Outcome Report on

CLean coal technology (CCT) Training programme

Under CEA-JCOAL co-operation from

January 11-19, 2017, Japan

Objective

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 clean coal power development through UMPPs (Ultra Mega Power Projects), etc.

In April 2010, Japan and India decided to embark 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; CEA-JCOAL Cooperation through diagnostic activities and other means such as knowledge and technology exchange program, annual/ad-hoc workshops and meetings, etc.

The on-going cooperation between CEA and JCOAL, officially named as Japan-India Cooperation for Project on Efficiency and Environmental Improvement for Sustainable, Stable and Low-carbon Supply of Electricity and remains being called as CEA-JCOAL Cooperation, is expected to further 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.

It is well recognized that the power sector in India is experiencing a kind of 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. This CCT Training Program will constitute a crucial part of the bilateral endeavors in support of relevant actions by utilities for better environmental compliance and high efficiency. The Program, in its 4th year under the Cooperation, remains best tailored to the needs of Indian power sector. Expected participants are: key officials /officers /engineers of relevant government and institutions such as MOP, CEA and utilities such as NTPC, APGENCO, GSECL, etc. as well as major companies highly interested in Japan's CCT. The main objective 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. Participants will be updated about various applicable technologies and equipments as well as O&M technique. Exchanges and discussions are planned both during observations and at METI as well as JCOAL, which will enhance the effect of the overall training program.

Organizer

Japan Coal Energy Center (JCOAL) acts as the secretariat and coordinator of the entire program under the supervision by the Ministry of Economy, Trade and Industry (METI), Japan.

Central Electricity Authority (CEA) , acts as coordinator and facilitator for the entire programme from Indian side regarding contents and composition of the programme.

Qualifications required to a participant of Group 2

The following experience and qualifications are required to a participant.

(1) Work experience

The participant must be functioning in a field relevant to thermal power generation and should be involved in the decision-making process in his/her division, so that he/she may contribute to expedite R&M and relevant daily activities at their original organization through giving a great deal of feedback after completion of the Course. Those who have worked in the past JCOAL diagnosis and/or other relevant activities under the CEA-JCOAL Cooperation will be of an advantage.

(2) Health condition

Participants must be physically fit to withstand long and rather busy trips to participate throughout the program period.

Based on the above criteria and consultation with different utilities CEA vide letter no. 2/9(JCOAL)/TPRM/CEA/2016/1594-1619 dated 14.12.2016 (letter is enclosed as Annex-I) nominated 14 participants including two from Ministry of Power (MoP) from where participants could be nominated by MoP. Finally, 11 out 14 were participated in the Group-II of Clean Coal Technology(CCT) Training Programme. Two from MoP and One from Rajasthan could not make it due to various reasons.

List of 11 participants who have participated in the CCT training programme is as under:-

Sl No	Name	Designation	Organization
1.	Rajeev Kumar	Director	TPR&M Division , CEA
2.	Sanjay Jain	Deputy Director	TPP&D Division, CEA
3.	Kamal Sethy	Deputy Director	UMPP Division, CEA
4.	K.K. Sharma	Deputy Director	TPPE&CC
5	Lakshmanan Raju	Managing Director	BSPGCL
6.	Ravindra Kuamr Wahi	Chief Engineer	UPRVUNL
7.	Rajan Kumar	DGM	NTPC
8.	Jeppu Yogish	Superintending Engineer	KPCL
9.	Ambika Sharan Singh	DGM	WBPDCL
10.	Chelladurai Raju	Executive Engineer	TANGEDCO
11.	Kishore Motilal Shirbhaiye	Executive Engineer	MSPGCL

Schedule of visit: -

January 11 Wed 19:35 Leave Delhi (on JL740)

