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Implementation of Clean Coal Technologies to comply with "New Emission Norms" for Thermal Power Plants - Way forward for Southern Region

Summary Report of NITI Aayog-DST-NIAS Workshop, 17th September 2019

National Institute of Advanced Studies
Bengaluru, India

NIAS Workshop Report NIAS/NSE/EEP/U/WR/13/2019

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Cover photo: India's first ultra-supercritical (USC) 660 MW coal-fired unit at Khargone (state of Madhya Pradesh) with an efficiency of 41.5% and station heat rate of 2,070kcal/kWh. Courtesy: NTPC

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1. Background and Rationale for the workshop

Coal based Thermal Power Plants (TPP) are the backbone of the power generation utilities in the country. Coal based TPPs constitute to around 56.1% of the total installed capacity and generates around 74.2% of the electricity generated in India (CEA Sept. 2019 – Anx 1a). The main emissions from coal-based power plants that contribute to air pollution include Suspended Particulate Matter (SPM), SOx, NOx and Mercury. TPPs also draw fresh water for running the plant. Considering the high pollution and resource impact, the Ministry of Environment, Forest and Climate Change (MoEF&CC) notified the Environment Protection (Amendment) Rules (EPAR) on December 5, 2015 with a two-year window for TPPs to meet these standards.

The new pollution norms brought in standards for SO_2, NOx, and Mercury for the first time, and the SPM norms were also tightened. While the new standards are comparable with the norms of other coal based power-producing countries, older and smaller plants have to comply with more liberal norms compared to bigger and newer plants. When implemented, these norms are expected to have positive environmental and health benefits by leading to lower pollution levels from TPPs. However, compliance with the new emission norms would require retrofitting existing thermal power plants with various Pollution Control Technologies (PCT) in the form of auxiliary systems to control SO_2, NO_X and PM emissions. These include Flue Gas De-Sulfurization (FGD) systems, Selective Catalytic Reduction (SCR) systems, Electrostatic Precipitation (ESP) systems etc. The implementation of these PCTs must be carried out in phases to avoid problems in power supply, as multiple baseload TPPs in the same region cannot remain shut down for prolonged duration for retrofitting at the same time. Therefore, CEA along with its regional power committees drafted a plan in 2018 for phased implementation of FGD systems at power plants covering around 166.6 GW of power plant capacity. Thereafter, discussions were held between Ministry of Power (MoP) and MOEF&CC to finalise the revised timelines in order to ensure 24x7 supply of electricity. Finally, CPCB circulated revised timelines which provided an additional five year window (until December 2022) for the TPPs to meet the norms. (CPCB June 2018 Table)

The extract related to the Southern Region from the 'Table covering timelines circulated by CPCB for each Generation Company to retrofit FGDs and ESPs in the existing TPPs' is shown in *Annexure 1*. CEA has also started monitoring the status of implementation by the TPPs and is publishing the same as part of the Thermal Renovation & Modernisation (R&M) Quarterly reports which indicates that 80% of the plants run the risk of missing the deadline. As of June 2019, the current status of the identified TPPs with a total capacity of 166.6 GW is as follows:

- While TPPs with a cumulative capacity of 136.6 GW have completed the feasibility study for retrofitting FGDs, TPPs with a total capacity of 30 GW (18%) which is scheduled to be fitted with FGDs in the country are yet to complete the feasibility study.
- TPPs with a combined installed capacity of 95.2 GW (57%) are in the tender stage, after which they will take at least two to three years for operationalising FGD system.
- FGDs have been commissioned in TPPs with a total capacity of 1.82 GW while orders have been placed for installing FGDs with a cumulative capacity of 13.86 GW.

As a part of the DST Clean Coal Project, the Energy and Environment Programme (EEP) at NIAS interacted with various Power Plant Generation companies (Gencos) in the

Southern Region to understand their challenges and way forward with respect to the huge capital investment and schedules for implementation. A "Concept Paper" (Annexure 2) was brought out considering the current emission levels, power generation costs, and capital investments needed as well as technologies related to pollution prevention and control. Even with the revised deadline of 2022 for compliance with the new emission norms, there are many concerns and challenges that various Gencos are facing during implementation. The concerns of these Gencos must be addressed to ensure a smooth transition.

The theme of the workshop was set as "Strategies and Action Plans needed for transition to an environment friendly and sustainable Electricity Source mix for the Southern Region." In line with this, NIAS planned a one-day workshop on the 17th September 2019 at NIAS, Bangalore and invited key stakeholders - Power Plant Owners (Central & Southern States), Pollution Control Equipment Suppliers, Regulators and Policymakers to share their experience and deliberate on the challenges to develop a road map for implementation.

The major objectives of the workshop were to:

- Create a platform and initiate meaningful dialogue among the major stakeholders for compliance to the new emission norms with a comprehensive road map for implementation
- Address the issues and challenges faced in implementation specifically in the older power plants and suggest remedial measures
- Enhance awareness on various available technologies for controlling SO_X, NO_X and PM emissions along with Capex & Opex
- Consolidate the key findings and recommendations and pursue them with GOI through NITI Aayog

2. Agenda

The workshop had five sessions - an Inaugural session followed by three Technical Sessions and a Closing session to sum up the observations and bring out the policy recommendations. The workshop was inaugurated by Dr V.K. Saraswat, Member/NITI-Aayog who also set the rhythm to the workshop through his opening remarks. Apart from the eminent speakers listed in Annexure 3, the Workshop had participation from NTPC, TSPGENCO, BHEL, Doosan Power India, POSOCO – SRLDC and Consultants in addition to the relevant faculty and students from NIAS.

Prof Shailesh Nayak, Director/NIAS welcomed the gathering and Prof. Srikanth presented the theme and background of the Workshop. The technical sessions had presentation by speakers covering the topics related to – "Electricity perspective for future," "Initiatives

taken by Power Generation companies for clean coal power generation" and "Clean Coal Technologies".

In the closing session, the summing up of the proceedings was done by Shri R.N. Nayak, former CMD/PGCIL which was followed by discussions to come up with key recommendations. The closing remarks by Dr V.K. Saraswat consolidated the policy recommendations for the consideration of the Government.

3. Inaugural Session & Address by Guest of Honour

Dr V.K. Saraswat, Member, NITI-Aayog, Government of India formally inaugurated the Workshop and brought out certain key points that he felt can be deliberated during the presentations and deliberations. The key highlights from the opening remarks are:

- There are three major routes to bring down CO_2 viz., (i) improving the energy efficiency of Thermal Power Plants, (ii)enhance renewable energy, and (iii) encourage CO_2 capture and utilization after conversion.
- Addition of new sub-critical units are not permitted, and the Government has also funded a research project for an Advanced Ultra Super Critical (AUSC) demonstration plant.
- While Rooftop Solar has not made a big headway, large amounts of rooftop solar energy are likely to create grid stability issues which can be alleviated only with high-capacity distributed storage systems.
- As far as wind energy is concerned, the capacity addition growth is slow. Other than the Southern region, other parts of the country have not achieved much.
- Ocean energy is still in its infancy stage and would take decades to take off.

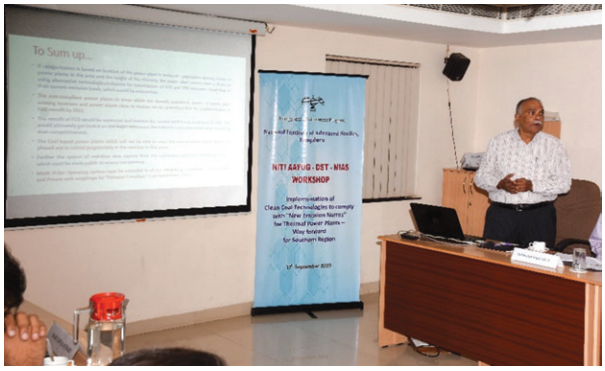
- Also, there is high dependence on import for solar power plants, while thermal and nuclear power plants have high indigenous content.
- We have made a beginning in clean coal technologies, Advanced Ultra Super Critical (AUSC) technology, gasification (production of Methanol) etc. but all these technologies need to be scaled up by setting up demonstration plants. We also need to focus on multi-feed gasification plant. Accelerated research is required in the Clean Coal technology (CCT) area since coal will continue to be the mainstay of our power sector for the next 2 -3 decades.
- Impact of pollution from coal-based TPPs is very high, and we must act fast to introduce appropriate pollution mitigation techniques.

4. Technical Session

4.1 Electricity perspective for the future

This technical session was chaired by Prof Shailesh Nayak and had two speakers – first from NIAS and the second from Southern Region Load Despatch Centre (SRLDC), POSOCO.

