

Worldwide Pollution Control Association

ESKOM Scrubber Seminar
April 12th – 13th, 2007



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High Performance DFGD

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13/04/2007

POWER SYSTEMS |

ALSTOM

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Introduction

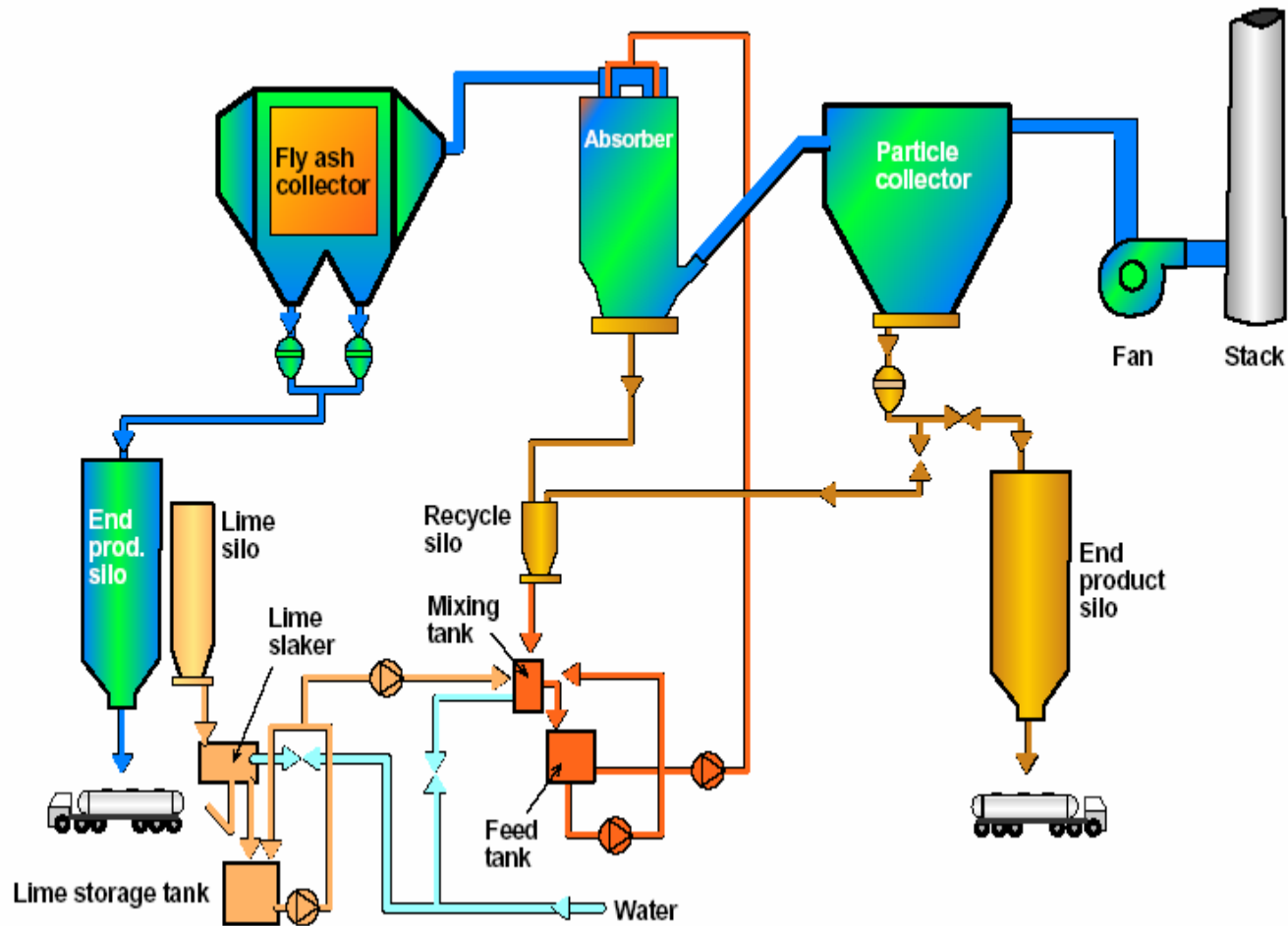
Several technologies are available for power plant flue gas desulphurisation, for example:

- DFGD - SDA (first DFGD technology)
- DFGD - NID (second generation DFGD)
- SWFGD (sea water desulphurisation)
- WFGD (wet flue gas desulphurisation)
- ASFGD (ammonium based desulphurisation)
- Other special technologies for example developed for petrochemical and chemical industry

History in short...

- Late 70's - first requirement on small on medium size power plants in northern Europe to lower their SO₂ emission
- Search for suitable technology started – aim to find less complicated system to operate
- Basic understanding of chemistry and physics for dry systems established - Ca(OH)₂ reacts with SO₂ if the temperature and humidity is right (not to saturation)
- First systems used spray dryers, a known mechanical component, able to cool the gas and inject lime at the same time.

Spray Dry Absorption



Spray Dry Absorption



South Carolina Electric &
Gas

Cope Unit 1, 385 MW

History in short...

- Two main types of spray dryers developed
 - Nozzles using compressed air for injection
 - Rotary atomisers using a spinning disk
- Support systems in form of lime slaking and slurry preparation
- Removal of produced dust (CaSO_3) with either fabric filters or electrostatic precipitators
- Systems developed both with and without pre-collector for fly ash
- Several hundred spray-dryer-based air pollution control systems have been installed at power plants, waste incineration plants and industrial processes

History – lessons learnt

- Wearing on the nozzles could influence the drop size causing:
 - deposits on the walls and sudden fall downs into the bottom
 - corrosion on the spray dryer walls due to low temperature behind the deposits
 - wet bottoms and difficulty to discharge fall-outs
- Clogging in the slurry pipes and tanks
- Sometimes difficulty to inject sufficient amount of lime and re-circulate dust due to small amount of water needed for cooling - result, limitation in performance and higher than necessary operating costs
 - In the spray dryer there is a link between the cooling and the amount of solid material possible to inject due to limitations

History – ALSTOM development initiative

Aim:

- a system without lime slurry
- no link between cooling and amount of lime possible to inject
- lower maintenance costs
- less complicated operation (forgiving in case of operator faults)

ALSTOM development

- Novel Integrated Desulphurisation (NID) developed 1995.

