plant was totally created by sea water land reclamation. The plant area is approx. 290 Acres out of which Power Plant: 118 Acres and Ash Disposal: 76 Acres. Raw water for industrial use is tapped from Tororo Dam (multi-purpose dam) about 5 km away from station. The condenser cooling water from both units is discharged deep into sea through tunnels about 500 m offshore so that no warm water recirculates into the intake pit area within station port. Both units are supercritical pressure capable of a variable load demand or medium load operations featuring high efficiency, multiple coal firing and **15% min load operation (exclusively coal combustion)** functions.

Noise (Level set by Environment Preservation Agreement)	
Day (8:00am – 7:00pm)	≤ 65 dB
Morning(6:00am – 8:00am) Evening(7:00pm – 10:00pm)	≤ 60 dB

Night (10:00pm – 6:00am)	≤ 50 dB
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Note: the plant area is bordering with residential area so comply with 3<sup>rd</sup> area regulation.

Emissions of Reihoku TPS (Level set by Environment Preservation Agreement)	Unit 1	Unit 2
SPM (mg/Nm <sup>3</sup> )	40	30
NO <sub>x</sub> (ppm)	60	60
SO <sub>x</sub> (ppm)	100	80

The power plant is importing beneficiated coal from Australia with two different GCV and also blending 1% wood chip by weight with coal. The ash generated is being utilized for sea water land reclamation adjacent to site. So 100% ash generated is fully utilized.

## 9.2. Observations of the team

Reihoku is a former coal mining town in the Amakusa district, Kumamoto. The power plant is a coastal plant in the East China Sea. The TPS is built on approx. 290 Acres of reclaimed land. The plant operates 2x700 MW supercritical units. Both units have wet limestone-gypsum based FGD with De-SO<sub>x</sub> efficiency of ≥90% and ≥92% and dust removal efficiency of ≥70% and ≥85% respectively. Further, dry ammonia catalytic reduction technology with efficiency of ≥66.7% is used in both units for flue gas desulfurization.

The following observations were made during the visit:

- i. The plants have area-wise environmental pacts. While the law provides for overall norms in many cases through negotiation locals enforce tighter area-wise norms than the overall norms. Pacts are then signed with local bodies.
- ii. The present annual PLF is 80%. The capacity of coal yard is 4 lakh tonne and the inventory of coal is 2 lakh tonne. Capacity of oil is 3000 liters and inventory is 2000 liters.
- iii. The plant policy is to not keep any spare parts. Less than 1% are kept as spares, if any. There are no modular spare parts kept. It is learnt that the manufacturers immediately respond and supply spares.
- iv. It was informed that the frequency of Boiler tube failures is rare which is once in two to three years.

- v. Like in India, Boiler soot blowing is done thrice a day to maintain boiler temperature. It is due to the reason that that better quality coal has lower ash fusion temperature which makes it sticky.
- vi. During summer and winter, the plant operates at full load. It is remarkable that during spring and autumn time, which is high renewable season, the plant undergoes a 7-hour shutdown from 9 AM to 4 PM on a regular basis.
- vii. The plant informed of no problems in any of its boilers so far. It is noted that the FGD manufacturer is same as the boiler manufacturer and computability issues are less likely.
- viii. Under low load (as in case of Flexibilization), there is a possibility of flame instability. This aspect was considered in design of boiler way back in 1995.
- ix. The plant can run at 15% of rated load without oil support.
- x. The startup time from capital overhaul to full load i.e. from first gun to full load is 14 hours. 150 kiloliters of oil is consumed during these hours.
- xi. The ramp rate is 4% for 100-50% load, 3% between 50-30% load and 1% between 30-15% load with one hour interval between ramp rates. One water pump and one mill is shutdown during ramp down from 100 to 50% load.
- xii. The data on heat rate and deviation from heat rate were not available.

## 10. MHPS Head Office on 21.10.19 at Yokohama

### 10.1. Introduction

MHPS claims to have the most advanced FGD & SCR technologies, which are of critical importance to Indian power plant in order to meet the new environment norms. MHPS has 35 yrs of experience in denitrification (De-NOx) by SCR catalyst technology.