January 12 Thu 06:50 Arrive in Narita; 13:30 Observation to Isogo TPS

January 13 Fri Observation to Toshiba Keihin Works

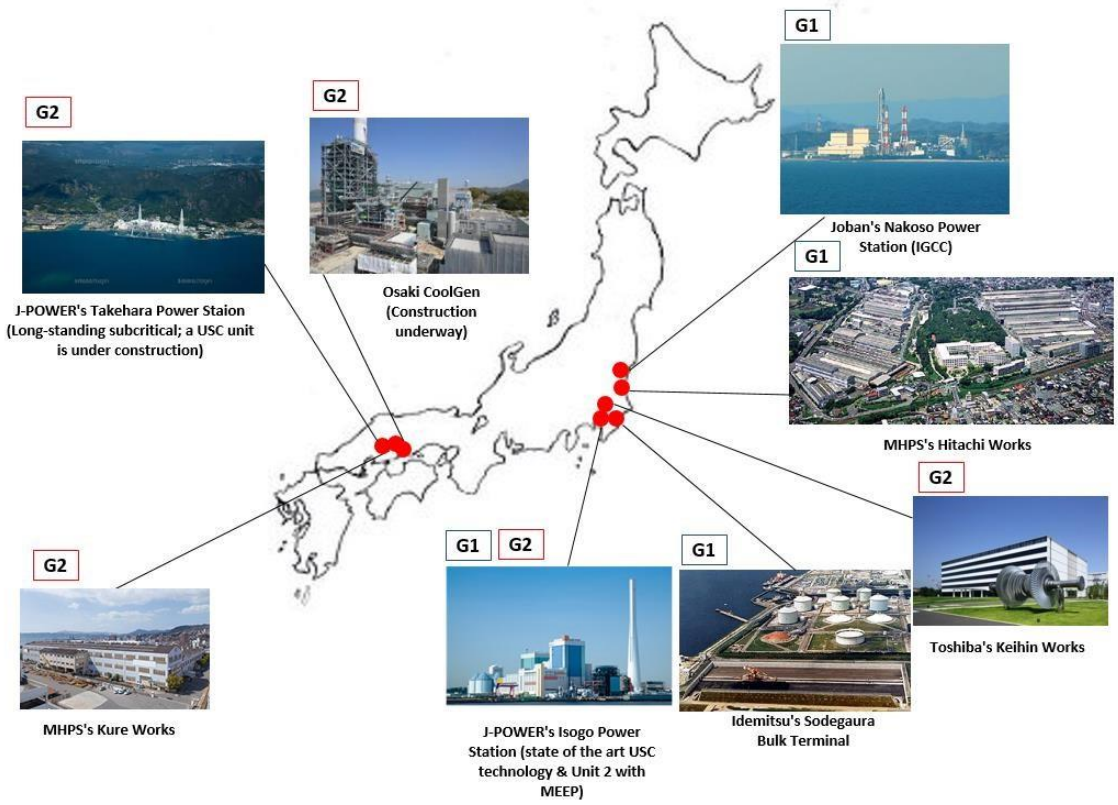
January 14 Sat Rest day

January 15 Sun Move to Osaki Stay in Osaki

January 16 Mon AM Observation to Osaki CoolGen Move to Hiroshima

January 17 Tue AM Observation to Takehara TPS PM Observation to MHPS's Kure Works

January 18 Wed AM Preparation for presentation PM Wrap-up Meeting at Embassy January 19 Thu 11:30 Narita-Delhi (on JL749) 17:35 Arrive in Delhi



Kick-off Meeting with JCOAL

President of Japan Coal Energy Center (JCOAL), Mr. Osamu Tsukamoto welcomed the participants from different power utilities of India. He appreciated that after gap of three programme participations from CEA has been ensured. He extended all his wishes and support for the programme. During the meeting extensive discussion was held between participants from India and JCOAL official on ongoing issues related to coal fired thermal generating units from Indian point of view. Brief summary record of the issues discussed during kick off meeting are as follows: -

1. The primary and biggest concern of each utility and the power sector in India is how to comply with the new environmental norms while ensuring economy of generation. The term "economy" in the context of economic viability of power generation comprises not only financial aspects but also space constraints.
2. As management of utility, a firm roadmap that clearly describes the optimal plan of new development and phased shutdown/abolishment of the existing old power station.
3. Concerns in relation to the required shutdown period remains a(n) barrier/issue to R&M, since it may affect power supply sustainability.
4. R&M, specifically that of ESP is being considered. In this connection, JCOAL was requested to provide the delegates with detailed ESP with information.