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POWER SYSTEMS

ALSTOM

First commercial installation 1996 operated since

Introduction & history summary

Dry Desulphurisation (DFGD)

- First ALSTOM DFGD SDA-system started up in 1982
- More than 140 dry systems installed by ALSTOM until today
- NID - a DFGD technology based on more than 25 years of experience
- First commercial NID installation operated since 1996

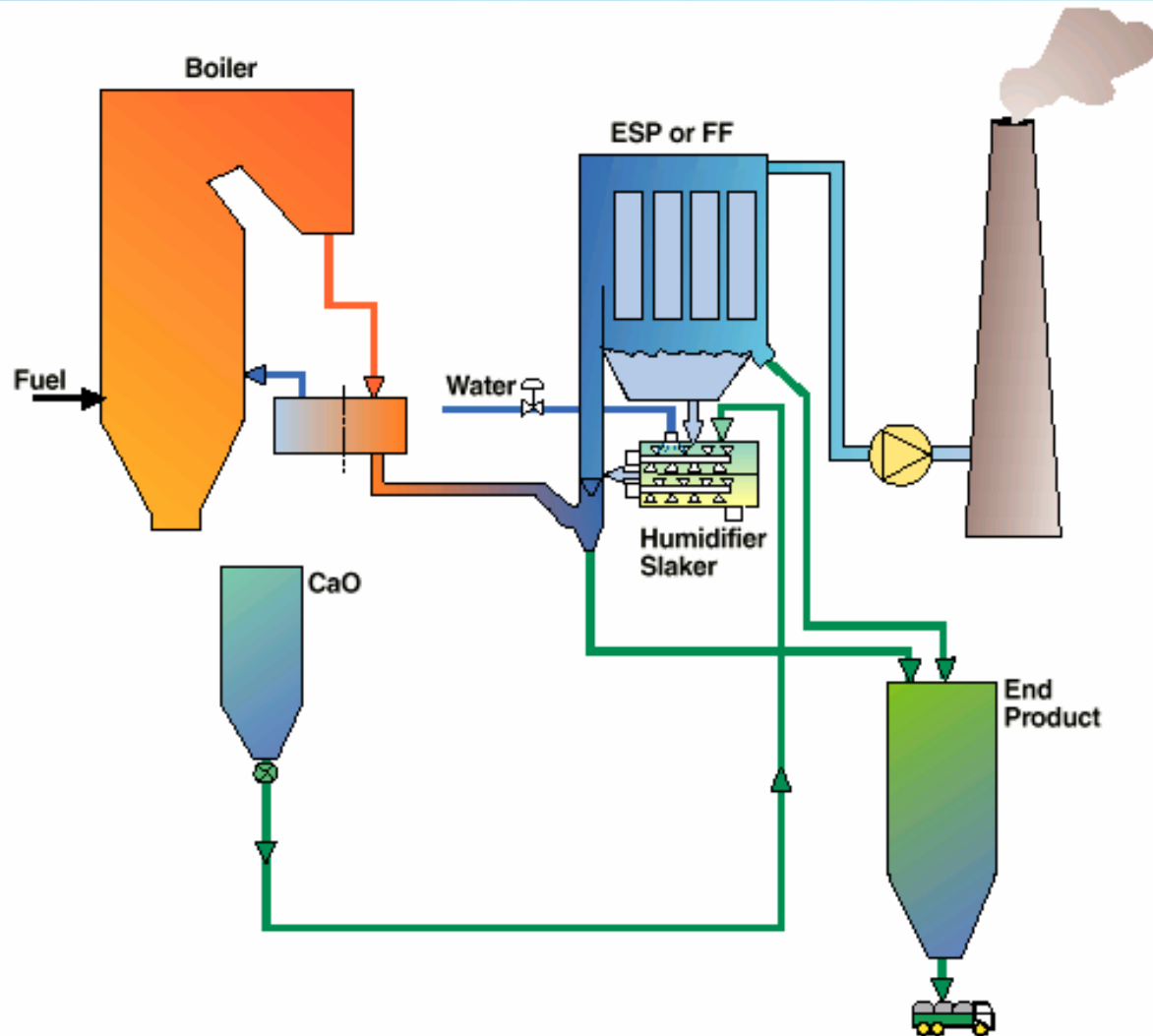
Laziska Power Plant,
Poland,
2 x 120 MW.
First NID installation



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NID - Novel Integrated Desulphurisation



NID - Novel Integrated Desulphurisation



Uskmouth Power,
Unit 13, 14 & 15, 3 x 120
MWe

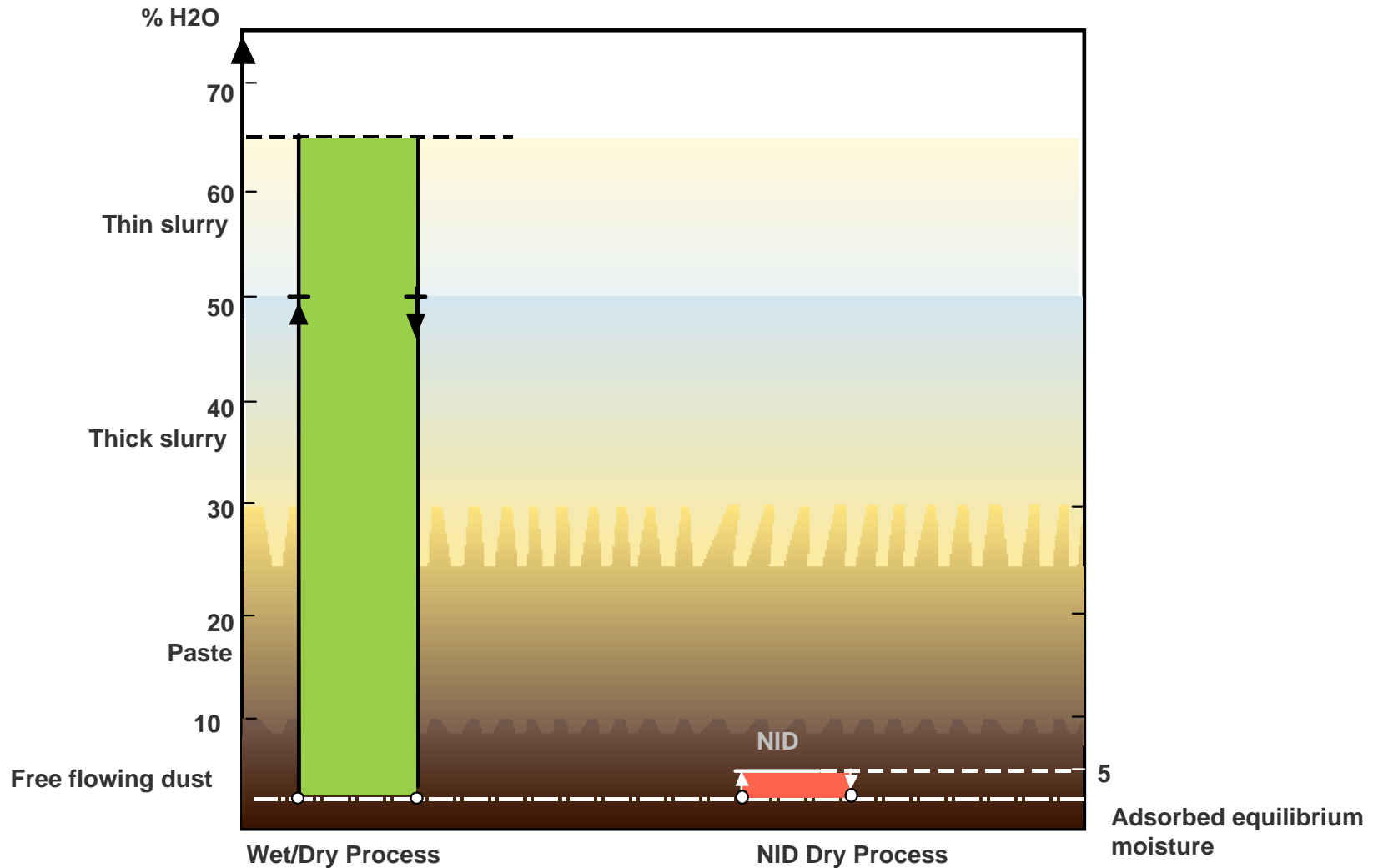
DFGD Basic Principles

- Over all chemical reaction
$$\text{SO}_2 + \text{CaO} + \frac{1}{2}\text{H}_2\text{O} \rightarrow \text{CaSO}_3 \cdot \frac{1}{2}\text{H}_2\text{O}$$
- Absorption
$$\text{SO}_2 + \text{Ca}(\text{OH})_2 \rightarrow \text{CaSO}_3 \cdot \frac{1}{2}\text{H}_2\text{O} + \frac{1}{2}\text{H}_2\text{O}$$
- Hydration if the process start with CaO
$$\text{CaO} + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Ca}(\text{OH})_2 + \text{Heat} [\text{H}_2\text{O}(\text{g})]$$
- Reaction prerequisites for all DFGD systems if lime utilisation shall be efficient:
 - Reaction temperature low enough
 - Relative humidity high enough
 - Contact time and contact surface (area) sufficient

