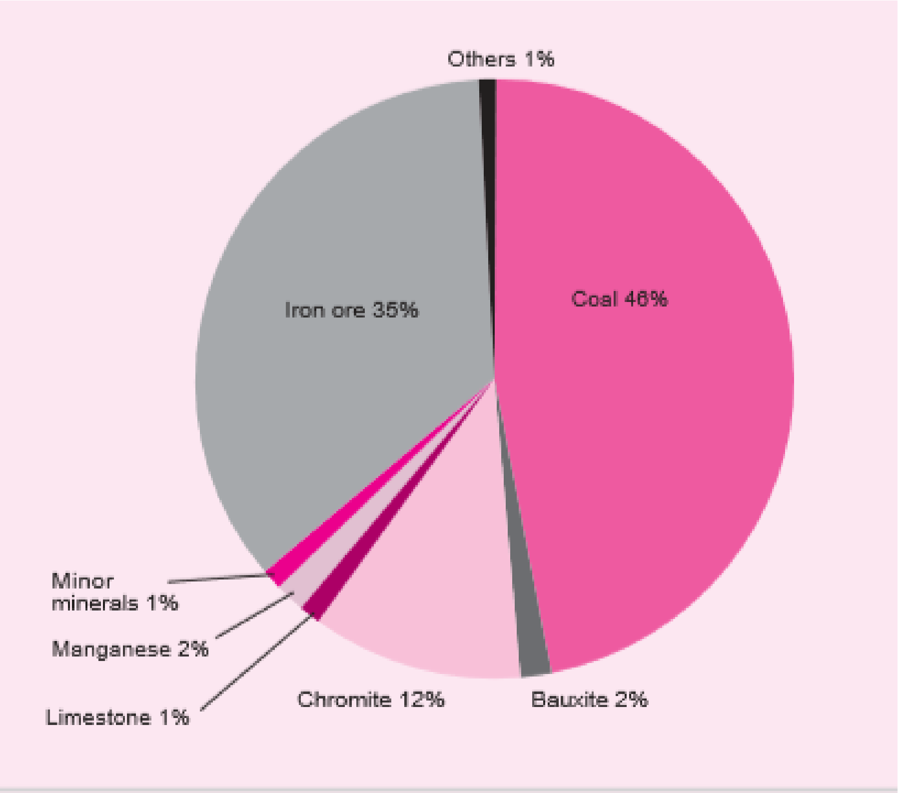
Reducing pollution from industries – Coal-based thermal power plants

Overview

- Major industrial segments – Iron and Coal – should be roughly 80 per cent in material volume of all the industrial production happening in the state
- IRON
  - 110 million tonne Iron ore production
  - 18 million tonnes of steel (around 15 steel plants), 11.45 mtpa of sponge iron and 4.23 mtpa of other products
- **COAL**
  - **150 million tonne coal production**
  - **7 utility based thermal power stations -~6 GW and captive of ~4-5 GW**



- 31 units of glass and ceramic industries, 18 chemical & allied industries, 15 food & allied industries and 26 other units , Bauxite and Aluminium (also largest)

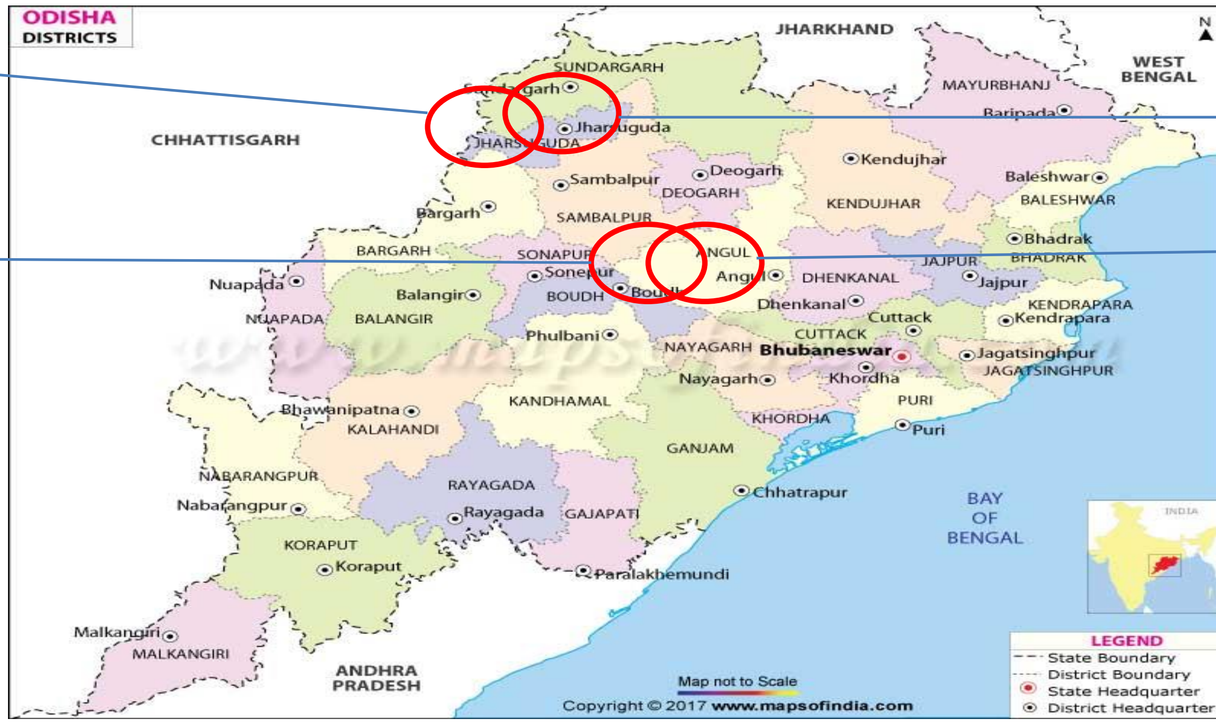
Orissa TPP MAP

Ind Bharath 1*350 MW
GMR ENERGY 3*350 MW

Sterilite 4*600

NTPC Talcher STPC 6*500 MW

JITPL 2*600 MW



OPGCL 2*210 MW

NTPC Talcher (Old TPS) 4*60 MW 2*110 MW

Coal-based thermal power stations in Odisha

- Utility ~ 6 GW and ~3-5 GW of captive (prominent large ones - Vedanta's 1,125 MW, NALCO's 1,200 MW, and Jindal Steel and Power Limited's (JSPL) 810 MW)
- Mostly private run - Private – 5 GW, Central – 3.5 GW, rest – state
- Install FGD systems and upgrade burner technology/optimize combustion, some might upgrade ESP systems
- Only 3 GW – Centre-run plant has plans, rest no plans available on public domain on up-gradation

Unit size in MW	before 1990	1990-03	2009-16	Total (MW)
<150	460			460
210		420		420
>250 - 490			1,400	1,400
490 to 600		3,000		3,000
600			3,600	3,600
Total (MW)	460	3,420	5,000	8,880