Prof A.V. Krishnan, Principal Scientist made the presentation from the Environment & Energy Programme (EEP), NIAS which covered details



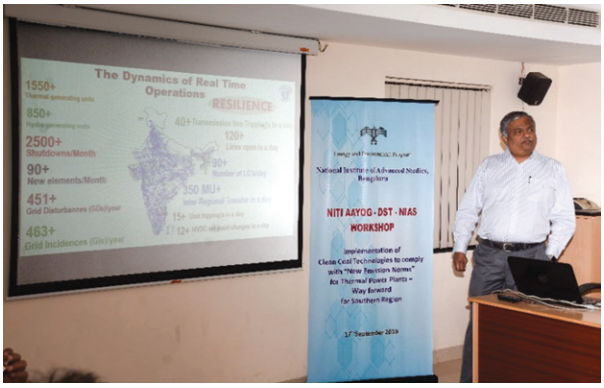
of current level of emissions (PM, SO_2 & NOx), water consumption and coal consumption from 85 operating thermal power plants in the Southern Region covering Tamil Nadu, Telangana, Andhra Pradesh and Karnataka. The cost of power generation, the investments needed for retrofit of PCTs, issues and challenges in retrofit of FGD and the impact of the additional investments on the generation cost were presented in detail. As per the CPCB schedule, 92 FGDs are to be retrofitted in various TPPs of the Southern Region. The cost of retrofit in the four State-owned (i.e., excluding, NTPC and NLC TPPs) GENCOs in the Southern Region is estimated at Rs 6000 Crores. The current weighted average of cost of power generation in the TPPs in the Southern Region is Rs 4.00 per kWh. This cost of generation is projected to increase by 25-30% considering the investment for retrofit of PCTs. Further the environment footprint for mining, handling and transportation of limestone as well as the gypsum which would be generated as a byproduct of using FGDs to reduce SO_x content in the emissions was also deliberated upon. The presentation also generated a lot of discussions on the alternative technologies for preventing pollution rather than mitigating through expensive retrofits.

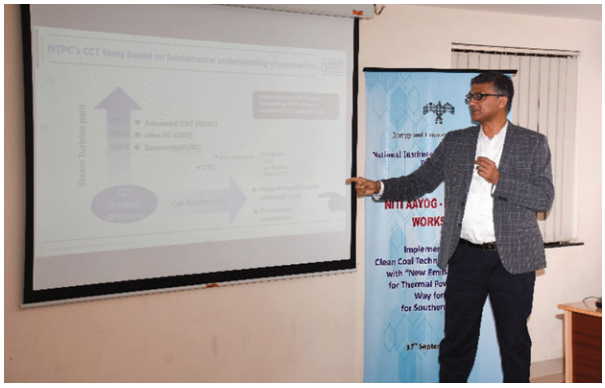
Shri Abhimanyu Gartia ED/SRLDC, POSOCO and Shri S.P. Kumar, Sr GM/ SRLDC, POSOCO made the presentation on the Challenges and Strategies in the National Grid Management. The presentation covered the dynamics of real time operation, and a typical Southern Region power demand over a year covering all the seasons. The challenges and Grid issues with RE penetration and integration was presented. They also covered the ramping requirements and strategies for Grid Management with variable energy sources. The maximum penetration of RE power in Southern Region is 47% and 30% instantaneous over a single day. Finally, they brought out the Forecasting and Scheduling details and Transmission planning for RE. This was followed by lively deliberations on the need for flexible operation as well as energy storage requirements.

4.2 Initiatives taken by Power Generating companies towards Clean coal generation

This technical session was chaired by Shri R.N. Nayak, former CMD/PGCIL and had two speakers – first from National Thermal Power Corporation (NTPC) Limited and the second from Telangana State Power Generation Corporation (TSPGENCO) Limited.

Shri Sanjay Pande, GM (NI & AUSC) made a presentation on the Strategies and actions for Clean Energy generation by NTPC. His presentation detailed the various initiatives taken at NTPC for emission reduction, NTPC's experience in super-critical technology, and the work being done in advancing AUSC by setting up a 800 MW Demo plant at NTPC's Sipat



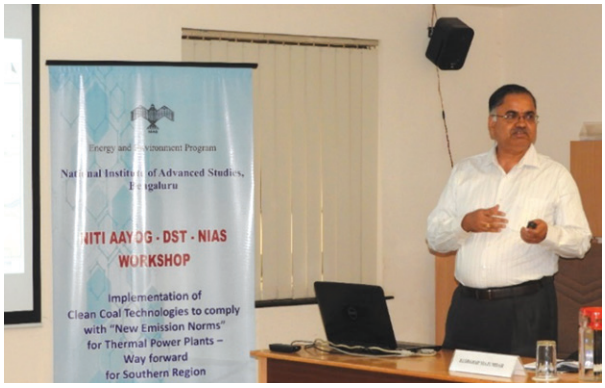


Power Plant in Chhattisgarh by 2024. He also covered NTPC's forays in Energy security, CO_2 emissions and CCT. He also highlighted the various studies taken up in the past on Integrated Gasification Combined Cycle (IGCC) as well as the initiatives taken for implementation of DeSOx and DeNOx systems in NTPC's TPPs to meet the new emission norms. Retrofit of FGD systems are under implementation in TPPs with a cumulative capacity of 47 GW, while tendering is under progress for TPPs with a capacity of 17 GW. Pilot studies have been taken up for DeNOx at 7 locations by installing SCR/SNCR systems to evaluate the suitability of this technology for high-ash Indian coals which constitute the bulk of coal supplies to TPPs in India. This was followed by detailed interactions and deliberations which brought out the need for a Long-term Energy Policy and creation of a National Platform of dedicated Experts with linkage to Equipment manufacturers, Power Generation companies, Laboratories and Academic Institutes so as to target advanced technologies like IGCC, Oxy-combustion, pressurized combustion etc. Suggestions for creation of a National fund on CCT development were also made. Dr Saraswat remarked that NTPC must invest 10% of their reserves for development of CCT. He added that targeted research must be taken by all the public sector units in the energy field.

Shri Ravinder Reddy, Divisional Engineer (Thermal) made his presentation on TSPGENCO's installed capacity, status of emission levels, new plants under construction and various initiatives taken up for reducing water consumption and emissions. His presentation also covered the actions taken for retrofit of FGDs and ESPs in various plants to meet the new emission norms as well the joint working with SCCL mines to improve coal quality fed to TSPGENCO's plants. Of the 7 older units in the Kothagudem TPP (3x60 MW + 4x120 MW), three of the oldest units have been retired and the remaining four would be phased out by December 2019. The loss of power generation from these units has been compensated by the new 800 MW unit for which the contract for wet FGD has already been awarded. Similarly, the proposals for installation of FGD in Unit V (250 MW) and Unit VI (500 MW) are being submitted. TSPGENCO is also preparing a Detailed Project Report (DPR) for retrofit of FGDs in the two units of Kakatiya TPS, while their oldest TPP (Ramagundam B) is slated for closure. TPPs under construction (Bhadadri and Yadadri) will be commissioned with FGDs and other PCTs.

4.3 Clean Coal Technologies

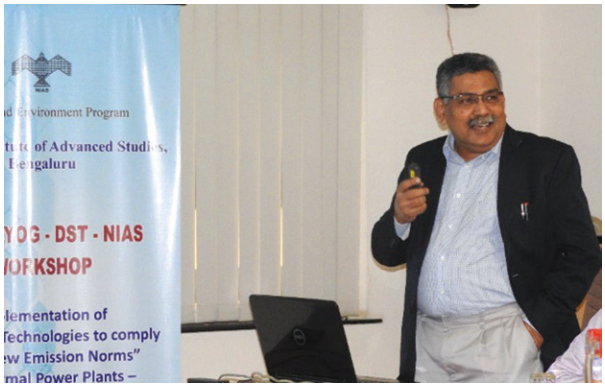
This technical session was chaired by Prof V.S. Ramamurthy, former Secretary/DST, GOI and Professor Emeritus /NIAS, Bangalore. The following four speakers covered varied topics related to Clean Coal Technologies. Dr. Srikanth, Professor and Head/EEP, NIAS covered Air Quality in and around Thermal Power Plants,



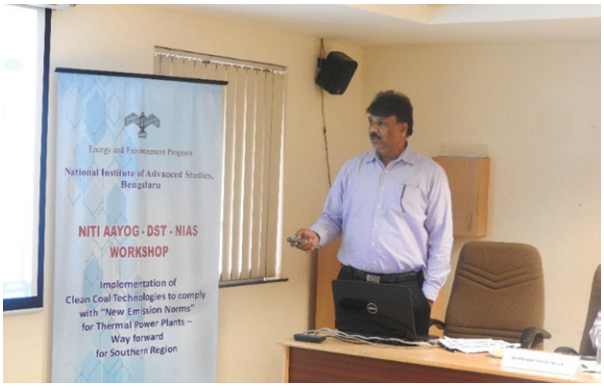
Shri D.N. Prasad made a presentation on Coal Washing – Issues and Challenges, Shri Sunil Mandawat, Sr GM/Doosan Power Systems India presented Coal Gasification and IGCC while Shri Shaktikanta Das, DGM/FGD, BHEL, Ranipet presented the methodology for retrofit of FGDs in existing TPPs.

