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First evaluation of a multicomponent flue gas cleaning concept using chlorine dioxide gas – Experiments on chemistry and process performance

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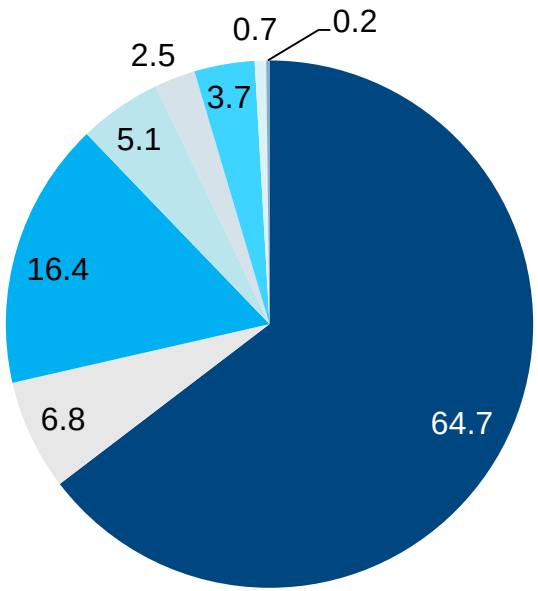
OUTLINE

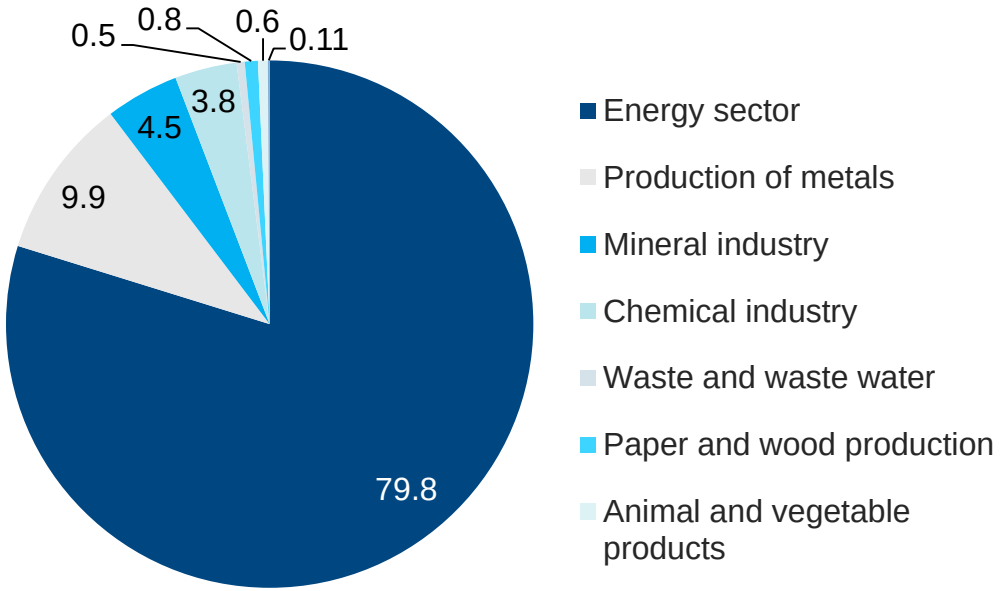
- Introduction
- Objectives
- Method
- Result
- Conclusions

INTRODUCTION

- Energy sector stands for the major part of the NO_x and SO_x release in Europe.
- NO_x and SO_x are associated with adverse effect on human health and are responsible for environmental problems.



Share of NO_x release in Europe 2014[1]



Share of SO_x release in Europe 2014[1]

[1]http://prtr.ec.europa.eu/#/home

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INTRODUCTION

- With concern over the environment and health consequences of NO_x and SO_x, stricter legislation and regulations are continually being implemented, which requires improved emission control systems.

- Today, emission control systems in a conventional combustion plant typically employ technologies designed to remove one specific pollutant; several emission control systems are needed in series in order to meet the emission regulations.

- There is a need to develop new emission control systems, for instance multi-pollutant systems, to improve the removal and cost efficiency, as well as to make implementation easier in retrofit cases.