Emission Norms – Rationale

- CREP commitments by industry in 2003 –
  - meeting 100 mg/m^3 particulate matter levels;
  - SOx/NOx standards to be implemented by 2005/06

- Environmental clearances were granted since year 2008 requiring particulate matter emissions at 50mg/m^3 for 500 MW size units

- ECs required allotment of space for FGD installation since year 2003 – space constraint should not be an issue

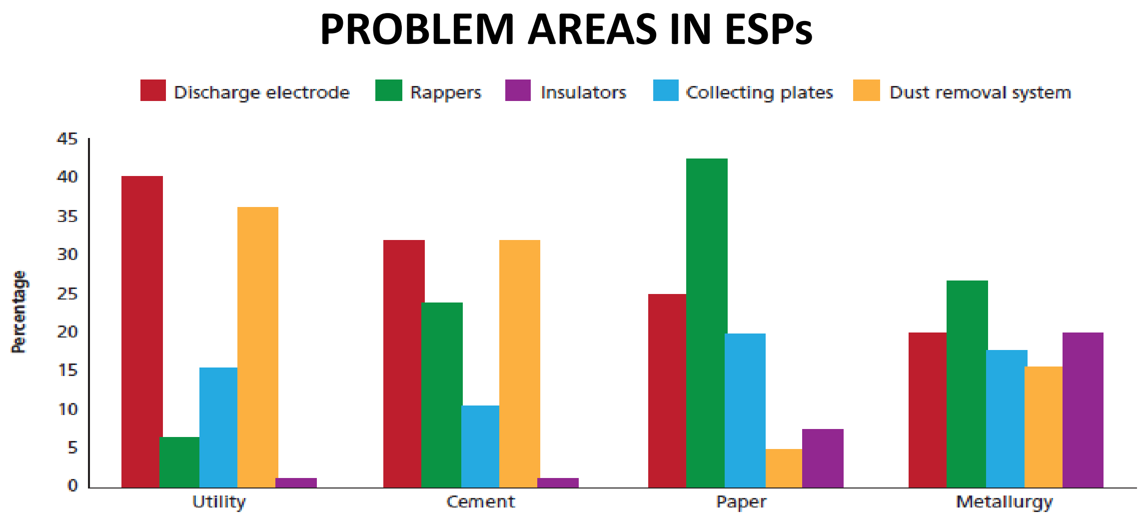
- CEA water use guidelines - 3m^3/kWh water use by plants with 100% ash use

New Norms – Overview

mg/Nm^3	Unit size	Installed before Dec 31st, 2003 *	Installed between 2004 and 2016 *	Installed Jan 1, 2017 onwards
PM	All	100	50	30
SO_2	<500MW	600	600	100
	>=500MW	200	200	100
NO_x	All	600	300	100
Hg	All	0.03 (>500 MW)	0.03	0.03

- Evolved through extensive consultations organized by MoEF&CC with relevant stakeholders and independent studies.
- Key considerations:
  - **Age and Size of Fleet:** Helps determine the most appropriate pollution-control options; economic considerations.
  - **Pollution control technology:** cuts achievable using different options
  - **Global Benchmarks:** regulatory standards/best practices
  - **China has introduced even tighter standards for metro and highly polluted areas (PM 10 mg/Nm^3, SO_2 35 mg/Nm^3 and NO_x 50 mg/Nm^3)**

Particulate matter: Control



- Designed to meet new norms
- Reasons for deviation from design
    1. Dust removal systems:
        - hopper level switches are bypassed deliberately to avoid labour costs.
        - Mismatch of flyash evacuation system and ESP ash dislodging capacity exacerbates the issue.
    2. Discharge electrodes:
        - operated at an inappropriate voltage, suffer mechanical damage

Upgrading ESPs: Methods

Control

- Improved diagnostics of operating behavior and faults
- Micro-processor-based intermittent charging controllers

Process

- Flue gas conditioning

Electrical

- Increased rating of TR sets
- Increased high-tension sectionalization

Mechanical

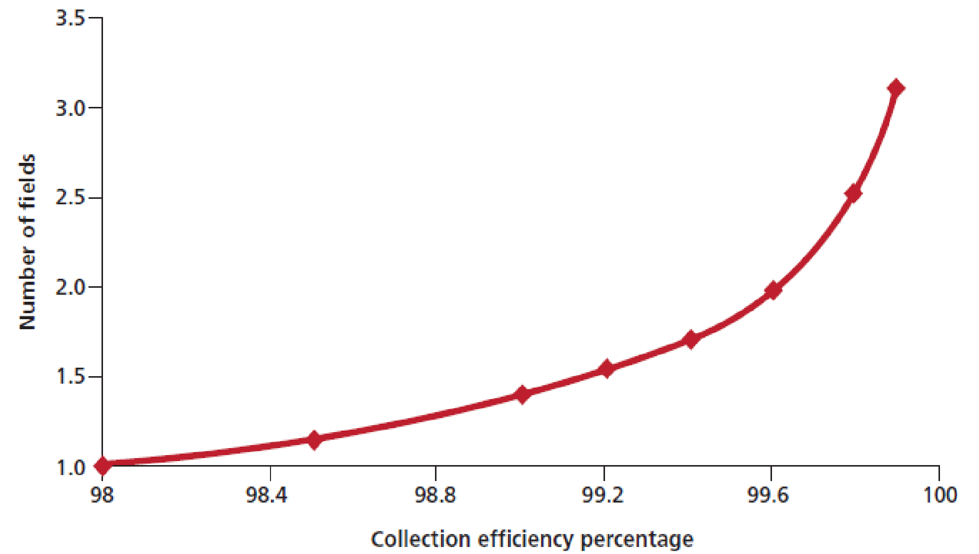
- Augumenting collection area
- Electrode strength and alignment

Refurbishment techniques: Preferred solutions

1. Adding fields in series to an existing ESP
2. Placing additional ESPs parallel to an existing ESP
3. Adding new internals by increasing the casing height
4. Replacing old ESPs with new ones
5. Filling the dummy fields of ESPs

SIZE OF ESP VS COLLECTION EFFICIENCY

To improve collection efficiency from 99.2 to 99.8 per cent, the size of ESPs needs to be doubled

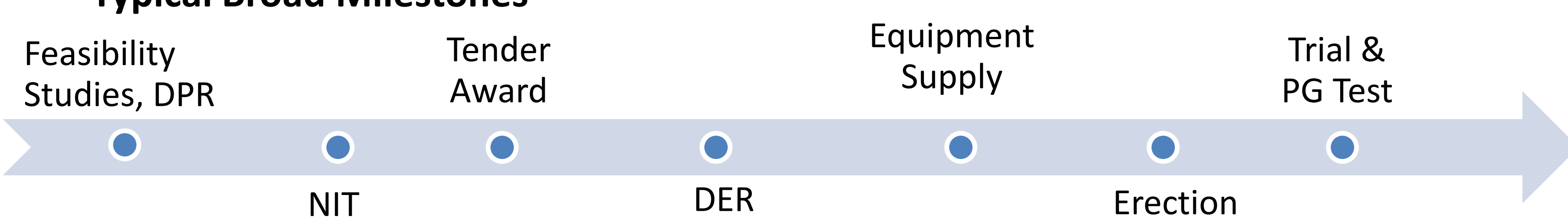


Refurbishment techniques: Minor improvements

- Optimizing power supply
- Introducing more bus bars and transformer rectifier sets
- Flue gas conditioning (FGC)
- Introducing a bag filter in an existing ESP’s casings, changing electrodes etc

