

LIME in FGT

What is Lime?



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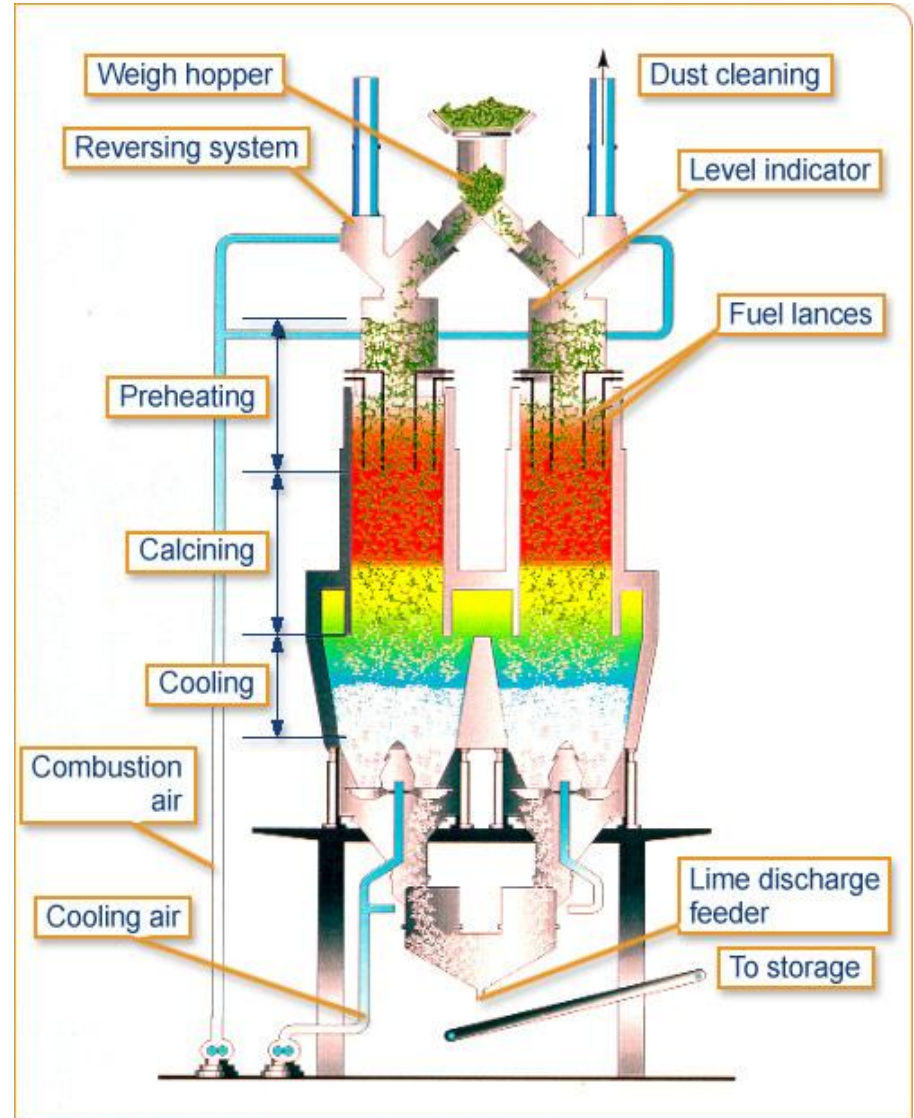


Kilns

- Calcine @ 1000°C

What is Lime?

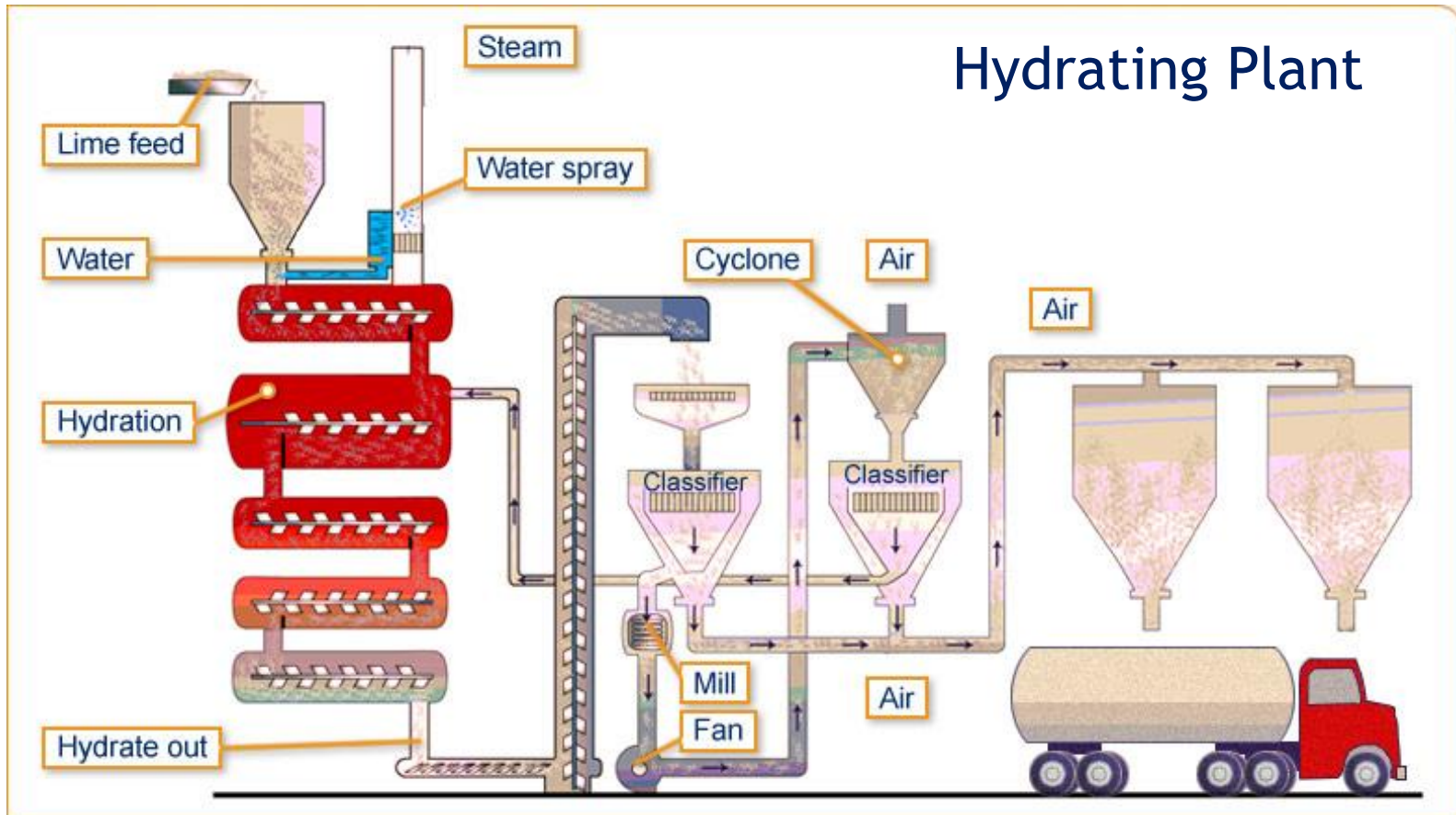
- CALCIUM CARBONATE decomposes to CALCIUM OXIDE
- This Process is called 'CALCINATION'
- CALCIUM OXIDE is also known as QUICKLIME or BURNT LIME



