Council of Enviro Excellence

Topic :-
FGD Operations - Case Study NTPC, Dadri

ENvX
3rd NATIONAL POWER-GEN ENVIRONMENT EXCELLENCE SUMMIT & AWARDS 2024

Speaker :-
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CEE-3rd National Power Gen Environment Excellence Summit & Awards 2024

Flue Gas Desulphurization Installation at Dadri A Case Study

Presentation by :
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Ex. GM-Environment Management Group

NTPC LIMITED

- ***NTPC is India's largest power utility with an installed capacity of 76,048 MW (including JVs), plans to become a 130 GW company by 2032. Established in 1975, NTPC aims to be the world's largest and best power major.***

- ***Present installed capacity of NTPC Group is 76,048 MW (including 13,275 MW through JVs/Subsidiaries) comprising of 52 NTPC Stations (27 Coal based stations, 7 gas based stations, 1 Hydro station, 1 small hydro, 16 Solar PV) and 42 Joint Venture stations (9 coal based, 4 gas based, 8 hydro, 1 small hydro 4 Wind and 16 Solar PV)***

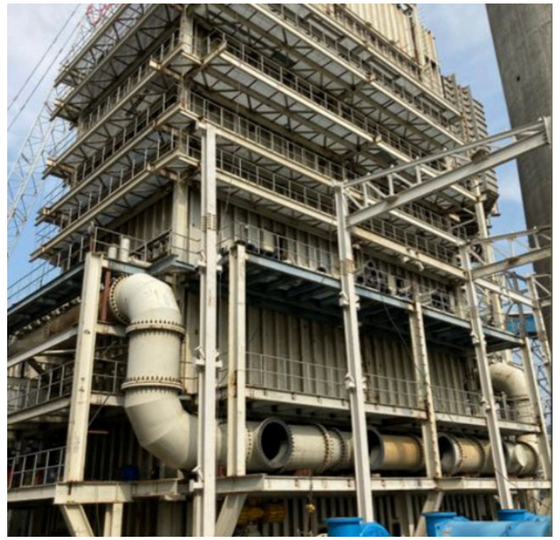
NTPC DADRI OVERVIEW

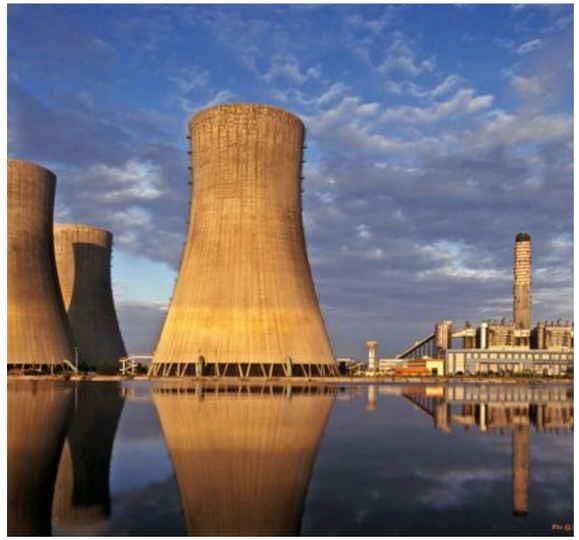
NTPC DADRI- TOTAL INSTALLED CAPACITY

THERMAL-1820 MW
STAGE-I - 840 MW
STAGE-II - 980 MW

GAS PLANT – 829 MW
SOLAR PV- 5 MW

TOTAL ASH GENERATED AT 80%PLF – 24 Lakh MT
FLY ASH – 19.2 LMT
BOTTOM ASH – 4.8 LMT





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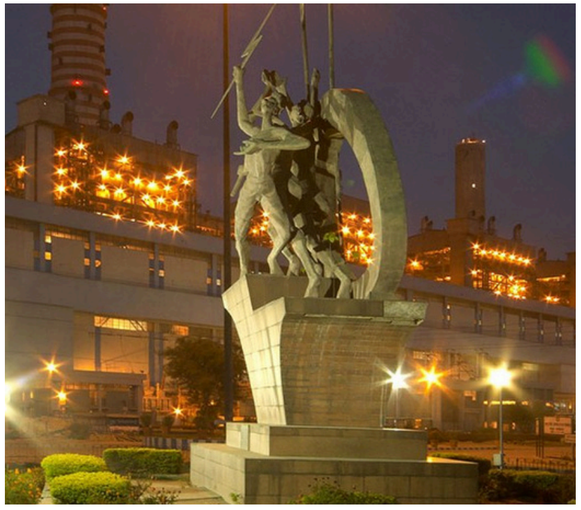
NTPC
A Maharatna Company

DADRI

FLUE GAS DESULPHURIZATION (FGD)



COMBUSTION OF FUEL HAVING SULPHUR RESULTS IN SULPHUR DIOXIDE EMISSION
Coal with 0.5 % Sulphur, Generates SO2 of range 1500 – 2000 mg/Nm3
95-96 % of Sulphur is converted into SO2 , Sulphur content in Indian Coal ranges from 0.25 to 0.5 % and in imported coal it is more than 0.6 %
SO2 emission results in Acid rain, Corrosion of Buildings & Structures and affects Human Health

Wh

In 2015, MOEF issued new environment norms & added three more stack emission norms in December 2015.