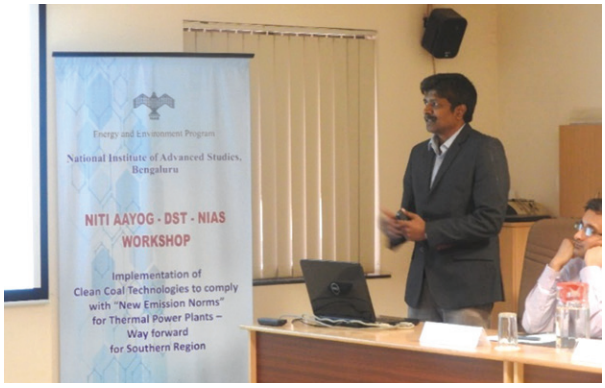
The first presentation of this session on Air quality was based on a study done in the State of Telangana, where Thermal Power Plants of 3900 MW and three clusters of underground and opencast mines are currently operating. Data collected from statutory reports filed by coal mines and pithead STPPs was analyzed to study the spatial and temporal patterns of airborne pollutants in the Ramagundam area. He explained that, while ambient air concentrations of gaseous pollutants are below the NAAQ standards in this region, the concentrations of particulate matter (PM_{10} and $PM_{2.5}$) in the ambient air are generally higher than the NAAQ standards. This may be due to the low sulphur content of raw coal (0.5 – 0.7%) fed to these TPPs as well as the dispersion effect created by the 225/275 m tall chimneys installed in the two STPPs. He explained the need to expedite the upgradation of ESPs as well as the use of washed coal (even in pithead TPPs) to reduce air pollution and minimize fly ash generation. The consensus was to focus on expediting the upgradiation of ESPs by delinking this from installation of FGDs (which require large investments) since fine particle pollution has a prolonged impact on public health.

Shri D.N. Prasad, former Advisor – Projects, Ministry of Coal presented his views on Coal Washing – Issues & Challenges. His presentation gave an insight into Indian coal characteristics (high ash with low calorific value and low sulphur content) which necessitate the need for coal beneficiation. He also dwelled on the existing Government policies related to coal washing. MOEF&CC notified the Environmental (Protection) Amendment Rules (EPAR) in January 2014 (EPAR, 2014) mandating that



TPPs with a capacity of 100 MW or above located between 500 -749 kilometres (km) from the pit head "*shall be supplied with* and shall use *raw or blended or beneficiated coal with ash content not exceeding 34 percent on quarterly average basis from 05 June 2016*." By the same notification, TPPs with an installed capacity of at least 100 MW located beyond 1000 km from the pithead or, in an urban area or in an ecologically sensitive area or in a critically polluted industrial area, irrespective of its distance from the pit-head (except a pit-head power plant), "*shall be supplied with and shall use raw or blended or beneficiated coal with ash content not exceeding 34 percent on quarterly average basis with immediate effect*." However, CIL was able to supply only 11 MT of washed coal for power generation during FY 2018-19, though there are plans for setting up 9 non-coking coal washeries with a capacity of about 94 million tonnes per annum. He then brought out the benefits of coal washing with case studies from select operating power plants in India and highlighted the issues for consideration, the challenges to be overcome and policy interventions needed. The deliberations at the end of the presentation highlighted that the price impact of washed coal by a third party is estimated to be around Rs. 150-200/ton. It was discussed that coal washing should be done at the pit head and, cost of mining and washing can be included in the fuel supply cost as per a recent judgement of the Hon Supreme Court in this regard. He suggested that a detailed techno-economic study on coal washing can be carried out by NIAS.





Shri Sunil Mandawat, Sr. GM of Doosan Power Systems (India) made his presentation on Coal Gasification and IGCC. His presentation covered coal gasification technology, concepts of IGCC and types of fuels that can be used. He also shared the details of the 'Taean' 300 MW IGCC plant commissioned in Korea and indicated the efficiency, fuel requirements, emission levels and performance of the plant. There were detailed discussions on the viability of the plant after which there was a consensus that IGCC is a more effective process not only to eliminate pollution but also to reduce CO_2 emissions by better utilisation of the heat content of coal. The 'Taean' IGCC plant is designed for sub-bituminous coal of 15% ash and 25-35% volatile matter. The stand-alone efficiency of the Entrained type gasifier is 80% while the plant efficiency is 42.3% (Net). The NO_x and SO_2 concentrations were less than 1 mg/m^3 and PM concentration was 0.2 mg/m^3. While the viability of IGCC technology could not be proven in the past, the huge increase in coal prices in recent years (in addition to hike in railway freight and the recent hike in cesses on coal) all enhance the competitiveness of IGCC technology today. Dr Saraswat advised that the viability of IGCC should be evaluated not only with respect to power generation but also by using the by-products effectively.

Shri Shaktikanta Das, DGM/FGD, BHEL (Ranipet) delivered his presentation on the retrofit of FGD for SO_2 reduction. He covered the concept of desulphurisation, the types of FGD configurations and operating systems, and shared BHEL's experience in the supply and performance of FGDs. He explained the complete retrofit process covering the entire gamut of activities including, feasibility study, engineering & supply, erection and commissioning along with the technical challenges. In order to capture the SO_x effectively, limestone of 89% purity must be used and this would generate 90% purity Gypsum, which is saleable. The cycle time for engineering and supply would be around 18 months and erection & commissioning would take another 15 months. The shutdown of the plant would be 3 months. The deliberations were mainly focussed on the high cost for retrofit of FGD which was due to the huge import content in the system. Dr Saraswat advised that the technology of FGDs is more than two decades old and BHEL should indigenise the entire system so that it is cost effective. Also, to enhance the capacity, efforts must be taken to develop and outsource sub systems with the SMEs so that the overall cycle time can also be brought down.

5. Discussions and Summing up

This session was chaired by Prof. P.S. Goel, Hon. Distinguished ISRO Professor, who appreciated the participation of the delegates in facilitating a healthy discussion and thanked all the speakers for their preparation and presentations.

Shri R.N. Nayak, former CMD/PGCIL summarized the outcome of the presentations and discussions as follows:

1. Particulate Matter (PM) is a more serious health hazard than Gaseous pollution (SOx and NOx) from TPPs in India.
2. Mitigation of PM can be done more quickly at a lower cost while maximizing the beneficial impact on Public Health and the environment.
3. Prioritization is needed in our efforts to reduce emissions. The implementation guidelines by CPCB and CEA are only focused on FGD retrofit as a single solution to solve the emission issues related to TPPs.
4. CIL dispatched nearly 492 MT of coal (more than 80 percent of its total dispatches of

608 MT) to the Power sector, during FY 19. However, CIL has not been able to build sufficient washery capacity till date. CIL must give topmost priority to its legal obligation to supply only washed coal to relevant TPPs within a period of two years.

5. Techno-economic study of coal washing must be done to assess cost and benefits.
6. Since the washery rejects must be used in pithead CFBC power plants, CIL must commission washeries and linked CFBC power plants at central locations in all large coalfields.
7. CIL must invest its own capital in setting up coal washeries and the linked CFBC power plants but may outsource the construction and O&M of the plants as per international practice.
8. Indigenous content has to be increased in FGD technology to bring down the cost.
9. For introducing IGCC, NTPC & BHEL must take up Joint Research to be jointly funded by the Government as well as these two Maharatnas.

6. Conclusions and Policy Recommendations

The final session of the workshop was chaired by Dr Saraswat who, after taking note of all points summarized in the observation and discussions, addressed his concluding remarks.

1. While it is important for India to transform to a cleaner Electricity source mix, it is equally critical for the MoP to develop and implement a more phased transition plan in consultation with MOEF&CC as well as the Ministry of Coal (MoC).

2. MOEF&CC must prioritize the pollution control technologies to be installed by coal-fired TPPs in India according to well-documented environmental and health concerns that are almost always centered around Particulate Matter (PM) pollution during the mandatory Public Hearings (PH) held before granting environment clearances.

3. Reducing PM_{10} and $PM_{2.5}$ should be prioritized. The short-term and long-term targets should be separated out and removal of PM_{10} and $PM_{2.5}$ can be under short term targets.

4. MOEF&CC must also provide 'Graded priority' between pollutants in the order of PM, CO_2, SO_2, NO_x and Mercury.

5. While indigenous technologies and manufacturing capacities have been developed for Electrostatic Precipitators (ESPs) with a 99.98% collection efficiency, Indian companies are still dependent on foreign technology suppliers for FGDs, which also increases the cost of such equipment.

6. Alternatives to FGD technology like Dry Sorbent Injection (DSI) should also be explored on plant-specific basis on older TPPs (200/210 MW) to reduce the capital investment since these TPPs were not mandated to provide space for FGDs in their layouts at the time of approval/ construction. We must also ensure that indigenous development of FGD technology is expedited to bring down the cost and promote "Make in India."