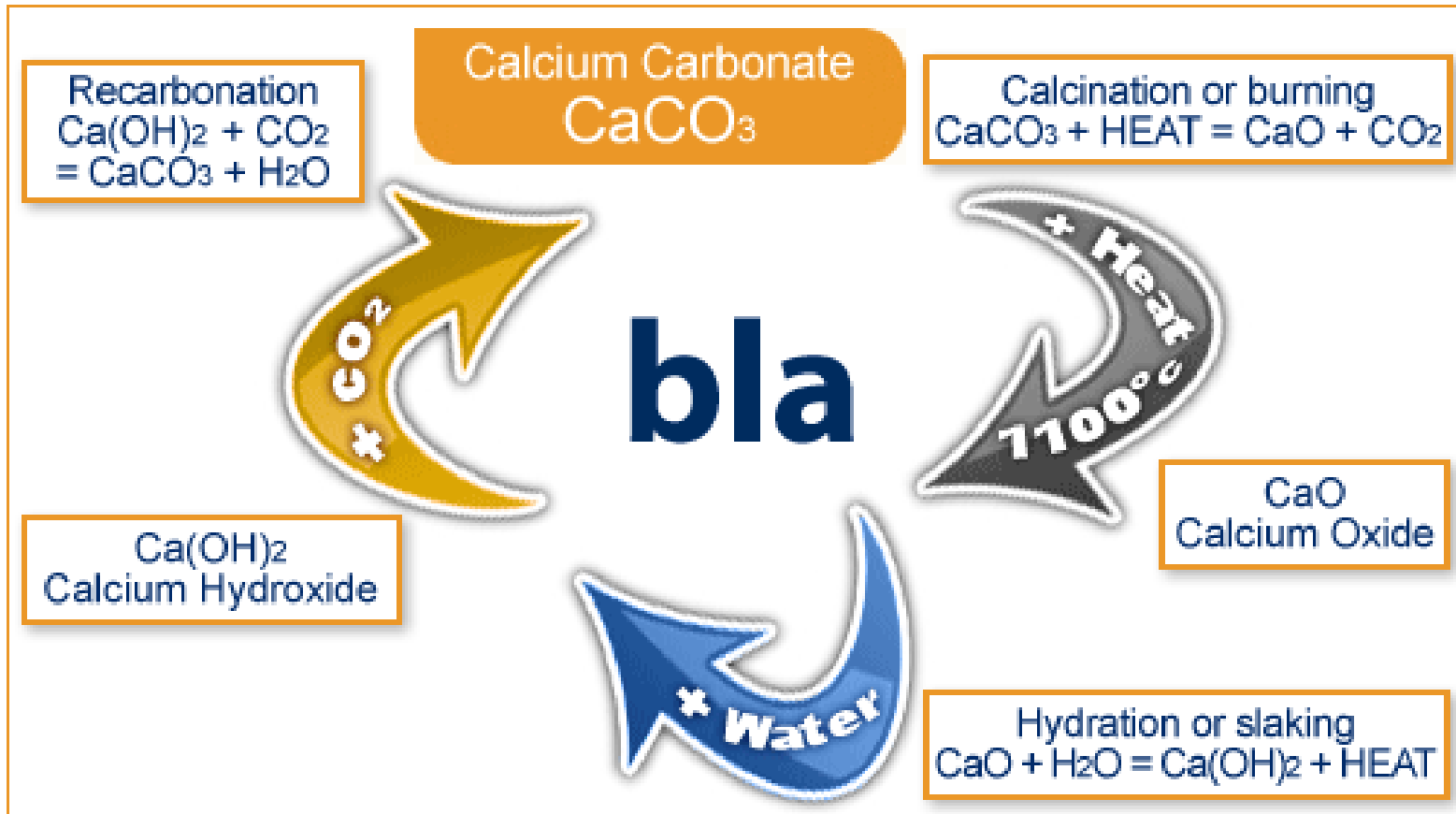
What is Lime?

- QUICKLIME is reacted with water to form HYDRATED LIME or MILK OF LIME
- $\text{CaO} + \text{H}_2\text{O} = \text{Ca}(\text{OH})_2 + \text{HEAT}$
- This reaction is known as 'SLAKING'

What is Lime?



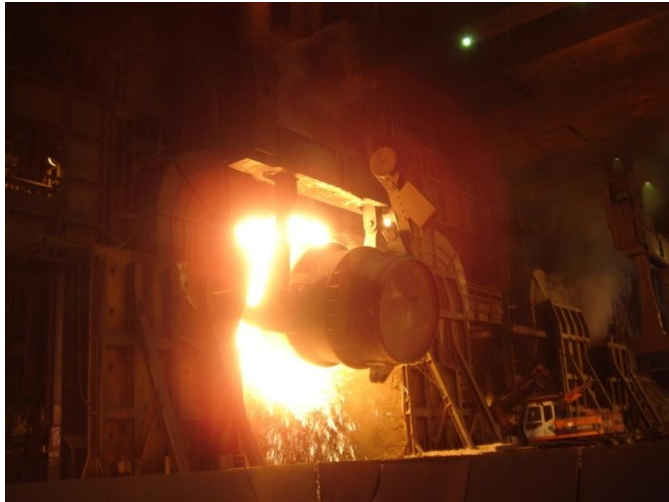
The Lime Cycle



The Versatile Chemical

- Mankind's first industrial chemical.
- Used for at least 5000 years and still important in many activities essential to society.
- Lime is still the cheapest and most widely used alkali.
- Global production of lime products is now estimated to be well in excess of 200 million tonnes per annum.