PM Control - Milestone

- Milestone report – shared with MoEF&CC, Chairman-CPCB, Chairman-MoP, MoP additional secretary
- According to RPC plans, 121 GW compliant with PM norms – Should be Verified
- 13 GW requires Major ESP upgrades
  - Addition of more fields in existing ESPs (14 Months)
  - Converting a few fields to hybrid filters (18 Months)
- 40 GW plans to achieve the PM Compliance with FGD - **not an advisable strategy**
  - Improving Transformer Performance by Conversion to the Switch Mode Power Supply (SMPS) system (4 Months)
  - Adding filtering channels (5 Months)
- **Typical Broad Milestones**



Under – reporting data: Common

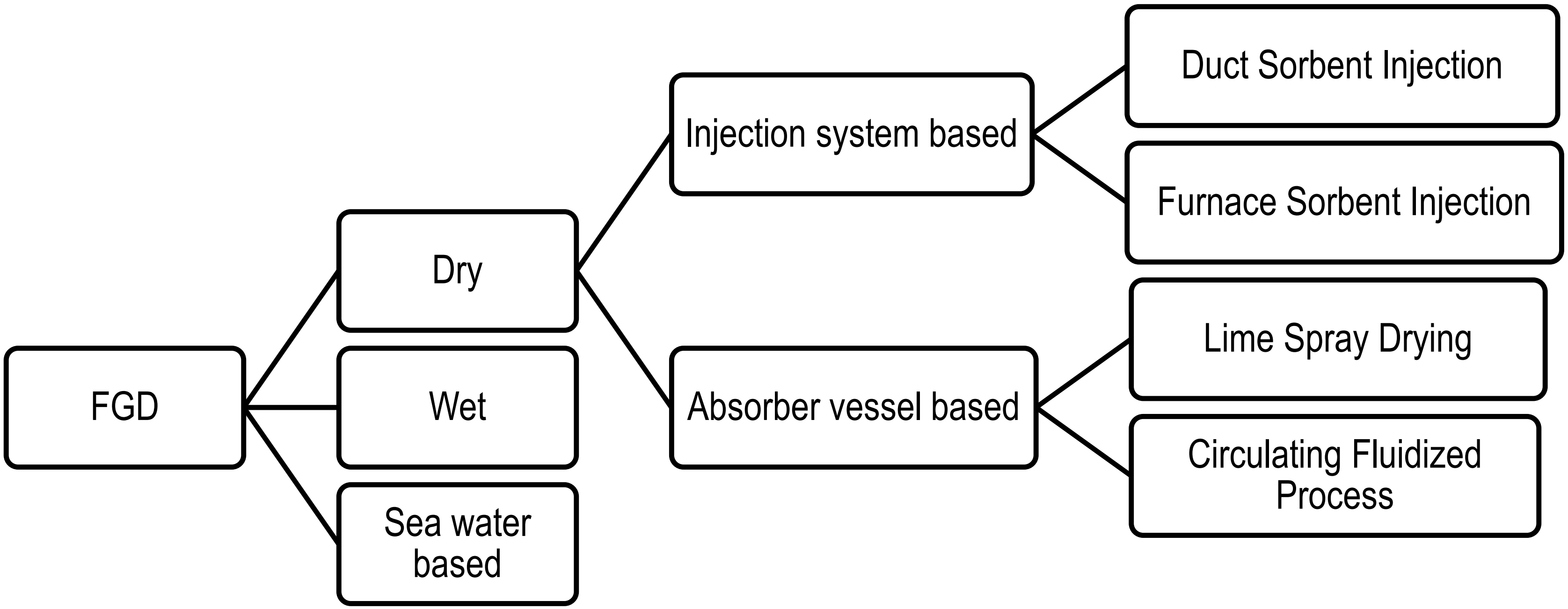
Sulphur di oxide: Control

- SO_2 emissions can be controlled by three methods:
  - Before combustion, by lowering sulphur content in the fuel.
  - During combustion, by injecting sorbents such as limestone.
  - After combustion, by treating flue gas with sorbents in FGD devices or in ducts.

Emissions Range

Sulphure in Coal	SO_2 emission	
	Indian Coal	Imported Coal
NCV (Kcal/kg)	4100	5500
Wt%	mg/Nm^3	mg/Nm^3
0.1	258	190
0.2	516	380
0.3	775	570
0.4	1033	760
0.5	1291	950
0.6	1549	1140
0.7	1808	1330
0.8	2066	1520
0.9	2324	1710
1.0	2582	1900
1.2	3099	2280
1.4	3615	2660
1.6	4132	3040
1.8	4648	3420
2.0	5165	3800
2.2	5681	4180
2.4	6198	4559
2.6	6714	4939
2.8	7231	5319
3.0	7747	5699

Sulphur di oxide: Control



Sulphur di oxide: Control

	WET FGD	Dry FGD
Commercially available range	~ 1,100 MW	300–400 MW single absorber For novel integrated desulphurization (NID) each module of 75 MWe
Types	1) Seawater 2) Freshwater	1) Spray dry absorber (SDA) 2) Circulating dry absorber 3) NID.
SO2 removal efficiency	Upto 99 per cent	Upto 99 per cent (90–95 per cent for SDA)
Sorbent use	Approximately 1.5–2 tonne limestone consumed per tonne SO2 removal	Approximately 0.75–1.5 tonne lime consumed per tonne SO2 removal
Water consumption in m^3/ MWh	0.2–0.25 m^3/ MWh for power plants between 200–500 MW;	0.1–0.2 m^3/ MWh for power plants up to 200 MW. The semi dry system is not recommended for power plants > 200 MW
Auxiliary power con-sumption	Freshwater FGD: 0.7 per cent Seawater FGD: 0.7–1.5 per cent	1–2 per cent
Condition of existing stack	Existing stacks to be modified in all cases	Existing stacks can be used without modification
FGD by-product	Freshwater FGD: gypsum Seawater FGD: no by-product	$CaSO_3$/ $CaSO_4$: Has to be land filled

FGD: space and Installation time

	1*150 MW[1]	4*150 MW[+]	2*660 MW[+]	5*800 MW[+]
Area required for the wet FGD system in acres	0.6	2.2	2	7.6

