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Control of Sulphur Dioxide, Oxides of Nitrogen and Mercury

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New Emission Norms

Industry	Parameter	Standards
Thermal Power Plant	**TPPs (units) installed before 31st December, 2003**	
	Particulate Matter	**100 mg/Nm3**
	Sulphur Dioxide (SO2)	**600 mg/Nm3 (Units Smaller than 500MW capacity units)** **200 mg/Nm3 (for units having capacity of 500MW and above)**
	Oxides of Nitrogen (NOx)	**600 mg/Nm3**
	Mercury (Hg)	**0.03 mg/Nm3(for units having capacity of 500MW and above)**
	TPPs (units) installed after 1st January,2004, up to 31st December, 2016	
	Particulate Matter	**50 mg/Nm3**
	Sulphur Dioxide (SO2)	**600 mg/Nm3 (Units Smaller than 500MW capacity units)** **200 mg/Nm3 (for units having capacity of 500MW and above)**
	Oxides of Nitrogen (NOx)	**300 mg/Nm3**
	Mercury (Hg)	**0.03 mg/Nm3**

New Emission Norms

Industry	Parameter	Standards
Thermal Power Plant	TPPs (units) to be installed from 1st January, 2017	
	Particulate Matter	**30 mg/Nm3**
	Sulphur Dioxide (SO2)	**100 mg/Nm3**
	Oxides of Nitrogen (NOx)	**100 mg/Nm3**
	Mercury (Hg)	**0.03 mg/Nm3**

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Effect on Tata Power

Current Status and Path forward for CGPL – Unit 10 to 50

Plant & Unit Description	New Norms	Current Status & Action Plan	Remarks
5x830MW Unit # 10 COD – 7th Mar 2012 Unit # 50 COD – 22 Mar 2013	OTC to CT based cooling water system	Detailed feasibility study is being taken up. However, even with cooling towers, meeting the specific water consumption of 3.5m3/MWh is not possible.	Specific water consumption for station along with plant water requirement of remain above 8m3/MWh even with CT
	Particulate matter emission < 50mg/Nm3	Plant is meeting the new norms of particulate matter emission, hence no action is required.	No action required
	SOx - 200 mg/Nm^3	Installation of FGD Unit is possible. Detailed Feasibility Study is being taken up.	In progress
	NOx - 300 mg/Nm^3	Two options will be attempted for NOx reduction: a) Combustion optimization with low NOx burners. b) Installation of SNCR/SCR system will be studied	Detailed study is in progress.
	Mercury - 0.03 mg/Nm3	Being measured offline and found less than the norm.	No action required.

Current Status and Path forward for Trombay Unit 5

Plant & Unit Description	New Norms	Current Status & Action Plan	Remarks
1x500MW CoD – 25 Jan 1984. Completed 32 years	OTC to CT based cooling water system	Implementation of cooling towers is not feasible due to space constraints	• Station is planned within 0.27 acres/MW as against CEA norm of 0.42 acres/MW for coastal plants • Condenser replacement reqd
	Particulate matter emission < 100mg/Nm3	R&M is being carried out for improving the ESP efficiency to meet the norm.	In progress
	SOx - 200 mg/Nm^3	Meets new norms as SWFGD already in operation.	No action required.
	NOx - 600 mg/Nm^3	Meets new norms.	No action required.
	Mercury - 0.03 mg/Nm3	Being measured offline and found less than the norm.	No action required.

Current Status and Path forward for Trombay Unit 6

Plant & Unit Description	Applicable Norm	Current Status & Action Plan	Remarks
1x500MW CoD – 23rd Mar 1990. Completed 26 years.	OTC to CT based cooling water system	Implementation of cooling towers is not feasible due to space constraints	• Station is planned within 0.27 acres/MW as against CEA norm of 0.42 acres/MW for coastal plants • Condenser replacement reqd
	Particulate matter emission < 100mg/Nm3	Norm is not applicable as it is a oil and gas fired unit.	No action required.
	SOx - 200 mg/Nm^3	Unit is kept under reserved shutdown.	No action required.
	NOx - 600 mg/Nm^3	Unit is kept under reserved shutdown.	No action required.
	Mercury - 0.03 mg/Nm3	Norm not applicable as it is a oil and gas fired unit.	No action required.