NID Parameters

- Flue Gas SO₂ Content
 - Tested up to 3500 ppm
 - Economics often limits application to max 1,5 - 2,0 % S in fuel
- Flue Gas Inlet Temperature
 - Low temp preferred; max approx. 200°C
- Gas flow
 - Operating range from 40 000 Nm³/h to 1 200 000 Nm³/h
- Acid mist
 - SO₃ removed approx. to the detection limit
- Hydrogen halogens
 - HCl, HF removed by +90 %
- Fine particulate matter efficiently collected by filtration and absorption
- Mercury removal with minor addition in equipment

SDA vs. NID – Moist content in slurry & on dust



NID features

- Simple, robust & reliable
- Proven technology
- Internal slaking of the reagent
- Less maintenance due to less equipment
- No slurry handling
- Small footprint - Integrated FGD and Fabric Filter saves space
- High SO₂ removal efficiency
- Very low particulate emissions
- Low investment cost (compared to ESP + Wet FGD & SDA)
- No pre collector required
- 3000 MW in operation

NID - End Product Chemical Composition

<u>Main components</u>	<u>Typical range (%)</u>
Fly ash/lime inert	3-10
CaSO ₃	40-70
CaSO ₄	5-15
Ca(OH) ₂	2-10
CaCO ₃	5-15
CaCl ₂	1-4
Moisture (free)	1-3

Besides these main components there will be a trace metal content in the end product, which is associated with the content of fly ash and the lime sources. Due to the dense and alkaline nature of the dry FGD material it has a low leachability.

NID - End Product Characteristics

- Dry FGD product particle size
 - ca. 5 μ m to 60 μ m, with a mass mean size of 10 to 15 μ m.
- Bulk density of dry product:
 - about 700 kg/m³
- Water solubility:
 - the total solubility of the dry FGD product in water is very low. With exception for CaCl₂ the different compounds are sparingly soluble to insoluble.
- At ambient air conditions calcium sulphite (CaSO₃) will slowly oxidize to calcium sulphate (gypsum) and calcium hydroxide will be converted to CaCO₃ by CO₂.

NID - End Product Utilisation

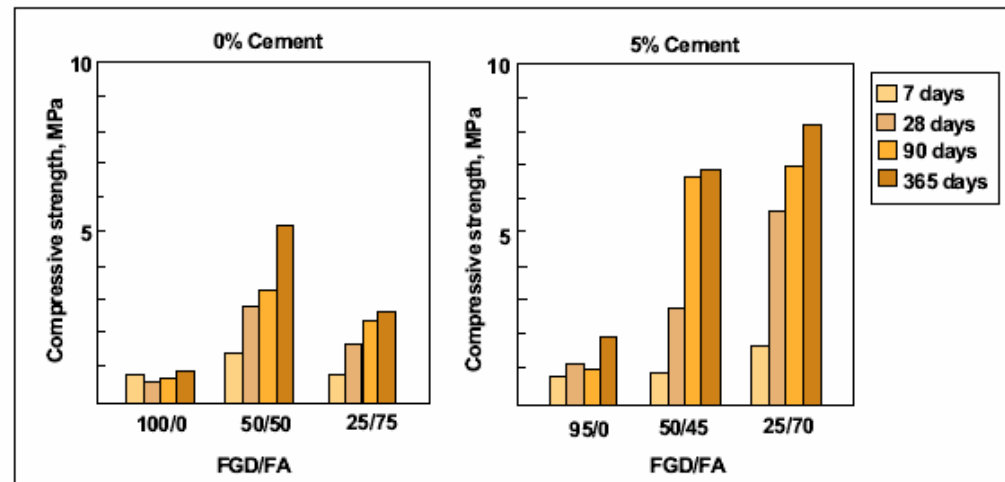
- Civil works
- Sealing material
- Base course material
- Fill for landscaping / land reclamation
- Fertilizer in agriculture and forestry
- Dry FGD product as Reagent for Wet FGD and Conversion to Gypsum
- Dry FGD product as raw material for aggregates, bricks and cement
 - Sand-lime bricks
 - Cellular concrete (autoclaved aerated concrete, gasbeton)
- Cement (special cement process)
- Aggregates/Synthetic gravel

ND End Product Utilisation

Properties for End Product + Fly Ash

Type	Dry FGD	Fly ash (%)	Cement (%)
A	70	30	0
B	50	50	0-5
C	30	70	0-8

Water can be added to between 20 and 35 % to attain a soillike or a flowing type product.



Compressive strength development vs mixing ratio of dry FGD product and fly ash (FA) with and without cement.

DFGD - End Product Utilisation Examples



Storage area for wood chippings and coal on Cefill base course at CHP Västerås, Sweden



Coal mine application in Poland (Photo: UTEX, Rybnik)