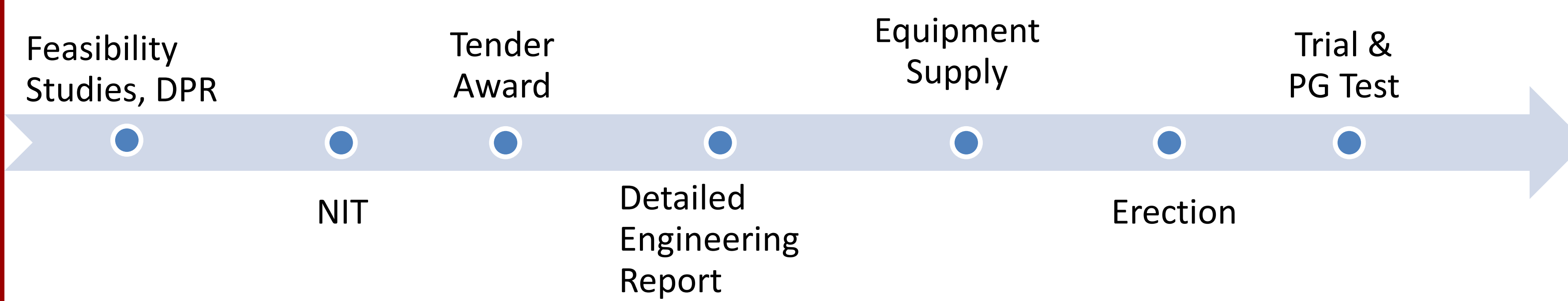
[1]Dedicated Limestone Slurry Preparation and Dewatering system
[+] FGDs have common Limestone Slurry Preparation and Dewatering system
Source: Thermax, 2016

- The construction of an FGD unit involves both civil and mechanical work— installation of scrubbers, gas re-heaters, ducting and chimney lining, or the construction of a new chimney.

- Typically, construction requires about 18 months for a 500 MW unit. The shutdown time to hook up a wet FGD system to the unit takes upto one month, depending on the chimney construction.

SO_2 Control - Milestone

- According to RPC and CPCB, 444 units (163GW) requires an FGD
- Timeline for Installation of FGD
  - Documentation & Procurement: ~6 Months
  - Erection: ~24 Months
  - **December 2020 - Should have already floated tenders**
  - December 2021- Should be floating tenders by March 2019
  - Most plants should already be done with Feasibility studies
- CSE has also suggested Dry Sorbent Injection (DSI) Technology, can be adopted by smaller units (<500MW) - cost effective and quickly implementable (~12 Months)



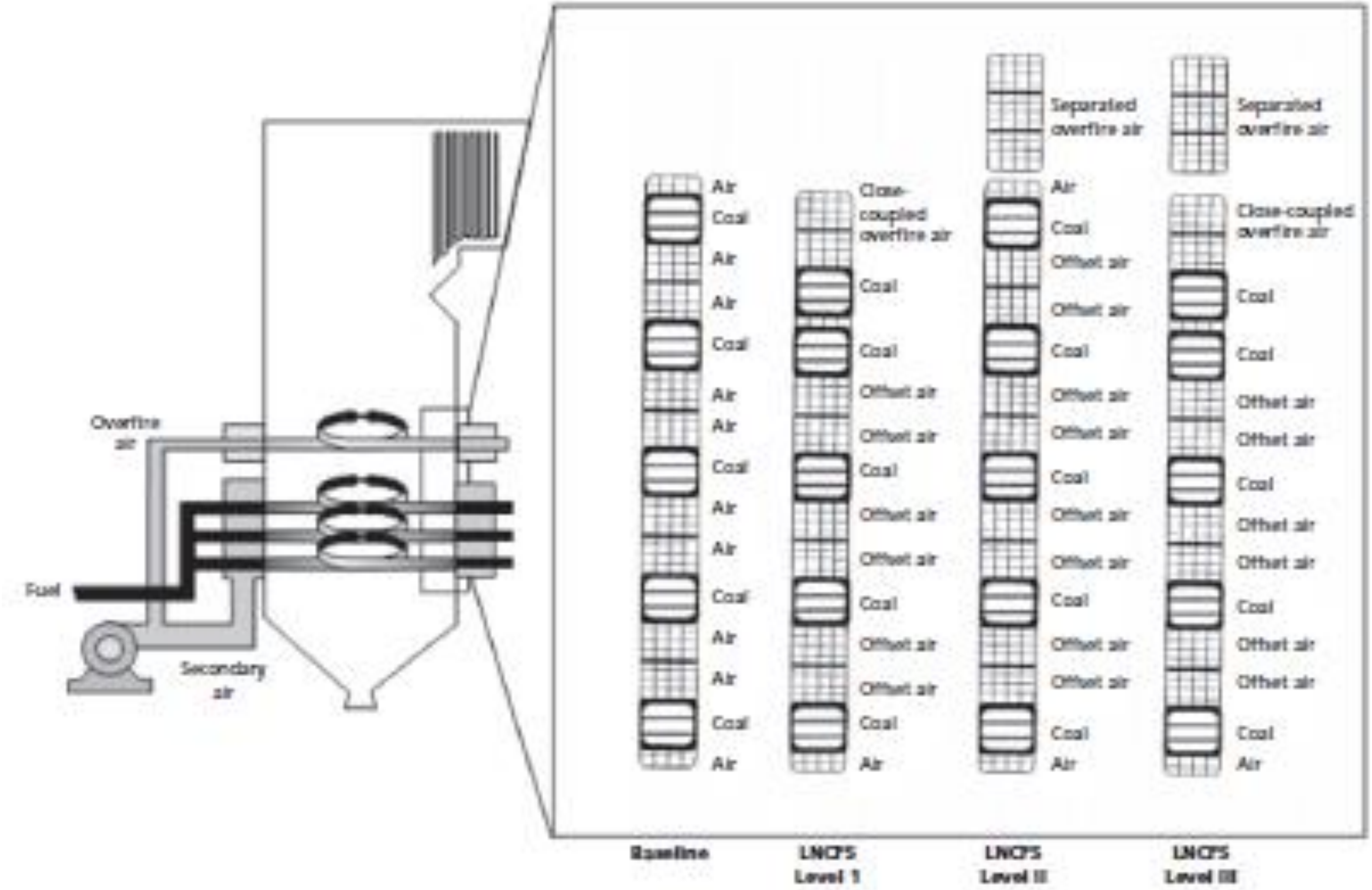
Oxides of nitrogen: Control

- NO_x abatement
  - Burner modification
  - Flue gas treatment
    - Selective catalytic reduction
    - Selective non catalytic reduction

