

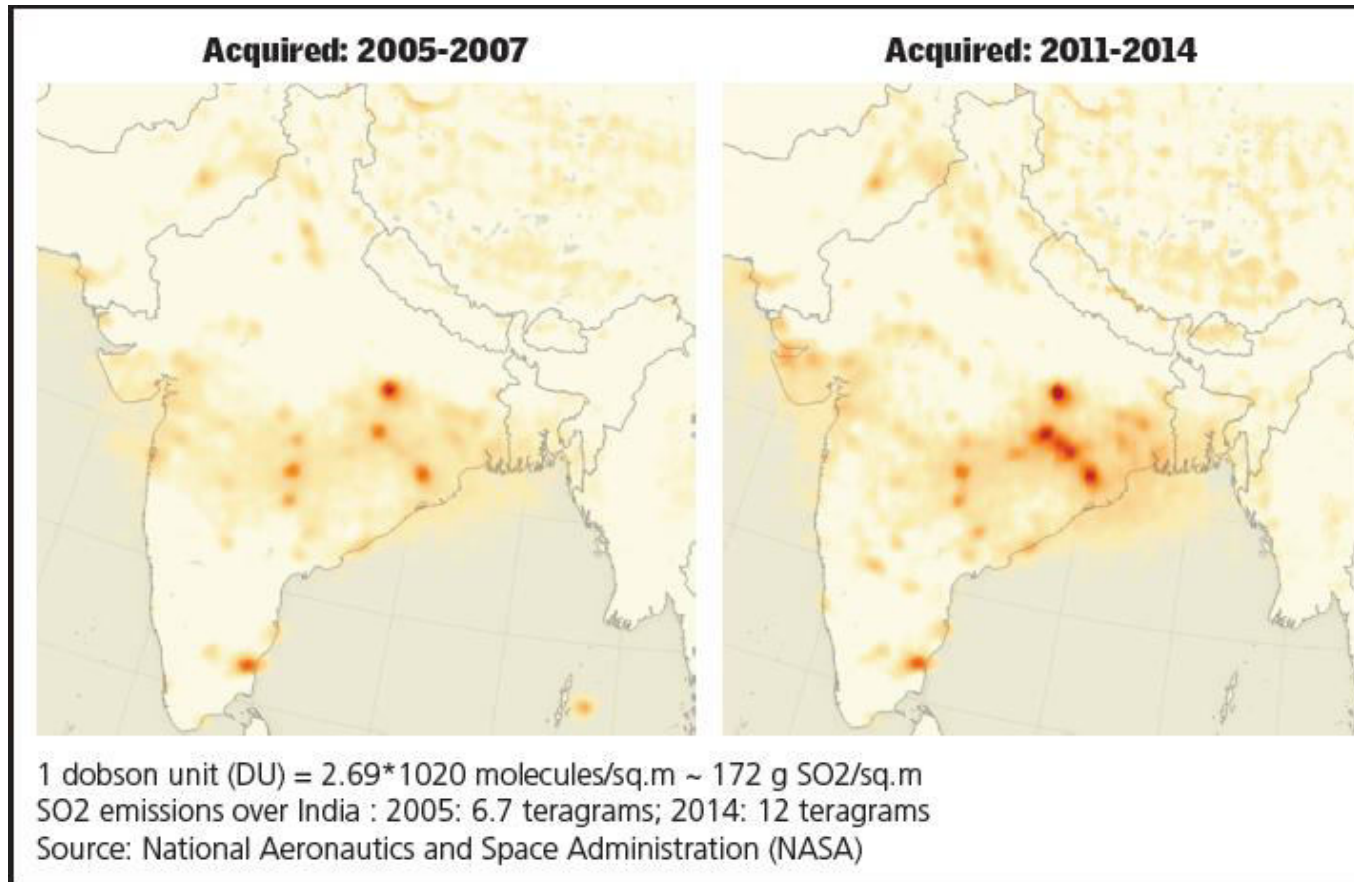


Flue gas desulphurization

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Sulphur dioxide - Issue



- Images from Aura Satellite showing increasing sulphur di oxide concentration over India
- India's ambient sulphur dioxide concentration has doubled in seven years

Lower Sulphur coal then why it is an issue?

- Calorific value of coal – Quantity – emissions

	Imported	Indian
Coal used in kg per unit power	0.45	0.90
Percent sulphur in coal	1.0	0.5
Sulphur in coal in kg per unit power	0.005	0.005
Sulphur dioxide in kg per unit power	0.009	0.009

Sulphur di oxide: Control

- SO₂ 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.