Senior experts of MHPS Akitsu will cater to the needs of the delegates about ESP and all other environmental equipment/technology.

5. How to conduct NOx/SOx emissions monitoring to comply with the new environmental norms issues in December 2015 is a pressing issue.
6. Transmission loss in Japan-approx. 5%. Transmission & Distribution loss graph was provided.
   Delegates posed a question if this figure included not only technical loss but also commercial loss, to which JCOAL will obtain information by the Wrap-up Meeting.
7. In connection with the issue of required flexibility of thermal power station in accordance with the expected massive RE introduction, it is a matter of great concern that how serious impacts on machines and equipment may be avoided under the situation where frequent start-up and stop of operation is required.
8. Knowledge and information are requested about how to avoid boiler tube leakage in order for preventing breakdown or tripping .
   -At Isogo, it was clarified that there had been observed only one or two cases of minor boiler tube leak since its COD. JCOAL will try its best in obtaining further information about any particular method or measures for boiler tube leak prevention.
9. Safety method, practices and procedures at coal fired power station
10. The on-going UMPP by the Government of India is to introduce SC on a large scale-as large as 4,000MW. USC would be also one of the options in this context.
11. Regular inspection frequency and period

-This matter was clarified at Isogo as described below.

12. The relevant law regulates that boiler should be inspected every two years and turbine every four years. It is a common practice for Japanese utilities and power generators to conduct interim inspection in-between the obligatory regular inspections. Period of regular inspections may vary from two months to 1-2 weeks, the latter of which is the case of a utility that conducts regular inspection every year.
13. In order for supporting the efforts by utilities to comply with environmental requirements, CEA established in 2009 awards for power station with high environmental compliance and/or high PLF (e.g. “Gold” for those at higher than 90% PLF) and have been continuing its policy endeavors.
14. Up to some recent point of time, utilities have been working for capacity addition. However, after having achieved supply surpassing demand, we have come to think of the quality rather than the quantity. In principle, power generation and supply is for the sake of community. In this context, since the

community requires better environment, utilities have to make efforts to cater to the needs by trying to take environmental measures by introducing FGD, etc. In the meantime, for new development, taking such measures may not have much constraints, while for environmental improvement with the existing ones, major constraints are there-space constraints, etc.

15. We have to take into consideration not only ambient air and water but also soil. We have to do something with coal ash, but just disposing coal ash on an empty, "available" land may cause a large problem as it will affect the soil as well in the long term.
16. Water treatment is one of the major issues to be addressed since the new environmental regulation requires power station to use sewage water processed on its own.
17. How unburnt carbon would be able to be reduced.
18. Information about air-heater sealing method is required.
    -the aforesaid is already addressed at Isogo. They use computerized hydraulic system.
19. It is a headache that there is a large discrepancy between the heat value of the designed coal and that of the coal actually used at power station. E.g. Designed: 4,500-5,000kcal, Actual: 3,000kcal (GCV)
20. Coal is storage in an open yard, which causes coal to have more water content due to being exposed to rainwater.
21. Coal handling is another matter of concern. Generally recommended practices such as water quenching, compaction, etc. have been already performed regularly. However, issues like spontaneous combustion and dust are yet to be well addressed.
    -At Isogo, it is emphasized that the only way to prevent spontaneous combustion is to regularly move coal so that it does not remain stationary at one place.
22. Coal ash utilization in connection with the high ash content. Cement companies receive coal ash regularly. However, a considerable amount remains unutilized.
23. How to reduce water consumption?
24. A comparative study on O&M with focus on Isogo and a plant of NTPC as its counterpart would be quite beneficial to identify which part of standard practices of O&M by Indian utilities should be modified and improved and whatever best practices that are to be introduced from Japan.
25. To comply with the requirement by the supply-demand situation, many power stations of NTPC are forced to operate on partial load. How to sustain efficiency under such situation is a crucial issue.