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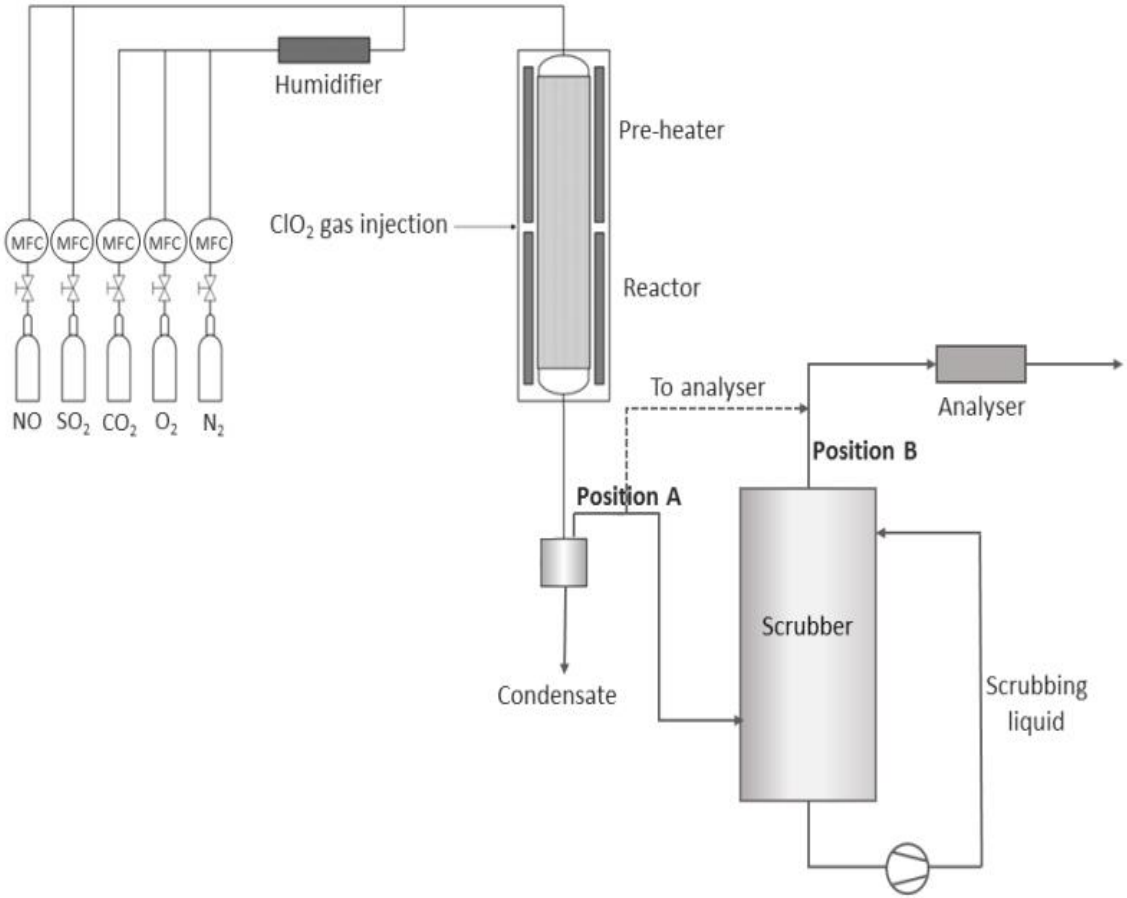
OBJECTIVES

- Evaluate a multi-component flue gas cleaning concept for NOx and SOx removal by the use of chlorine dioxide (ClO_2) gas and subsequent scrubbing with sodium sulphite (Na_2SO_3) and sodium carbonate (Na_2CO_3) as absorption solution.

- Determine the type and amount of N-species in different positions in the system at various process conditions, representing the conditions before and after a quench.