#### NOx systems – using Titanium/Vanadium Oxide based SCR

Titanium/Vanadium oxide- based denitrification catalysts are used in honeycomb and plate type catalyst SCR system. The plate type catalyst is suitable for high ash content coal. The MHPS is conducting a pilot of De-NOx system with slipstream using the plate type catalyst at Sipat TPS of NTPC. The key challenge in the SCR process is uniform ammonia distribution across the catalyst section, which has been done efficiently by MHPS.

## FGD

MHPS have two type of FGD, double contact blow scrubber and spray tower scrubber. Selection of type is depending on flue gas condition and site layout. They provide wet FGD system and have worldwide experience in new and retrofit systems. The computer tools like CFD are using for system design of FGD flow dynamics. This practice ensures zero sneakage and low liquid to gas ratio. The **innovative concept of single scrubber tower** for multiple boilers was explained to participants, for the situations where the space limitation around the boilers is a major constraint. This is very important in the context of FGD retrofitting at old power plants in India. In this system, the existing chimney may or may not be used depending upon site condition and flue gas characteristics. The lining of chimney with an anticorrosion material is recommended in wet FGD operation.

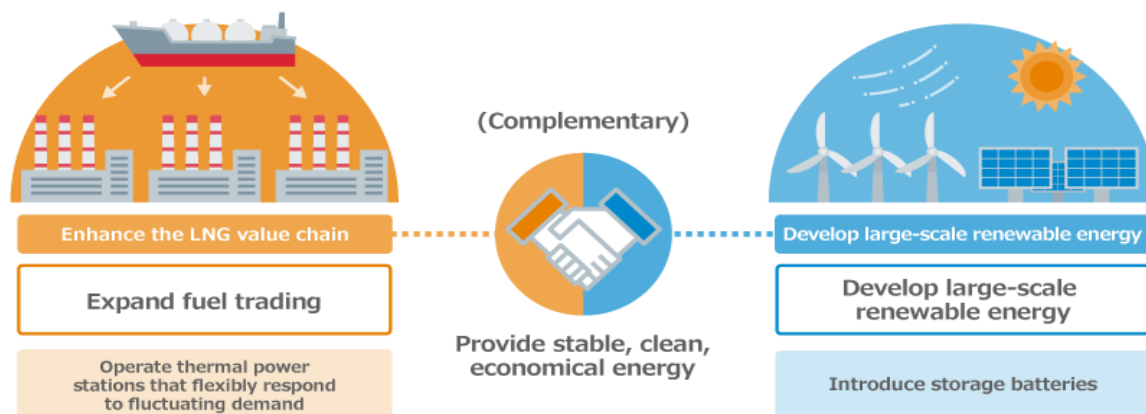
## ESP

The high resistivity of ash in Indian coal is known to be a limitation for ESP performance. The use of GGH before ESP to reduce the ash resistivity and to improve ESP performance is considered one of the option for high resistivity of coal ash. Another option is MEEP (moving electrode ESP) to handle the situation of ash of high resistivity and improve ash collection in the ESP. Both the systems, low -low ESP and MEEP are very important to Indian Power Plant in order to meet the new environmental norms.

### 10.2. Observations of the team

The delegation also interacted with various agencies and companies. Offices of Mitsubishi Hitachi power system (MHPS) and J-Power were visited. MHPS gave a presentation on Air Quality Control System (AQCS) for Thermal Power Plants. It boasted of its integrated AQCS system with world lowest level emission for Sox, NOx and dust removal system. MHPS informed that 61.5 % share of De-SOx market in 2018. The presentation covered topics as selection of FGD Technology (wet, dry and semidry), its design feature (absorber type, tray tower, spray tower, advanced spray tower etc. and byproducts of them), water saving features (Use of gas cooler to condense FGD evaporated water), Ammonia based SCR for De-NOx, SCR design for high ash Indian coal, ESP system (fixed type and moving electrode type). The remote monitoring service for FGD was also explained. The component condition is monitored parameter as Boiler load, Sox removal, limestone consumption etc. is monitored and serviced as required.