- SPM (existing)
- SOx (new)
- NOx (new)
- Mercury (new)
  India made commitments in COP 21 (Conference of the Parties, held in Paris, Dec-2015).
- Achieve about 40 % cumulative installed capacity from non-fossil.
- Introducing new, more efficient, cleaner technologies in thermal power generation.

Emission parameter	TPPs(units) installed before 31.12.2003 (**Stage-I, 210 MW Units**)	TPPs(units) installed after 31.12.2003-31.12.2016 (**Stage-II, 500 MW Units**)	TPPs (units) Installed from 01.01.2017	Initiative by NCPS Dadri	Target Date
Particulate Matter (PM)	100 mg/Nm3	50/Nm3	30 mg/Nm3	ESP since inception of units	Emission standards met through existing ESP only
SOx	600mg/Nm3	200mg/Nm3	100 mg/Nm3	FGD for Stg-II, DSI System for Stg -I	FGD commissioned in Unit# 5 on 31.12.2021 & Unit # 6 on 08.02.2024
NOx	600 mg/Nm3	300mg/Nm3	100 mg/Nm3	Combustion Modification in Stg- II	SOFA system installed in Unit # 5&6 in March' 2019

FGD Implementation at Dadri

As per MoEF & CC directives, Dec' 2015 w.r.t. new emission norms both the conditions are applicable on Dadri Station. Dadri stage-I commissioned before 31.12.2003 and Stage-II commissioned during July, 2010.

- Limits of Particulate Matters (PM) for Dadri station is 100 mg/Nm3 and 50mg/Nm3 respectively stacks of Stage-I & II which is being met through high efficiency Electro Static Precipitator (ESP).
- Limits of NOx for Dadri station is 600 mg/Nm3 and 450 mg/Nm3 respectively for stage-I&II which had met through combustion modification which has done in Dec' 2019.
- Limits of SOx for Dadri station is same i.e. 600 mg/Nm3. For stage-I units Dry FGD (DSI-Dry Sorbent Injection) has implemented between Dec' 2019 to July' 2020 which is in operation.
- Flue Gas Desulphurisation (FGD) in Unit # 5 implemented in June' 2022 and in Unit # 6 is in Feb' 2024.

Dadri is the first plant to implement DSI and FGD in retrofit

Chemical Reaction

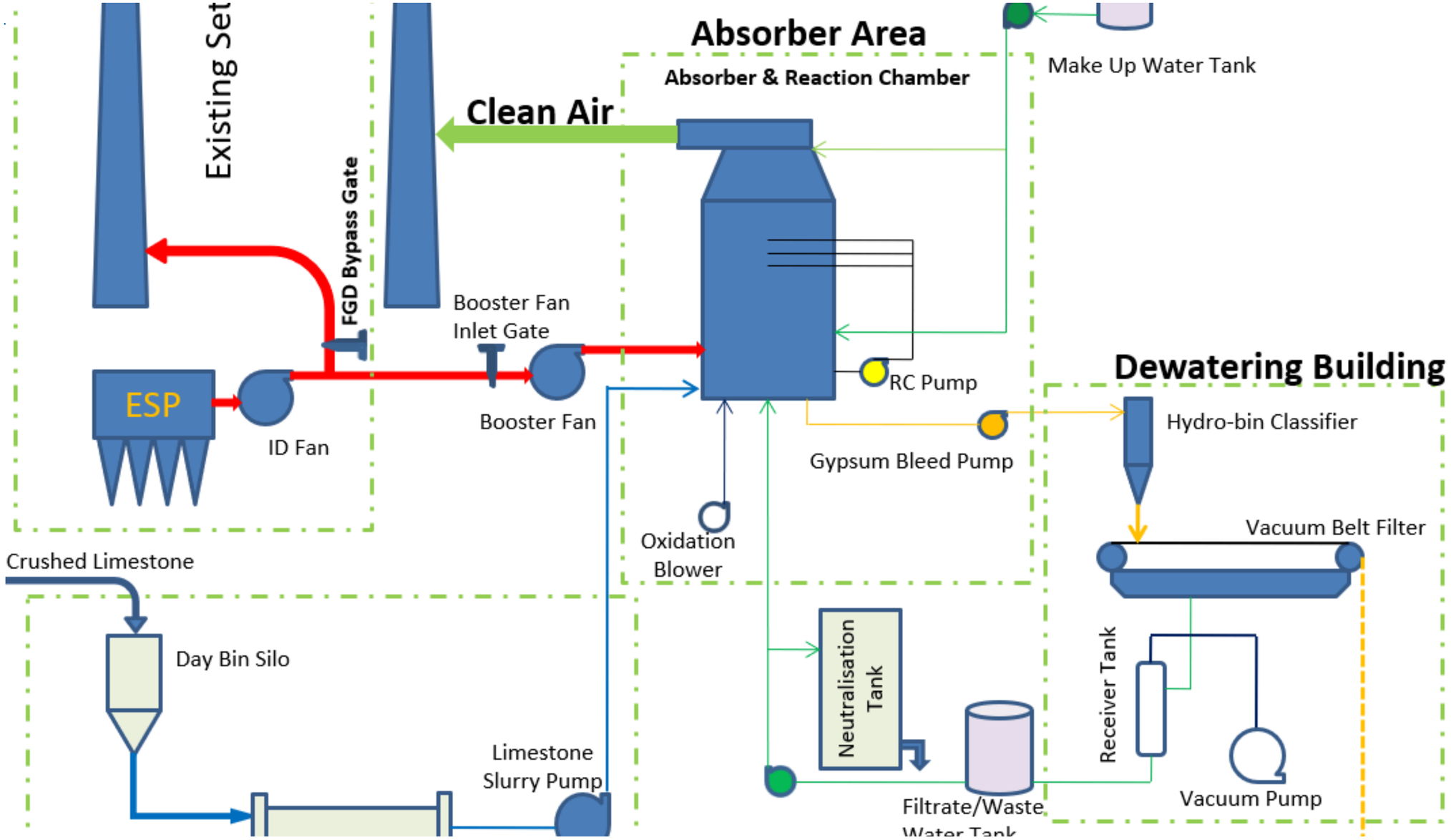
Sulphur Oxides (SOX) + Lime Stone ($CaCO_3$) = Gypsum ($CaSO_4.2H_2O$)