Current Status and Path forward for Trombay Unit 8

Plant & Unit Description	Applicable Norm	Current Status & Action Plan	Remarks
1x250MW CoD – 29th Mar 2008	OTC to CT based cooling water system	Implementation of cooling towers is not feasible due to space constraints	• Station is planned within 0.27 acres/MW as against CEA norm of 0.42 acres/MW for coastal plants
	Particulate matter emission < 50mg/Nm3	Meets new norms	No action required.
	SOx - 600 mg/Nm^3	Meets new norms with SWFGD in place.	No action required.
	NOx - 300 mg/Nm^3	Meets new norms	No action required.
	Mercury - 0.03 mg/Nm3	Being measured offline and found less than the norm.	No action required.

Current Status and Path forward for Maithon Station

Plant & Unit Description	Applicable Norm	Current Status & Action Plan	Remarks
2x525MW CoD U1 – 1st Sept 2011 CoD U2 – 24th Jul 2012	Specific water consumption up to maximum of 3.5m3/MWh	Meets new norms	No action required.
	Particulate matter emission < 50mg/Nm3	Meets new norms	No action required.
	SOx - 200 mg/Nm^3	Installation of FGD Unit is possible. Detailed Feasibility Study is being taken up.	In Progress
	NOx - 300 mg/Nm^3	Two options will be attempted for NOx reduction: a) Combustion optimization and Utilization of low NOx burners. b) Installation of SNCR/ SCR system will be studied	Detailed study is in progress.
	Mercury - 0.03 mg/Nm3	Being measured offline and found less than the norm.	No action required.

Current Status and Path forward for Jojobera Unit # 1 to 3

Plant & Unit Description	Applicable Norm	Current Status & Action Plan	Remarks
U1 Size – 67.5 MW U2 Size – 120 MW U3 Size – 120 MW CoD U1 – 1st Apr 1997 CoD U2 – 1st Feb 2001 CoD U3 – 1st Feb 2002	Specific water consumption upto maximum of 3.5m3/MWh	Meets new norms	No action required.
	Particulate matter emission < 100mg/Nm3	1. Unit # 1: ESP R&M is being carried out 2. R&M of ESP for Unit # 2&3 will be planned.	In progress.
	SOx - 600 mg/Nm^3	Considering the age of the units and present layout, installation of FGD units are not feasible.	Space for installation of flue gas desulphurization unit is not available within the existing layout
	NOx - 600 mg/Nm^3	Meets new norms.	No action required.
	Mercury - 0.03 mg/Nm3	Being measured offline and found less than the norm.	No action required.

Current Status and Path forward for Jojobera Unit # 4 & 5

Plant & Unit Description	Applicable Norm	Current Status & Action Plan	Remarks
U4 Size – 120 MW U5 Size – 120 MW CoD U4 – 23rd Nov 2005 CoD U5 - 27th Mar 2011	Specific water consumption upto maximum of 3.5m3/MWh	Meets new norms	No action required.
	Particulate matter emission < 100mg/Nm3	Necessary measures will be planned to meet the new norms.	Detailed study is being taken up
	SOx - 600 mg/Nm^3	Space is available for installation of FGD for Unit 5 alone. For Unit 4, FGD is not possible due to space constraints.	Detailed study is being taken up
	NOx - 300 mg/Nm^3	Two options will be attempted for NOx reduction: • Combustion optimization and Utilization of low NOx burners. • Installation of SCR system will be studied and implemented as required.	Detailed study is being taken up
	Mercury - 0.03 mg/Nm3	Being measured offline and found less than the norm.	No action required.

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Control of Sulphur Di-Oxide

Technology Options for Abatement of Sulphur Di-Oxide

Apart from using fuel with low sulphur, which is a scarce resource, SO_2 emissions may be abated as follows:

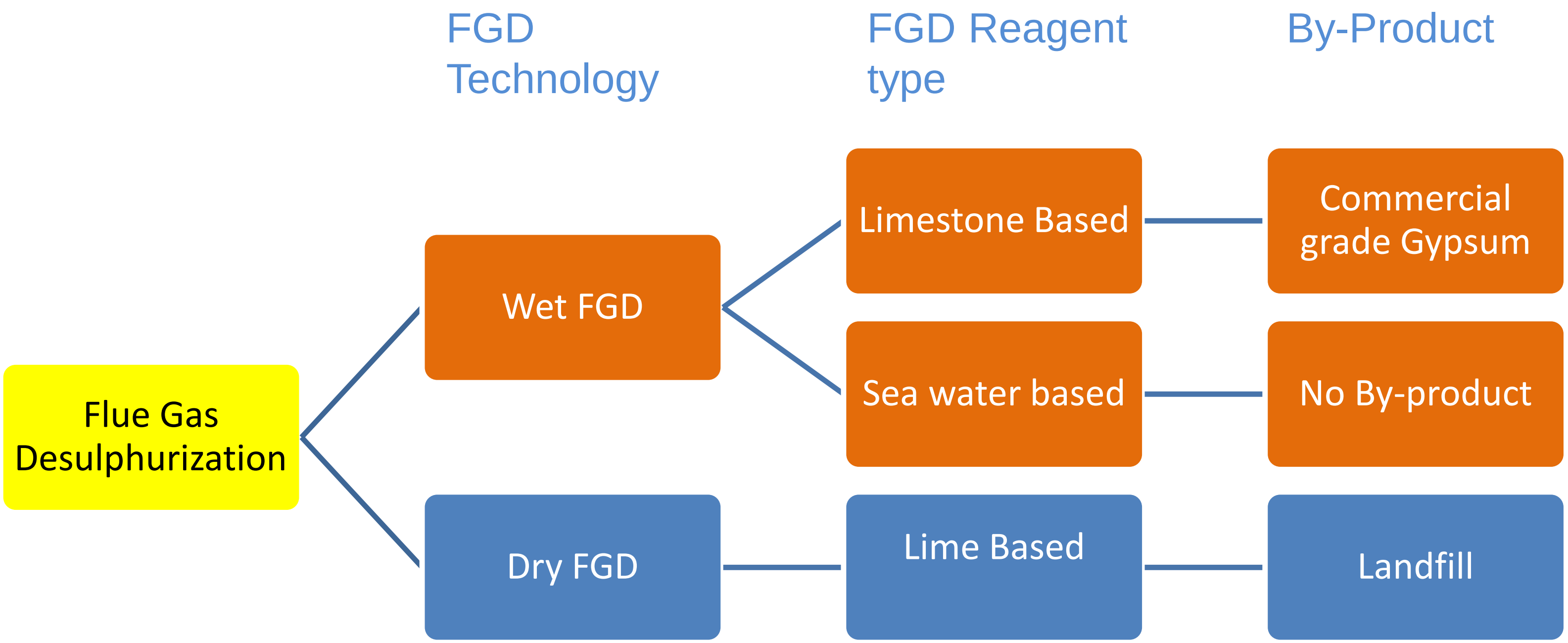
1. ***Post Combustion Abatement Technology:***

    - Installation of Flue Gas De-Sulphurization (FGD) Units is the only methodology for abatement of SOx for PF fired boilers.

2. ***In-Situ Abatement Technology***:

    - In CFBC, AFBC boilers, emission of SOx is diminuted by addition of limestone into boilers.

Classification of post-combustion FGD



Comparison of Technologies for FGD Units

Description	WFGD	DFGD	Seawater FGD
Reagent	Lime stone	Lime	Sea water
Byproduct	Saleable gypsum or landfill	Landfill	Treated sea water
Sulphur in Coal	<6%	<2.5 %	<2%
Removal efficiency	>98%	>90-95%	<=95%
Footprint	12-13 sq.m/MW	Smaller than WFGD	8-10 sq.m/MW
Pros	Large reference list Fuel flexibility	Dry byproduct No GGH required	No reagent No byproduct
Cons	High power Consumption Large footprint Extensive logistics GGH mandatory	Less abundant and expensive reagent Byproduct use limited to landfills.	Effluent discharge Limited Applicable only to coastal power plants
Comparative Cost	Highest	Higher than seawater	Base

Cost Estimates for Different Technologies for FGD Units

Attributes	WFGD	SWFGD
Capital Cost	Approx Rs.1.0 Cr/MW	Appox Rs 0.8Cr/MW.
Aux power consumption	Increase in aux power consumption is about 1.5% to 1.7%.	Increase in aux power consumption is about 1.0% to 1.2%.
O&M cost per annum	Approx Rs 20-25 Crores for an Unit of 500MW excl aux power cost.	No additional consumable cost excl aux power cost.

Lime based Dry FGD has not been considered due to scarce availability of Lime in India

Due to restrictions on specific water consumption, use of sea water based FGD for coastal stations are also not feasible.

Hence, the most techno-commercially feasible option left is Limestone based FGD in most of the cases.