Isogo Thermal Power Station of J-Power – 12.1.17

Isogo Thermal Power Stations was constructed in the late 1960 in line with Japan's national coal policy. 1st unit was commissioned in May, 1967 while 2nd was commissioned in 1969 each unit was of 265 MW capacity. This power plant is in Yokohama city and was equipped with Flue Gas desulfurizer ahead of other plants in the world. To meet the objectives of Environmental improvement plan of the Yokohama City Authorities especially in terms of reducing nitrogen oxide (NOx) emissions and renewal in response to obsolescence and aging of the old power generating facilities it was decided to replace it by two units, 600 MW each of Ultra Super Critical (USC) technology units having. In new plant Unit no 1 and unit 2 commissioned in 2002 while unit 2 was commissioned in 2009.

Old Isogo 2x265 MW TPS

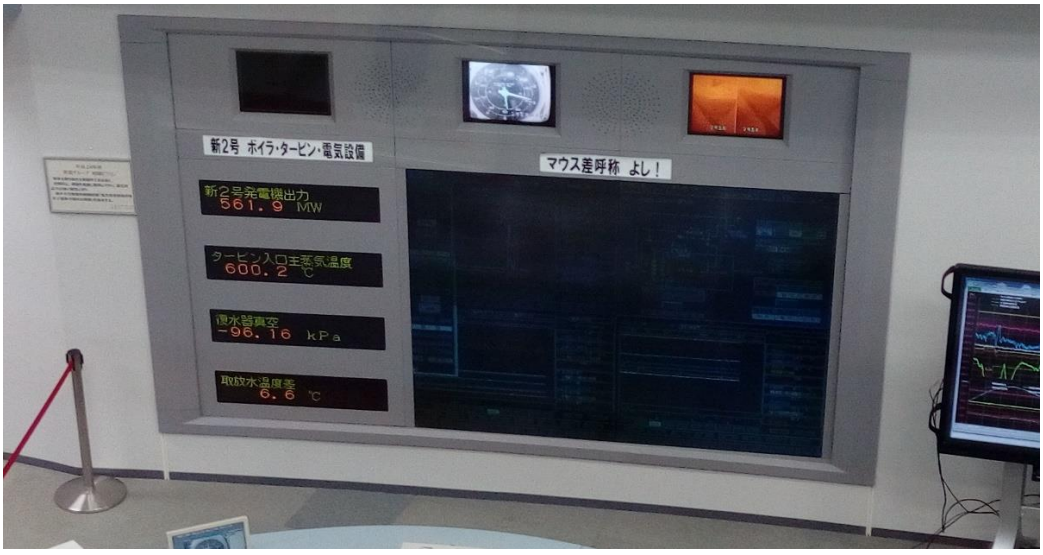
New Isogo 2x600 MW TPS

Following points have been observed during the visit of Isogo TPS of J-Power in Japan: -

- Replacement of 2 old sub critical units of 265 MW by new super critical 600 MW unit without shutting down the old unit.
- Only coal fired power station in Tokyo Bay area under strict emission norms.
- Gross plant efficiency – 45% (old plant – 40%)

- Very low emissions achieved – much better than prescribed norms, the picture below shows at the time of our visit SO_2 emission from Units 1 and 2 were 0.5 ppm and 0.00 ppm respectively.

While the unit was generating 561.9 and 600.2 MW respectively.



- Clean and Safe operating environment
- Very low operating manpower – high level of automation

- Auxiliary Power Consumption was around 5 % only.
- Boiler Tube Leakage has been witnessed only twice in last 8 years
- Efficient land use – Entire plant is in just 30 acers of land.
- Clover –type Coal Silo for the storage of coal to save space.

- The belt conveyors that carried the coal have air floating types belts in sealed pipe. This helps prevent coal dust dispersion and reduces noise and vibration.
- Dry type flue gas denitrification system for NOx mitigation, where Ammonia is injected to the NOx containing flue gas and converted it to harmless nitrogen and water in presence of catalyst.
- Dry type Desulfurization plant where sulfur oxides converted into useful sulfuric acid as by product in presence of activated carbon.
- Almost entire amount of coal ash is used to for fertilizer and for reinforcement of cement.
- Landscape design of power plant and especially stack is very beautiful.