$CaCO_3$ (Limestone) + H_2O = $Ca(OH)_2$ + CO_2

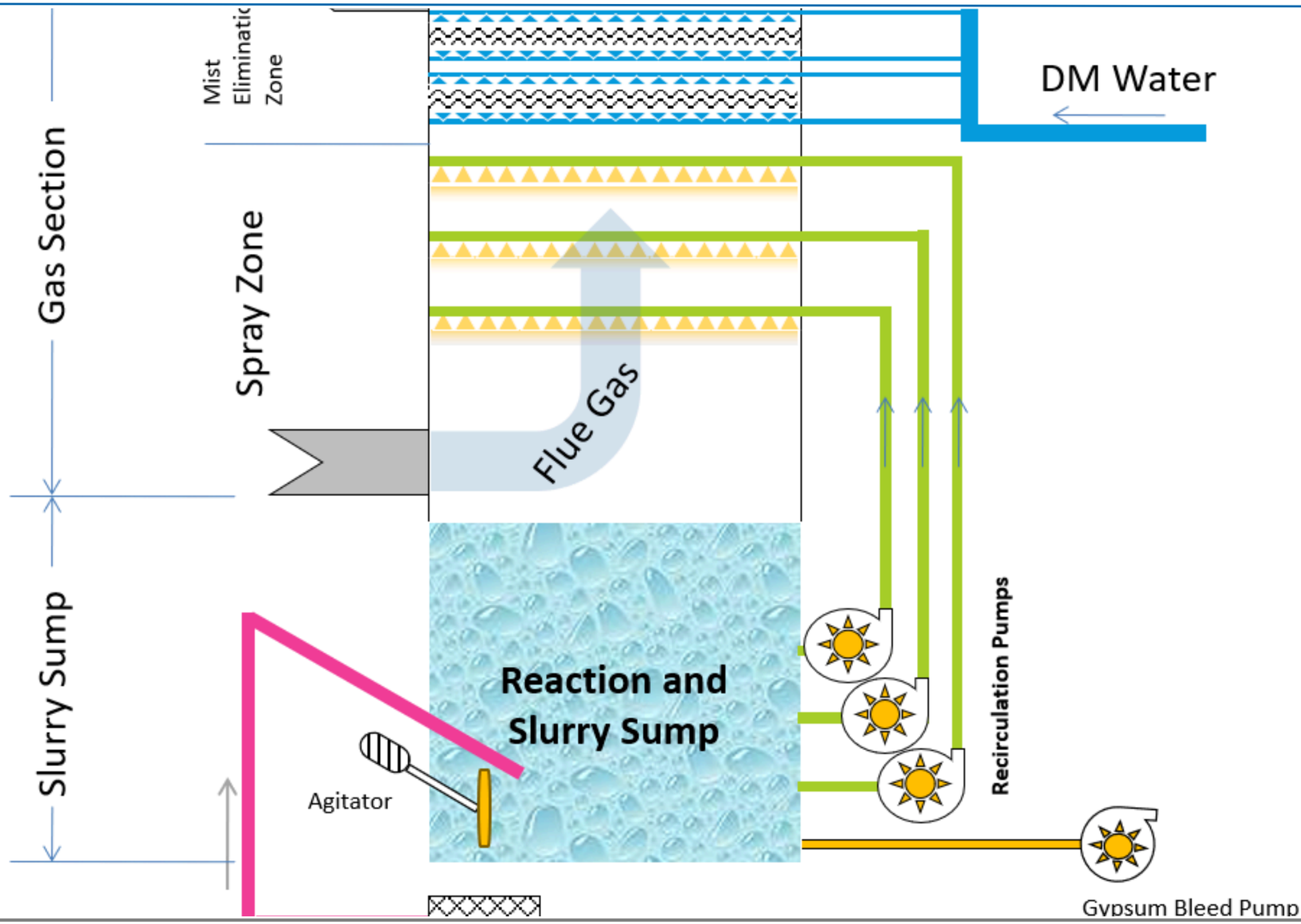
$Ca(OH)_2$ + SO_2 = $CaSO_3$ + H_2O

$CaSO_3$ + $3H_2O$ + 1/2 O_2 = $CaSO_4.2H_2O$(Gypsum) + H_2O