METHOD – Laboratory reactor



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EXPERIMENTAL – Operating conditions

Parameters/conditions	Unit	Setting 1	Setting 2
NO concentration	ppm	200	200
SO_2 concentration	ppm	0 and 200	0 and 200
O_2 concentration	vol.%	4.5	4.5
CO_2 concentration	vol.%	16.5	16.5
N_2 concentration	NL/min.	3 (Balance)	3 (Balance)
H_2O concentration		0 and 80% r.h.	0 and 8 vol.%
Reactor temperature	°C	65	160
ClO_2 injection	ClO_2:NO mole ratio	0.2-0.6	0.2-0.6

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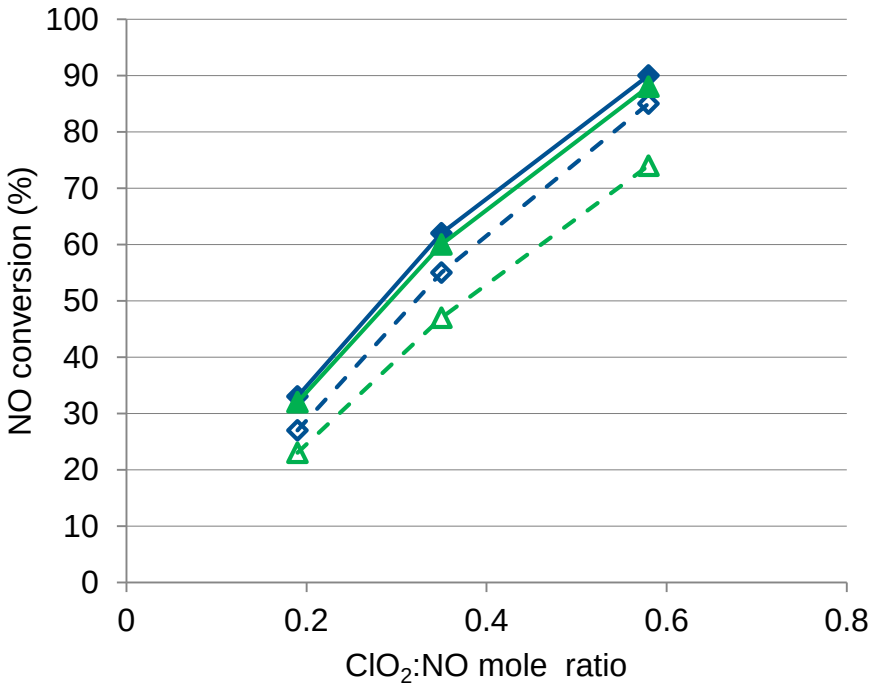
EXPERIMENTAL – Operating conditions

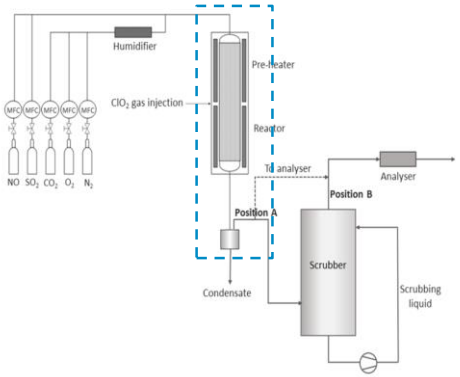
Parameters/conditions	Unit	Setting
Pipe volume	mL	500
Void volume	mL	326
Area/volume ratio	m^2/m^3	808
Gas velocity at 3 NL/min.	m/s	0.061
Residence time at 3 NL/min.	s	6.52
Na_2CO_3	g/L	50
Na_2SO_3	g/L	10
pH		11.3
Liquid flow	mL/min.	100
Temperature of liquid	°C	20