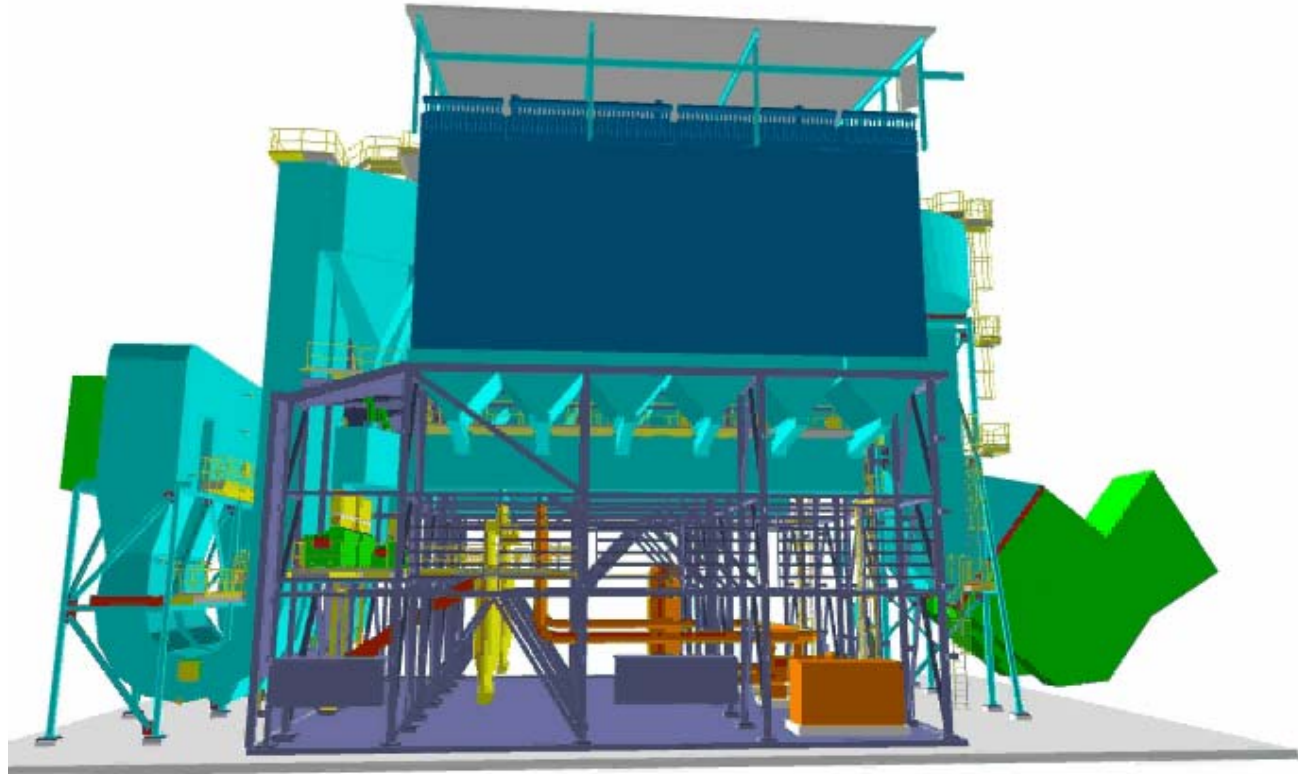


Picture on new harbour quay in Västerås, Sweden

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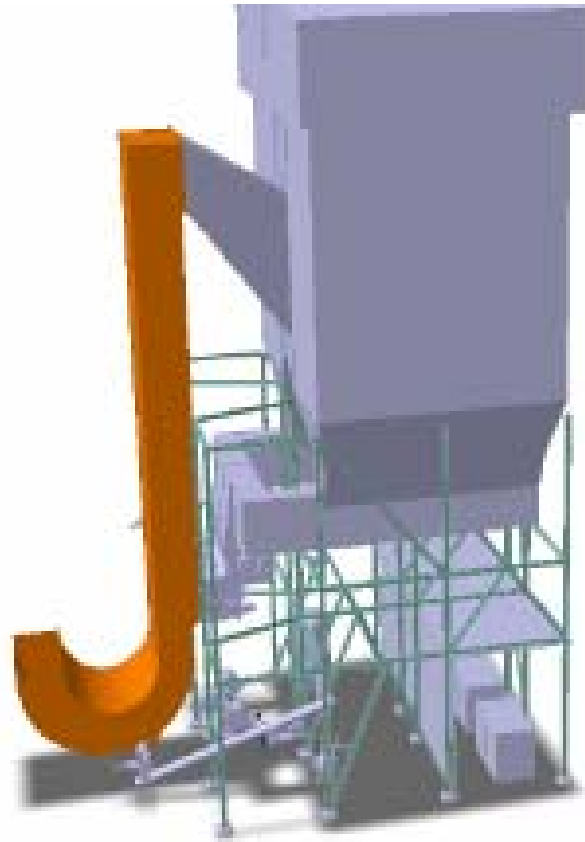
NID Side view of NID FF