Toshiba Kehin Factory

- Leading company in Super Critical (SC) & Ultra Super Critical(USC) technology.
- Saw manufacturing of generators and turbines for thermal, nuclear and hydro power plants
- Capacity – 30 MW to 1400 MW
- Modern and efficient machines to manufacture – turbine casing, rotor and blades
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- High level of automation

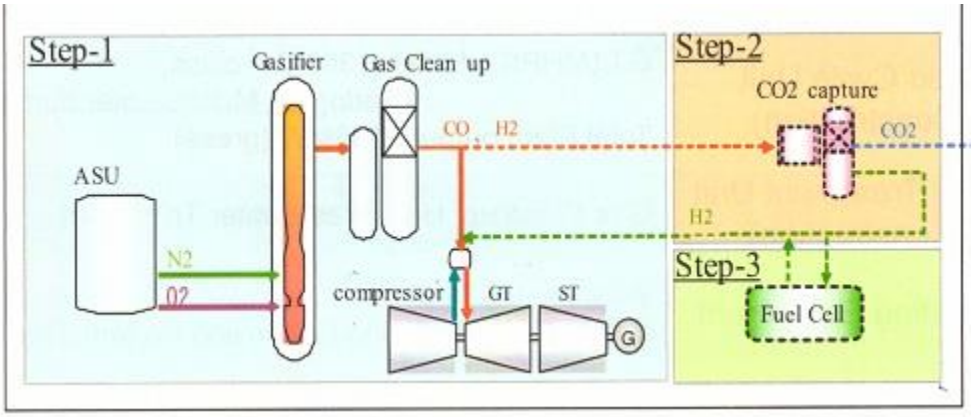
Osaki Coolgen Corporation

- Osaki CoolGen is a 166 MW R&D demonstration project for High Efficiency Low Emission technology of Coal thermal power generation technology at Hiroshima Prefecture, Japan.
- This project consists of three steps :-
    i. Integrated Coal Gasification Combined Cycle (IGCC)
    ii. CO_2 capture
    iii. Integrated Coal Gasification Fuel Cell Combined Cycle(IGFC)

- IGCC power plant efficiency - 46% & 15% CO_2 reduction - in commercial stage

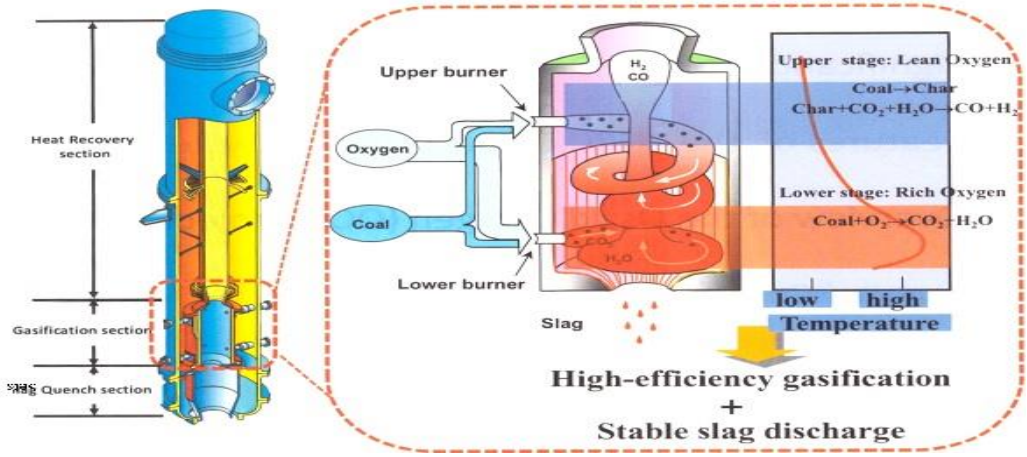
- IGFC - 55% efficiency and 30% CO_2 reduction -IGCC + Fuel cell