RESULTS

NO conversion versus ClO_2 addition over reactor at 65°C



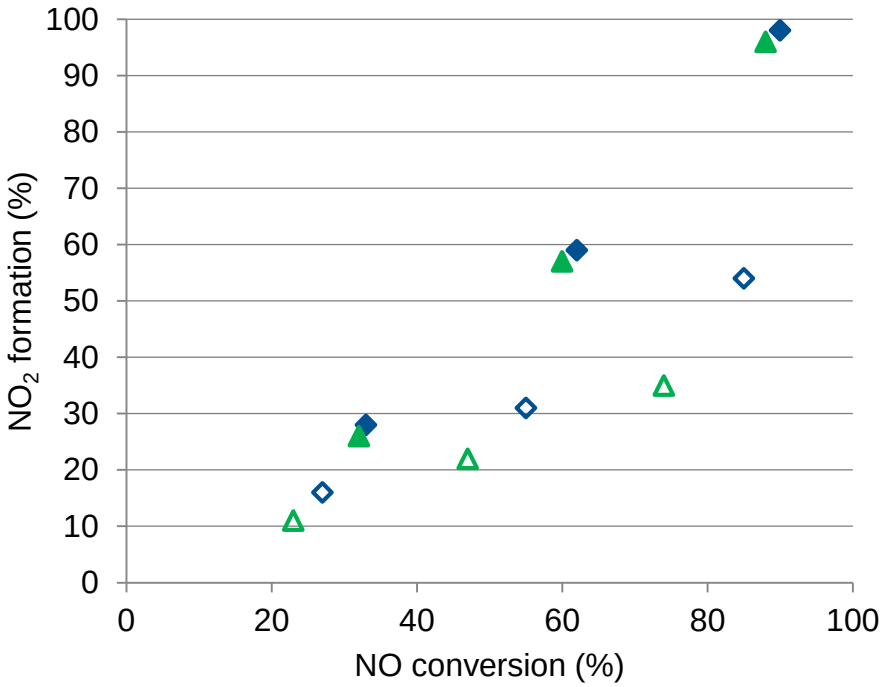
	SO_2 (ppm)	H_2O (% r.h.)
◆	0	0
◇	0	80
▲	200	0
△	200	80



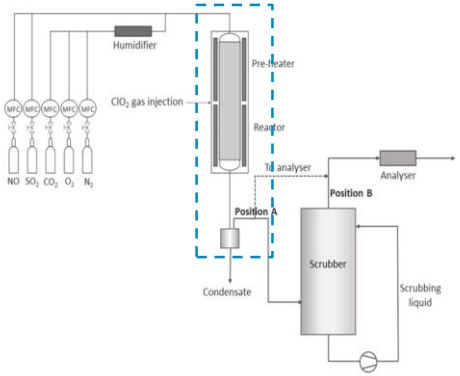
$2NO + ClO_2 + H_2O \rightarrow NO_2 + HNO_3 + HCl$

$5NO_2 + ClO_2 + 3H_2O \rightarrow 5HNO_3 + HCl$

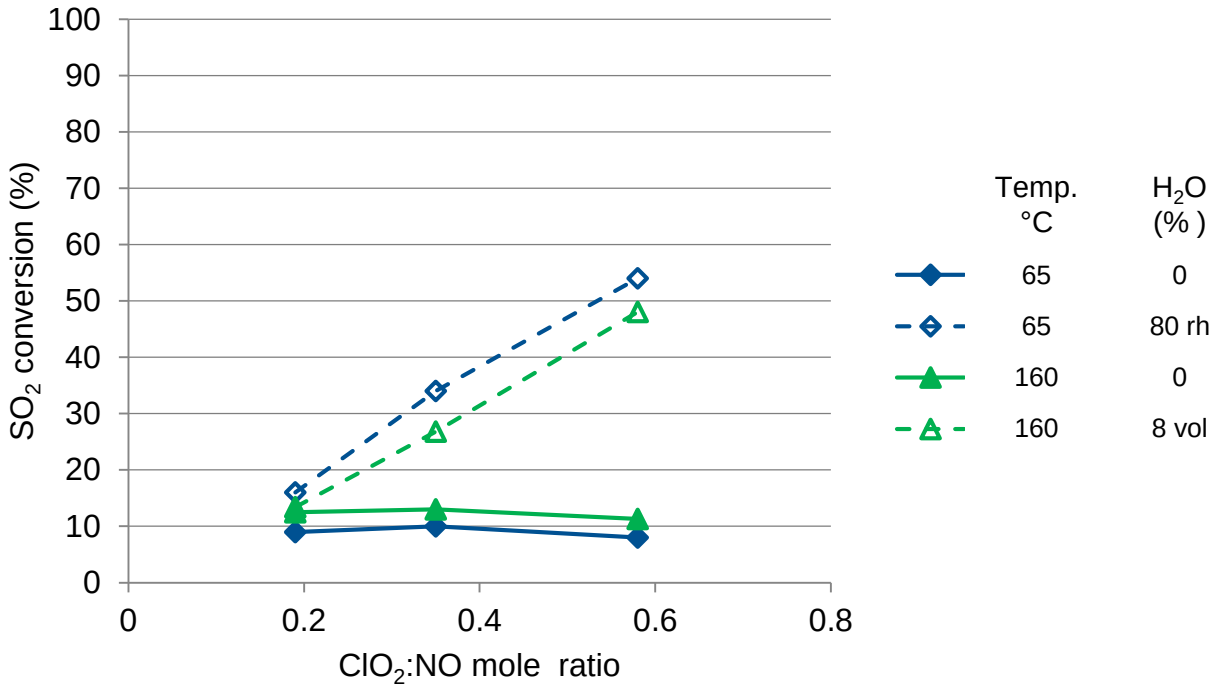
NO_2 formation versus NO conversion over reactor at 65°C