## 11. Data Analysis Centre of JERA on 21.10.19 at Yokohama



The operating environment for TPS has been changing with the expansion of renewable energy and the acceleration of efforts to reduce CO<sub>2</sub> emissions. In order to address problem faced by TPS, Japan Energy for a New Era (JERA) provides cutting edge solutions to the world's energy issues.

JERA established in Apr, 2015 by succeeding parent companies TEPCO and Chubu. It is a kind of plant operation center for East Japan. Total Installed capacity of East Japan is 90 GW. It is remotely monitoring TPS with 86 units having a capacity of 41 GW. There are 48 blocks in a day for power scheduling in Japan.

JERA also provides energy solution through data analysis. For that, there is Data Analysis Center (DAC) which currently provides energy solution for 36 units with total capacity 16.92 GW. DAC detects anomaly in data provided by TPS and provides energy solution for pre-fault situation in TPS. So DAC improves Asset performance of the plant equipment therefore reduction of forced outage so saves fuel cost. It also monitor others countries TPS like USA, Philippines etc.

## 12. Wrap Up Meeting

A Wrap up meeting was arranged at 3:00 PM on 21<sup>st</sup> October 2019 at TKP Shimbashi Conference Center, Tokyo. The meeting was attended by members from Ministry of Economy, Trade and Industry (METI), Japan; New Energy and Industrial Technology Development (NEDO), Japan; Japan Coal Energy Center (JCOAL); Mitsubishi Hitachi Power Systems Ltd (MHPS), Japan; Horiba Ltd.

Japan; Chugai Technos Corporation, Japan; Toshiba Corporation, Japan and the visiting team.

Shri Annepu Suresh, Director (TPP&D), CEA thanked Dy. Director, METI; Director, NEDO and President, JCOAL for arranging the technical study tour. He also highlighted the present issues & challenges and the future direction of Indian power sector during his presentation. He also highlighted the government initiatives on various issues in Indian Power Sector as well as the main learnings gathered by the participants from the study tour.

Representatives from NEDO, METI and JCOAL expressed their willingness for more cooperation between India and Japan in various frontiers of power sector.

### 13. Findings and Conclusion

- i. Government policy in Japan mandates necessary installation of FGD and SCR in all thermal power plants for emission control and reduction.
- ii. Notification of area-wise norms of SO<sub>x</sub> and NO<sub>x</sub> emissions in consultation with local bodies and limits under the overall ambit of national policy.
- iii. Efforts are being put in further reduction of other emissions (CCS).
- iv. Use of biomass to the extent possible in coal fired plants is being made.
- v. Insights into coal, ash and gypsum handling – salability and disposability.
- vi. Project execution at Isogo TPS serves as a model example for replacement and upgradation projects.
- vii. Novelty in operations – receipt of crushed coal, imported biomass, and erection of coal silos. (Hibikinada co-gen plant)
- viii. High standards of quality followed in construction of plants.
- ix. The good practices of O&M were visible in man, material and plant management.
- x. Stations like Reihoku are able to achieve flexibility in operations by ramping down to 15% of rated capacity on an intraday basis. The station showed ramp rates of 4%.
- xi. Japan has nuclear and thermal plants for base load and Gas plants for peak load. The intermittent RE issue is addressed with ample gas stations and flexible operation.
- xii. Adequate supply of good quality coal and gas.
- xiii. High quality plant equipment leading to smooth and comfortable operation.