Challenges for Installation of Technologies for FGD Units

Challenges	Description
Reagent availability	• A typical 500MW Unit requires about 6 Tonnes of limestone per hour with typical Indian coal. That translates to about 45,000 tonnes per annum. • For an installed total capacity of 175GW for India, the total limestone required per year is about 15.75 million tonnes. • Assuming 50% of the installed capacity, will install new WFGDs, it is about 7.8 million tonnes per annum, excluding the future units which will additionally require limestone for respective FGD units. • Hence, availability of such huge quantity of limestone suitable for FGD will be a challenge for the industry • This may impact availability of limestone for cement industry.

Challenges for Installation of Technologies for FGD Units

Challenges	Description
End Use of By-product	• About 12 tonnes per hour of Gypsum will be produced from a Unit of 500MW with typical Indian coal, which is about 90,000 tonnes per annum. • For an installed total capacity of 175GW for India, the total Gypsum production per year is estimated about 312 million tonnes. • Assuming 50% of the installed capacity install WFGD, it is about 156 million tonnes per annum, excluding the new units which will additionally generate Gypsum at the same rate from respective FGD units. • Though the Gypsum produced is commercial grade Gypsum, such abundant availability of Gypsum in India will pose challenges. • This will add to already mounting challenge of ash utilization which is being currently faced by coal based thermal power plants.

Challenges for Installation of Technologies for FGD Units

Challenges	Description
Fresh water requirement	• About 110 Cu.M per hour of fresh water will be required from a Unit of 500MW, which is about 8.2 lakh Cu.M of water per annum. • For an installed total capacity of 175GW for India, the total additional fresh water requirement per year is about 2,866 million Cu.M. • Assuming 50% of the installed capacity install WFGD, it is about 1433 million Cu.M per annum, excluding the new units which will additionally need fresh water at the same rate for respective FGD units. • This will add to already mounting pressure on fresh water resources and such huge amount of water will put additional challenges to meet new specific water consumption norms. (3.5 Cu.M/MWh)
Availability of Technology	• Domestic availability of required technology/equipment is limited. Even with global suppliers, simultaneous retrofit of so many Units will be difficult and will lead to time and cost overruns. • Though technology for FGD is available, it is not tested for abrasive high ash Indian coal (the existing plants with FGD are using substantial imported coal) • The aim of Make In India will be challenged with such heavy import of technology and equipment.

Challenges for Installation of Technologies for FGD Units

Challenges	Description
Footprint availability	• As stated above, 12-13 Sq.M of land per MW is required for installation of Limestone based FGDs. This turns into 1.6 acres for a Unit of 500MW. • In the older Units, FGD requirement had not been envisaged in plant design and hence accommodation of FGDs for such plants is very difficult. • Sufficient and foul free space is required near-by the existing ID fans, chimney area to install the scrubber, GGH and fans.
Issues in Retrofit	• Additional area for handling and storage of limestone, installation of conveyors etc will have to be identified and routed within the already installed facilities. This will bring up significant interference issues. • Additional acid resistant lining will need to be provided for the chimney, which will necessitate at least 3-4 months of Unit outage. • Plant electrical system, depending on the margin available, will have to be augmented with new transformers, cables etc

Challenges for Installation of Technologies for FGD Units

Challenges	Description
Time of implementation	• As per new norms, all Units in India have been mandated to install FGDs within two years from date of publication of notification. However OEMs have indicated at least 26-36 months for completion of any one FGD Unit for a Unit capacity of 500 MW.
Capability of OEMs	• Existing cumulative manufacturing capability of FGD OEMs to meet the above aggressive target is not sufficient.

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Control of Oxides of Nitrogen