The Versatile Chemical



Steelmaking



Construction
Materials

Water
Treatment



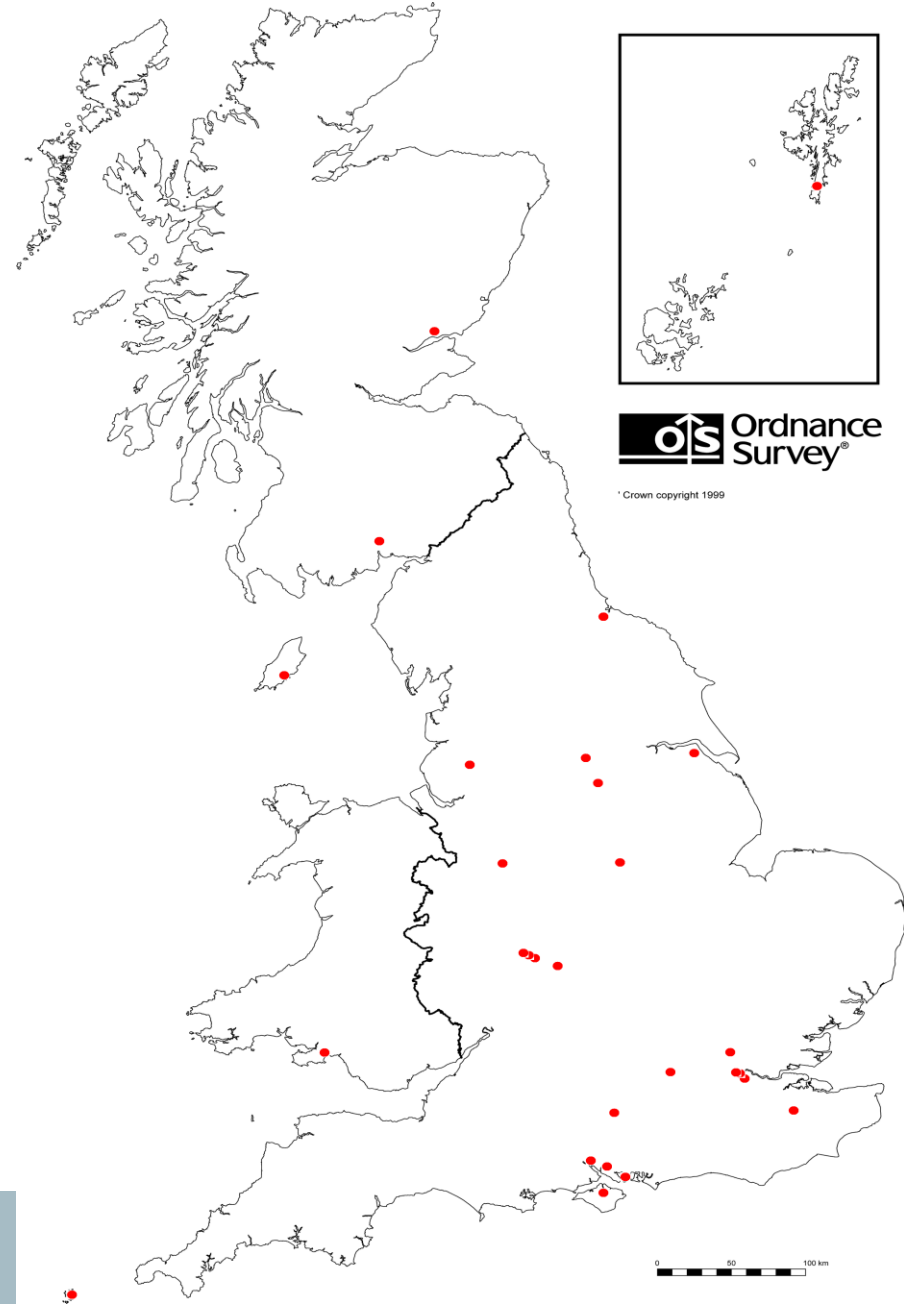
The versatile chemical

Glass Manufacture

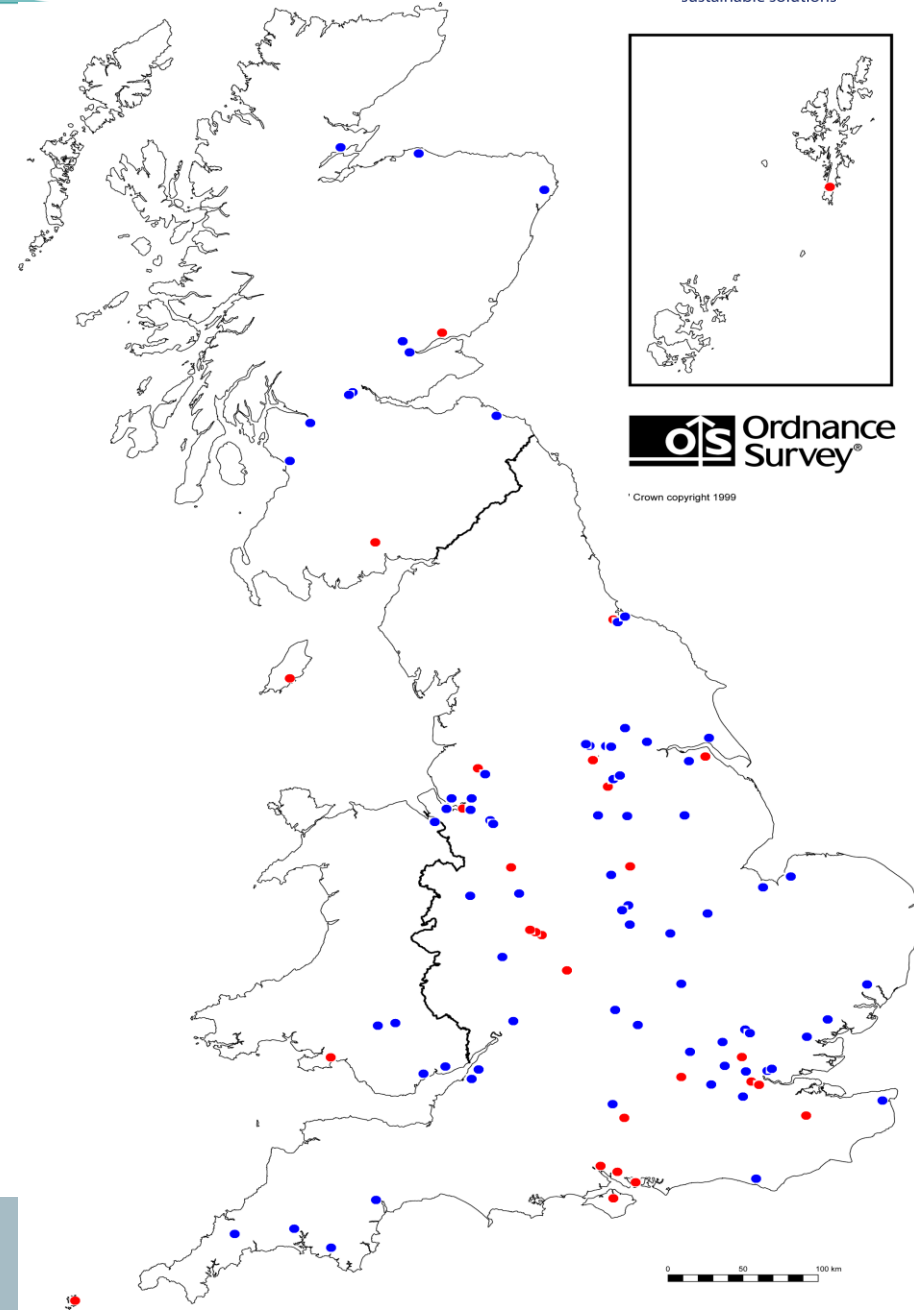


Flue Gas Treatment

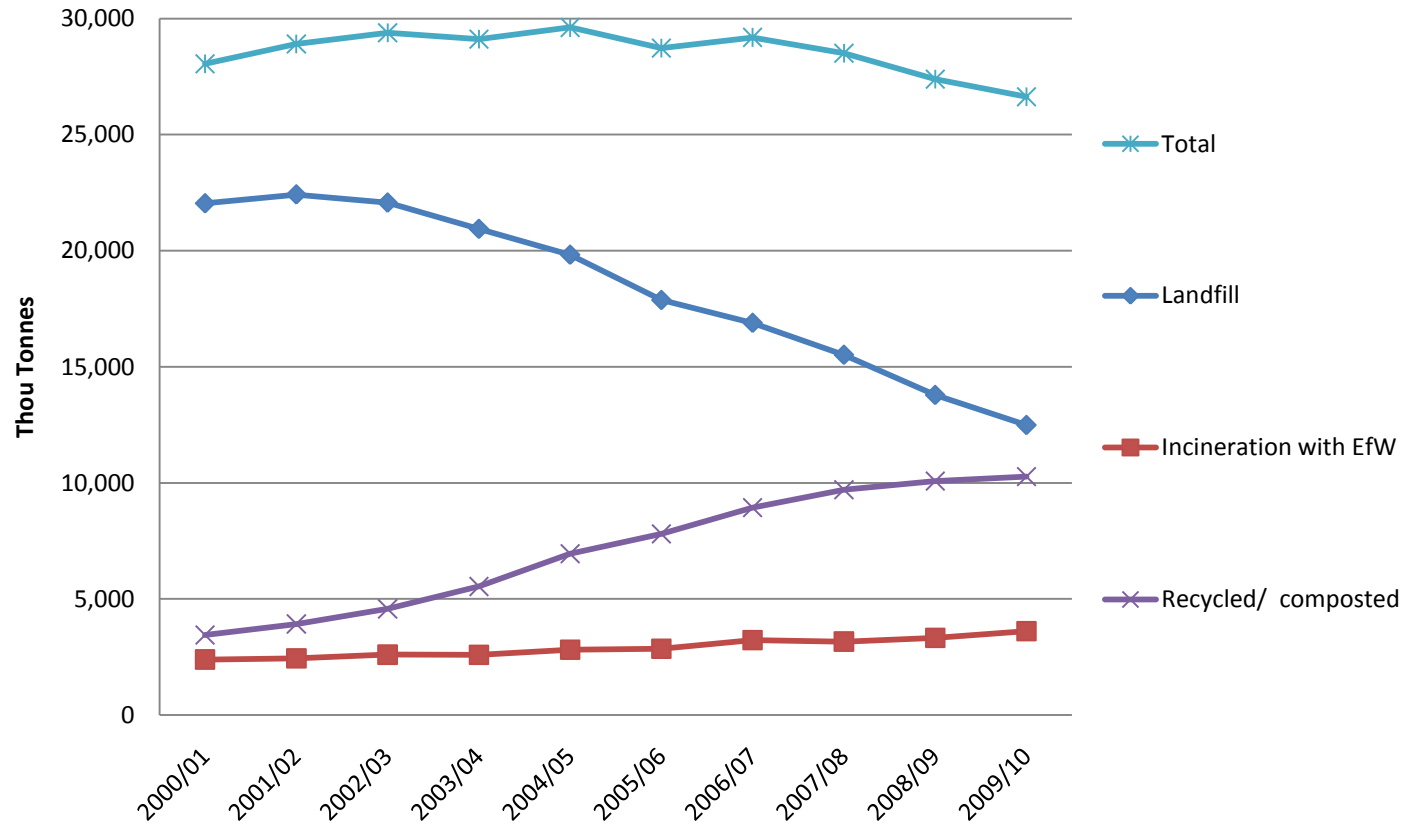
Energy from Waste Current Plants



Energy from Waste Current and Proposed Plants



Energy from Waste - Municipal Waste Trends



Source - DEFRA

Energy from Waste - Landfill

- Government targets set for recycling
 - 2013 = 50% of 1995 levels of biodegradable waste
 - 2020 = 35% of 1995 levels of biodegradable waste
- Landfill Tax
 - April '08 = £32/Te
 - Increases £8/te per year until 2013
 - '11/'12 = £56/Te
 - '12/'13 = £64/Te
 - '13/'14 = £72/Te
- Waste from Energy
 - DEFRA estimate growth from 11% (2011) to 25% by 2020