BEFORE COMBUSTION

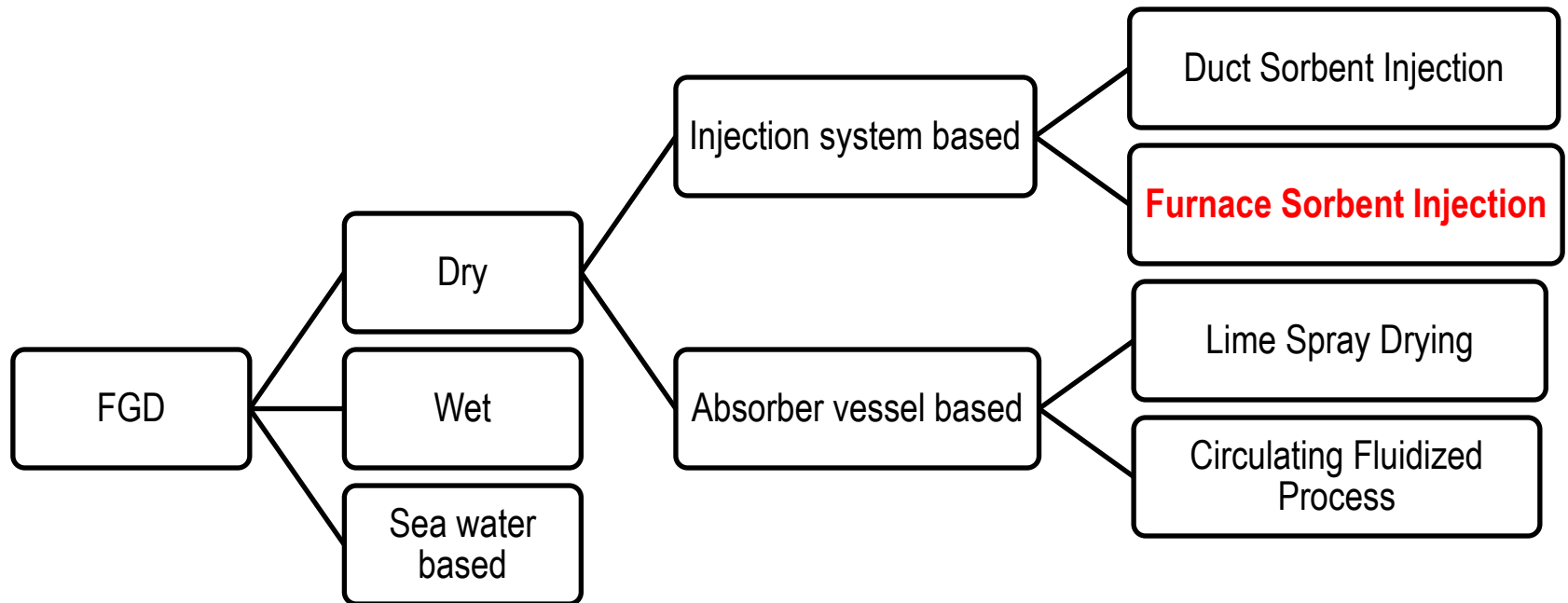
Lowering Sulphur content in fuel

- Sulphur in coal – Pyritic sulphur and organic sulphur
- Removing organic sulphur difficult
- 50% of pyritic sulphur can be removed by washing coal