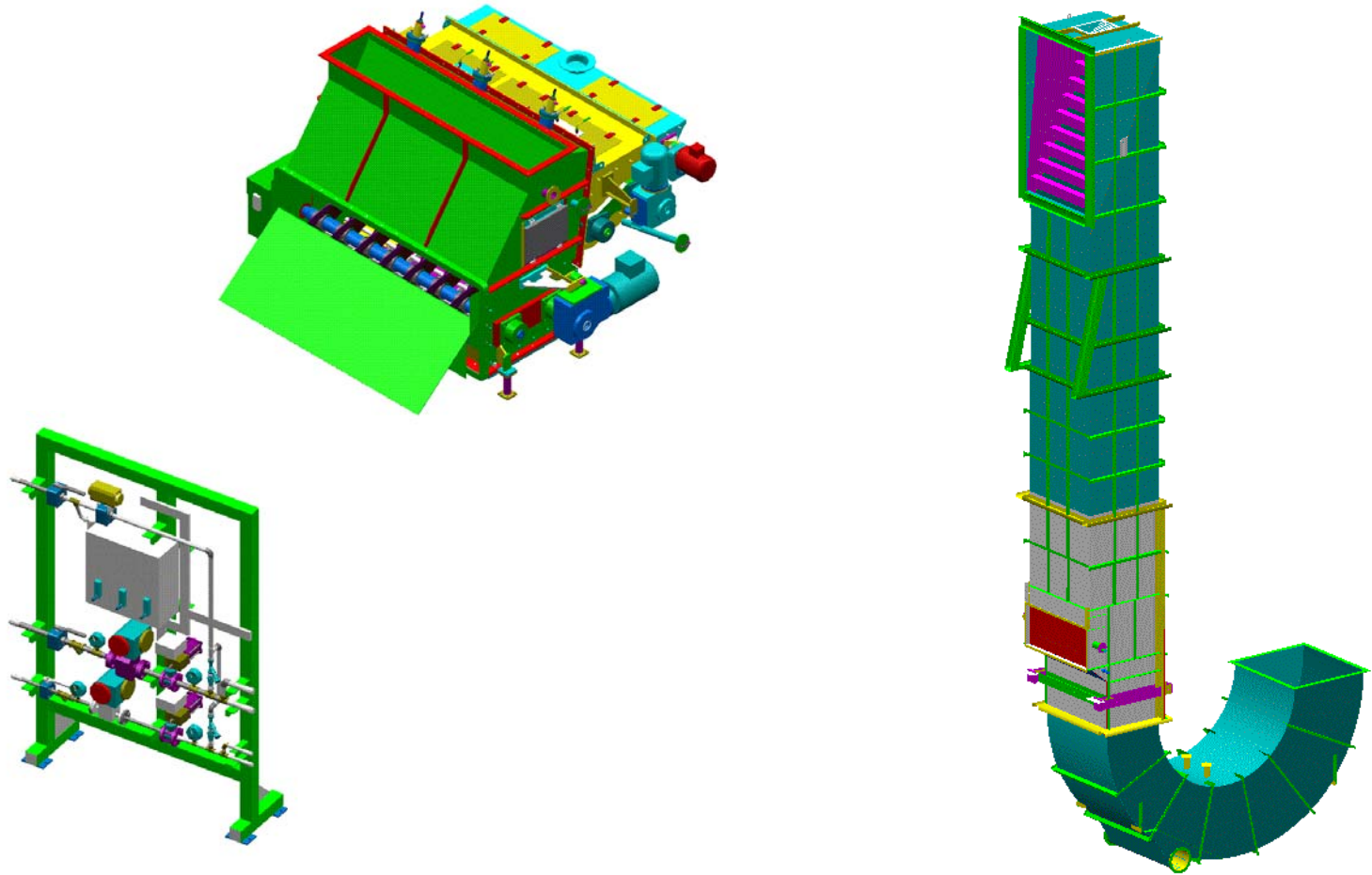
Gilbert Unit 3, CFB+NID

USA

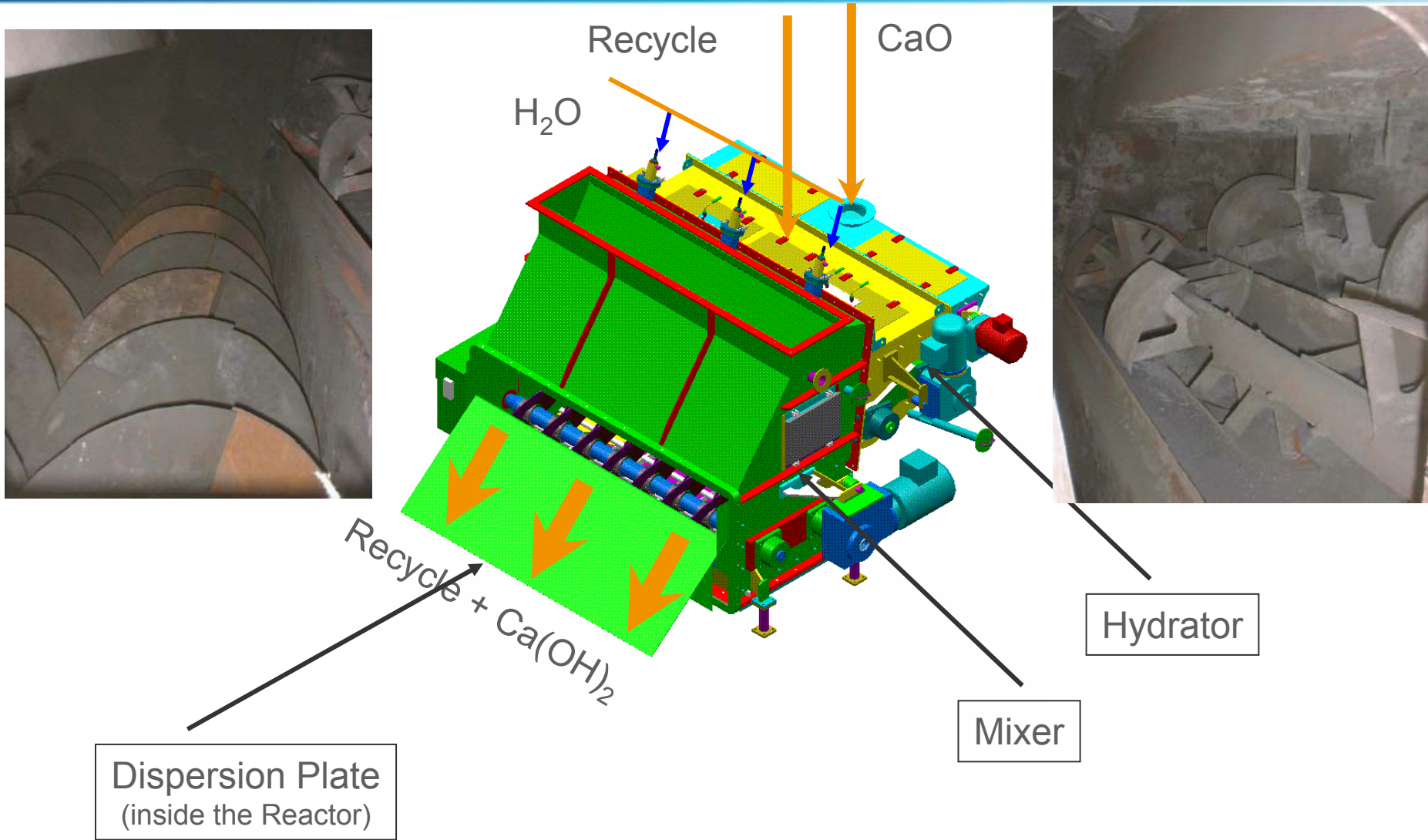
NID Layout



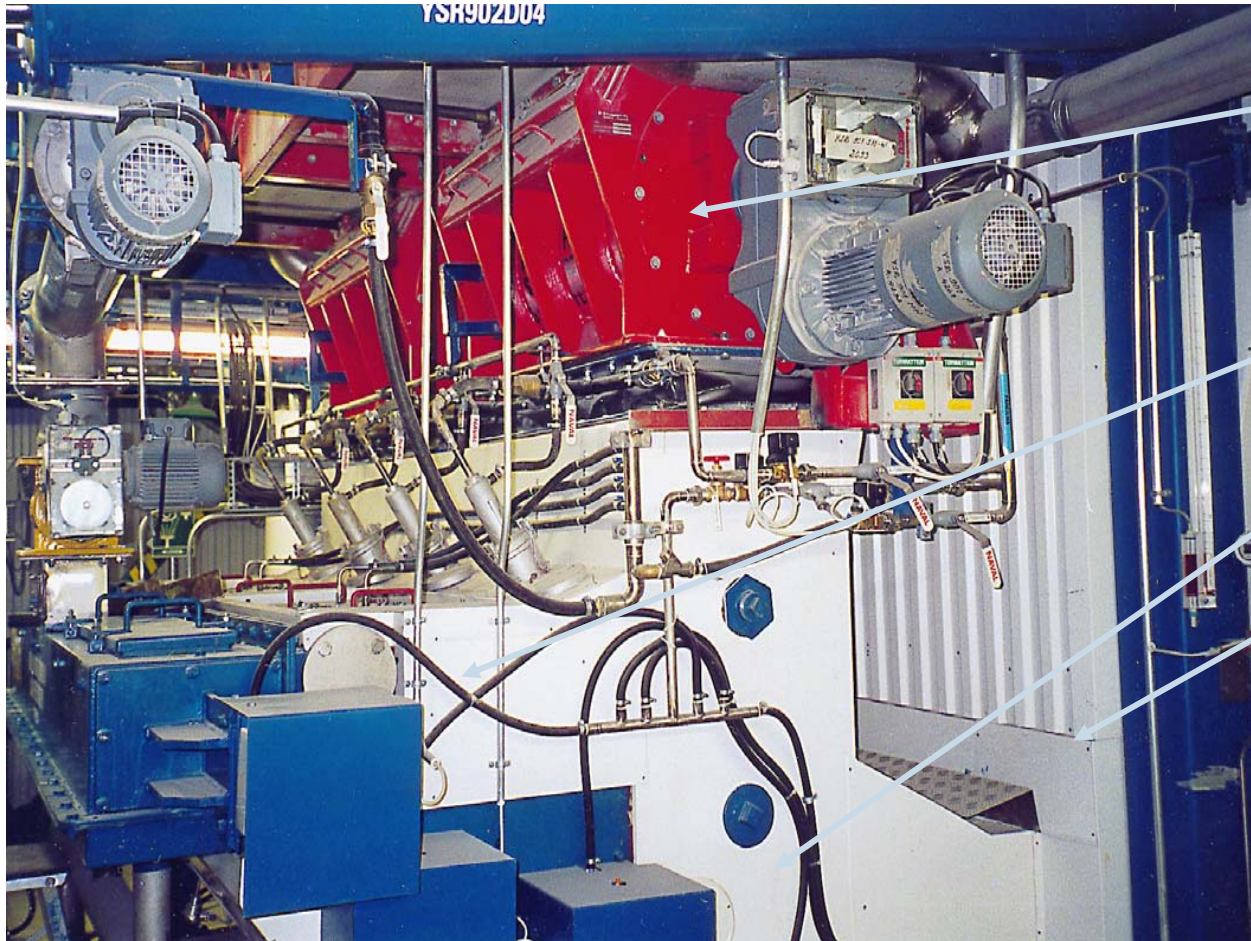
NID Standard Components



NID – Mixer / Hydrator



NID – Mixer / Hydrator



Recirculation
rotary valve

Hydrator

Mixer

Reactor

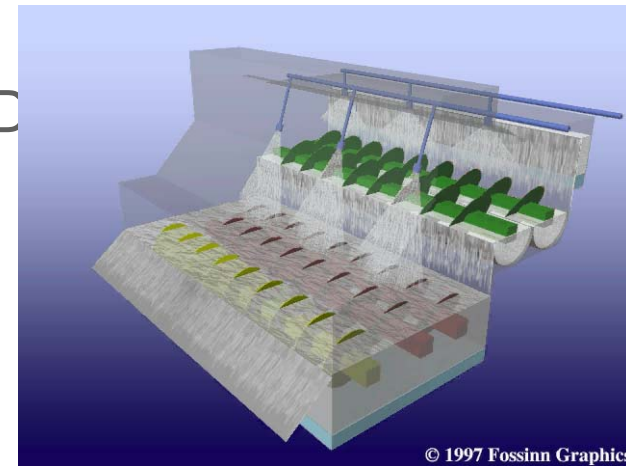
NID Hydrator Concept

Concept

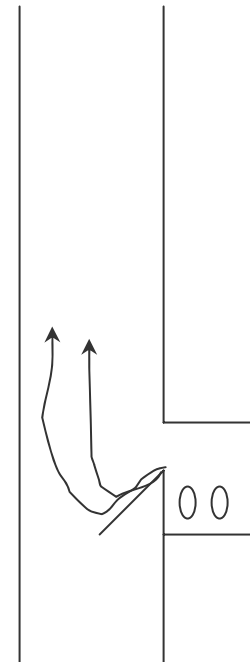
- Hydration in separate compartment integrated with the NID humidifier
- CaO feed controlled directly, based on SO₂ emission
- Hydrate added to humidifier by displacement of CaO addition; overflow directly into humidification section

Advantages

- No intermediate silo
- No separate filter; venting through NID