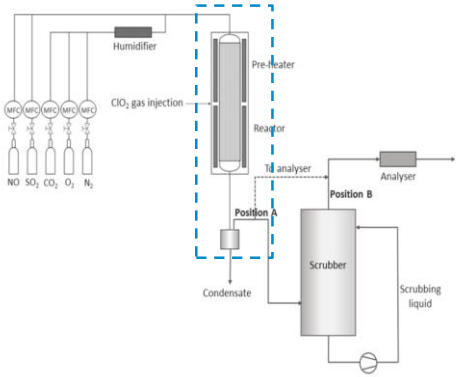


	SO_2 (ppm)	H_2O (% r.h.)
◆	0	0
◇	0	80
▲	200	0
△	200	80

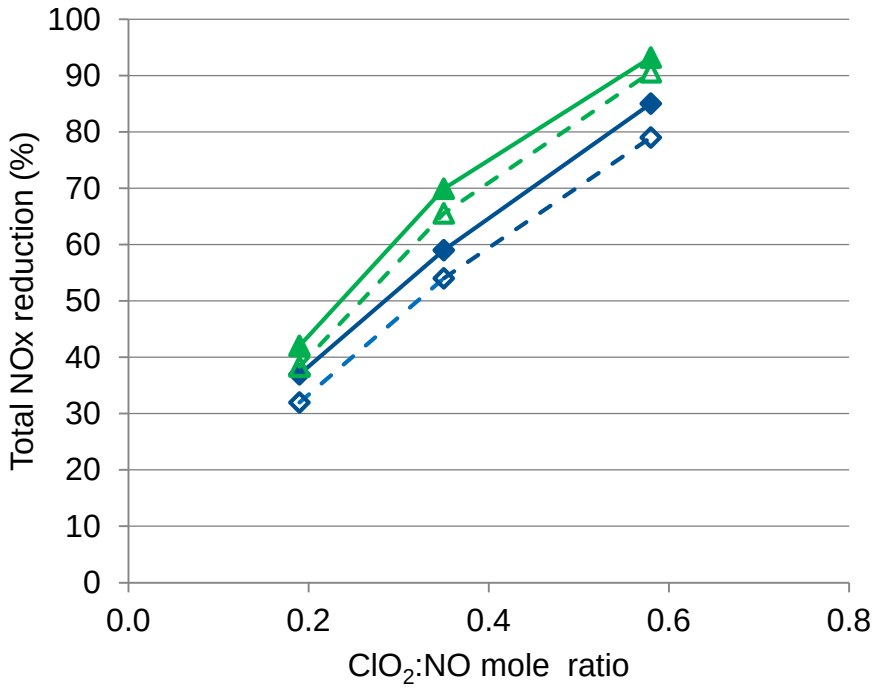


SO_2 conversion versus ClO_2 addition over reactor at 200 ppm SO_2

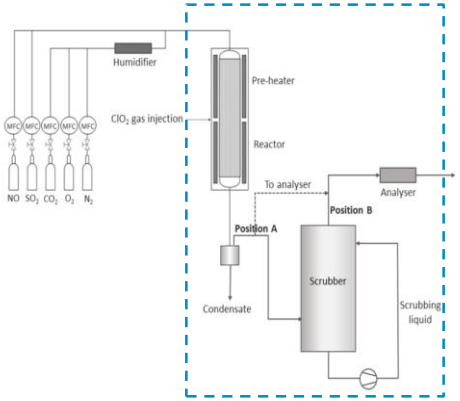




Total NOx and SOx reduction over the system versus ClO_2 addition at 200 ppm SO_2