Emissions Range

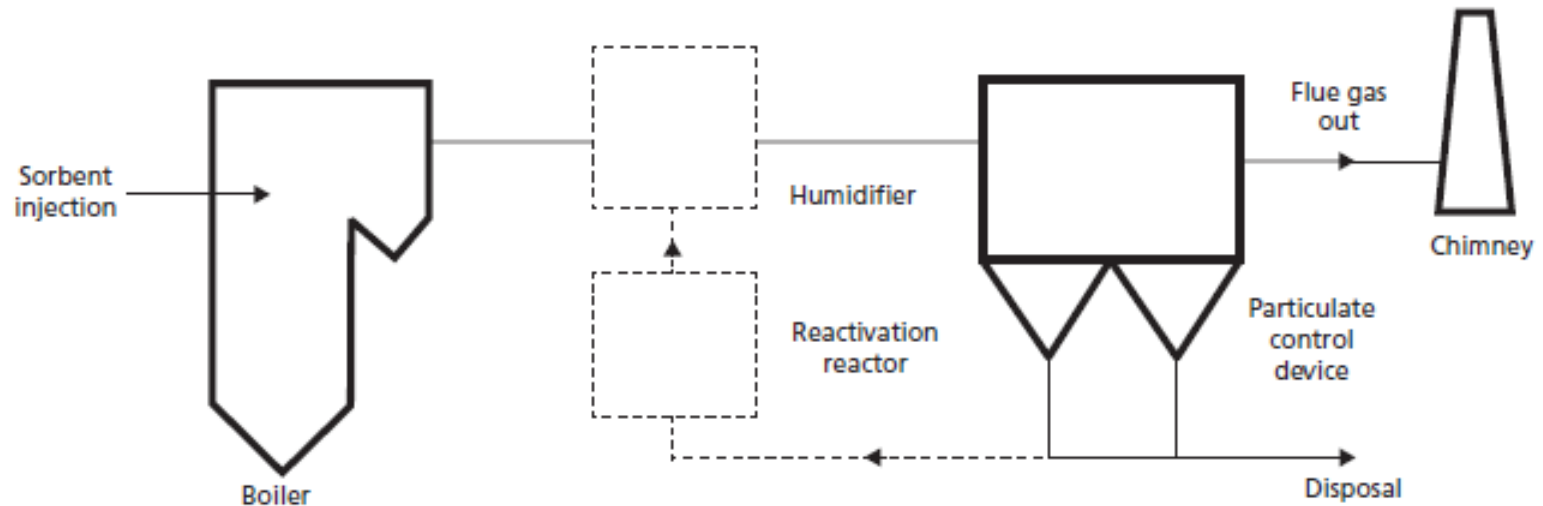
Sulphure in Coal	SO ₂ emission	
	Indian Coal	Imported Coal
NCV (Kcal/kg)	4100	5500
Wt%	mg/Nm ³	mg/Nm ³
0.1	258	190
0.2	516	380
0.3	775	570
0.4	1033	760
0.5	1291	950
0.6	1549	1140
0.7	1808	1330
0.8	2066	1520
0.9	2324	1710
1.0	2582	1900
1.2	3099	2280
1.4	3615	2660
1.6	4132	3040
1.8	4648	3420
2.0	5165	3800
2.2	5681	4180
2.4	6198	4559
2.6	6714	4939
2.8	7231	5319
3.0	7747	5699