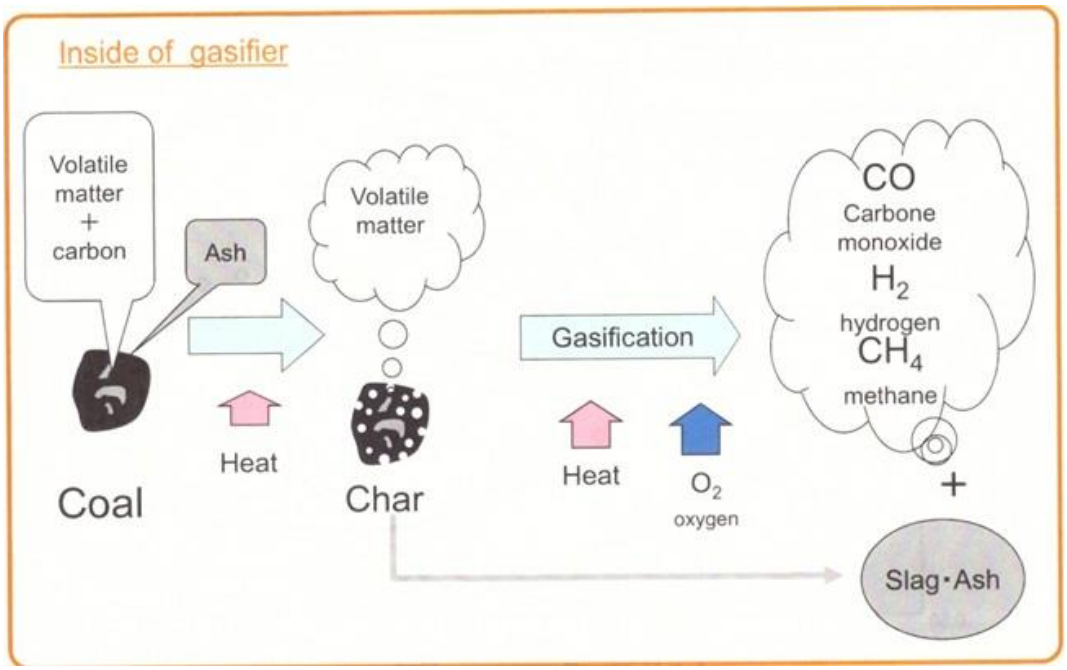
Basic Principle of operation: - Coal is gasified in a gasifier to generate syngas($CO+H_2+CO_2$) with carbon monoxide and hydrogen being the main components. After this, the heat of the syngas is recovered in a syngas cooler and gas clean-up unit removes impurities and sulfur from syngas. Next, the syngas is combusted in the gas turbine combustor to drive the gas turbine. The combustion exhaust gas in turbine is emitted from the stack after having its heat recovered by a heat recovery steam generator. Meanwhile, the steam turbine is driven by the steam generated in the syngas cooler and heat recovery generator. A combined cycle is then performed with this gas turbine and steam turbine. This makes it possible to achieve power generation efficiency beyond that of conventional pulverized coal-fired power generation.



Gasifier:-

Gasifier produce combustible gas from coal by thermal decomposition. The rotational flow of coal in the gasifier lengthens the residence time and encourages a gasification reaction. This will make it possible to obtain high gasification efficiency.





Inside of Gasifier

- It can handle wide range of coal - even coal with low CV and low ash melting point
- Indian coal with high ash content may require some modification in boiler slag removal system
- Excellent R&D which will help in reducing cost and emissions

Mitsubishi Hitachi Power Systems Ltd. - Kure works

- Pioneer in manufacturing, erecting and retrofitting of Air Quality Control Systems
- Relevant in the light of new emission norms in India
- Producing best quality plate type catalyst for NOX reduction
- ESP Retrofitting
- partial replacement of fixed electrode with moving electrode
- meet required norms with existing structure and space
- Helps in reducing SPM
- FGD Retrofit
- Normal practice to meet new norms
- with parallel work its possible to get it done within 1 to 2 months during periodic maintenance
- Integrated retrofit of ESP and FGD gives better results
- Helps in reducing SOX and Hg

Takehara TPS of J-Power

- Takehara Thermal Power Plant is situated in Takehara city also known as little "Kyoto" in Aki region near Hiroshima.
- Total installed capacity of Takehara TPS is 1300 MW , consists of 3 units of 250 MW, 350 MW and 700 MW.
- Unit 1 is of 250 MW was commissioned in 1967, around 50 years of age but still running efficiently.
- Unit no 2 was commissioned in 1974 while 700 MW capacity of unit no 3 in 1983.
- All the units were equipped with Sox and Nox removal equipment and strict environmental norms followed
- Unique feature of 700 MW super critical unit no 3 having two generators , at different speed 3600 and 1800 rom
- Existing unit no 1 and 2 with a total capacity of 600 MW will be replace by 600 MW Ultra Super Critical unit. Replacement works was under progress and will be completed by June , 2020 through Build and Scrap method.
- Plant is very close to residential area so taking comprehensive care of local community.

