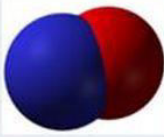





**TurNOx<sup>®</sup>** concept  
Integrated solution for lime plants

**2017**

Cimprogetti Srl | Via Pasubio 5 | 24044 Dalmine (Italy)

NOx (Nitrogen Oxides)	
Nitric Oxide (NO)	Nitrogen Dioxide (NO <sub>2</sub> )
	

Definition

**3** generally-accepted phenomena are responsible for NOx formation:

➤ **thermal NOx**, that occurs @  $T > 1000^{\circ}\text{C}$  and increases exponentially at temperature rise;

➤ **prompt NOx** formed from molecular nitrogen in the air combining with fuel;

➔ and **fuel NOx**, that typically occurs @  $T > 800^{\circ}\text{C}$  during the combustion process in Parallel Flow Regenerative (PFR).

## BAT-associated emission levels for NO<sub>x</sub> from flue-gases of kiln firing processes in the lime industry

KILN TYPE	UNIT	BAT-Associated emission level (*)
Parallel flow regenerative kiln (PFRK) Annular shaft kiln (ASK) Mixed-feed shaft kiln (MFSK) Other shaft kiln (OSK)	mg/Nm <sup>3</sup>	<b>100 – 350 (1) (3)</b>
Long rotary kiln (LRK) Rotary kiln with preheater (PRK)		<b>&lt; 200 – 500 (1) (2)</b>

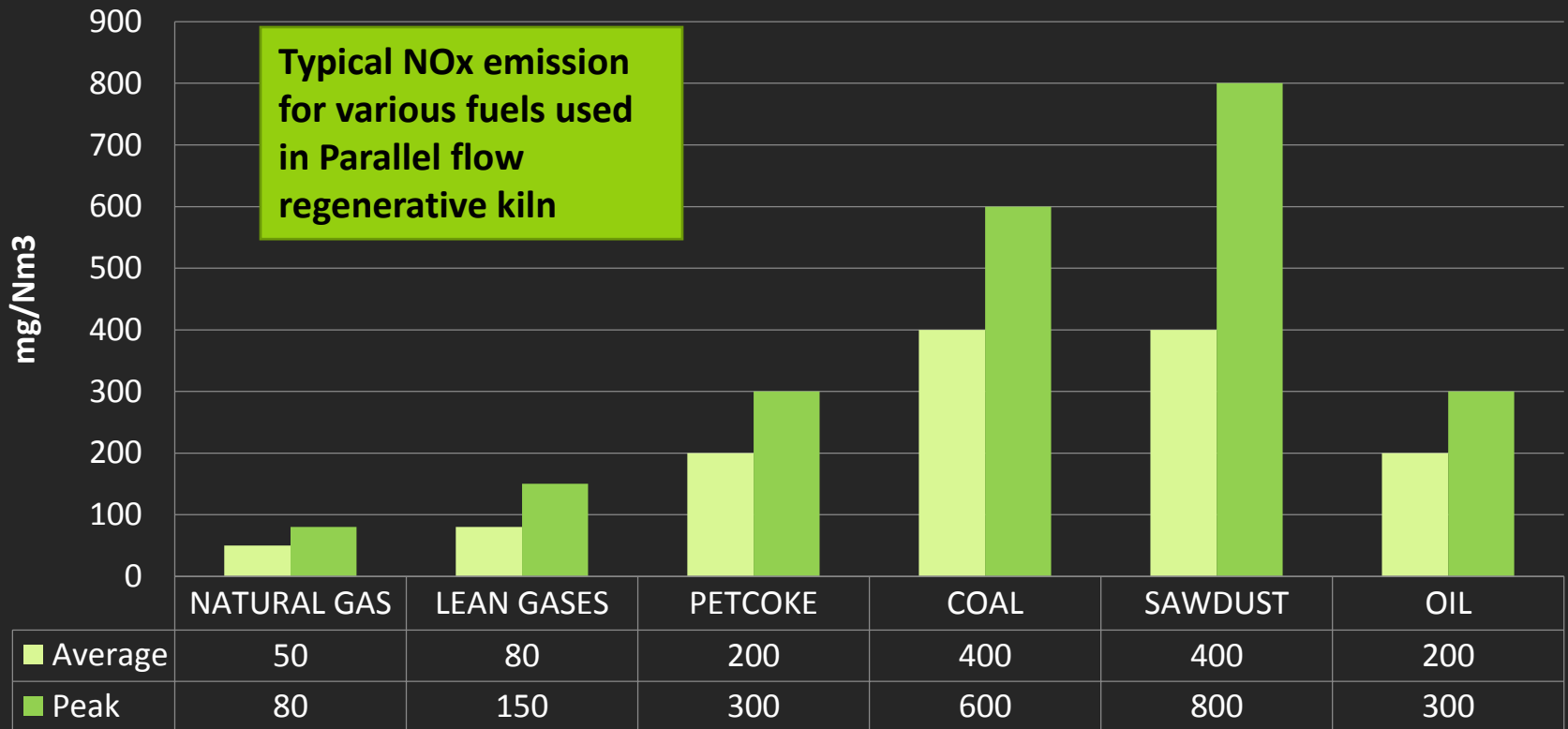
(\*) daily average value or average over the sampling period (spot measurements for at least half an hour), stated as NO<sub>2</sub>