- Quality wise class of boiler insulation, valve condition, overall housekeeping, CHP conveyor system, coal mill condition is excellent.
- xiv. Inventory and supply chain
    - Inventory of coal: 50% of yard capacity i.e. 0.2MT for 2x700 MW.
    - Capacity of OEMs to supply quickly.
    - Minimum no. of spares kept.
  - xv. Unit overhaul of BTG is for a period of 100 days at intervals of 3 years.
  - xvi. Plant maintenance is once in two years.
  - xvii. Plant safety aspect
    - Non dependence on SAP/MAXIMA and usage of manual systems.
    - OSHA and ANSI compliant safety aspects like gratings, zebra painting, and fire system followed.
  - xviii. Japan's more than 30 yrs. of experience in manufacturing and installation of De-SO<sub>x</sub> & De-NO<sub>x</sub> systems was evident to the visiting team. TiO<sub>2</sub> based SCR system with plate type catalyst for NO<sub>x</sub> and Wet FGD systems for SO<sub>x</sub> are suitable for Indian conditions of high ash contained coal.
  - xix. Japan's large manufacturing base in power plant equipment including Turbine, Turbine Blades, Generator and environmental equipment can be utilized by India to meet its power equipment demand. It is also revealed that 5% generation increase is possible over rated capacity of old unit by replacing latest design turbine.
  - xx. The expertise of several measuring instruments manufacturers like MHPS can be employed to monitor the stack emission level of Indian power plants in order to ensure long-term environment compliance.
  - xxi. Considering the example of Japan's Isogo and Reihoku TPS, India can learn useful skills regarding plant operation and maintenance for clean, efficient, reliable, safe operation and high availability of Indian power plants. India can also utilize the experience of construction for replacement of old unit by supercritical & ultra-supercritical unit at a small piece of land without shutdown of the old units as being done by Japan.
  - xxii. Indian power plants can consider employing covered coal storage for environmental improvement and maximum utilization of land which is being used in Japan TPS (Hibikinada TPS).
  - xxiii. Advanced solutions for entire gamut of efficient emission control technologies along with remote monitoring services is available with manufacturers like MHPS in Japan.
  - xxiv. Digital transformation solutions in the energy field provided by Toshiba help in coal management, optimized load distribution, maintenance planning, fuel optimization, abnormality detection, equipment diagnosis,

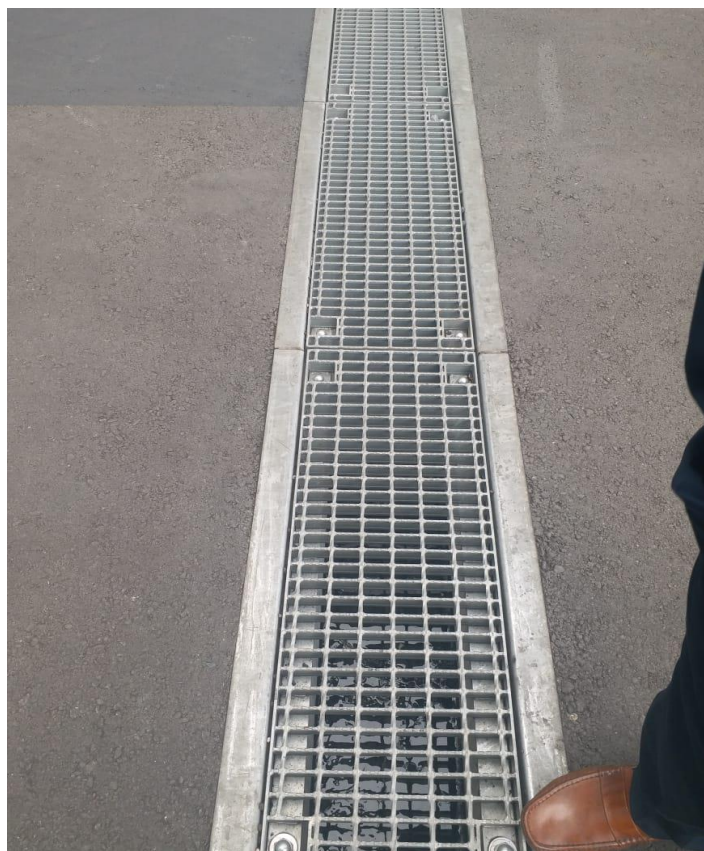


plant modernization etc. Digital transformation solutions are also available in areas as Smart use of renewable energy, virtual power plant, plant maintenance using digital twin and efficient sophisticated maintenance.

## List of Plant Pictures taken during Site visits to Hibikinada and Reihoku



Hibikinada: BTG



Hibikinada: Safety locks on grills



Hibikinada: Modular perimeter wall



Hibikinada: Covered coal yard



Reihoku: Entrance



Reihoku: Turbine Floor



2019/10/18 13:44

Reihoku: BTG



Reihoku: Coal yard



THANK YOU