Flue Gas Treatment

- Lime is the most common and widely used reagent in UK.
- Other reagents are sodium based, e.g. Sodium Bicarbonate (NaHCO_3), more widely used in Europe
 - older, “single pass” technology
 - residue disposal more widely available

Stoichiometric factor (molar) versus Dosing rate (kg/h):

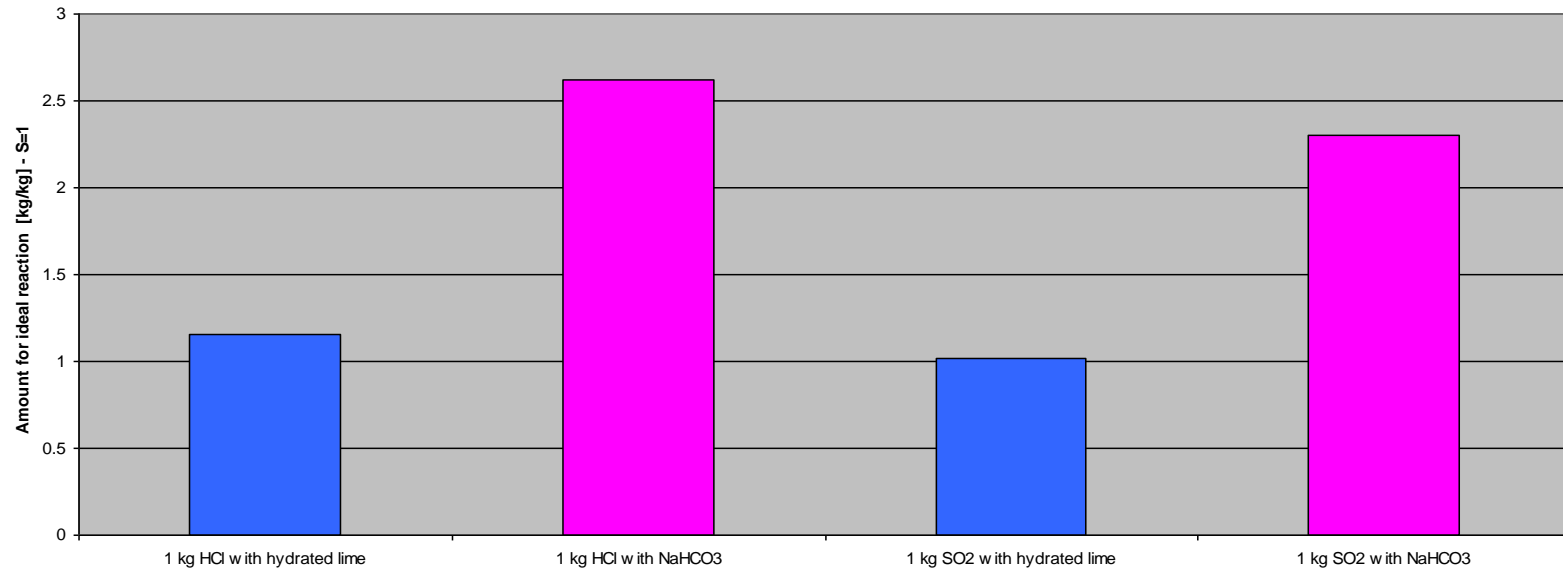
Chemical Reactions [g/mol]	Required Additive Amount for SF = 1 (theoretical !) to remove
$\text{Ca(OH)}_2 + \text{SO}_2 \rightarrow \text{CaSO}_3 + \text{H}_2\text{O}$ $74,08 + 64,05 \rightarrow 120,12 + 18,01$	1 t SO₂ : 1,156 t Ca(OH)₂
$\text{Ca(OH)}_2 + \text{SO}_2 + 0,5\text{O}_2 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O}$ $74,08 + 64,05 + 0,5(31,99) \rightarrow 136,12 + 18,01$	
$2\text{NaHCO}_3 + \text{SO}_2 \rightarrow \text{Na}_2\text{SO}_3 + \text{H}_2\text{O} + 2\text{CO}_2$ $2(83,99) + 64,05 \rightarrow 126,02 + 18,01 + 2(43,99)$	1 t SO₂ : 2,624 t NaHCO₃
$2\text{NaHCO}_3 + \text{SO}_2 + 0,5\text{O}_2 \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{O} + 2\text{CO}_2$ $2(83,99) + 64,05 + 0,5(31,99) \rightarrow 142,01 + 18,01 + 2(43,99)$	
$\text{Ca(OH)}_2 + 2\text{HCl} \rightarrow \text{CaCl}_2 + 2\text{H}_2\text{O}$ $74,08 + 2(36,46) \rightarrow 110,99 + 2(18,01)$	1 t HCl : 1,016 t Ca(OH)₂
$\text{NaHCO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$ $83,99 + 36,46 \rightarrow 58,44 + 18,01 + 43,99$	1 t HCl : 2,304 t NaHCO₃

➔ Additives are bought by weight, not stoichiometric factors

Expressed in Dosing Rates (kg/h), SF of 2,3 for Hydrated Lime is equal to SF of 1,0 for Bicarb !

Comparison between chemical reactions

Reactions equation (with according molecular weights)
and theoretic use of additives:



- The theoretical use of additives ($SF^* = 1$) is **2.3 times** higher for NaHCO_3 compared to $\text{Ca}(\text{OH})_2$

Sodium Bicarbonate only makes sense if it's reactivity is needed to comply with emission limits

Flue gas: What are the requirements?

Waste incinerators: untreated [mg/Nm³]

10-15

1000 - 1500

200-400

HF

>

HCl

>

SO₂

Waste incinerators: after treatment [mg/Nm³]

< 1

<10 (5)

< 50 (25)

HF

>

HCl

>

SO₂

>

CO₂

Filtration efficiency [%]