Burner modification

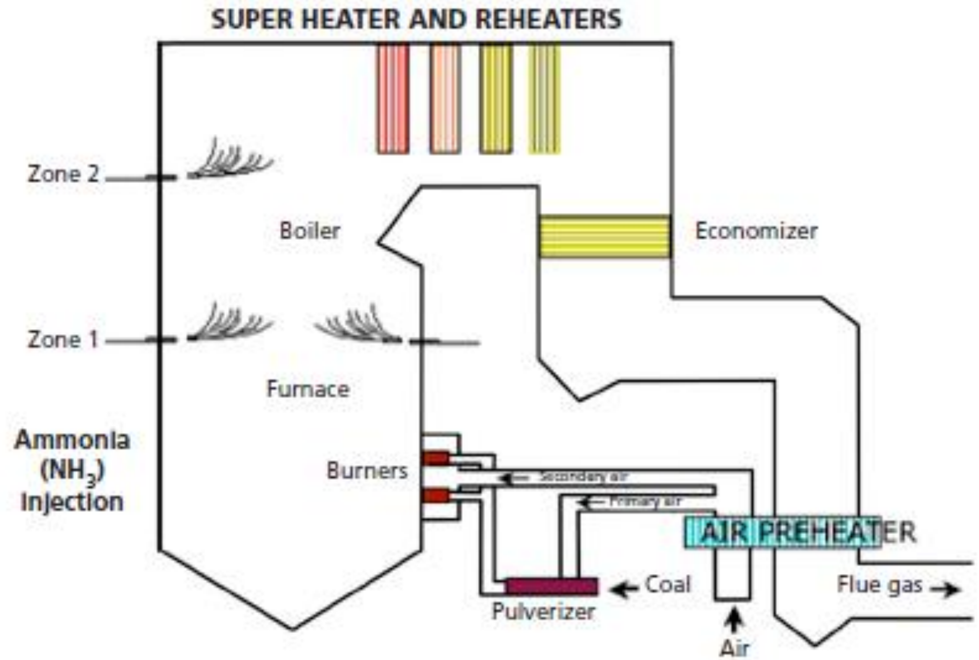
- Low NOx burners are boilers having extra ports to supply air and fuel compared to conventional burners.
- By altering the air–fuel mix, temperatures at different locations in a boiler are kept below a certain level so reaction between nitrogen and oxygen is minimized and relatively lower quantity of NOx is formed.
- These technologies are the basic and most cost-effective control mechanisms.
- The process has a relatively low capture efficiency of around 50 per cent, which means NOx emissions can be cut down to around 400mg/ Nm^3.

Over fire air



Selective non catalytic reduction (SNCR)

- SNCR reduces NOx by reacting urea or ammonia with the NOx at temperatures of around 900–1,100 °C.
- Urea or ammonia is injected into the furnace in the post-combustion zone to reduce NOx to nitrogen and water.
- Capture efficiency of SNCR is only 25–40 per cent.

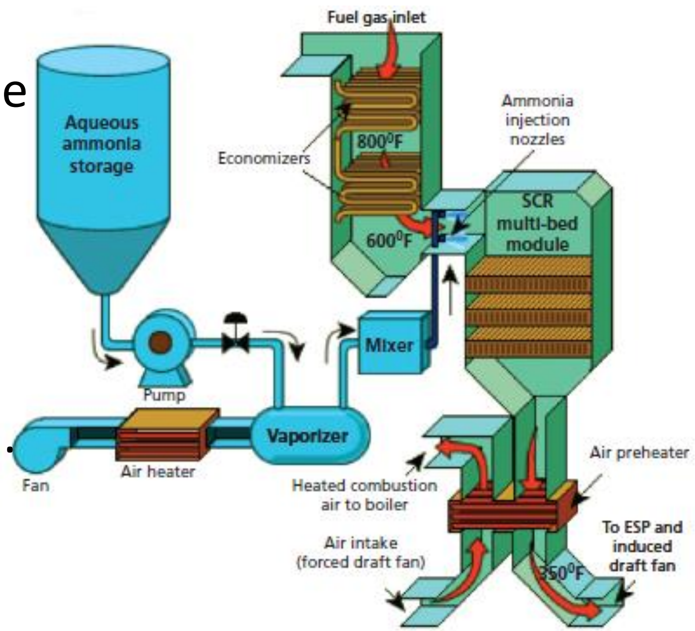


Source: NTPC Limited

Selective catalytic reduction (SCR)

- **Would be needed only for upcoming units**

- SCR utilizes ammonia as a reagent that reacts with NOx on the surface of a catalyst. SCR catalyst reactor is installed at a point where the temperature is about 300– 390 °C, normally placing it after the economizer and before the air pre-heater of the boiler.



Source: NTPC Limited

- The SCR catalyst must periodically be replaced. Typically, companies will replace a layer of catalyst every two to three years. Multiple layers of catalysts are used to increase the reaction surface and control efficiency.

- Emission reduction of up to 90 per cent can be achieved.

SNCR/SCR: Installation time

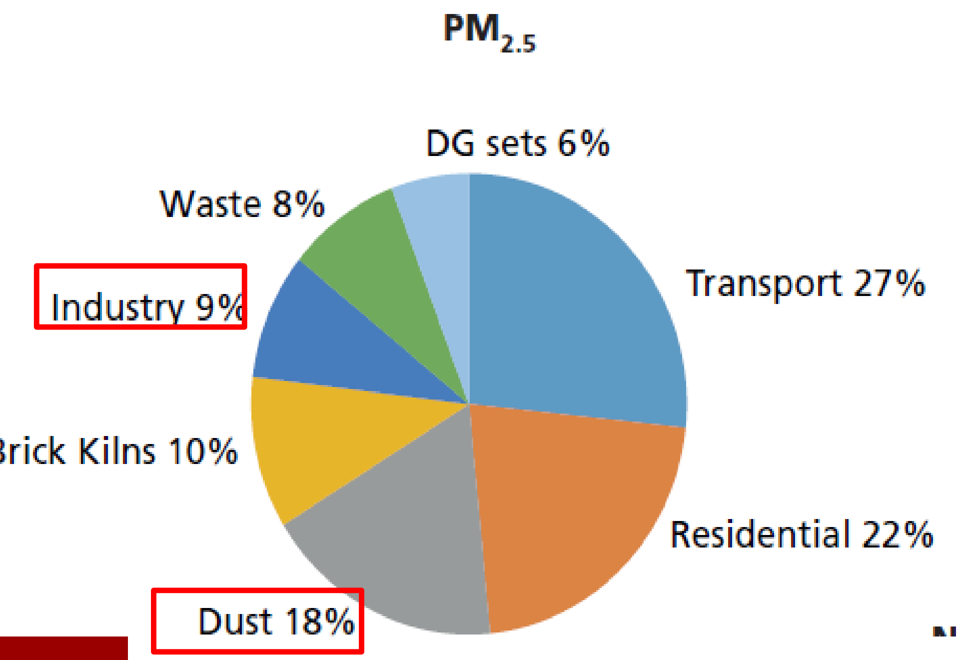
- SNCR system installation requires about 4 months for a 500 MW unit in a typical situation. The installation includes ducting work near the fire box and construction of a mixing/storage tank.