- No transport of hydrated lime; direct overflow



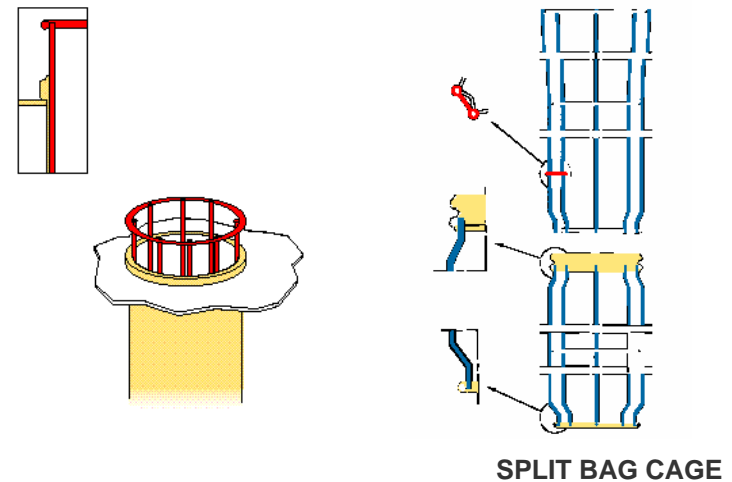
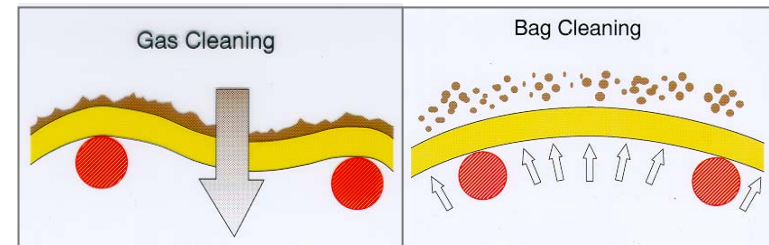
NID Reactor



Entrained Flow
Reactor

Fabric Filter Bags and Support Cages

- Outside/ in filtration
 - low face velocity
 - non-obstructed release of dust cake
- Filtration media options
 - various fabric material and treatment
 - 5-10 m bag lengths
- Support cage options
 - adopted to selected fabric material
 - whole or split design



NID Fabric Filter

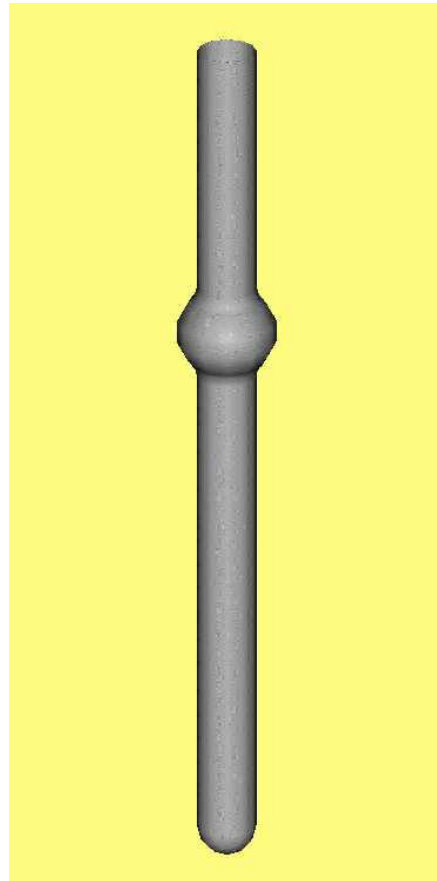
- **Flushing**

- ✓ Reduces re-deposition of fine dust
- ✓ Cleaning the internal of the filter media
- ✓ Low pressure (200 kPa)
- ✓ Short and quick pulse (deep pulse)
- ✓ Deep pulse = long bag capability