> 90-93

> 99-99,3

> 75-94

HF

>

HCl

>

SO₂

>

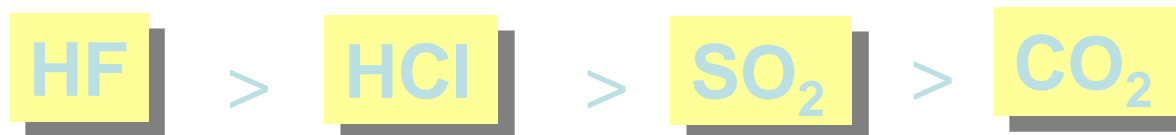
CO₂

Reaction speed

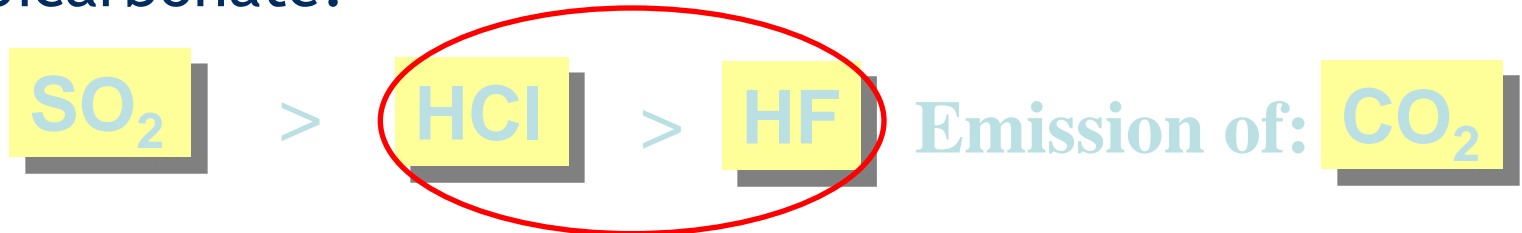
Required:



Lime:



Sodium bicarbonate:



Reaction speed

Lime:

The pollutants react with the hydrated lime according to the required filtration efficiency.

Sodium bicarbonate:

First reaction with SO_2 , then removal of HCl and finally HF.

If higher concentration of HF occur (100-150 mg/Nm³; e.g. in glass factories, brick making industry) or the ratio of SO_2 to HCl changes (peaks in waste incinerators or use of RDF in power plants), problems occur.

Consequences: **Exceeding of thresholds and increased consumption**

Lime compared to Sodium Bicarbonate

Dry FGT with hydrated lime is...

...easier:

- Ready to use, easier handling

...more effective:

- Lower usage of reagent

...more secure:

- Buffer effect in flue gas treatment system for gas peaks

...cheaper:

- Lower consumption at cheaper prices

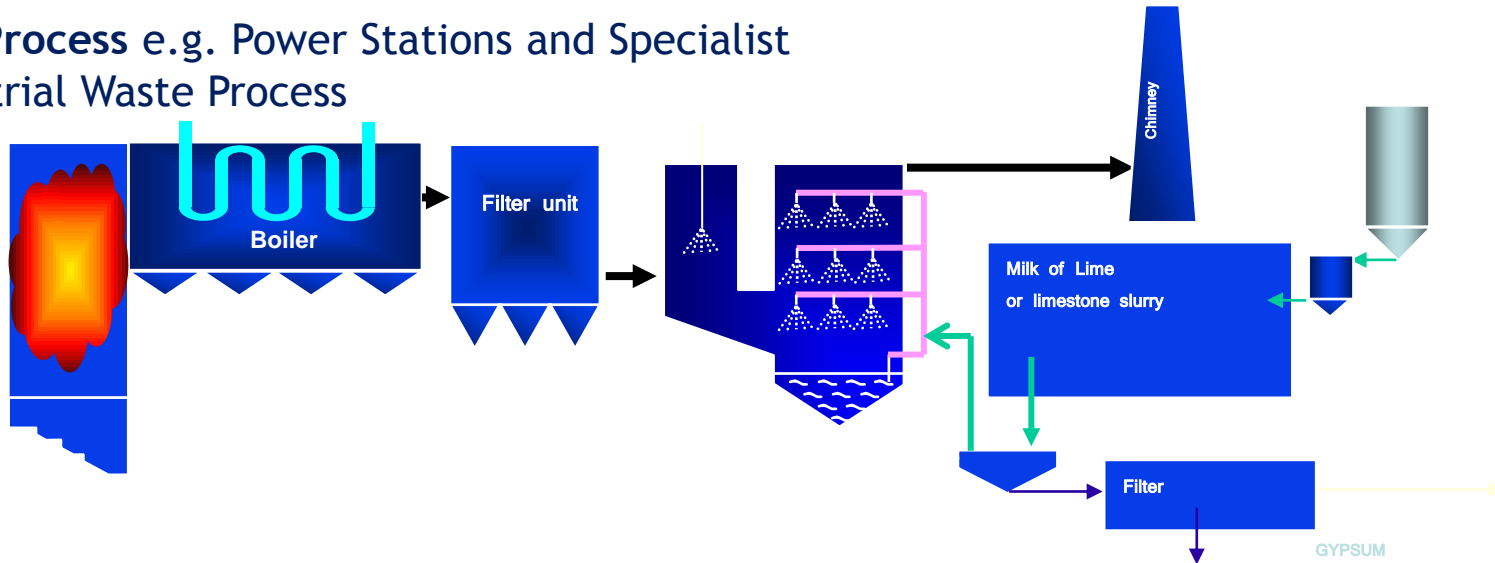
Flue Gas Treatment

Four Types of Lime Treatment for neutralisation of acidic combustion gases (principally SO_2 and HCl)

1. *Wet scrubbing* - Spray with milk of lime to remove acids and reaction products are removed as a liquid suspension.

Flue Gas Treatment

Wet Process e.g. Power Stations and Specialist Industrial Waste Process



Reagent used as a slurry or solution in a reactor tower, and liquid effluent by-product is then neutralised