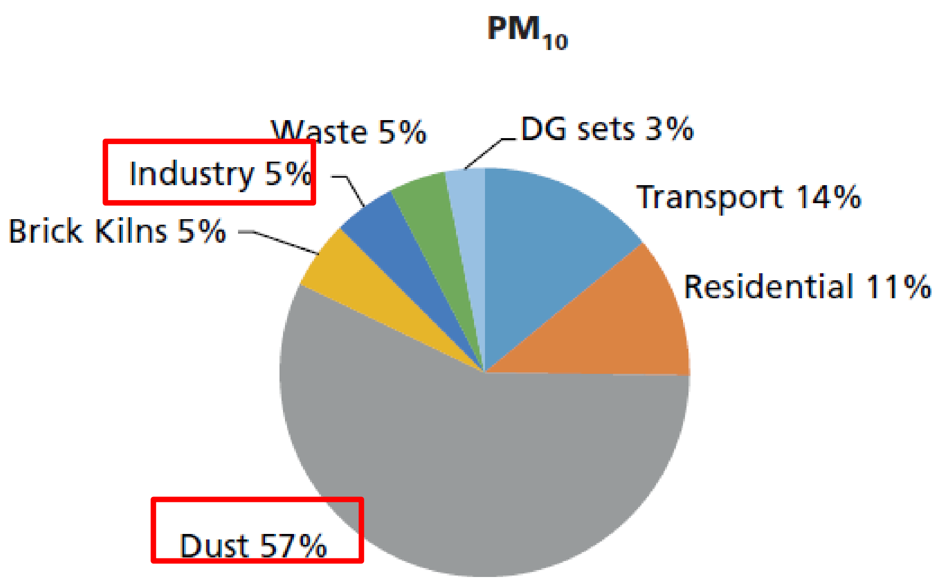
- SCR system construction involves installation of an aqueous ammonia storage tank, vaporizer, mixer and catalyst bed. The installation period is approximately 5 months for a 500 MW unit in ideal situations.

- Down time for both the technology is approximately 1 month.

Coal : source of ambient air pollutant

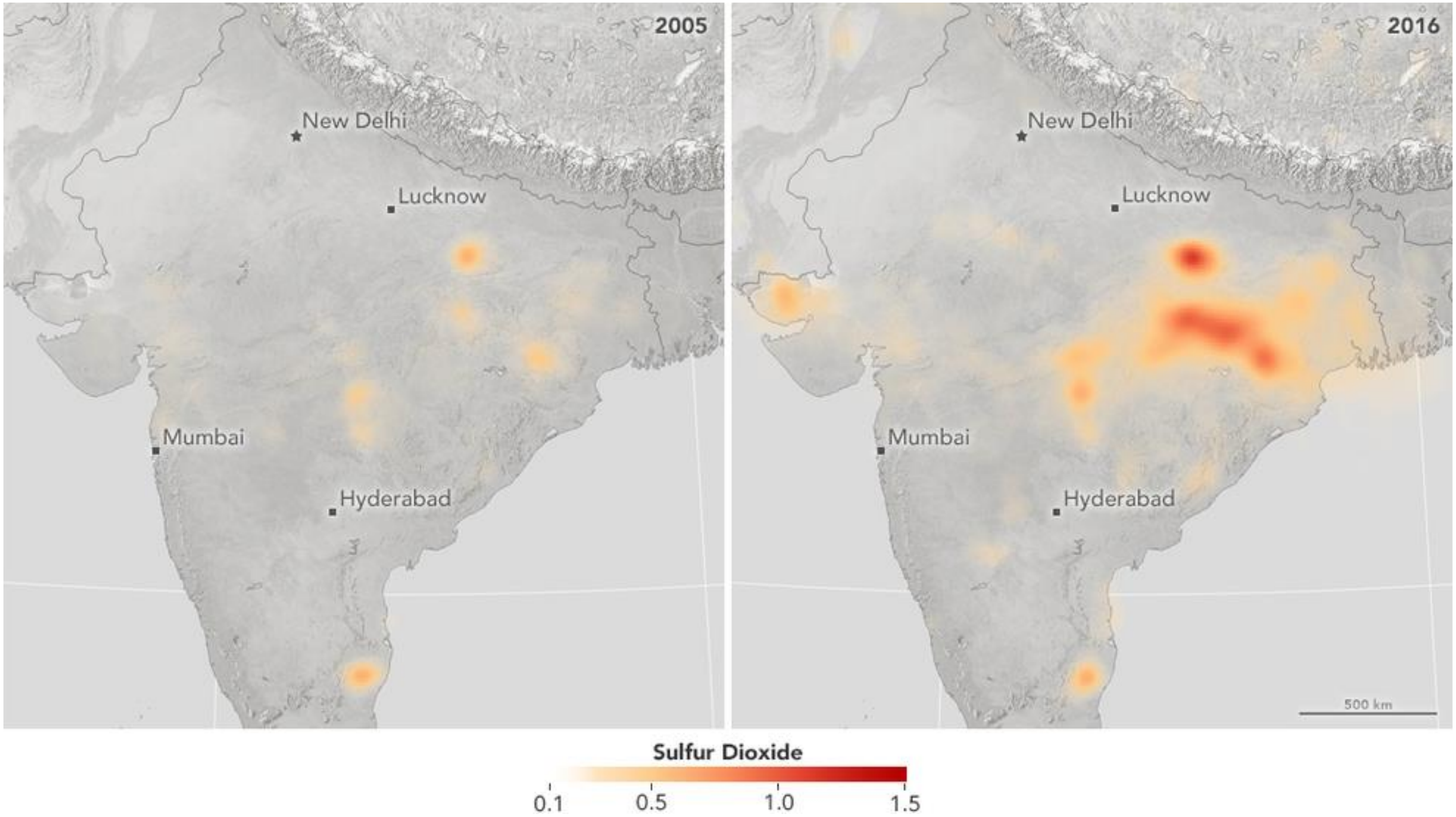
- Coal & related activity – a major source of dust, amongst industry coal power contributes significantly – to ambient air pollution
- Sulphur dioxide triggers more particulate matter formation
- Receptor modelling studies in Delhi – indicated predominantly dust having sulphur based components





Pollution – doubling

- Visible: Satellite imageries (NASA, Sentinel - Copernicus) – indicating doubling of pollution from coal-based thermal power stations



Way forward: Monitoring Strategy

- Regional offices of PCBs can ask plants to:
  - Submit feasibility study reports immediately
  - Submit a detailed implementation plan with key milestones and timelines- Plants Should clearly communicate technology options selected
  - Submit subsequent documents (DPR, Copy of NIT, Detailed engineering report etc.) as per the schedule provided by them in implementation plan
- Field officers and Engineers at regional offices can conduct quarterly visits to take stock of the ground situation
- PCB Head office can:
  - Coordinate the entire process and
  - Take swift remedial/enforcement action in case of delays
  - Update various stakeholders as and when required