Types



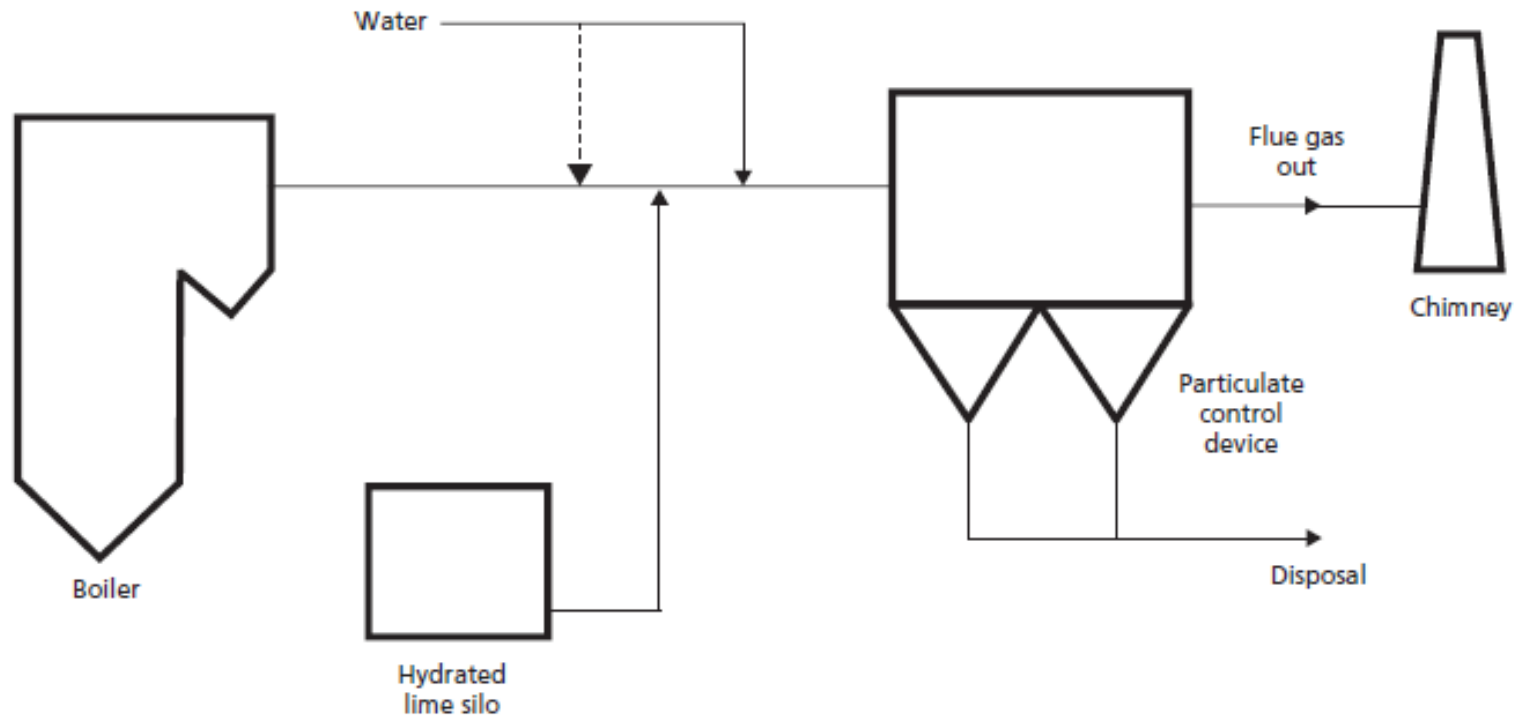
DRY FGD - INJECTION SYSTEMS

Furnace Sorbent injection



In this process, dry sorbent is injected directly into the furnace in the optimum temperature region above the flame. As a result of high temperature (approximately 1,000 °C), sorbent particles decompose and becomes porous solids which aids in absorption of SO₂ and removal.