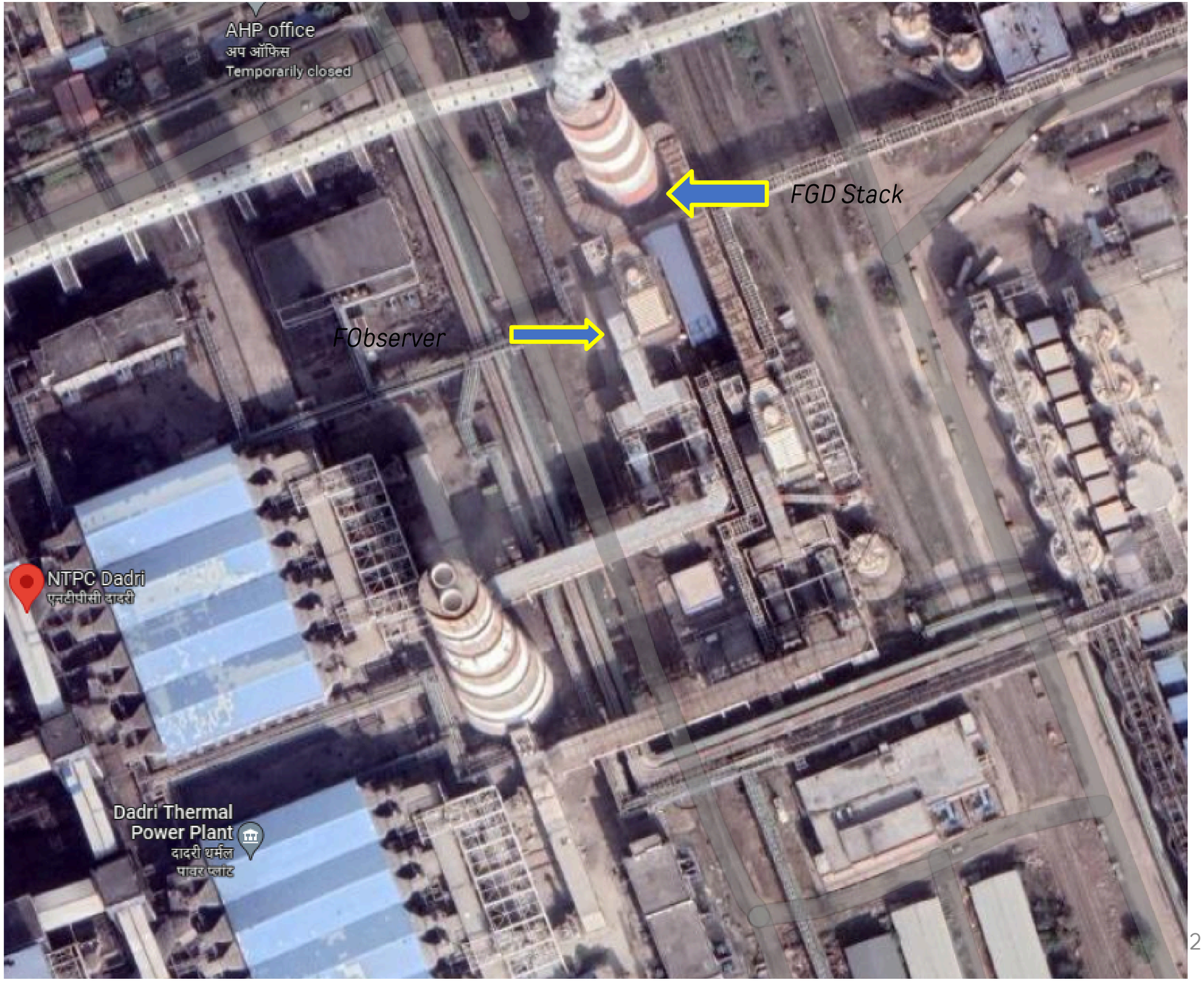
- Limestone consumption Rate : approx 8.79 MT/Hr/unit
- Gypsum Production Rate : approx 14.55 MT/Hr/unit



Absorber Tank Details



Arial view of FGD



Actual Site Photographs of FGD..