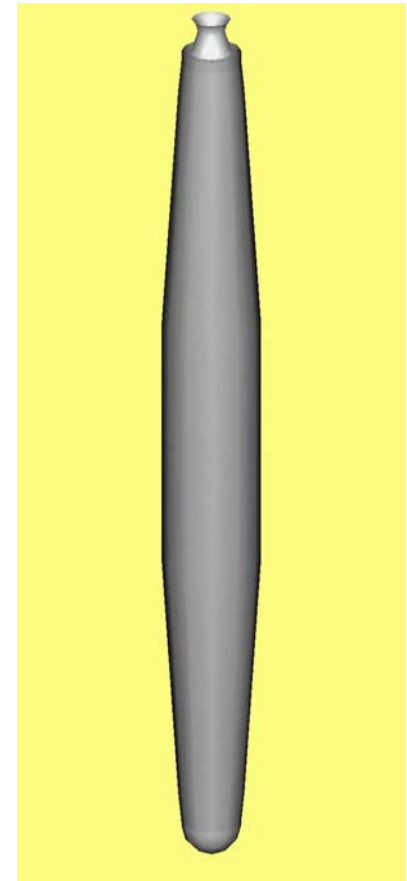
- **Modulated return of filter media**

- ✓ Soft return to operation
- ✓ Reduces dust emission
- ✓ Increase bag life

OPTIPOW[®]-Valve



Venturi

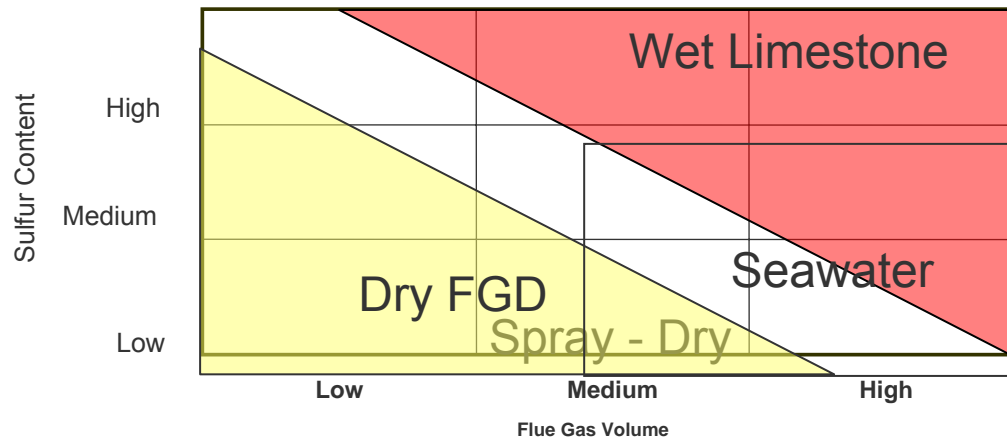


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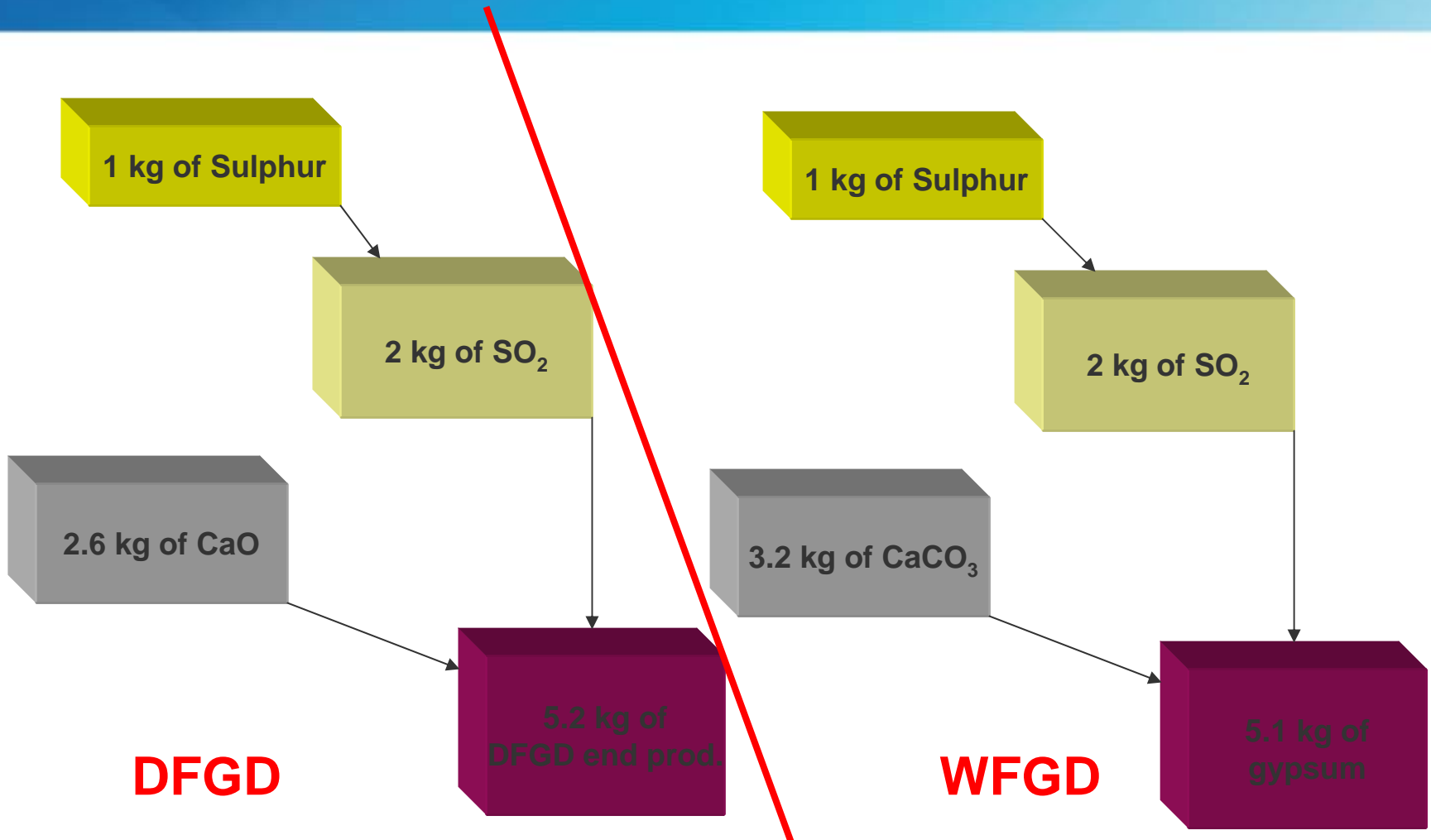
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FGD technology indicators

	Seawater	Limestone	Dry
Positive Indicators	<ul style="list-style-type: none"> Near sea Low/medium sulphur Larger flue gas flow Long cost evaluation period Medium/high annual operating hours 	<ul style="list-style-type: none"> High sulphur Larger flue gas flow Gypsum market Medium/long cost evaluation period Medium/high annual operating hours 	<ul style="list-style-type: none"> Low/medium sulfur Small/medium flue gas flow Short/medium cost evaluation period Low/medium annual operating hours
Negative Indicators	<ul style="list-style-type: none"> Effluent perception issues 	<ul style="list-style-type: none"> Emerging economy 	<ul style="list-style-type: none"> Limited landfill area High lime/limestone cost ratio