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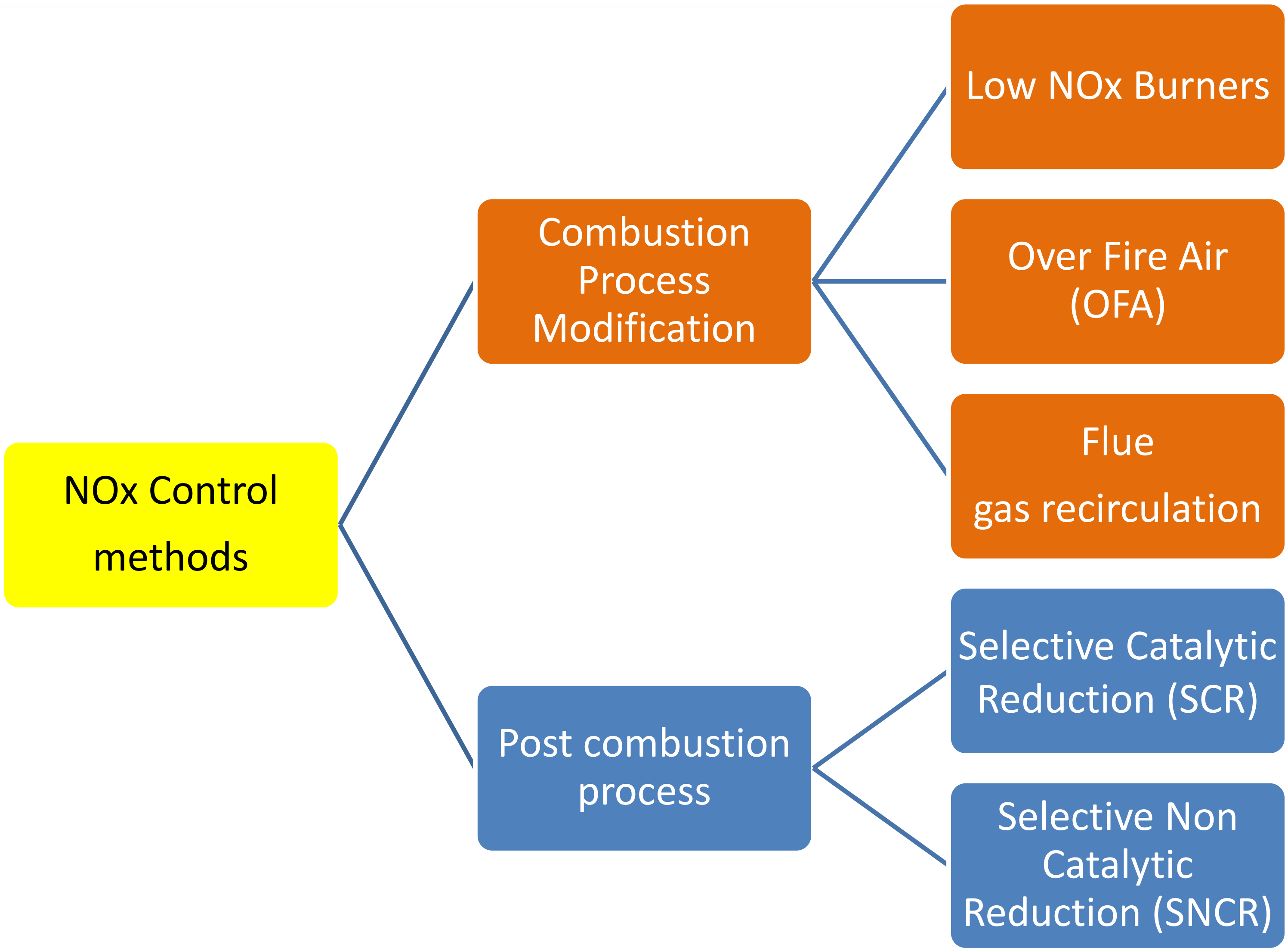
Classification of Methods of NOx Abatement



Qualitative comparison of NOx abatement technologies

Types	Description	% Reduction
1. Combustion modification		
Low-NOx Burners (LNB)	• Better air-fuel mixture • Staged combustion process • Reduces the available air during primary combustion of coal.	30-40%
Over Fire Air (OFA)	• Staged availability of process air	20-50%
Flue gas recirculation	• Part of the flue gas recirculated to reduce the combustion temperature below the NOx formation temperature.	20-50% applied only for oil & gas fired boilers
2. Post combustion process		
Selective Catalytic Reduction (SCR)	• Ammonia (NH_3) or Urea solution is injected into the flue gas before passes through the catalytic bed in a low temp zone i.e. Eco outlet	80-95%
Selective Non Catalytic Reduction (SNCR)	• Ammonia (NH_3) or Urea solution is injected into the flue gas in high temperature zone of 900-1150 Deg C. No catalyst is used.	30-50% Typically used for CFBC boilers

Comparison of Technologies for NOx Reduction

Description	SCR	SNCR
Reagent	NH_3 or Urea solution	NH_3 or Urea solution
Byproduct	N_2+H_2O Ash containing Ammonium Bi-sulphate	N_2+H_2O Ash containing Ammonium Bi-sulphate
Removal efficiency	80-95%	30-50%