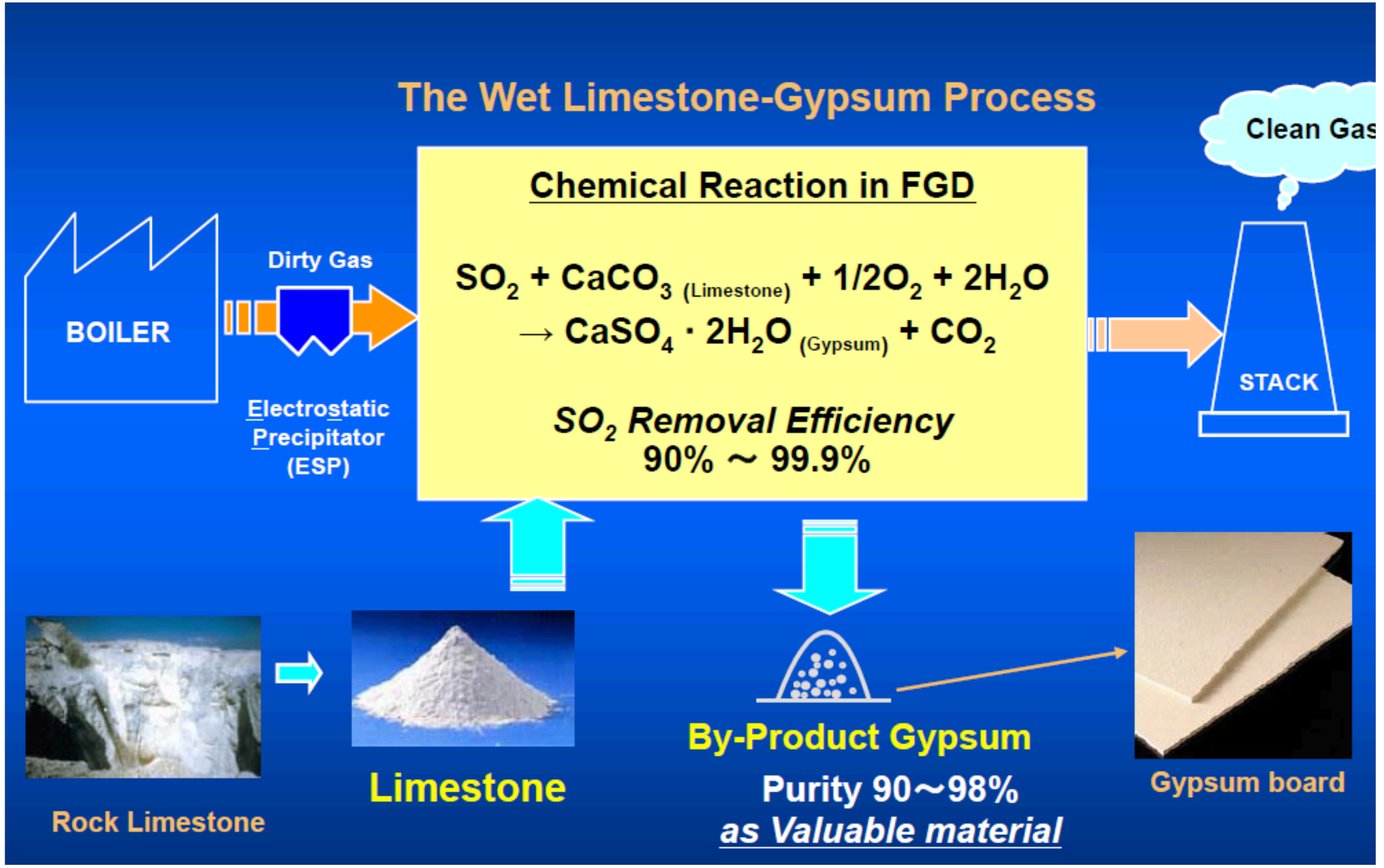
In a flue gas desulphurization system (FGD), Sulphur compounds are removed from the exhaust emissions of fossil-fueled power stations. This is done by means of an industrial process through the addition of absorbents

The Chemical reaction in FGD (Absorber tower)

$CaCO_3 + SO_2 + 3H_2O + 1/2O_2 = CaSO_4.2H_2O + CO2 + H_2O$

(limestone) (Flue gas) (Oxidation) (Gypsum)

WET LIMESTONE FGD SYSTEM



BASIC CHEMISTRY OF FGD SYSTEM

SULPHUR DI OXIDE (SO_2) 3.2 T/Hr

LIMESTONE ($CaCO_3$) 8.79 T/Hr

GYPSUM ($CaSO_4.2H_2O$) 14.55 T/Hr

CHEMICAL REACTION

$$CaCO_3 \text{ (Limestone)} + H_2O = Ca(OH)_2 + CO_2$$
$$Ca(OH)_2 + SO_2 = CaSO_3 + H_2O$$
$$CaSO_3 + 3H_2O + 1/2O_2 = CaSO_4.2H_2O \text{(Gypsum)} + H_2O + CO2$$