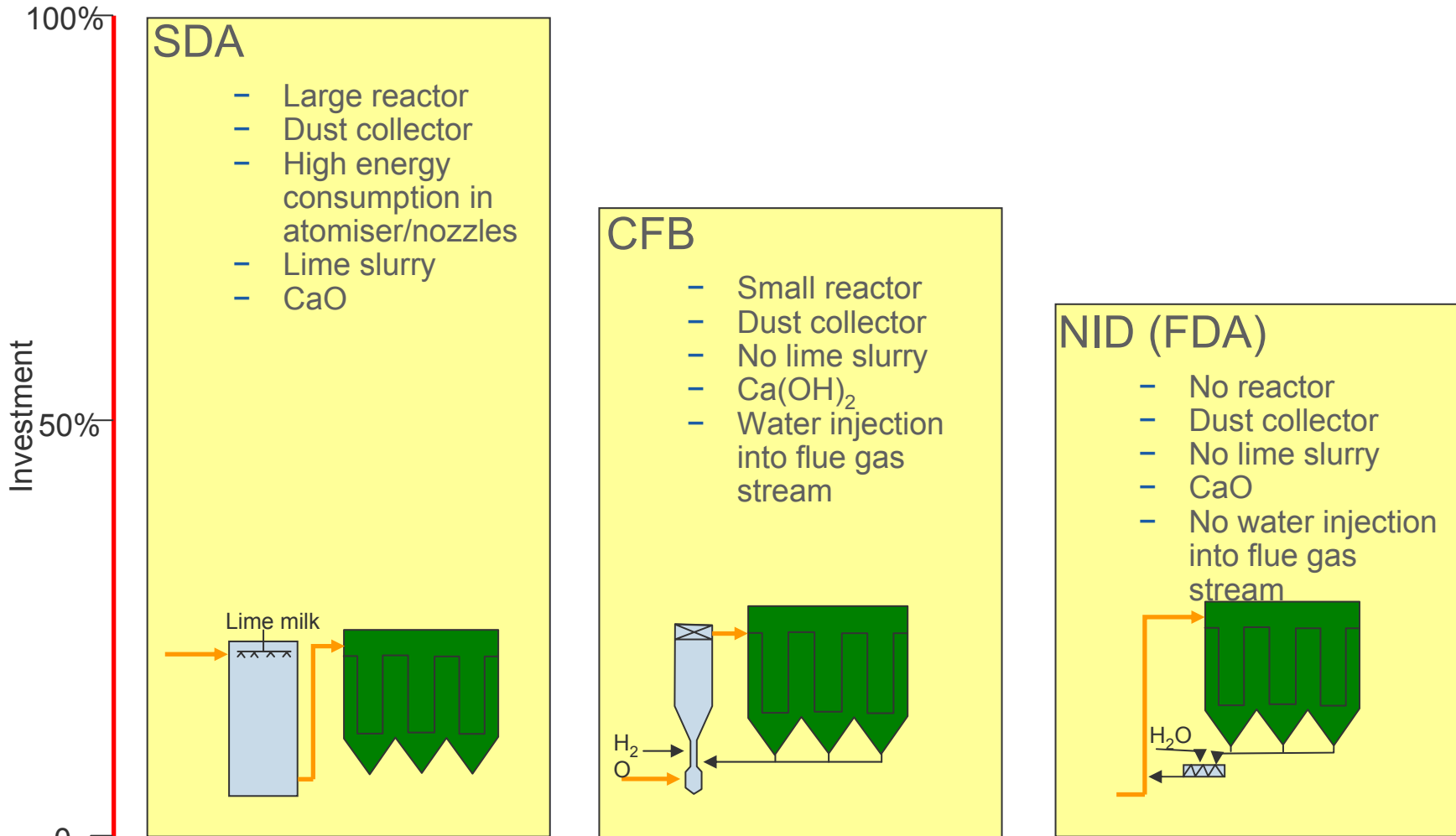


Comparison DFGD - WFGD



Note, for illustration, approximate values only

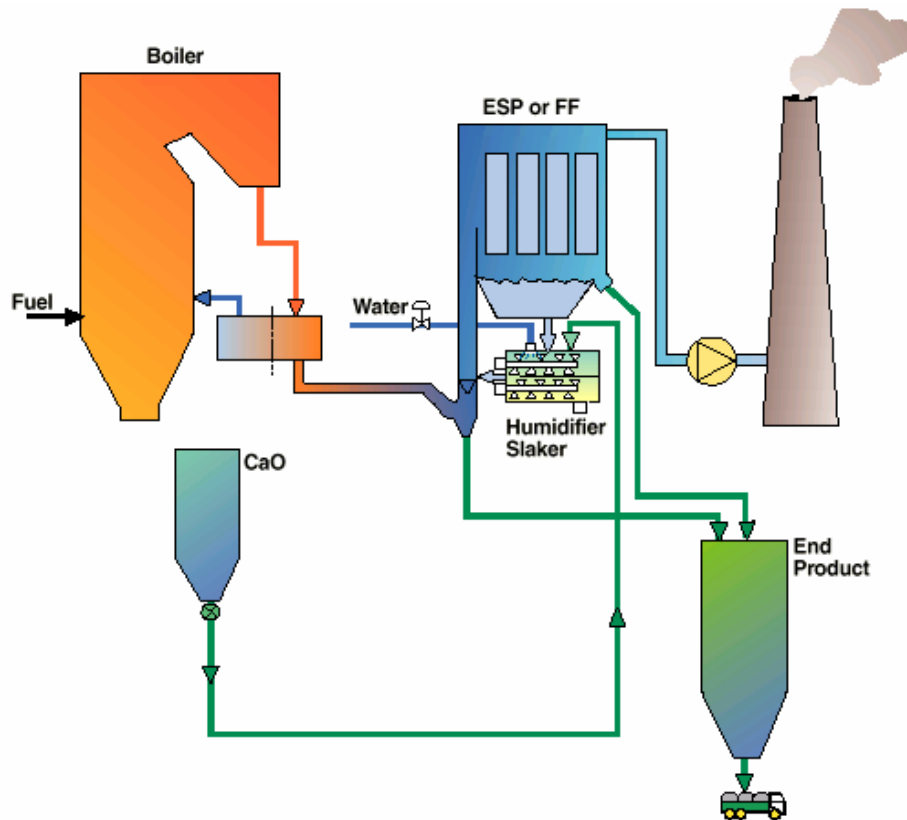
DFGD comparison



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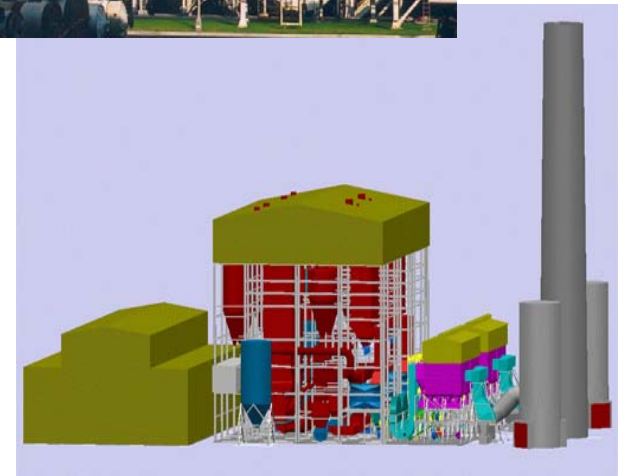
NID - Novel Integrated Desulphurisation



- Proven technology
- Simple, robust & reliable
- Low capital investment cost
- Internal slaking of the reagent
- No slurry handling
- Less equipment – less maintenance
- Integrated dust collector
- Small footprint

NID Advantages

- Process water flexibility
- Uncomplicated operation
- No waste water
- Dry reagent and end product
- Cleaned gas above saturation without reheat
- Suitable up to 300 MW
- No free droplets in the flue gas stream



Mai Liao, CFB+NID,
Formosa Heavy Industries, Taiwan

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