7. The most optimal way to control emissions from TPPs is by using washed coal since almost all non-coking (thermal) coal seams in India must be beneficiated to reduce their

Key Takeaways from Workshop

MoP and MoEF&CC have narrowed down the emission issues related to TPPs by prioritising the retrofit of high cost imported FGD systems, while lesser attention has been paid to critical issues like reduction of water consumption and PM pollution which are also key concerns during Public Hearings conducted by TPPs.

Huge capital and operating expenditures on FGDs will ultimately contribute to lowering the competitiveness of industries in India affecting employment due to major tariff increase.

Comprehensive analysis must be done with respect to other pollutants like $PM_{2.5}$ and PM_{10} and the dispersion effect of increased chimney height of TPPs (500 MW and above).

The environmental impacts and infrastructure requirements for mining, handling and transportation of the huge quantity (~16 MT/annum) of limestone (95%+ purity) as well as the disposal of gypsum generated in huge quantity (~25 MT/annum) along with associated environmental impacts have not been thought through.

ash content to below 34% on a consistent basis.

8. Though more than three years have elapsed since EPAR (2014) regarding supply of washed coal to TPPs located at distances of more than 500 km from the pithead came into effect (June 2016), CIL has made rather tardy progress in the supply of washed coal to the TPPs covered by EPAR (2014).

9. The committed linkage of CIL to the TPPs located beyond 500 km was 236 million tonnes in 2015-16 which has increased to 271 million tonnes (MT) in 2019-20. There is an urgent need for setting up of additional washeries. The current availability of coal of less than 34% ash from CIL sources is about 208 MT and by 2019-20 around 63 MT of additional coal needs to be washed. This excludes about 129 million tonnes of coal being supplied to the pit head plants.

10. To enhance the beneficiation capacity, CIL is setting up 9 new non-coking coal washeries with an aggregate capacity of 63 MTY. However, this is grossly inadequate considering the growing requirement of washed coal to meet the pollution and ash utilization norms. Therefore, expansion of coal washing capacity must be expedited by CIL. This will also reduce the amount of fly ash generated by TPPs, thereby leading to reduction of water/air pollution during ash disposal.

11. CIL must also set up Circulating Fluidized Bed Combustion (CFBC) plants to handle the washery rejects (around 26% of the throughput of the washery) and produce power. Based on the requirement of washed coal for 2019-20, about 20 MT of washery rejects generated which can generate ~ 2500 MW of power. CIL may tie up with power generators like NLC or BHEL that have the proven capability to design/operate CFBC power plants.

12. CIL must expedite washing of coal before supplying to TPPs in the Southern Region to reduce the load on the already stretched railway links between the coalfields and the TPPs. This will also reduce the landed cost of coal in all non-pithead TPPs by reducing freight charges for coal since the CAGR of railway freight for coal in India was more than four times the wholesale inflation rate during FY 2012 to FY 2017 as per a recent study (2019) by Brookings India.

Key Takeaway from Workshop

Indigenous economical solutions like Dry Sorbent Injection (DSI) systems to minimize SO_2 emissions can be adopted in older TPPs (200/210 MW).

Since more than 75% of TPPs are using Indian coal with Sulphur less than 0.5%, the DSI technology would help in meeting the SO_2 emission norms.

The major pollutant - Particulate Matter (PM) which is the largest pollutant from TPPs in India has not been given due consideration except for use of high-efficiency (99.98%) ESPs in new TPPs.

There has been no significant development in the use of washed coal in the Power Sector though five years have elapsed since the notification of EPAR (2014).

Coal washing is a preventive approach to minimize the PM emissions which are more important in TPPs in India due to the high ash content of Indian coals.

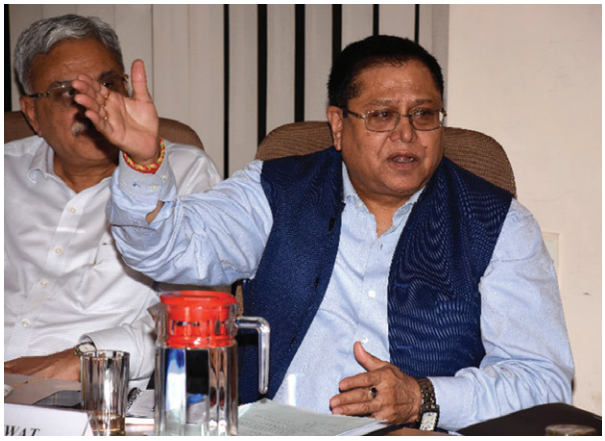
Use of washed coal also helps in reduction of SOx emissions since sulphur content in Indian coals is largely from the pyritic bands which can be removed during the washing process.

13. For IGCC, NTPC & BHEL should take up combined studies and come out with a proposal to set up a demonstration IGCC plant in line with the AUSC model.

14. For optimal electricity source mix, not only clean coal technology but renewable integration costs and implications must also be studied.

15. NIAS should carry out techno commercial studies on "End-of-life plants" focused on the Southern region and bring out a framework of specifications along with binding parameters which can then be extended to the National level.

16. We must also focus on the reduction of water consumption and ensure that TPPs recycle water to the maximum extent and increase the Cycles of Concentration (COC). All GENCOs must explore avenues to set up modern Sewage Treatment Plants (STPs) in urban centres within a 50 km distance of their TPPs in order to reuse treated water in their TPP instead of fresh water. All GENCOs in the Southern Region depending on freshwater sources must prioritize such STPs to reuse the treated water (from the adjacent towns) in view of the grave water scarcity in the Southern region especially during droughts. This will also yield economic benefits for these GENCOs since the National Tariff Policy enables them to recover the costs of such environment-friendly alternatives through hikes in the tariff. Needless to say, the towns which provide waste water to the TPPs for treatment will also gain by securing more fresh water that was hitherto supplied to the TPPs.



In his concluding remarks, Dr Saraswat mentioned that we are giving up many alternative technologies because Western countries have not shown any interest. It is important for us to look at these technologies, bring out techno-commercial analysis to take decisions. This would also require investment and R&D for which NTPC and BHEL should use funds from their own reserves to do targeted CCT-focussed research. Finally, Dr Saraswat stated that the workshop had achieved its purpose of capturing the voice of key stakeholders and collating the same which would help to move forward and bring out the recommendations that would enable NIAS and other stakeholders to take up with the Government. The workshop concluded with a formal vote of thanks to all the invited delegates for taking their time to participate and make the workshop a grand success.

7. Acknowledgement

The EEP group of NIAS thanks all the Speakers for their presentation and delegates for their participation and meaningful deliberations in making the Workshop a grand success. We also acknowledge the contributions of the dignitaries who chaired the sessions. We are particularly grateful to Dr Saraswat for sparing an entire day to participate in this interactive Workshop and steering the deliberations in his usual forceful manner.

Thanks are to the team, who played an important part in organising the logistics and conductance of the workshop, which includes Head/ Administration and his team, Dr Tejal Kanitkar, Associate Prof/EEP/NIAS, Nikhil Thejesh, Upasna Ranjan and Soumya Deep Das.

Annexure 1

CPCB Timelines for Retrofit of FGDs and ESPs (Extract for Southern Region TPPs)

Timelines for implementation of new emission norms for Thermal Power Plants (notified on 07.12.2015) as per direction issued on 11.12.2017 and 06.04.2018 u/s 5 of EP Act, 1986 (Extracted for Southern Region)

Sl. No.	Name of Thermal Power Plant	State	FGD/ ESP	Unit-1	Unit-2	Unit-3	Unit-4	Unit-5	Unit-6	Unit-7	Unit-8	Unit-9	Unit-10	Unit-11
1	Vizag TPP, HNPCL	Andhra Pradesh	FGD	Jun-20	Sep-19									
			ESP											
2	Damodaram Sanjeeviah TPS, APPDCL	Andhra Pradesh	FGD	Dec-20	Dec-19									
			ESP	Dec-20	Dec-19									
3	Rayalseema TPS, APGENCO	Andhra Pradesh	FGD	Dec-21	Sep-21	Sep-20	Jun-21	Jun-20						
			ESP	Dec-21	Sep-21	Sep-20	Jun-21	Jun-20						
4	Dr. N. Tata Rao TPS	Andhra Pradesh	FGD	Dec-20	Dec-20	Dec-20	Dec-20	Dec-20	Dec-20	Dec-20				
			ESP	Dec-20	Dec-20	Dec-20	Dec-20	Dec-20	Dec-20	Dec-20				
5	Sembcorp Gayatri Pvt Ltd	Andhra Pradesh	FGD	Dec-21	Sep-21									
			ESP											
6	Painampuram TPS, APGENCO	Andhra Pradesh	FGD	Dec-21	Sep-21									
			ESP											
7	Simhadri NTPC	Andhra Pradesh	FGD	Mar-22	Jun-22	Sep-22	Dec-22							
			ESP			Sep-22	Dec-22							
8	Thamminapatnam TPS, Meenakshi Energy Ltd.	Andhra Pradesh	FGD	Complying	Complying									
			ESP											
9	Simhapuri TPS, SEPL	Andhra Pradesh	FGD	Complying	Complying	Complying	Complying							
			ESP											
10	Bellary TPS	Karnataka	FGD	Dec-20	Jun-21	Dec-21								
			ESP											
11	Raichur TPS	Karnataka	FGD	Mar-21	Jun-21	Sep-21	Dec-21	Mar-22	Jun-22	Sep-22	Dec-22			
			ESP	Mar-21	Jun-21	Sep-21	Dec-21	Mar-22	Jun-22	Sep-22	Dec-22			
12	Yermarus TPP, KPCL	Karnataka	FGD	Dec-21	Dec-22									
			ESP		Dec-22									
13	Udupi TPP, Adani Power	Karnataka	FGD	Mar-22	Jun-22									
			ESP											
14	Torangallu TPS Extn, Jindal	Karnataka	FGD	Jun-22	Sep-22									
			ESP	Jun-22	Sep-22									
15	Torangallu TPS, Jindal	Karnataka	FGD	Complying	Complying									
			ESP											
16	Kudgi NTPC	Karnataka	FGD	Jun-22	Sep-22	Dec-22								
			ESP		Sep-22	Dec-22								