CSE – Interventions

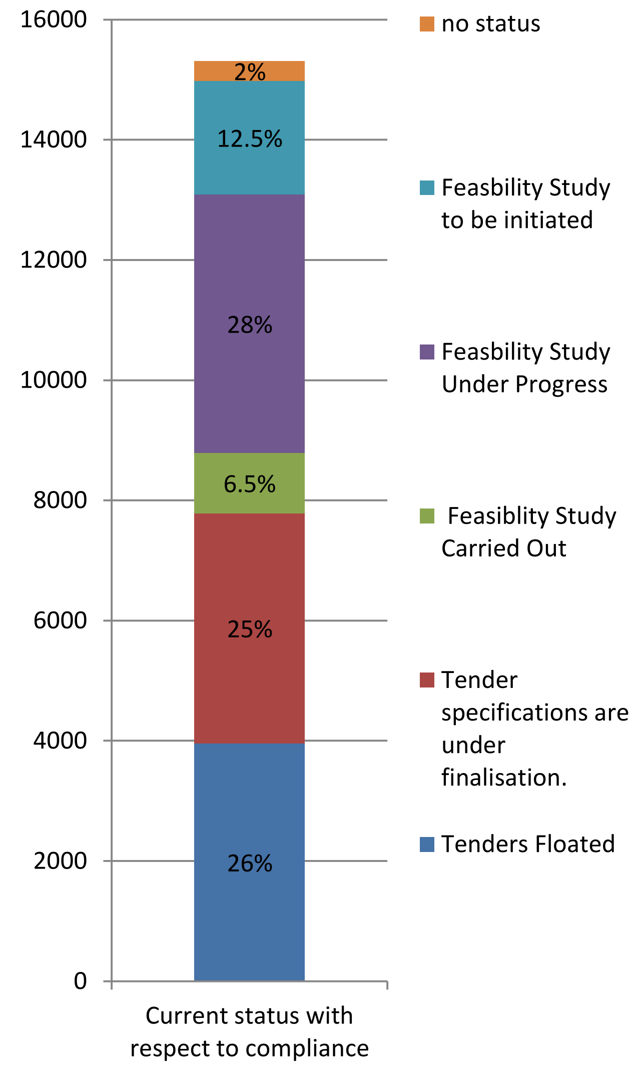
- CSE working since 2012 to improve environmental performance of coal power stations
- Conducted environmental performance assessment and rating of nearly half of India's installed power capacity between 2012 and 2015.
- Rating report: **Heat on Power** released in February 2015 – suggested numerous policy reforms including tighter pollution standards
- Revised emission norms announced by MoEF&CC in December 2015

- **CSE's Current Work:** assist in the implementation of standards
  - Survey of plants to check emissions, technology choices, and implementation plan
  - Track progress made by power stations to achieve compliance
  - Capacity building of power plant officials and regulators
  - Publish policy briefs to overcome bottlenecks (technology, financing..)

CSE State Surveys – M.P & U.P

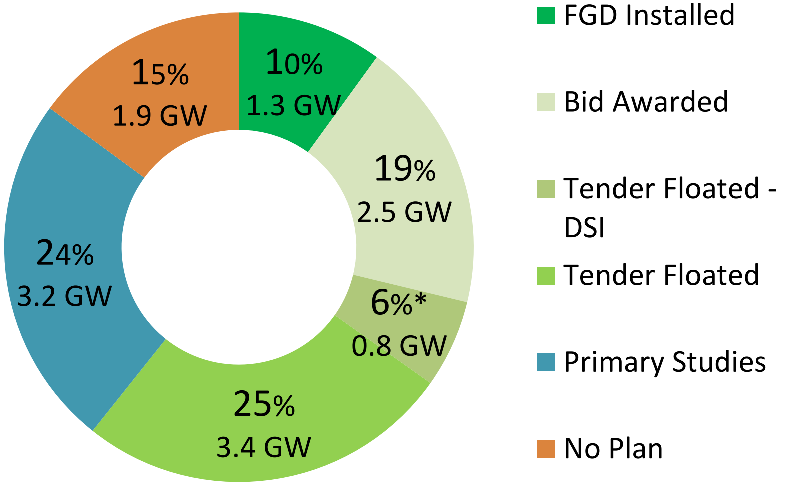
15.7 GW surveyed in partnership with MPPCB and UPRVUNL

- **PM:** 66% capacity compliant (less than 50 emissions), 13% require addition of fields, 21% minor up-gradation
- **SO_2:** Tenders for FGDs floated for only a quarter of the capacity, 40% still at the stage of conducting feasibility studies (see Graph) (about 80% emit over 1000, rest 750-1000)
- **NO_x:** 47 per cent non-compliant - no clarity on compliance plans - (20% emit 300-500, 40% 500-700 (includes few old stations), rest below 300)
- **Water:** 23 per cent non-compliant - no clarity on compliance plans

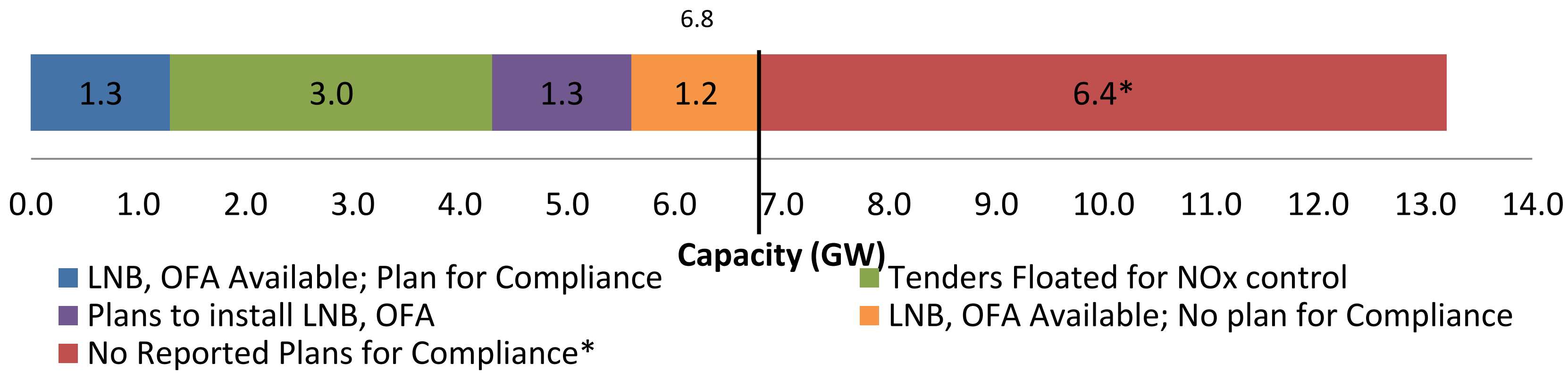


State Surveys – Delhi- NCR

- 13.2 GW surveyed - 2019 deadline
- Most stations falling short but efforts by many
- PM – 8.5 GW report compliance
- FGD installation – DSI opted by smaller units so ~60% may meet by 2020; another 24% completed primary studies, only 15% unclear – mostly old units, likely to close

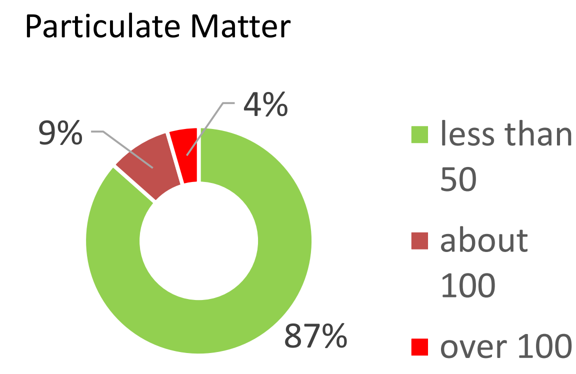


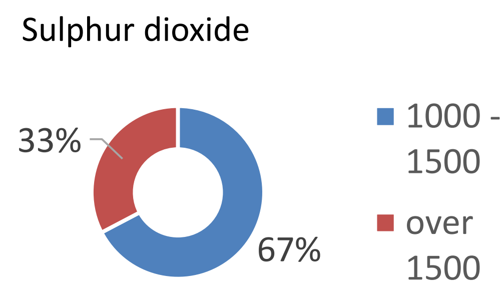
NOx: 6.4 GW (nearly 50%) capacity has not reported any plans to achieve compliance with NOx norms.