SOx Control Parameters After FGD Installation

Time	Stack_ Boiler FGD 5 NOX (mg/nm³)(avg)	Stack_ Boiler FGD 5 PM (mg/nm³)(avg)	Stack_ Boiler FGD 5 SOX (mg/nm³)(avg)	Stack_ Boiler FGD 6 NOX (mg/nm³)(avg)	Stack_ Boiler FGD 6 PM (mg/nm³)(avg)	Stack_ Boiler FGD 6 SOX (mg/nm³)(avg)
2024-04-27 00:00:00:000	121.23	N/A	18.82	247.96	0.48	12.37
2024-04-28 00:00:00:000	N/A	N/A	N/A	237.17	1.12	18.31
2024-04-29 00:00:00:000	123.26	1.47	19.9	188.07	1.35	12.25
2024-04-30 00:00:00:000	144.77	1.61	18.17	239.9	2.21	13.06
2024-05-01 00:00:00:000	155.36	1.7	18.34	306.6	1.17	12.85
2024-05-02 00:00:00:000	152.8	1.81	16.01	342.86	1.48	10.82
2024-05-03 00:00:00:000	120.77	1.92	24.24	205.47	0.94	17.6
2024-05-04 00:00:00:000	142.45	1.2	27.17	258.39	1.17	16.38
2024-05-05 00:00:00:000	32.55	0.97	4.95	205.21	1.3	16.83
2024-05-06 00:00:00:000	18.98	0.81	3.88	173.86	0.71	12.21
2024-05-07 00:00:00:000	17.7	0.85	3.26	208.03	0.76	11.65
2024-05-08 00:00:00:000	95.56	0.79	20.92	231.67	0.72	10.5
2024-05-09 00:00:00:000	131.9	0.62	13.63	186.35	0.28	7.91
2024-05-10 00:00:00:000	122.69	0.68	16.53	214.1	0.36	10.17
2024-05-11 00:00:00:000	136.71	0.71	15.26	200.52	0.81	9.57
2024-05-12 00:00:00:000	138.09	0.72	15.74	163.21	0.75	11.44
2024-05-13 00:00:00:000	146.25	0.64	16.21	171.64	0.45	11.22
2024-05-14 00:00:00:000	119.63	0.66	18.13	191.09	0.51	12.87
2024-05-15 00:00:00:000	134.42	0.66	21.88	197.52	0.99	13.04
2024-05-16 00:00:00:000	146.01	0.7	19.59	192.68	1.02	15.29
2024-05-17 00:00:00:000	128.06	0.71	17.24	203.63	1.73	18.54
2024-05-18 00:00:00:000	156.39	0.77	23.31	254.78	1.62	16.89
2024-05-19 00:00:00:000	148.2	0.71	20.77	267.79	1.82	11.04
2024-05-20 00:00:00:000	168.04	0.63	21.16	256.73	0.96	12.86
2024-05-21 00:00:00:000	183.89	0.61	20.09	226.82	0.69	11.09

LIMESTONE CONSUMPTION AND GYPSUM PRODUCTION

CONSUMPTION OF LIMESTONE	
PER HOUR per unit-	8.79 MT/Hr
PER YEAR for 2 units-	1,54,000 MT /Year
COST OF LIMESTONE CONSUMPTION-	34 Crore/Year (Approx.)
PRODUCTION OF GYPSUM	
PER HOUR per unit –	14.55 MT
PER YEAR for 2 Units–	2,54,916 MT
Expected Revenue for Selling of Gypsum:	37 Crore/Year (Approx.)

EFFICIENCY

SO2 REMOVAL EFFICIENCY	
SO2 IN FLUE GAS-	3.2 T/Hr , 2025 mg/NM3
SO2 IN CLEAN FLUE GAS	< 200 mg/NM3
DESIGN EFFICIENCY-	95.06%

Impact of FGD on ECR / tariff

1. Due to 1% increase in IRR as per CERC recommendation	**3.81 paisa/unit**
2. Due to Limestone Consumption	**2.66 paisa /unit**
3. Increase in Fixed Charges	**15.9 paisa/unit**
Total	**22.37 paisa/unit**

Effect on ECR of FGD installation at Dadri Station

Due to APC			
	Unit	**Before FGD**	**After FGD**
Heat Rate	Kcal/Kwh	2363	2363
APC	%	**5.75**	**6.75**
Sp oil consumption	ml/kwh	**0.5**	**0.5**
CV of Coal	Kcal/kg	3646	3646
CV of Oil Kcal	Kcal/l	9800	9800
Land cost of Coal	Rs/MT	5140	5140
Land cost of oil	Rs/KL	46500	46500
ECR (paise)/KWh		**355.11**	**358.92**
Increase in ECR due to increase in APC(a)	**Ps/kwh**		**3.81**

Due to Limestone Consumption			
Normative specific limestone consumption (Assuming 0.36% of Sulpher content in Dadri coal) using formula **35.2 X Normative Heatrate X Sulpher content of coal(%) / GCV of coal**	kg/kwh		0.008
Landed cost of limestone (As per PO Cost of limestone 500 Rs/MT+ Cost of Transportation 2475 Rs/MT)	Rs/MT		3025
Increase in ECR due to limestone consumption(b)	**Ps/Kwh**		**2.66**

EFFECT ON FIXED CHARGE

	IN CR
Total Project cost of FGD with GST	559.07
Debt @ 70%	391.35
Eqity @ 30%	167.72
Return on equity @15.5% and effective tax rate @ 24% (A)	34.21
Interest on loan @ 8.5% (B)	33.26
Depreciation @ 5.28 % (C)	29.52
O&M Expenses @ 2% of project cost (D)	11.18
Total Annual fixed cost due to Add Cap for FGD (A+B+C+D)	**108.17**