17	North Chennai Expn. TPS	Tamilnadu	FGD	Dec-19	Sep-20									
			ESP											
18	Tuticorin (JV) TPP	Tamilnadu	FGD	Dec-21	Jun-20									
			ESP	Dec-21	Jun-20									
19	TAQA Neyveli TPS	Tamilnadu	FGD		Jun-20									
			ESP											
20	Mettur TPS Extn	Tamilnadu	FGD	Dec-20										
			ESP											
21	Neyveli TPS - I, NLC	Tamilnadu	FGD	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19		
			ESP	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19	Sep-19		
22	Neyveli Extn TPS, NLC	Tamilnadu	FGD	Jun-21	Dec-21									
			ESP											
23	Neyveli TPS-2, NLC	Tamilnadu	FGD	Dec-21	Sep-21	Jun-21	Mar-22	Jun-22	Sep-22	Dec-22				
			ESP											
24	Neyveli TPS-2 Expn, NLC	Tamilnadu	FGD	Complying	Complying									
			ESP											
25	North Chennai TPS	Tamilnadu	FGD	Dec-22	Jun-22	Mar-22								
			ESP	Dec-22	Jun-22	Mar-22								
26	Vallur TPP, NTEC	Tamilnadu	FGD	Jun-22	Sep-22	Dec-22								
			ESP											
27	Muthiara TPP, Coastal Energen	Tamilnadu	FGD	Sep-22	Dec-22									
			ESP											
28	M/s IL & FS Tamil Nadu Power Company Ltd.	Tamilnadu	FGD	Complying	Complying									
			ESP											
29	Mettur TPS	Tamilnadu	FGD	Complying	Complying	Complying	Complying							
			ESP	Mar-21	Jun-21	Sep-21	Dec-21							
30	Ennore TPS, Tangedco	Tamilnadu	FGD	Retired	Retired	Retired	Retired	Retired						
			ESP	Retired	Retired	Retired	Retired	Retired						
31	Tuticorin TPS, Tangedco	Tamilnadu	FGD	Dec-20	Dec-20	Dec-20	Dec-20	Dec-20						
			ESP	Dec-20	Dec-20	Dec-20	Dec-20	Dec-20						
32	Tuticorin (P) TPS, IND Barath	Tamilnadu	FGD	Dec-20	Dec-20									
			ESP	Dec-20	Dec-20									
33	Singareni TPP, SCCL	Telangana	FGD	Dec-19	Sep-19									
			ESP											
34	Kothagudem TPS	Telangana	FGD	Dec-19	Dec-19	Dec-19	Dec-19	Dec-19	Dec-19	Dec-19	Dec-19	Dec-20	Dec-20	Sep-19
			ESP	Dec-19	Dec-19	Dec-19	Dec-19	Dec-19	Dec-19	Dec-19	Dec-19	Dec-20	Dec-20	Sep-19
35	Kakatiya TPS, TSGENCO	Telangana	FGD	Mar-20	Jun-20									
			ESP	Mar-20										
36	Ramagundam STPS, NTPC	Telangana	FGD	Mar-22	Mar-22	Jun-22	Jun-22	Sep-22	Sep-22	Dec-22				
			ESP		Mar-22		Jun-22	Sep-22	Sep-22	Dec-22				
37	Ramagundem-B TPS, TSGENCO	Telangana	FGD	Dec-19										
			ESP	Dec-19										

Annexure 1a

Installed Capacity
CEA Report – September 2019

ALL INDIA INSTALLED CAPACITY (MW) OF POWER STATIONS
(as on 30.09.2019)
(UTILITIES)

Region	Ownership/ Sector	Mode wise breakup								Grand Total
		Thermal					Nuclear	Hydro	RES * (MNRE)	
		Coal	Lignite	Gas	Diesel	Total				
ALL INDIA	State	65061.50	1290.00	7118.71	236.01	73706.21	0.00	26958.50	2349.98	103014.69
	Private	74173.00	1830.00	10580.60	273.70	86857.30	0.00	3394.00	77357.10	167608.40
	Central	57660.00	3140.00	7237.91	0.00	68037.91	6780.00	15046.72	1632.30	91496.93
	Total	**196894.50**	**6260.00**	**24937.22**	**509.71**	**228601.42**	**6780.00**	**45399.22**	**81339.38**	**362120.02**

Share of Coal = Lignite is (196894.50+6260) / 362129.02 = <u>56.1%</u>

CEA Generation Report - Source wise Monthly distribution of Energy Generation Programme for the year 2018-19

CATEGORY	FUEL	IST QTR	2ND QTR	3RD QTR	4TH QTR	TOTAL 2018-19 (GWh)
Thermal	COAL	249760	242888	256632	259010	1008290
	LIGNITE	8633	8611	8934	9822	36000
	NATURAL GAS	11661	11861	11806	11672	47000
	DIESEL	51	50	50	49	200
	NAPTHA	5	5	0	0	10
Thermal Total		**270110**	**263415**	**277422**	**280553**	**1091500**
Nuclear	NUCLEAR	8796	8360	10477	10867	38500
Hydro	HYDRO	33515	48718	25733	22034	130000
Import from Bhutan	HYDRO	925	1912	1493	670	5000
Renewable	Solar, Wind, Bioenergy					126760
Grand Total		**313346**	**322405**	**315125**	**314124**	**1376096**

Annexure 1B

Monitoring Report
CEA Thermal Projects

R&M Quarterly Review Report
April - June 2019

Summary of Current Status of Implementation of phasing plan for FGD Installation

General Summary

S.No.	Sector (Capacity in MW)	FGD planned	Feasibility Study Started	Feasibility Study Completed	Tender Specs Made	NIT Issued	Bids Awarded	FGD Commissioned
1	Central Sector	53350	53350	51510	51510	50850	12040	0
2	State Sector	51520	48870	41400	21150	14775	0	0
3	Private Sector	61737	59107	43730	33720	29610	1820	1820
	Total	166607	161327	136640	106380	95235	13860	1820
S.No.	**Sector (No. of units)**	**FGD planned**	**Feasibility Study Started**	**Feasibility Study Completed**	**Tender Specs Made**	**NIT Issued**	**Bids Awarded**	**FGD Commissioned**
1	Central Sector	143	143	135	135	134	24	0
2	State Sector	164	153	137	73	49	0	0
3	Private Sector	134	128	87	62	52	3	3
	Total	441	424	359	270	235	27	3

Annexure 2

Concept Note for NITI Aayog-DST-NIAS Workshop

on

Implementation of Clean Coal Technologies to comply with "New Emission Norms" for Thermal Power Plants – Way Forward for Southern Region

in
NIAS Conference Hall 2
(Date: September 17, 2019)

Background:

India has ratified the Paris Agreement on climate change and thus agreed to a long-term goal of keeping the increase in global average temperature well below 2^0C above the pre-industrial levels, by bringing down Greenhouse Gas (GHG) emissions.

This has marked a significant shift in the policies of the Government specifically in sectors that are key contributors to GHG emissions in India. MoEF&CC has been regulating the emission norms from time to time for controlling pollution levels from Thermal Power Plants (TPPs). The latest notification was dated 07.12.2015 and all TPPs were required to comply with the new emission and water consumption norms within two years of the date of notification. However, the deadline has now been extended to 2022 for all TPPs to comply within the stipulated norms.
As per the said Notification, TPPs are categorized into **3** categories for compliance with the new norms as detailed in the table below;

Pollutant	Plant Size	Existing Norms (Mg/Nm^3)	Thermal Power Plants		
			Installed before 31st Dec'03 *	Installed between 1st Jan'04 to 31st Dec'16 @	Installed after 1st Jan'17
PM	All	150 – 350	100	50	30
SO_2	< 500 MW	None	600	600	100
	>= 500 MW	None	200	200	100
NO_x	All	None	600	300	100
Hg	All	None	0.03 (>=500MW)	0.03	0.03

* *Around 370 Units of Coal Based TPPs* @ *Around 300 units of Coal-based TPPs*

Similarly, water consumption in TPPs is also sought to be brought down as follows:

a) All plants with Once through cooling (OTC) shall install Cooling Tower (CT) and achieve specific water consumption of 3.5 m^3/MWh.
b) All existing CT Plants must reduce specific water consumption to 3.5 m^3/MWh.
c) All plants installed after 1st Jan'17 must achieve maximum specific water consumption up to 3.0 m^3/MWh and achieve zero wastewater discharge.