Visit to Indian Embassy (18.01.2017, forenoon):-

Officials from CEA along with Shri Lakshmanan Raju, MD, BSPGCL were visited Indian Embassy in Japan . Dr. Purnima Rupal , Counsellor(Science & Technology) welcomed the participants of training programme. After brief introduction issues related to CCT training programme and Indian power sector were deliberated in detail. She was of the view that future co-operation area and programme with Japan should be intimated to Indian Embassy in advance. Rajeev Kumar, team leader assured her that in future embassy will be kept in loop.

Wrap Up meeting (18.01.2017, afternoon):-

A wrap up meeting was organized between study group team from India and officials from different organizations involved in power sector of Japan including Ministry of Trade and Economy (METI), NEDO, JCOAL, J-Power, Toshiba, MHI etc. Director, METI has stated that at present India and Japan shared a very good political relation courtesy due to personal chemistry of prime minister of two nations. He was of the view that it should be used for the betterment of two nations. He has assured that Japan will extend all its support in overcoming issues pertaining to Indian power sector. He has specially pointed out that Japanese power equipment manufacturers willing to contribute in pollution mitigation issues which has been arisen due to new environmental norms for thermal generating units in India. He has cited example of China regarding pollution mitigation drive from coal fired thermal generating plants and how Japanese companies contributed in it.

Rajeev Kumar, Director, CEA and team leader thanked Director, METI for his kind words and support extended. He has informed that environmental norms prescribed for coal fired thermal generating unit are similar to that of China and govt of India is committed to implement these norms in thermal power plants. He has stated that no doubt Japanese technologies in power sector are one of the best in the world but they should look into the cost aspect and should tried to be competitive. He has also presented a brief presentation on Indian Power sector overview and future development related to it.

MD, BSPGCL, Lakshmanan Raju has given a presentation on behalf of all team members regarding different sites visit and lesson learnt. He has also deliberated

potential issues for future cooperation between two countries with respect to coal fired thermal generating plant.

Secretary General, JCOAL, has facilitated all the participants from India. Meeting concluded with exchanges of information and view.

Return Journey

Team departed on 19.01.2017 via morning Japan Airlines flight from Narita airport to New Delhi.

Summary of outcome and future co-operation scope: -

- Indian Power Sector specially coal fired thermal generating units are hard pressed to comply new environmental norm after MoEF notification of December 2015. Japan has more than 30 years of operating experience of DeSox and DeNox equipments and also have manufacturing capabilities of these equipment, so collaboration in Air Quality Control Systems to meet emission norms.
- Around 35000 MW of coal fired thermal generating units are more than 25 years old and has outlived their design life. Government of India is in process to either retire these units or replace it through efficient Super Critical or Ultra Super Critical technology units. Experience of Japan at Isogo TPS and Takehara TPS would be beneficial for replacement of old thermal generating unit with Ultra Super Critical (USC) unit
- Government of India has ambitious target of adding 175 GW of renewal capacity addition by 2022. It will affect the operation of coal fired generation due to intermittent nature of renewal generation. Flexible operation of coal based thermal power station may be one of the future area of co-operation.
- AS per the assessment IGFC technology could improve the efficiency of coal fired plant up to 55 %. So, R&D Collaboration

in the field of thermal generation between India and Japan specially testing of IGCC and IGFC technology with respect to high Indian Coal would be beneficial.

- Integration of renewable energy with grid and operational challenges.
- Closed coal storage / silos – plants in metropolitan area
- Sharing of O&M and safety related best practices as it was observed that boiler tube leakage and other frequent forced outage phenomenon observed only twice or thrice in Isogo TPS as against frequently observed in Indian Thermal Power station. Also, at Takehara 50 years old plant has been operated on full load and efficiency, their experience would be beneficial for minimizing outage at sub critical plants in india
- Optimisation of land use in thermal plant construction

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