Comparison of Technologies for NOx Reduction

Description	SCR	SNCR
Pros	• Higher reduction efficiency	• No additional pressure drop • Lower auxiliary power consumption • No special catalyst is required.
Cons	• Flue gas pressure drop and hence higher aux power consumption. • A need for sufficient downstream gas duct length to ensure proper mixing of reactants. • Production of velocity disturbances downstream of catalyst bed. • Fouling of air pre-heater due to ammonium bi-sulphates. • Ammonium bi-sulphate mixed fly ash by secondary reaction with SO2 and Ammonia	• Lower reduction efficiency • It needs sufficient residence time. • More effectively applicable for CFBC / AFBC boilers. • Fouling of air pre-heater due to ammonium bi-sulphates. • Ammonium bi-sulphate mixed fly ash by secondary reaction with SO2 and Ammonia.

Cost Estimates for Different Technologies for NOx Reduction

Attribute	SCR
Capital Cost	Approx Rs.0.5-0.6 Cr /MW
Aux power consumption	Additional aux power consumption of about 0.5% of Unit capacity
O&M cost per annum	Approx Rs 70-75 Crores for an Unit of 500MW with typical Indian coal excluding aux power cost.

SNCR has not been considered as it alone may not be able to meet the required NOx reduction.

Ammonia Availability in India

Sector in India	Production capacity in Million Tonnes/Annum
Public Sector	8500
Co-Operative Sector	6200
Private Sector	9000
Total Production	**23,700**

Challenges for Installation of Technologies for NOx Reduction

Challenges	Description
Reagent availability	• A typical 500MW Unit requires about 3.45 Tonnes per hour of aqueous ammonia per hour. That translates to about 26,000 tonnes per annum. • For an installed total capacity of 175GW for India, the total ammonia required per year is about 90 million tonnes. • Assuming out of above, 50% will install SCRs, about 45 million tonnes per annum will be required. • Hence, availability of such huge quantity of ammonia will be a challenge for the industry

Challenges for Installation of Technologies for NOx Reduction

Challenges	Description
End Use of By-product	• Use of SCRs in system will contaminate ash with ammonium bi-sulphates, thus making is further challenging for useful utilization of the same.
Issues in Retrofit	• Additional area for handling and storage of ammonia and its related systems will have to be identified within the already installed facilities. This will bring up significant interference issues. • Installation of SCR systems requires extensive changes in duct work, potential relocation of air preheater, change in ID fan etc. • It will also significantly impact the O&M cost of the plant due to excessive power consumption on account of increased pressure drop in the system. • Plant electrical system, depending on the margin available, will have to be augmented with new transformers, cables etc

Challenges for Installation of Technologies for NOx Reduction

Challenges	Description
Availability of Technology	• Installation of SCR will require major changes in design of boiler and burner system. • Proven SCR technology for Indian coal with high ash is not available. Interactions with global suppliers of SCR systems has revealed that they do not have adequate experience with handling coal with such high ash content as Indian coal. • Domestic availability of required technology/equipment is not there. • The aim of Make In India will be challenged with such heavy import of technology and equipment.

Challenges for Installation of Technologies for NOx Reduction

Challenges	Description
Time of implementation	• As per new norms, all Units in India have been mandated to install FGDs within two years from date of publication of notification. However OEMs have indicated at least 26-36 months for completion of any one SCR Unit for a Unit capacity of 500 MW. • Since, it requires modification in duct work for APH, burner system, introduction of catalyst into ducts, more than 5-6 months of outage is mandatory for the completion of installation process. Such long duration of outage will disrupt power supply across the country.
Capability of OEMs	• Existing cumulative manufacturing capability of SCR OEMs to meet the above aggressive target is not sufficient for existing 175GW.

Financial and Regulatory Challenges

Challenges	Description
Financial Requirement	• Approx Rs 1.5 to 2.0 Cr/MW capital investment will be required to be install FGD, SCR and Cooling tower systems. • Hence, about Rs 200,000 Crores will be required to upgrade the existing installed capacity of about 175GW. • Arranging for such huge fund will be a challenge for the industry.
Regulatory and Institutional framework	• Approve changes required and devise phased implementation programe • Ensuring full recovery of capital investments under Change in Law provisions with minimum delay • Approval of tariff increases as per new operating parameters; amendment in PPA • Deemed Availability during shutdown period – recovery of fixed charges • Recovery mechanism for this investment for plants with less residual life (5-10 years).

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We value your inputs, suggestions and critique."

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