Implementing the new Emission Norms:

Compliance with the new emission norms would require retrofitting existing thermal power plants with auxiliaries to control SO_X, NO_X and PM emissions. These include Flue Gas De-Sulfurization (FGD) systems, Selective Catalytic Reduction (SCR) systems, Electrostatic Precipitation (ESP) systems, etc. The implementation must be carried out in phases to avoid problems in power supply, as many units cannot be taken out for retrofitting at the same time. CEA along with regional power committees drafted a plan in 2018 for phased implementation of FGD systems at power plants covering around 160 GW of power plant capacity.

CEA – FGD Phasing Plan

Year	Capacity (MW)	No of Units
2018	500	1
2019	11950	29
2020	24560	47
2021	61447.5	165
2022	61934.5	172
Total	**160092**	**414**

(Source: CEA Report)

As of 31.03.2019, 441 thermal power generation units with a cumulative capacity of 166,917 MW are monitored by CEA. Of these, FGDs have been successfully commissioned in power plant units with a total capacity of 1,820 MW while FGD orders have been placed to another 15,360 MW. Apart from this feasibility studies have been completed for thermal power plants with a total capacity of 12,971 MW.

Subsequently, the Central Pollution Control Board (CPCB) has issued *"Timelines for implementation of new emission norms for Thermal Power Plants (notified on 07.12.2015) as per directions issued on 11.12.2017 and 06.04.2018 u/s 5 of EP Act, 1986."* This provides clear deadlines to each TPP for implementation of FGD and associated systems to comply with the new emission norms. Similarly, the retrofit or upgradation of ESPs to reduce the Suspended Particle Matter (SPM) and the use of Low NO_X Burners/Over fire Air systems or SCR/SNCR systems to control NO_X are also scheduled.

Issues and Challenges:

While the implementation of the new emission norms is a progressive move, there are various issues and challenges which need to be addressed to ensure a smooth rollout of the new norms. The various challenges are in the form of;

(a) **Timeline for implementation** - All the TPPs must comply with the new emission norms by the year 2022. While all TPPs have to comply with this stringent timeline, it must also be noted that there is no capacity in the country to manufacture 400+ FGDs within this period

(b) **Shut down and related revenue loss** - An overall project period of 30 to 36 months is required. During retrofit of the FGDs, a shutdown of the unit for about 6-9 months is envisaged. These will reduce the electricity available in the grid to meet the baseload requirements which also burdening the TPP with revenue loss which has to be ultimately paid by the consumer.

(c) **Additional auxiliary power** - An incremental auxiliary power of 1.5 to 2.0 percent is envisaged on account of additional equipment like an FGD being installed in the TPP which will also increase the consumer tariff.

(d) **Space constraint for installation of FGD as a retrofit in the existing old plant** - In case of greenfield projects, this is not a burden. However, in the case of old plants, the available space may not be adequate to install the new FGD units. Already TPPs with a total capacity of 17 GW of units have declared that FGDs cannot be installed in their layout.

(e) **Increase in generation cost** - The addition of new FGD will increase the capital cost and recurring O&M cost of the units. The generation cost is estimated to increase by 20-25%. The envisaged capital expenditure on account of FGD alone will be about Rs 0.5 crore/MW.

(f) **Additional resource requirement** - Depending upon the type of FGD, there will be an additional resource requirement such as water and limestone. Further, the mobilization of limestone for FGD in power plants and the disposal of additional waste produced by an FGD create their environmental footprints, which need to be studied and compared with the benefits of installation of FGDs.

In addition to FGD, it is also worth reviewing the other technologies for emission reduction based on the removal efficiency (η) needed and the capital/operating costs.

Bird's View of Cost and Removal η of Pollution Control Technologies (PCT)

REMOVAL η → / COST ↓	LOW	MEDIUM	HIGH
HIGH (Rs 40-50 lakhs/ MW)			FGD (90-95% reduction in SO_2) SCR (90-95% redn in NOx)
MEDIUM (Rs 15-20 lakhs/ MW)	OFA (20-30% reduction in NOx) Low NO_x Burner (LNB) {30-45% reduction in NOx}	Dry Sorbent Injection (DSI) {30-35% reduction in SO_2} SNCR (50-70% reduction in NOx) DSI + Coal Washing (60-65% reduction in SO_2) LNB+OFA (50-55% reduction in NOx)	High Perf ESP or Bag Filters (99.5 to 99.9% reduction in SPM)
LOW (~Rs 10 Lakhs/MW)	Coal Washing/ Beneficiation (25% reduction in SO_2 & 30% redn in SPM)		

Coal washing is a pre-combustion process**.** OFA/LNB, DSI & SCR are during combustion and the others are 'End of the pipe' mitigating process.

Review of Current Emission levels

Water consumption, coal consumption, and emission data were collected from 20 Thermal Power Plants (**85 Units**) in the Southern Region by reviewing the Environmental Statements for the last three years submitted by the Power Plants to the respective State Pollution Control Boards.

Pollutant	Level of Emissions
Suspended Particulate Matter (SPM)	60 - 250 mg/Nm^3
Sulphur Dioxide ($SO_{2)}$	300 - 1700 mg/Nm3
Nitrogen Oxides ($NO_{x)}$	100 - 550 mg/Nm^3
Specific Water consumption	4 to 10 m^3/MW
Specific Coal consumption	0.64 to 0.77 kg/kWh

The above data indicates that there is a wide divergence in environmental performance between the TPPs in the Southern Region.

Review of Current Generation Costs – Southern Region

Based on Generation Tariff Orders, the power generation costs were arrived at for each State and trends studied for last 6 years in case of Coal-based Power Plants and for the last 3 years in case of Hydro, Solar and Wind. Considering Southern Region as a single entity, the weighted average cost of generation was estimated based on the tariff and electricity supplied during the period. The average generation cost for SR is Rs 3.88/kwh in FY17 and comes down to Rs 3.77/kwh in FY19. Breaking it down, the weighted average for coal-based power plants in the Southern Region is estimated to vary between Rs. 3.44/kwh and Rs 4.15/kwh (2013-14 to 2018-19). Similarly, the weighted average for solar power is estimated to be Rs 5.5 - Rs 6.00 per kWh; Rs 3.5 to Rs 3.8/kwh for wind power, Rs 3.55/kwh for nuclear power (FY 2017-18), while Hydropower was most economical at Rs 1.6/kwh over the last 3 years. These costs cover procurement from the State-owned generating company, Central Generating Stations and IPPs across all the four States.

Review of additional Capex & Opex

Based on the existing design of each TPP, the 'Capital Costs' would *vary* to upgrade the equipment. Also considering the current emission levels, the level of Renovation & Modernization (R&M) must be ascertained. Hence, a customized solution must be developed for each power plant, which requires a thorough feasibility study.

A recent study has revealed that it would cost the plant owners anywhere between Rs 73,000 to Rs 86,000 crore for installing technology to control sulphur oxides, nitrogen oxides and particulate matter among other pollutants (CEEW, 2019). As per this Study, this investment could translate to an increase of Rs 0.60 per kWh of electricity (on an average) for the consumers. However, these costs vary from plant to plant-based on its size and requirements to meet the norms.

Going by recent tenders and contracts awarded for FGD retrofit and ESP upgradation, the average cost of investment for different emission control technologies is as follows:

No	Technology	Approx. Cost ₹
1	ESP Upgradation	10-15 lakh/MW
2	Wet FGD - Limestone	50-60 lakh/MW
3	Partial FGD – Limestone	25-30 lakh/MW
3	Sea Water FGD	30-40 lakh/MW
4	SCR/SNCR	20-30 lakh/MW

In addition to the above, the investments in FGDs and other pollution control equipment required to comply with the new norms are also linked with additional Operating Expenditure (Opex). FGD systems using lime or limestone as a chemical agent are widely used across the Globe for SO_2 emission control at coal-fired power plants. However, there are issues related to the availability of limestone and water consumption. The quantity of limestone required would vary from 6000 to 9000 kgs/hour (depending on limestone purity) for each FGD unit of the Power plant. Considering the 400+ FGD units, the annual consumption of limestone would be around 15-16 million tonnes. The annual production is around 270 million tonnes, at present. The environmental footprint for mining and transportation of limestone and the need for additional water again needs to be

analysed and compared with the benefits incurred by the installation of FGDs. It must also be noted that the above emission control equipment also consumes power which would impact the overall Auxiliary Power Consumption in the Power Plant and therefore the final tariff.