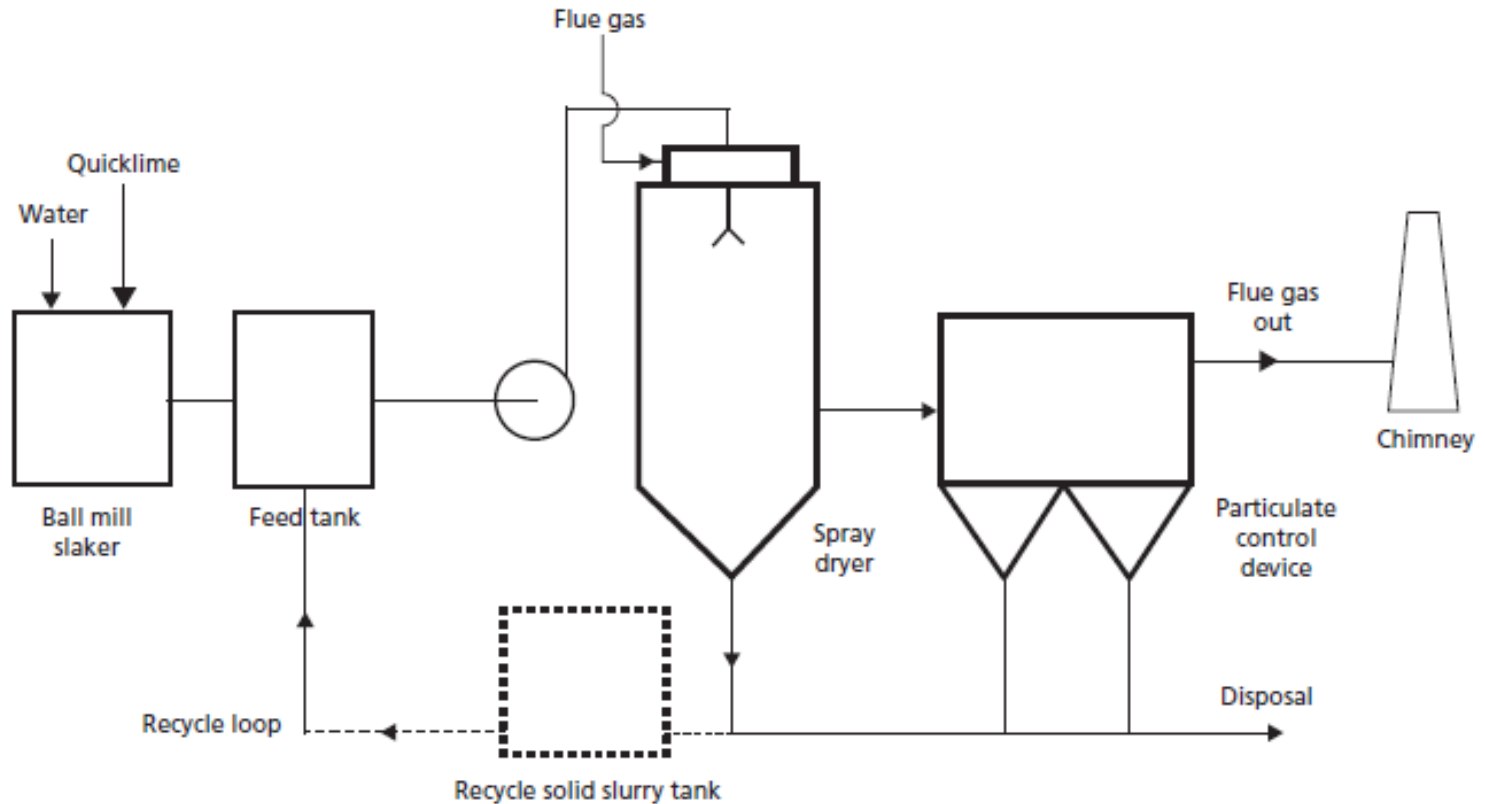
Duct Sorbent Injection



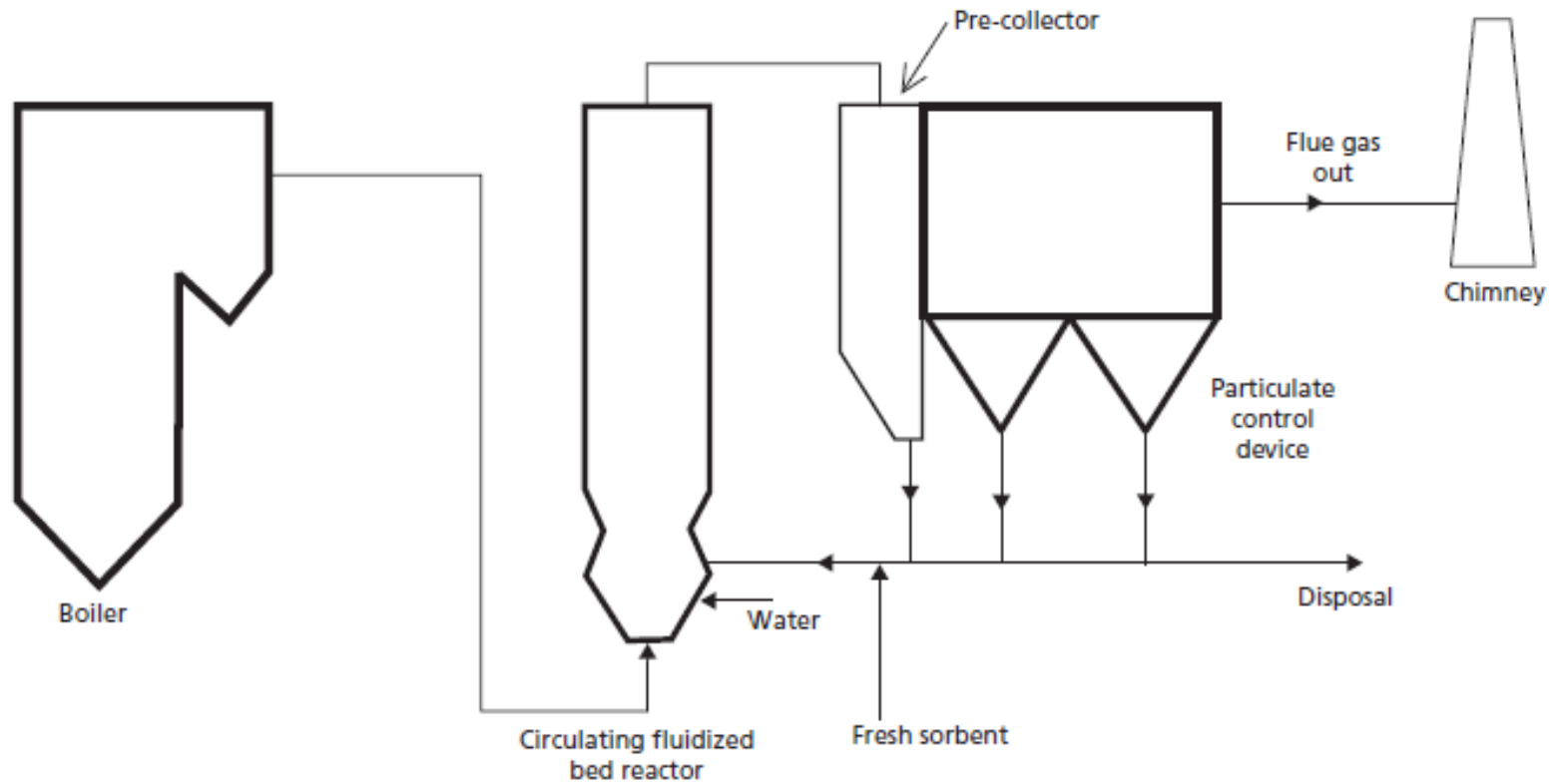
In this system, sorbent is injected into the flue gas downstream in the boiler's air pre-heater. The injector positions are optimized to maximally promote suspension of the sorbent particles.