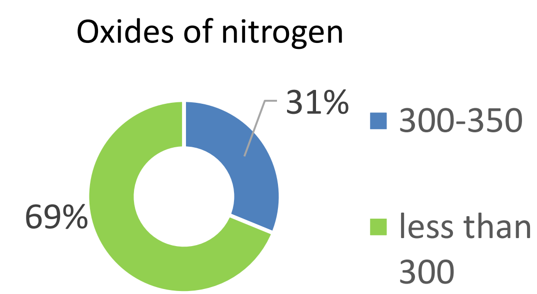


State Survey – Maharashtra

- 6 of 19 Plants, 12 of 23 GW capacity – Survey completed
- PM – largely reported compliance,
- NOx – fair share reported compliance – most units operated at full load during site visit – performance of these units under low load – to be studied
- SO_2 - coal sources – widely varying – stations report to source imported coal (10%), and domestic coal from 20 different sources in a year – truck transport of coal – also observed
  - Private stations – if tenders not awarded by end of this year will miss the deadline
  - State power station – behind schedule







**extrapolated based on lab reports of* 4.7GW out of 9.3GW plant capacity; Chandrapur awaited

Survey - Activity Overview

Multi-pronged strategy to assist in the implementation process:

- **Gather Baseline Data –** Through Questionnaire, Stack Sampling, Corporate level Discussions
- **Review of Plans** – Feasibility reports, technology selection, timelines
- **Provide independent assessment** - Extensive discussions of solutions and recommendations with experts and OEM for quality assurance
- **Timeline formation** and **development of monitoring schedules**
- CSE will prepare **a report summarizing issues and suggested action steps** – submitted to PCB and other regulators
- **Continued engagement post survey** – Technical and policy assistance, monitoring status and reporting to all stakeholders

Survey – Focus areas

- CONTROL ROOM –
  - 1. Secondary air flow dampers, 2. Flue gas system, 3. ESP, 4. FGD, 5. Other efficiency data
- CEMS system
  - 1. Calibration, 2. Instrumentation – at stack
- ESP –
  - 1. Past performance data assessment – insulator failures/vendor assistance difficulty/any other
  - 2. Preventive maintenance practices and annual maintenance practices
- FGD
  - 1. System design & operation – SOP
  - 2. Preventive and annual maintenance practices
  - 3. Performance – data and trends – operating challenges
- COMMUNICATIONS – with MPCB and other env. departments on compliance plans, current data
- OTHERS – Fly ash handling systems, ETPs & STPs

Expected Outcomes

- Emissions quality check – Which forms basis of technology selection
- CEMS check
- Independent assessment of technology plans and suggestions
- Plant by plant report on present status and implementation
- Assistance in developing a monitoring plan
- Assistance in monitoring process through quarterly inputs to potential task force
- Technical assistance/Identification of bottlenecks and their probable solutions
- Build capacity for all stakeholders

Recent Developments

- Compliance initial deadline: by December 2017
- Delay by industry/MoP citing various issues: high ash coal, tech. not available/suitable, inadequate space high cost, long installation time
  - **CSE published series of Policy papers in 2016-17 addressing all of these issues**
- CEA's new position –
  - costs manageable [PM 9 paisa/unit, NO_x 7 paisa/unit, SO_2 30-45 lakhs/MW]
  - Space for FGD at most plants
  - Revised timelines to 2022
- Given little progress by the industry, CEA/MoP issue goes to SC
- **Supreme Court**
  - In Dec 2018 MoP/MoEF file affidavit with committed timeline of Dec 2019 for Delhi-NCR airshed; between 2019-22 for rest;
  - SC unhappy and putting pressure – tighter timelines for densely populated areas and critically polluted
  - Issue of potential penalty for any delay still on table at SC

CSE BEGINS SURVEY IN STATES IN MAY 2017 TO ASSIST IMPLEMENTATION GIVEN DELAYS

Coal mines Odisha – dust level

TABLE 6: **State of the air**
Ambient air quality (in µg/m³) in mining areas of Orissa (2001-02) – concentration of SPM and RSPM is very high

	RSPM		SPM		SO_2		NO_x	
	Max	Min	Max	Min	Max	Min	Max	Min
Lingaraj open-cast mines	377	93	610	336	36.1	16.4	21.1	3.4
Bharatpur open-cast mines	216	91.3	486	63.6	34.6	16.6	16.8	1.86
Ananta open-cast mines	262	57.2	487	180	40.2	12.8	38	3.4
Balanda colliery	246	101	851	295.7	30.4	14.2	19.2	3.2
Kalinga open-cast mines	104.6	–	379.7	80.9	19.2	14.6	16.2	3.6
Jagannath colliery	210	81	600	225.6	38.1	10.2	42	3.1
Hingula open-cast mines	180.3	55.35	402	75.55	36	12.2	10.2	1.82
Belpahar open-cast mines	146.64	52.32	461.12	151.08	–	–	–	–
Lajkura open-cast mines	198.22	65.77	611.54	12.96	–	–	–	–
Lakhanpur open-cast mines	284	63.7	695.51	173	–	–	–	–
Samalesari open-cast mines	273.2	50.4	588.0	180.82	–	–	–	–
Lilari open-cast mines	170.8	70	695.6	142	–	–	–	–
Basundhara open-cast mines	–	–	552	194	–	–	–	–

- Unpaved roads and soil burden erosion – major source of dust from coal mines
- Imposing stringent standards – regular monitoring – help in curbing pollution

New pollution norms – Context

CSE conducted a 2-year study of coal-based power sector's operating and environment performance (released Feb, '15)

- Sample: 47 plants comprising 54 GW capacity - around half of the nation's thermal power sector capacity at that time
- Diversified by size, age, ownership & location
- **Key Findings**
  - Plants operating at **poor efficiency** (India average ~33%), which means high coal usage; around 10% higher CO_2 emissions compared to China
  - **Excessive water use** (around $4m^3$/MWh: China and US use around $2m^3$/MWh)
  - **Very high emissions** from stack - no controls for SOx and NOx
  - Large generation of fly ash that is dumped in ash ponds – pollutes water and fugitive emission
  - Weak monitoring and enforcement – manual testing with little credibility
  - **On top of that, Weak Norms for PM, None for SOx and NOx**
    - **2/3rd not in Compliance with these weak PM norms**