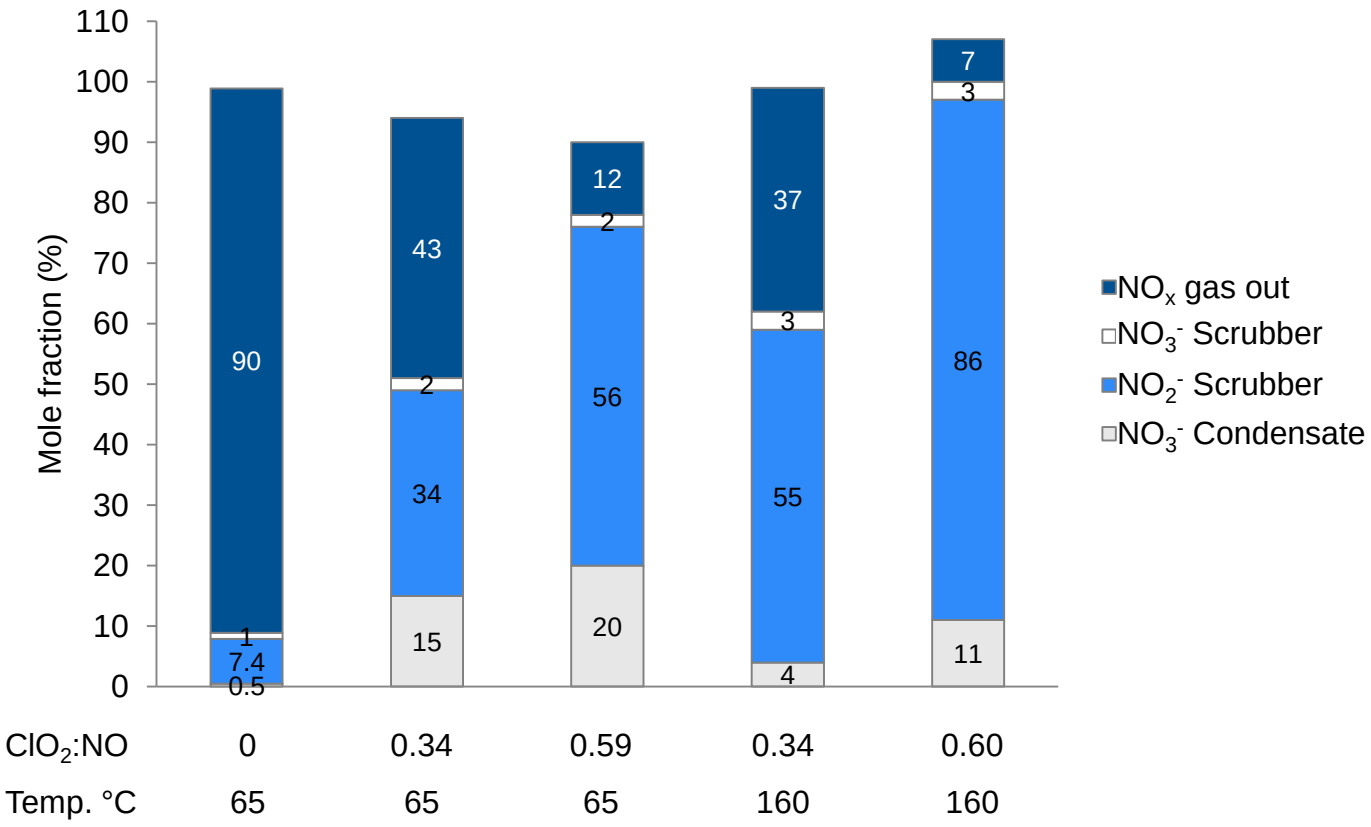


	Temp. °C	H_2O %
◆	65	0
◇	65	80 rh
▲	160	0
△	160	8 vol



Between 97 and 100% total SO_x reduction regardless of ClO_2 addition

N-species in the system



Analyzing points:
Flue gas in and out
Condensate
Absorption solution

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CONCLUSIONS

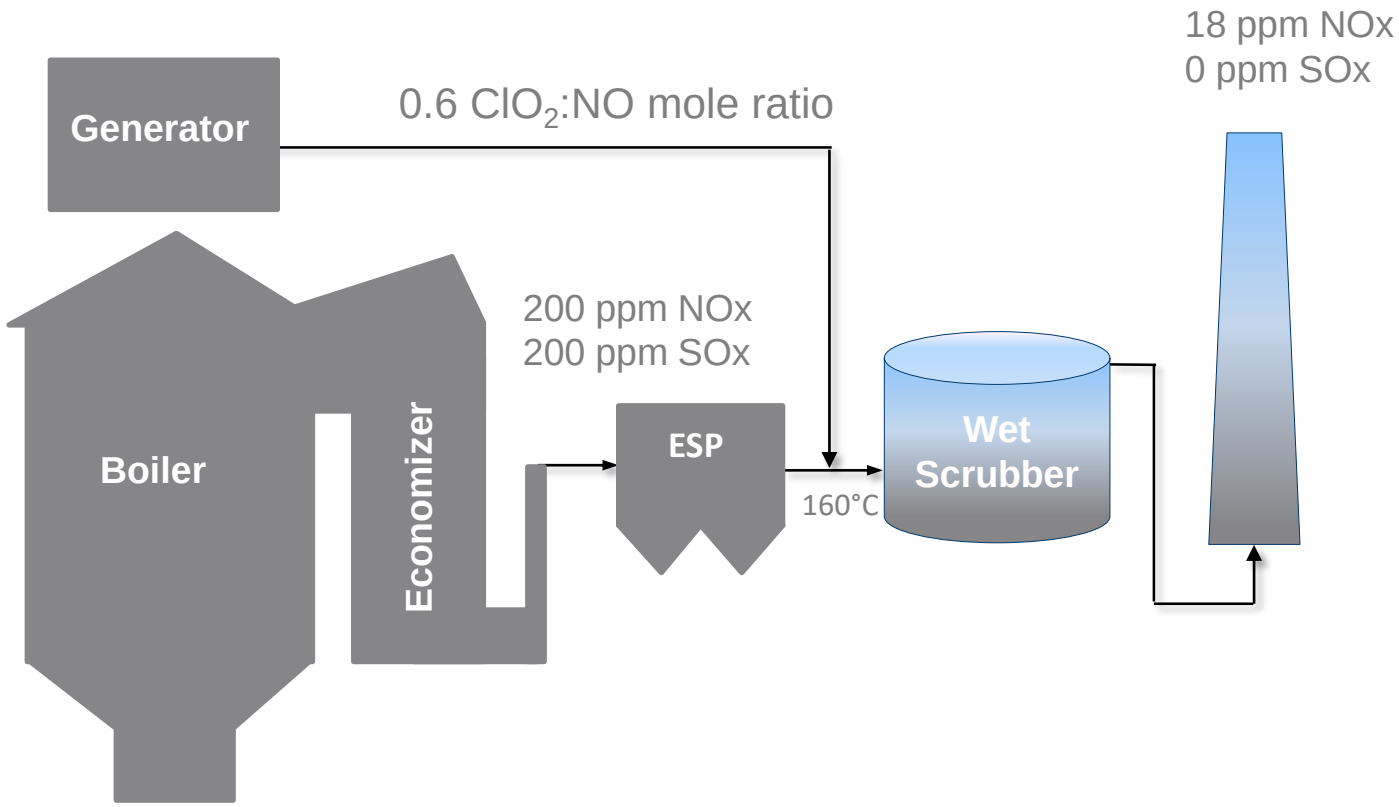
- ClO_2 gas efficiently oxidises NO to NO_2 under various process conditions, also in the presence of SO_2.

- The total amount of NO_x removed from the humidified flue gas at 160°C with SO_2 present at a molar ratio ClO_2:NO of 0.6 was 91%.

- SO_2 is removed in efficiencies of between 97% and 100% in the scrubber,
- regardless of the amount of ClO_2 gas added.

- The major part of the NO_x is converted to nitrate in the condensate liquor and as nitrite in the absorption solution.

SUM-UP
ClO_2 gas with subsequent wet scrubbing



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