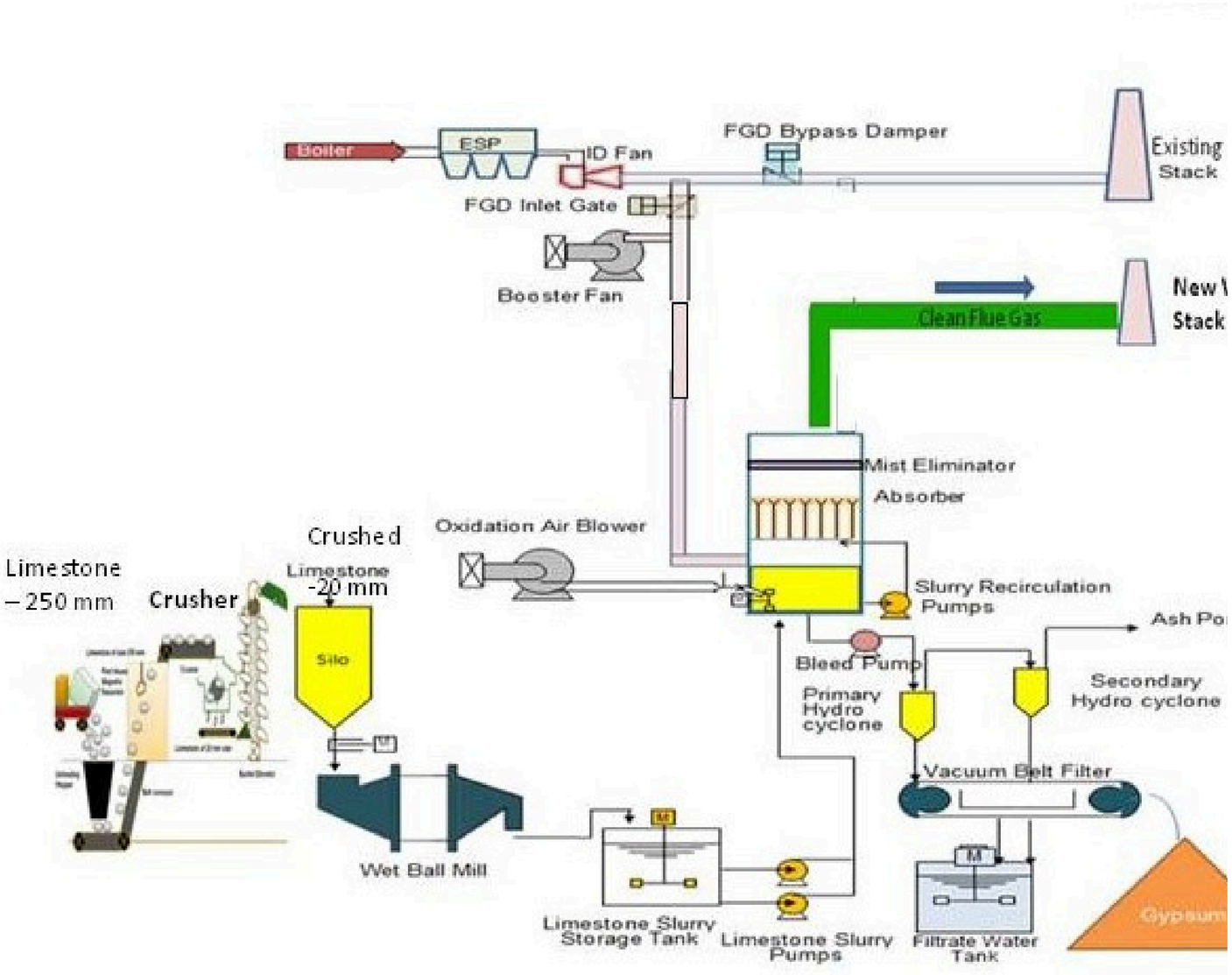
Capacity	980 MW
Normative DC @ 6.75% APC	913.9 MW
Annual DC @ 100 Availability	8005.3 Mu
Normaitve DC @ 85% Availability	***6804.5 Mus***
Increase in Fixed charges due to FGD(c)	**15.90 Ps/KWh**
Total effect on Tariff due to FGD(a+b+c)	**22.37 Ps/KWh**

FGD Characteristics	
Name of the Petitioner	NTPC LIMITED
Name of the Generating Station	National Capital Power Station
Unit(s)/Block(s)/Parameters	Stage-II(2x490MW)
Installed Capacity (MW)-Coal Based	1820 MW Stage-I(4x210 MW) +Stage-II(2x490 MW)
Actual COD	Unit-5: 15.06.2022
Type of System	Flue Gas Desulfurization System (FGD)
Name of the FGD Manufacturer	BHEL
Design Flue Gas Quantity at WFGD inlet	982 m3/sec
Design Flue Gas Quantity at WFGD outlet	809 m3/sec
Design Coal Sulphur Content	0.49%
Design Sox At Inlet	1957 mg/Nm3 (w)
Design Sox at Outlet	100 mg/Nm3 (d)
Design FGD Effeciency	95.06
Reagent Details	Limestone