DRY FGD - VESSEL SYSTEMS

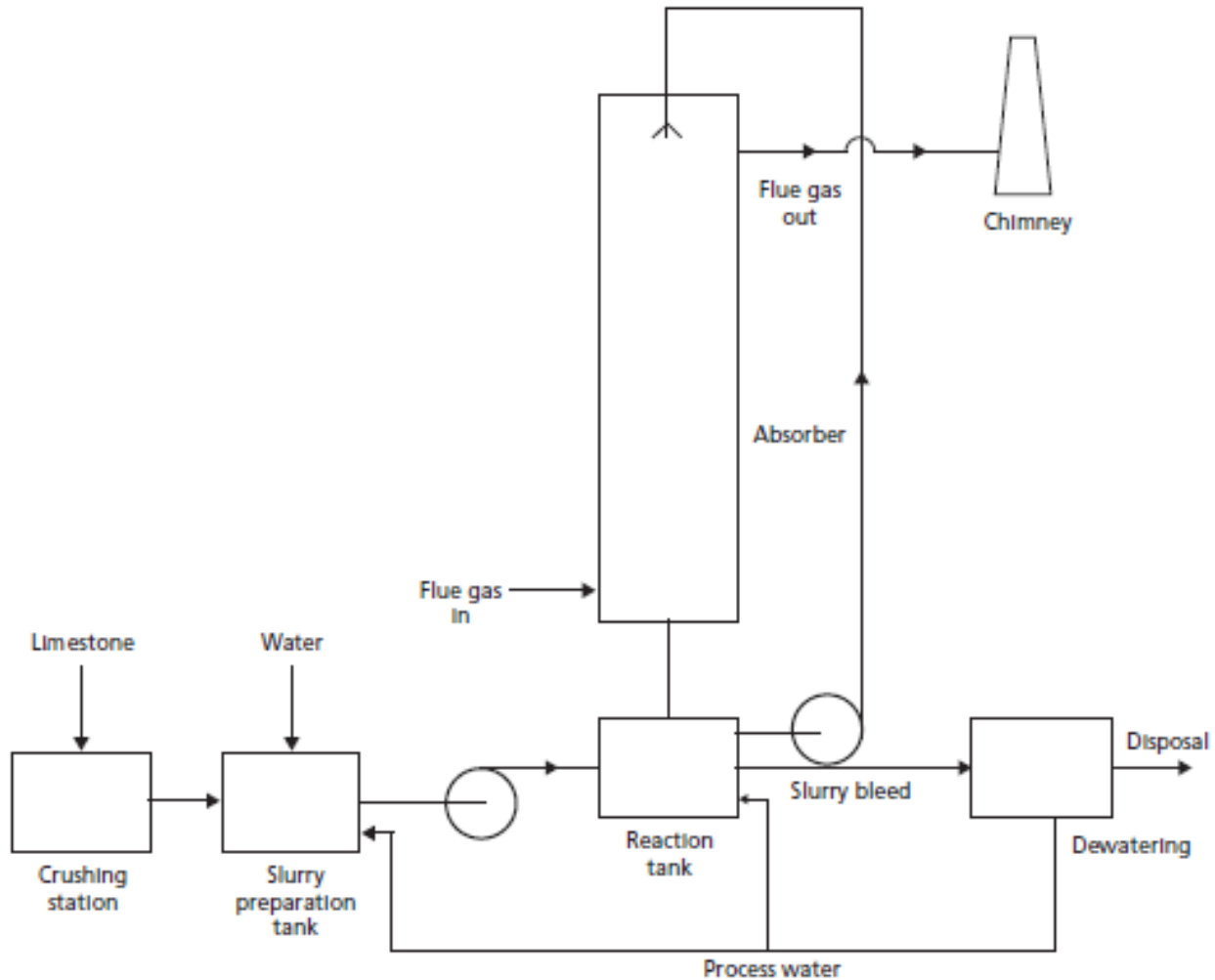
Spray dry system



Circulating fluidized bed system



Wet FGD system



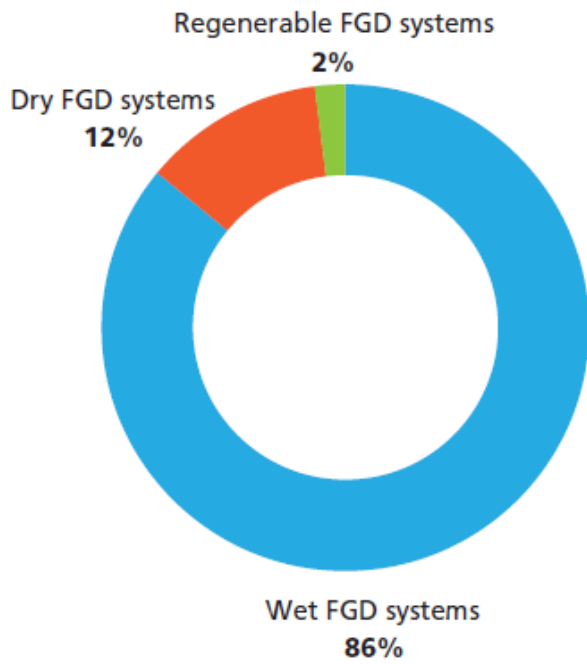
Sulphur di oxide: Control

	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.
SO ₂ 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 SO ₂ removal	Approximately 0.75–1.5 tonne lime consumed per tonne SO ₂ 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 consumption	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

Market Share

GRAPH 5: FGD TECHNOLOGY—GLOBAL POPULATION

Wet FGD technology dominates the global market



Source: USEPA, 2003

Sulphur di oxide: Control Status power plants

- Only 6 GW of capacity has FGD units

	Tata Trombay	Reliance Dahanu	Udupi thermal power station	Adani Mundra UMPP	JSW Ratnagiri	NTPC Vindhyachal stage V
FGD connected plant's capacity (MW)	750	500	1,200	1,980	1,200	500
Type of FGD	Seawater wet FGD	Seawater wet FGD	Limestone-based FGD	Seawater wet FGD	Seawater wet FGD	Limestone-based FGD
Area of construction (sq m/ acres)	7,200	Data not available	10,000	1,500 (scrubber alone)	Data not available	10,000–20,000
Water consumption (cu m/ year)	14,773,000	87,600,000–105,120,000	306,600–350,400	125,000–140,000	Data not available	613,200–876,000
Auxiliary power consumption (per cent)	1–1.5	1.25	0.5	1.5	0.5–1.5	1.1
Reagent used	Seawater	Seawater	Limestone	Seawater	Seawater	Limestone
Reagent consumption in kg/ hr	–	–	–	–	–	6,250