Capex cost of installation - HIGH

High operator cost

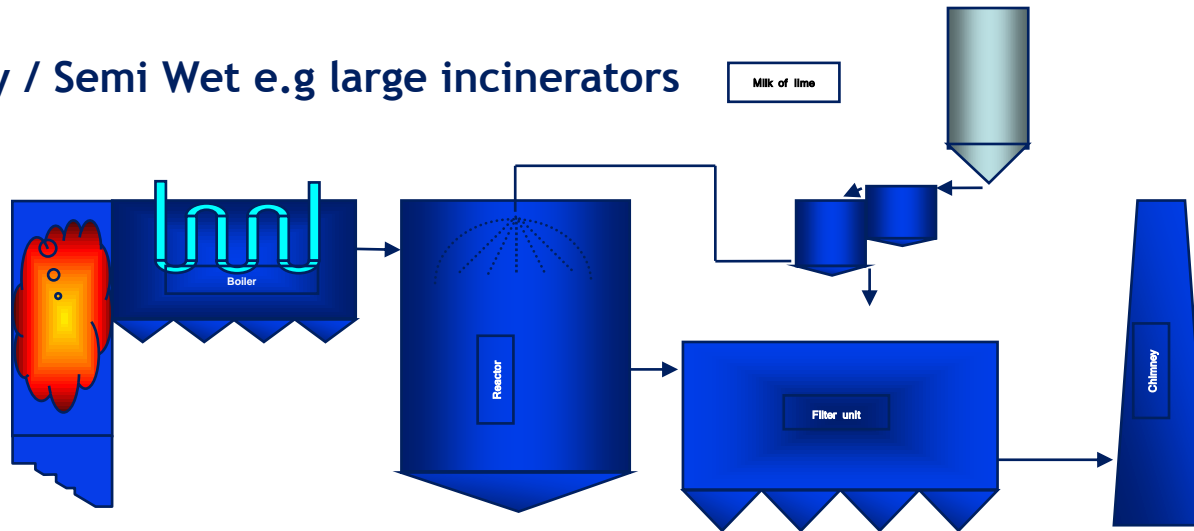
Very efficient removal rates over a wide range of acidic gases

Flue Gas Treatment

2. *Semi-dry scrubbing* - where milk of lime is sprayed onto the gases to remove acids and reaction products are removed with a dust collector.

Flue Gas Treatment

Spray Dry / Semi Wet e.g large incinerators

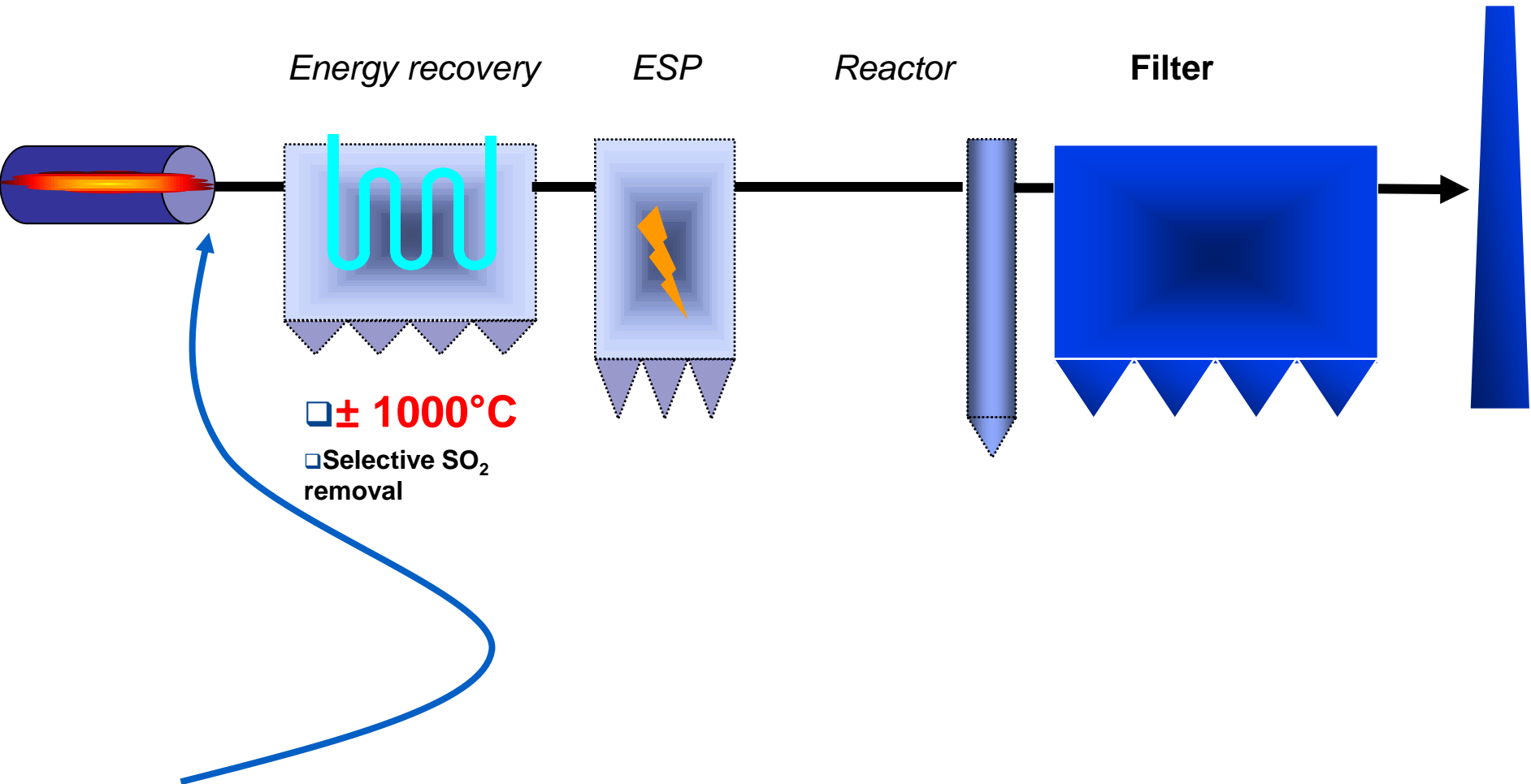


- Reagent injected as a slurry in a reactor tower prior to filter system
- Capex cost of installation - Relatively high
- Increased operator cost
- Relatively efficient removal rates

Flue Gas Treatment

3. High temperature (over 850 °C) dry injection of hydrated lime - where the hydrated lime calcines and the resulting calcium oxides reacts with the acid gases (SO_2). Reaction products are also removed using a dust collector.