Special Features/Site Specific Features	control of SO2 in Dadri Stage-II (2X490 MW) units. • This process is suitable for large-scale flue gas treatment, and uses a low-cost absorbent (limestone), and produces stable and valuable by-products (gypsum). • The flue gas is drawn from the boiler into the FGD ductwork and forced into the absorber tower by Booster Fans. • In the Absorber warm exhaust gases from the coal-fired boiler come into contact with limestone slurry which is sprayed through nozzles using Slurry Recirculation Pumps. • When the warm gas comes into contact with the limestone slurry a chemical reaction occurs between the Sulphur Dioxide (SO2) in the gas and the limestone. This reaction removes the SO2 from the flue gases and converts the limestone into

Special Features/Site Specific Features	• This Calcium Sulphite and limestone slurry then falls to the base of the absorber where it is injected with compressed air. The compressed air oxidises the calcium sulphite and converts it to Calcium Sulphate – commonly known as gypsum. • This reaction removes the sulphur dioxide from the flue gases. • The clean gas is exhausted through a new borosilicate lined chimney after removal of entrapped moisture in the 3 stage mist eliminators installed inside the Absorber.
Special Technological Features	• MHPS ,Japan is the technology collaborator of BHEL for the FGD System . MHPS double contact flow scrubber with single tower has been installed at Dadri.

Details pertaining to technology used for SOX control and its mechanism



Wet Limestone based FGD technology has been employed for control of SO2 in Dadri Stage-II (2X490 MW) units. This process is suitable for large-scale flue gas treatment, and uses a low cost absorbent (limestone), and produces stable and valuable by-products (gypsum).Typical system flow is shown below.

Details pertaining to technology used for SOX control and its mechanism

- The flue gas is drawn from the boiler into the FGD ductwork and forced into the absorber tower by a Booster Fans.
- In the Absorber warm exhaust gases from the coal-fired boiler come into contact with limestone slurry which is sprayed through nozzles using Slurry Recirculation Pumps.
- When the warm gas comes into contact with the limestone slurry a chemical reaction occurs between the Sulphur Dioxide (SO2) in the gas and the limestone. This reaction removes the SO2 from the flue gases and converts the limestone into Calcium Sulphite.
- This Calcium Sulphite and limestone slurry then falls to the base of the absorber where it is injected with compressed air. The compressed air oxidises the calcium sulphite and converts it to Calcium Sulphate – commonly known as gypsum. This reaction removes 92-95% of the sulphur dioxide from the flue gases.

Details pertaining to technology used for SOX control and its mechanism

The process chemistries in Absorber are as follows:

1.	$SO_2 + H_2O$	$\longleftrightarrow$ H_2SO_3	*Absorption*
2.	$CaCO_3 + H_2SO_3$	$\longrightarrow$ $CaSO_3 + CO_2 + H_2O$	*Neutralization*
3.	$CaSO_3 + ½\ O_2$	$\longrightarrow$ $CaSO_4$	*Oxidation*
4.	$CaSO_3 + ½\ H_2O$	$\longrightarrow$ $CaSO_3 + ½\ H_2O$	*Crystallization*

The clean gas is exhausted through a new borosilicate lined chimney after removal of entrapped moisture in the 3 stage mist eliminators installed inside the Absorber.

Reaction at serial no 5 shows the waste produced is Gypsum and same is sold to various vendors.

GYPSUM SALES DETAILS 01.06.2022-30.11.2022

S.NO	NAME OF AGENCY	TOTAL CONTRACT QUANTITY MT	Total Lifted Quantity MT
1	Ambuja Cements Ltd	20000	2992.47
2	Kanodia Cements Ltd		4562.2
3	Shree Cements Ltd		6071.88
4	Ultratech Cements Ltd		3311.21
Total			16937.76

GYPSUM SALES DETAILS 01.12.2022-31.05.2024

S.NO	NAME OF AGENCY	TOTAL CONTRACT QUANTITY MT	Total Lifted Quantity MT 22-23	Total Lifted Quantity MT 23-24 Till 31.03.2024	Total Lifted Quantity MT 24-25 Till 31.05.2024
1	Ambuja Cements Ltd	80000	1831.39	868.39	13357.21
2	Kanodia Cements Ltd		1899.75	760.18	-
3	Shree Cements Ltd		5308.02	960.29	5206.27
4	Ultratech Cements Ltd		1743.77	571.09	-
5	Garg Build Solutions		160.86	0	-
6	JK Cements Ltd		2830.44	966.38	-
7	Knaut India Pvt Ltd		1241.26	846.43	942.65
(Gypsum sale price@ Rs 1935-1954/Ton) Total			15015.49	4972.76	19506.13

Lime stone landed price at Dadri= Rs 2260 / ton

THANKS

ANY QUESTIONS ?

Thanking You on Behalf of !

Council of Enviro Excellence