Introduction of supporting technologies:

In addition to mitigation techniques, it is time now to review the use of Coal Gasification and Coal washing, which were considered expensive at the time when the new emission norms were not published. Now considering the Capex and Opex for the introduction of new pollution control equipment, it would be worthwhile to review and compare the generation costs using coal washing/coal gasification in new power plants. It is claimed that the use of such technologies would help in reducing the emission to a large extent. While the mitigation techniques have their own issues, improved technologies are much more environment-friendly. This also provides a preventive approach to minimize emissions rather than a curative approach.

Important areas of R&D in Thermal generation

Ultra-Super Critical (USC) and Advanced Ultra Super-Critical (AUSC) plants operate at higher temperature and pressure (approximately 600°C and 32 MPa) resulting in higher efficiency. These plants require low coal usage per kWh of electricity generated and have less CO_2 emissions. The efficiency of these plants goes up to 44%. However, the extreme operating parameters impose stringent requirements on materials.

Considering that coal shall remain as the mainstay of India's power industry for the next two decades at least, and the inevitability of global pressure, India should seriously focus on introducing these modern technologies to reduce emissions as well as air pollution due to lower coal consumption.

Development of AUSC technology for power plants has been taken as one of the four Sub-Missions as part of the National Mission under the guidance of the Principal Scientific Adviser to the Government of India. Under this initiative, it is proposed to develop and establish 800 MW Adv-USC Power Plant on a Mission Mode, as a collaborative project involving Indira Gandhi Centre for Atomic Research (IGCAR), NTPC and BHEL. Material degradation issues and condition assessment programs are also to be investigated. Research to increase the steam parameter to 700°C from the level of 600°C and to increase the efficiency levels beyond 40% needs to be explored. The research in this area for the development of suitable materials to handle high temperature is already under progress.

IGCC Technology

Integrated Gasification Combined Cycle (IGCC) integrates a coal gasifier, a gas clean-up system, and gas turbine in a combined cycle mode where coal is gasified with either oxygen or air. The resulting synthesized gas (or syngas) consisting of primarily hydrogen and carbon monoxide is cooled, cleaned and fired in a gas turbine. The technology has shown the capability to generate power with higher efficiency (> 45%) and lower emission levels vis-a-vis pulverized coal combustion technologies as demonstrated in the USA, Netherland, and Spain. The other important aspect of IGCC where technological advances are continuously made is in syngas cleaning, especially at a higher temperature. This removes the efficiency penalty of cooling the syngas to ~90ºC and again heating it to the required temperature for the gas turbine. These demonstration plants should have sufficient slipstream facilities where the upcoming warm gas cleaning technologies can be tested at the actual operating condition. Furthermore, IGCC technology opens up a new product area along with electricity generation like liquid fuel generation, hydrogen production, pre-combustion CO_2 capture and integration of fuel cell which may provide future options of zero-emission coal technologies with higher efficiency.

Looking Ahead for coal power plants to comply with the new standards by 2022

A study by 'Mongobay' observed that "*most experts are of the view that the deadline will still see many plants not complying with the new standards*" and to avoid this situation the Union Power Ministry must take a stricter position which precludes all non-compliant plants from generating, unless they exhibit a clear retirement or phase-out plan or have made material progress in awarding tenders and beginning the construction process.

Many of the existing plants will be able to meet NOx emission standard compliance by 2022. Given that 42 percent of non-compliant power plants have not even issued notifications inviting tenders, these plants are likely to miss the 2022 deadline for SO_2 compliance. At present, it is not clear as to what would happen against those power plants that do not follow these standards.

It also held that all coal power plants must be retrofitted if they are to operate in 2023 but if the cost of retrofit is proven to be far exceeding returns based on useful life and utilization factor, then "it must be retired".

At present, India's total installed power capacity is 357,875.48 MW and 194,489.50 MW (54.34 percent) is coal-based. In the CEA report, about 70+ GW of thermal capacity has been identified, where it is not feasible to install FGD due to non-availability of space/ layout issues. As it is observed that there are around 370 units installed before 2003. Most of these units have already completed 30 years of operation. Considering the Sulphur content in India coals (0.5 to 0.6% Max.) and the current emission levels reported, the SO_2 emissions (300 to 1700 mg/m^3) do not meet the new emission norms in all the plants. The categorization of the emission norms based on the "Year of Installation" does not make any sense and the impact of human health would continue to be the same irrespective of the age of the plant. The Ministry of Environment, Forest and Climate Change (MOEF&CC) has already ensured implementation of the "Chimney Height" standards based on the rating of the power plants so the impact of pollution on population living nearby is not much as these pollutants disperse over a range.

Instead, if the categorization is based on location of the power plant in terms of - population density, cluster of power plants in the area and the height of the chimney, the power plant owners have a choice of using alternative technologies/solutions for minimization of SO_2 and SPM emissions depending on their current emission levels, which would be economical. The non-compliant power plants in areas which are densely populated, cluster of power plant existing locations and power plants close to metros can be prioritized first for implementation of FGD retrofit by 2022.
The retrofit of FGD would be expensive and increase the current tariff levels by at least 25-30%. This would ultimately get loaded on the major consumers like industries and commercial users impacting their competitiveness.

The Coal-based power plants which will not be able to meet the new emission norms should be phased out or retired progressively in the next four to five years. Further, a policy intervention will be to RETIRE old Coal based Thermal Power Plants (installed before 2003) with Heat Rate deviation >20% to avoid overconsumption of coal and more emissions. It must also be noted that around 50% of this capacity is less than 20 years old and would not have recovered its initial investment.

Further, the system of real-time data capture from the continuous emission monitoring devices can be made public to ensure transparency. The Merit Order Operating system must be extended to all the Generating companies – Central, State and Private with weightage for "Emission Compliant" Coal-based Power Plants.

While several DISCOMs have tied up PPA for meet their Peak demand, ideally they must tie up PPAs only to manage Base Loads since they have to pay for the Capacity Charges (Fixed Charges) even in the Off-Peak time. Therefore, long term PPAs must be for Base Load and Seasonal and Peak-time variations in power demand should be through procurement from the available Power Exchanges.

Alternative Use of Retired Power Plant sites

Basin Bridge Power plant was decommissioned in 2018. The site (~30 acres) being converted to a LNG based power plant (Gas from Ennore Terminal) of capacity 2x730 MW. Similarly, many such sites can be explored for Nuclear Power Plants or Coal Gasification (IGCC) Plants to generate power with zero (or reduced) emissions.

Optimal Mix of Electricity for the future

The overall objective of the proposed project is to analyse the possibility of an optimum fuel mix and best operating practices for the Southern region as a whole. The grid is now integrated and can theoretically function in a manner that can use resources most efficiently and most economically across the region. However, the power sector in each state is still managed separately based on the requirements and availability of generating capacity in the respective states. While there is some autonomy that this affords the states in planning for their energy requirements and supply infrastructure, in an era of a rapid transition to cleaner and newer energy technologies mandated by the Government, state-level planning and operation can become restrictive and sometimes also expensive. In this project, therefore, we are trying to evaluate whether alternative operating practices are available, to reduce the economic burden on increasingly stressed distribution companies as well as to make the best use of available resources in an environmentally sustainable manner.

A preliminary analysis of the demand patterns for the Southern region shows that the load curves are varied enough to allow for the possibility of regional operation of generation and transmission capacities. The renewable energy potentials, targets, and capacities across states also vary as do the potentials of balancing technologies such as pumped hydro units. The idea is to arrive at an estimate of the cost of generation and cost to the end-user if the power supply in the southern region is determined by a regional optimal with and without regulatory requirements determining load dispatch. Data collection and collation for this is in progress and some preliminary analysis and results for the same will published soon.

Workshop at NIAS, Bengaluru:

While the Government has set a deadline of 2022 for compliance with the new emission norms, there are many issues/concerns and challenges that the various stakeholders face regarding its implementation. The concerns of various stakeholders must be addressed to ensure a smooth transition. In line with this, NIAS has planned a one-day workshop at Bengaluru and has invited key stakeholders - Power Plant Owners (Central & Southern States), Pollution Control Equipment Suppliers, Regulators and Policymakers to share their experience and deliberate on the challenges to develop a road map for implementation.

The major objectives of the workshop are to:

- Create a platform and initiate meaningful dialogue among the major stakeholders for compliance to the new emission norms with a comprehensive road map for implementation
- Address the issues and challenges faced in implementation specifically in the older power plants and suggest remedial measures
- Enhance awareness on various available technologies for controlling SO_X, NO_X and PM emissions along with Capex & Opex.
- Consolidate the key findings and recommendations and pursue them with GOI through NITI Aayog.