(1) The higher ends of the ranges are related to the production of dolime and hard burned lime. Higher levels than the upper end of the range may be associated with the production of sintered dolime.

(2) For LRK and PRK with shaft producing hard burned lime, the upper level is up to 800 mg/Nm<sup>3</sup>.

(3) Where primary techniques as indicated in BAT 45 (a)I are not sufficient to reach this level and where secondary techniques are not applicable to reduce the NO<sub>x</sub> emissions to 350 mg/Nm<sup>3</sup>, the upper level is 500 mg/Nm<sup>3</sup>, especially for hard burned lime and for the use of biomass as fuel.

Regenerative kilns are considered environmentally friendly among others type of kilns. However, the new regulation standards and the selection of new fuels for cost savings are necessitating development of technical solutions to protect environment in particular by NOx emission abatement.



**NOTE: Values calculated @ 11% oxygen on dried basis**



**NOx reduction by  
Cimprogetti**

Cimprogetti is developing idea, project and plants as part of a distinct system based on environmental sustainability.

## **Primary Techniques in order to reduce NOx**

- Appropriate Fuel Selection
- Process optimization for significant reduction in energy consumption
- Add-on technique for NOx removal in flue gases



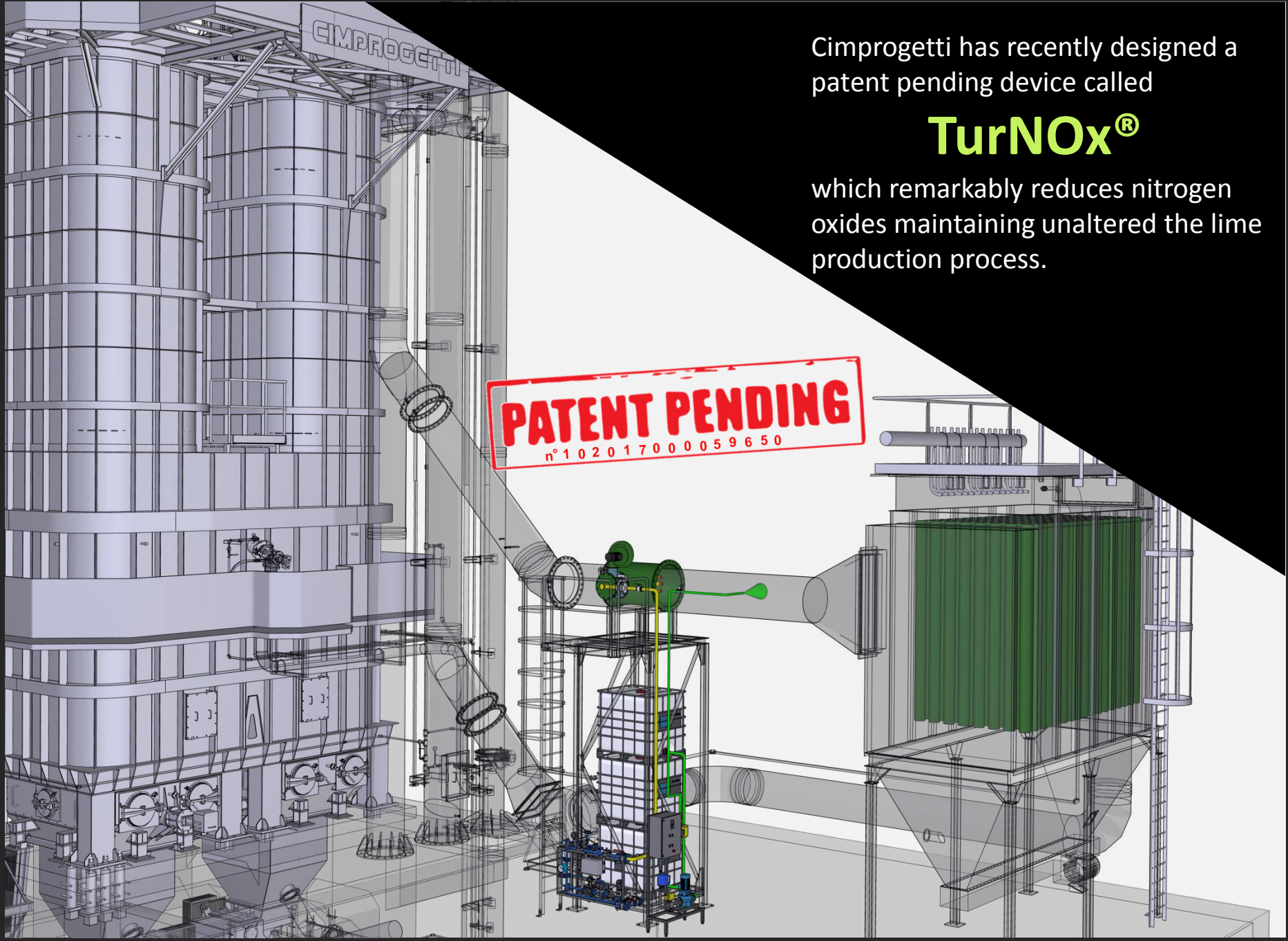
Each fuel has a different environmental impact or load on energy bills in lime business. These characteristics must be evaluated during the design phase in order to attain to the optimum compromise between costs, performance and sustainability.