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

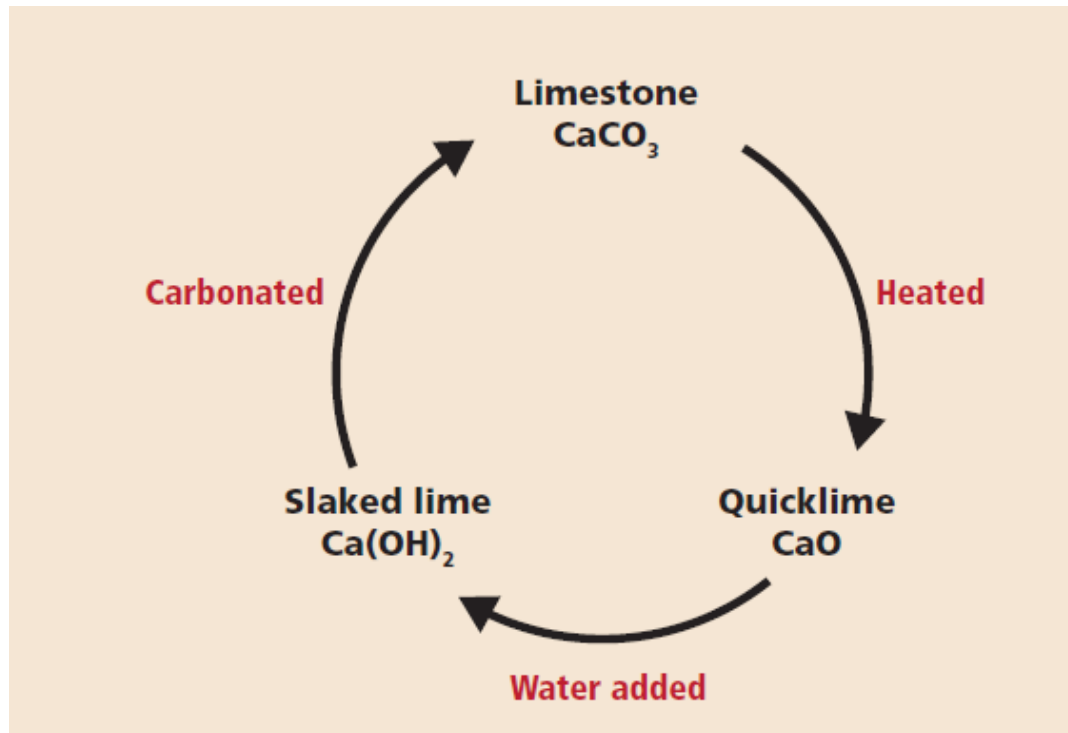
¹Dedicated Limestone Slurry Preparation and Dewatering system

⁺ 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.

Reagent/Sorbent - Alkali



Limestone is the unprocessed mineral from mines, while lime is a reagent obtained by processing limestone with heat to drive away the carbon in the mineral. Since lime is processed by heating using fuel, it is more expensive than limestone.

Reagent/Sorbent - Alkali

- Limestone – 1.56 kg/ kg sulphur di oxide removal (~INR 2,000/tonne)
- Lime – 0.75 kg/kg sulphur di oxide removal (~INR 6,000/tonne)
- Other reagents
 - Seawater
 - Soda ash/caustic soda

Limestone Availability

- There is no dearth of the mineral. India has an estimated 170 billion tonnes (bt), of which 7 per cent is under reserve category and remaining 93 per cent under resource category.
- Annual usage is around 280 million tonnes (mt)—cement industry consumes 269 mt, iron and steel industry 5.8 mt and chemicals industry 3.9 mt
- FGD for power stations – 15mt

Limestone Accessibility

- The May 2016 Amendment to Mines and Minerals (Development and Regulation) Act, 1957 allows transfer of captive mining leases with a written approval from the state government.

Gypsum

- Production – 3.5 mt/year (2012-13)
- Consume ~ 8 mt/year (2012-13)
- Varieties of gypsum
 - Natural gypsum (majority)
 - By-product gypsum - phospho-gypsum (5 mt generation – use is only 3 mt)
 - Marine gypsum (~0.3 mt)
 - Gypsum moulds

Gypsum

(In tonnes)

Category	Industry	2010-11	2011-12(R)	2012-13(P)
All Industries :	Grand Total	8215800	8868800	8667300
Natural-Gypsum :	Total	4503300	5177800	5199000
	Asbestos products	700(4)	700(4)	700(4)
	Cement	4484200(71)	5138600(78)	5159200(79)
	Ceramic	400(1)	400(1)	400(1)
	Fertilizer	100(1)	100(1)	100(1)
	Paint	++(2)	++(2)	++(2)
	Pharmaceutical	900(2)	900(2)	900(2)
	Plaster of Paris	17000(4)	37100(4)	37700(5)
	Refractories	++(1)	++(1)	++(1)
	Textile	++(1)	++(1)	++(1)
By-Product-Gypsum :	Total	3356600	3227700	2982600
	Cement	3355900(72)	3227100(74)	2981800(74)
	Ceramic	600(1)	600(1)	600(1)
	Fertilizer	100(1)	++(1)	200(1)
Marine-Gypsum :	Total	353000	460400	482800
	Cement	353000(15)	460400(16)	482800(17)
Gypsum-Moulds :	Total	2900	2900	2900
	Ceramic	2900(5)	2900(5)	2900(5)

Figures rounded off.

Figures in parenthesis denote the number of units in organised sector reporting consumption.*

*(*Includes actual reported consumption and/or estimates made wherever required).*