Annexure 3

Workshop Programme

17th September 2019

Inaugural Session (Chair: Dr Shailesh Nayak, Director/ NIAS, Bangalore)

Welcome Address by Dr Shailesh Nayak, Director/ NIAS, Bangalore

Theme of the Workshop by Dr R. Srikanth, Professor & Head/EEP, NIAS, Bangalore

Opening Remarks & Inauguration by Dr V.K. Saraswat, Member/ NITI Aayog, New Delhi

Technical Session I – Electricity Perspective for future (Chair: Dr Shailesh Nayak, Director/ NIAS, Bangalore)

Optimal Technology Mix and Policy Interventions to meet Southern Region's growing needs for reliable, low cost and clean energy by Shri A.V. Krishnan, Principal Scientist/EEP, NIAS, Bangalore

National Grid management – Challenges & Strategies by Shri Abhimanyu Gartia ED/SRLDC & Shri SP Kumar Sr GM/SRLDC, Bangalore)

Technical Session II – Performance and Planning for future (Chair: Shri R.N. Nayak, Former CMD – PGCIL and Adjunct Professor, NIAS, Bangalore)

Clean Energy Generation by NTPC by Shri Sanjay Pande, GM (NI & AUSC), NTPC, Noida

Initiatives of TSGENCO by Shri P. Ravinder Reddy DE/TSGENCO, Hyderabad

Technical Session III - Clean Coal Technologies (Chair: Prof V.S. Ramamurthy, Former Secretary /DST, GOI and Professor Emeritus /NIAS, Bangalore)

Air Quality in and around Thermal Plants by Prof Raman Srikanth, EEP, NIAS)

Coal Washing in India – Challenges and Way Forward by Shri D N Prasad, Ex Advisor-Projects, Ministry of Coal

Coal Gasification & IGCC plant by Shri Sunil Mandawat, Sr. GM, Doosan Power Systems, India)

Retrofit of FGD for reduction of SO_2 – Technology & Challenges by Shaktikanta Dash, DGM/FGD, BHEL, Ranipet

Concluding Session (Chair: Dr P.S. Goel, Honorary Distinguished Professor/NIAS, Bangalore)

Summing up the proceeding by Shri. R.N. Nayak, Former CMD/PGCIL

Closing Remarks by Dr V.K. Saraswat, Member/NITI Aayog

List of Abbreviations used

AUSC	-	Advanced Ultra Super Critical
CCT	-	Clean Coal technology
CEA	-	Central Electricity Authority
CFBC	-	Circulating Fluidized Bed Combustion
CIL	-	Coal India Limited
COC	-	Cycles of Concentration
CPCB	-	Central Pollution control Board
DSI	-	Dry Sorbent Injection
EEP	-	Energy and Environment Programme
EPAR	-	Environment Protection (Amendment) Rules
ESP	-	Electrostatic Precipitator
FGD	-	Flue Gas De-Sulfurization
GENCO's	-	Power Plant Generation companies
IGCC	-	Integrated Gasification Combined Cycle
MoEF&CC	-	Ministry of Environment, Forest and Climate Change
MoP	-	Ministry of Power
MoC	-	Ministry of Coal
NIAS	-	National Institute of Advanced Studies
PCT	-	Pollution Control Technologies
PH	-	Public Hearings
PM	-	Particulate Matter
RE	-	Renewable Energy
R&M	-	Renovation & Modernisation
SCR	-	Selective Catalytic Reduction
SMEs	-	Small and Medium Enterprises
SPM	-	Suspended Particulate Matter
SRLDC	-	Southern Region Load Despatch Centre
TPPs	-	Thermal Power Plants

Document Control Sheet

1	**Document No and Year**	:	NIAS/NSE/EEP/U/WR/13/2019
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4	**No. of Pages and Figures**	:	28 pages, 9 Tables, 16 photographs
5	**No. of References**	:	Nil
6	**Authors**	:	A.V. Krishnan, Shyam Sundar R, Shilpa Srivastava and R. Srikanth
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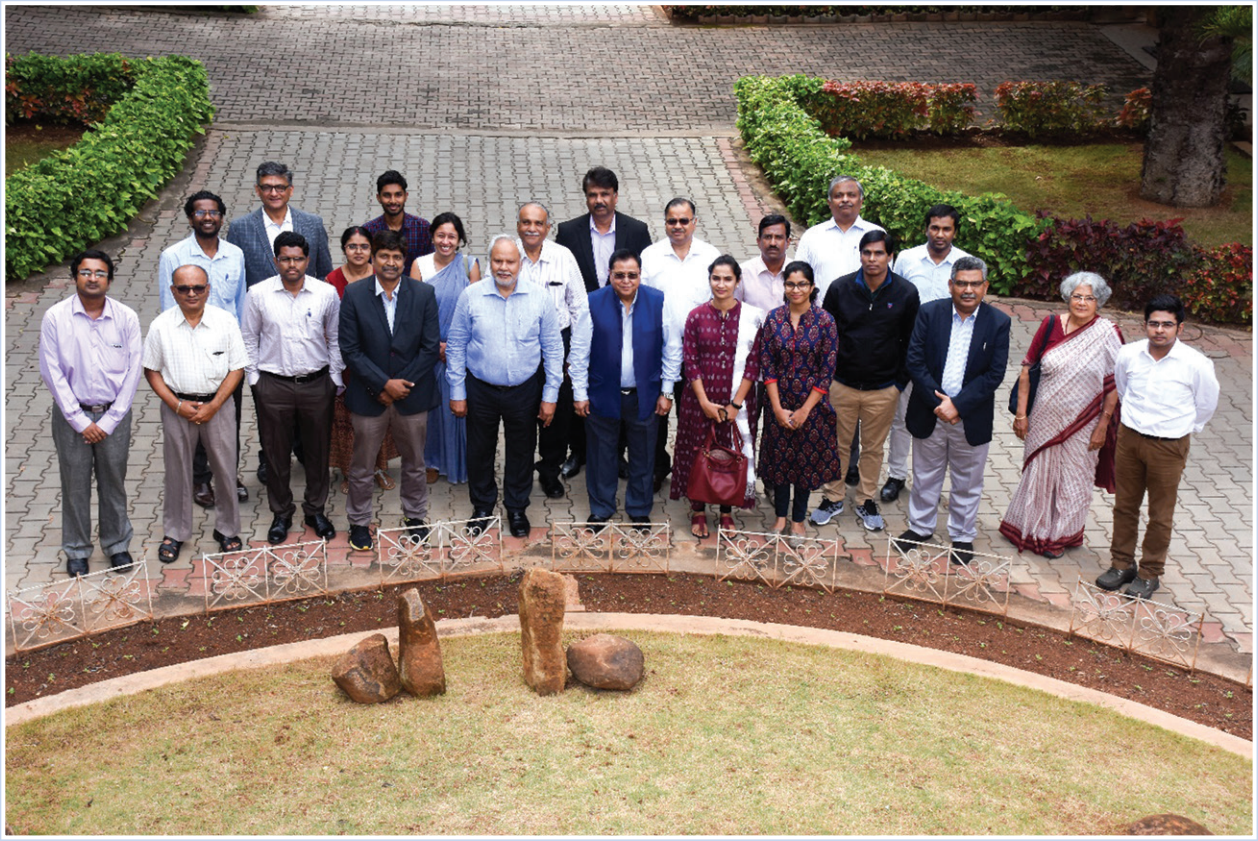
11 **Abstract:**

Coal based Thermal Power Plants (TPP) are the backbone of the power generation utilities in the country. Coal based TPPs constitute to around 56.1% of the total installed capacity and generates around 74.2% of the electricity generated in India. Considering the high pollution and resource impacts, of TPPs the Ministry of Environment, Forest and Climate Change (MoEF&CC) notified the Environment Protection (Amendment) Rules (EPAR) on December 5, 2015 with a two-year window for TPPs to meet these standards. When implemented, these norms are expected to have positive environmental and health benefits by leading to lower pollution levels from TPPs. However, compliance with the new emission norms would require retrofitting existing thermal power plants with various Pollution Control Technologies (PCT) in the form of auxiliary systems to control SO_2, NO_x and PM emissions. In order to ensure 24x7 supply of electricity, CPCB (in consultation with CEA) finalized the revised timelines for all TPPs to comply with the new emission norms by December 2022.

The team at Energy and Environment Programme (EEP) in NIAS, Bangalore interacted with various Power Plant Generation companies (GENCOs) in Southern Region to understand their challenges and way forward with respect to the huge capital investment and schedules for implementation. This team developed and a "Concept Paper" for a workshop with the theme, "Strategies and Action Plans needed for transition to an environment friendly and sustainable Electricity Source mix for the Southern Region". This Workshop was held at NIAS on 17th September 2019 to enable key stakeholders - Power Plant Owners (Central & Southern States), Pollution Control Equipment Suppliers, Regulators and Policymakers to share their experience and deliberate on the challenges to develop a road map for implementation. This report presents the gist of each talk by the invited participants, and also consolidates the key findings and recommendations of the Workshop. This summary report will form the basis for further research as well as for policy advocacy with GOI through NITI Aayog.

12 **Keywords:**
Clean Coal Technology, Flue Gas Desulphurization, Coal Washing, Pollution control in Thermal Power Plants,

13 **Security Classification** : Unrestricted



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