Flue Gas Treatment

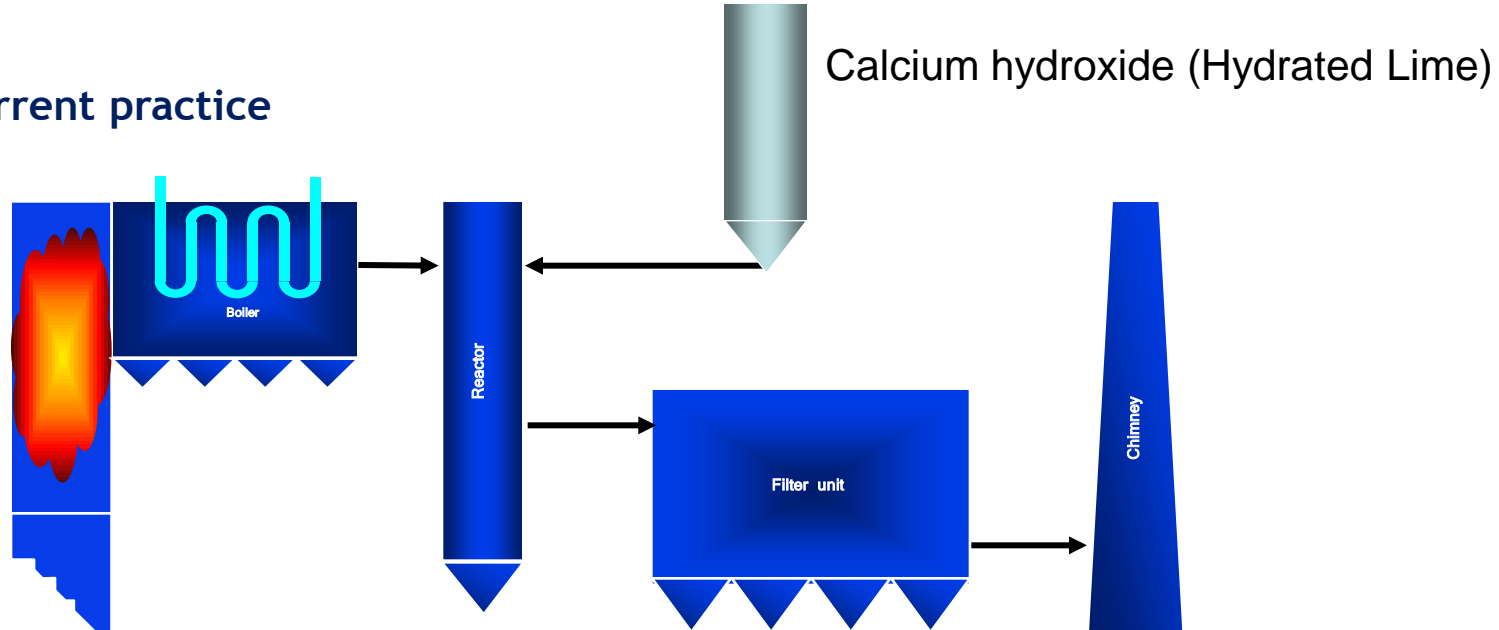


Flue Gas Treatment

4. Low temperature (below 300 °C) dry injection of hydrated lime - removes HCl, HF and SO₂. Similarly, reaction products are removed using a dust collector.

Flue Gas Treatment

Dry Process - current practice



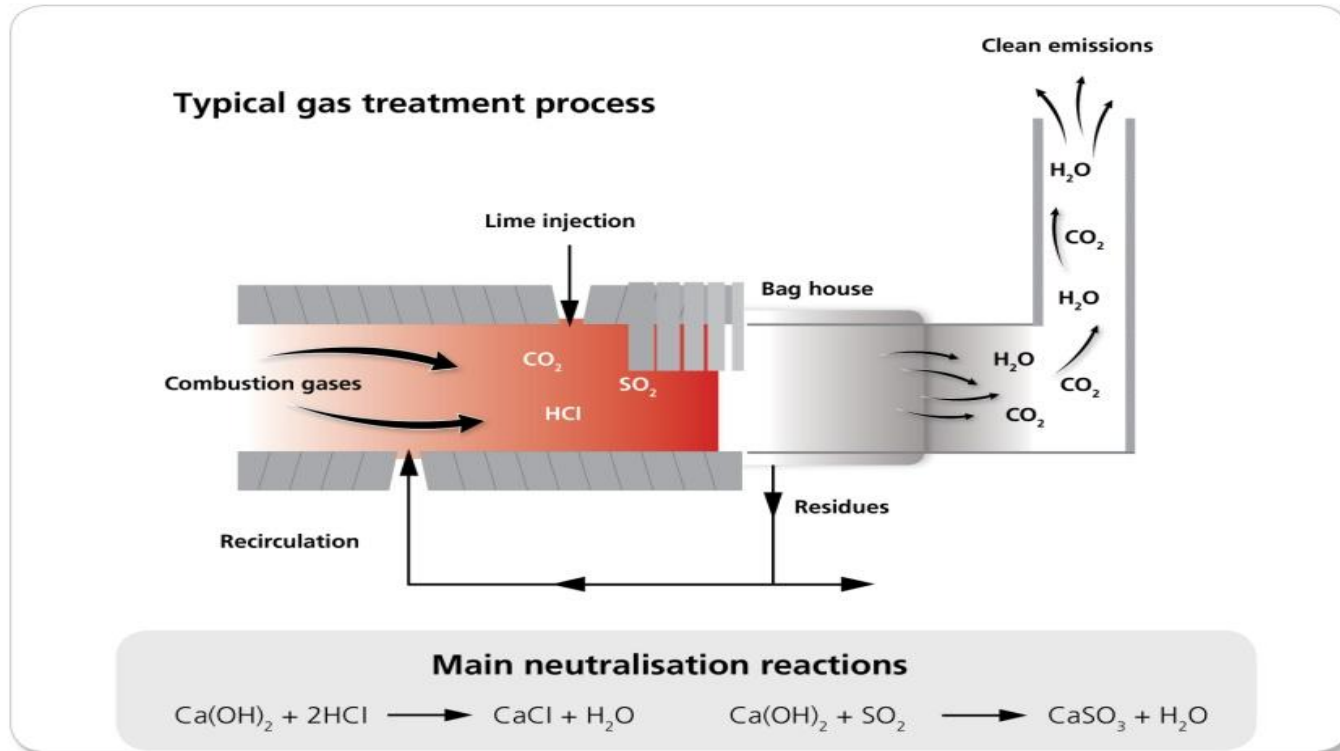
Dry injection of reagent in a reactor tower or duct prior to filter system

Capex cost of installation - Relatively Low

Ease of use -Simpler process

Widest operating range

Flue Gas Treatment



Current trend is dry & recirculation on large MSW

Operational security - buffering effect for operational issues and acid spikes

Improvements in efficiency - “regenerating” reagent

Lime Developments

BLA members working with the industry to give:

- Improvements in efficiency of reagent use with product development.
- Better plant performance by working with operators.
- Contributing to reduce landfill volumes

Lime Developments

Lime is Man's oldest chemical product

Still one of the most useful, versatile & cost effective

Continuing to serve today's industry