Fuel NO<sub>x</sub> is not a concern for gaseous fuels, which normally have no organically-bound nitrogen. However, fuel NO<sub>x</sub> may be important when oil, coal and alternative fuels are used.



**NO<sub>x</sub>  
emission limits  
depend on  
governmental  
legislation**



Cimprogetti has recently designed a patent pending device called


# TurNOx®

which remarkably reduces nitrogen oxides maintaining unaltered the lime production process.

**PATENT PENDING**  
n° 102017000059650

The device developed by Cimprogetti for the abatement of NOx is similar to an SCR system but distinguished by the following features:

- ❑ the device is specially designed for regenerative double- or triple-shaft kilns;
- ❑ the fumes heater modulates the thermal power delivered according to the temperature fluctuation during the combustion cycle, so as to contain the fuel consumed by the heater itself and to ensure the minimum operating temperature for the NOx reduction;
- ❑ possible adjustment of the minimum operating temperature of the NOx abatement device.

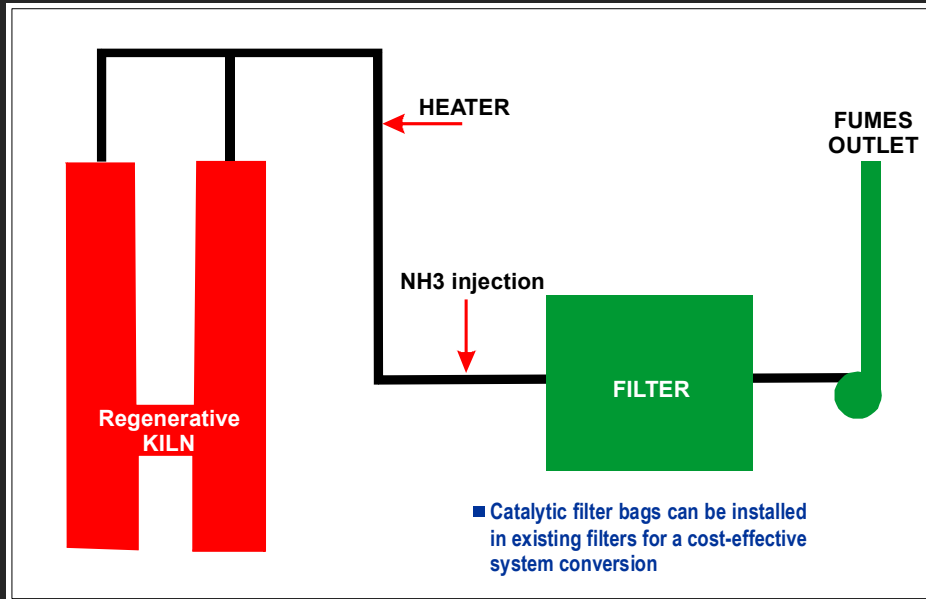


**SCR is the optimal  
NOx control and  
abatement system,  
able to meet stricter  
incoming legislation**



The TurNOx<sup>®</sup> is an innovative, integrated solution placed downstream of the kiln and composed by three relevant unit:

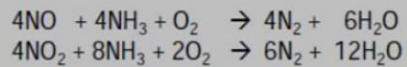
Concept



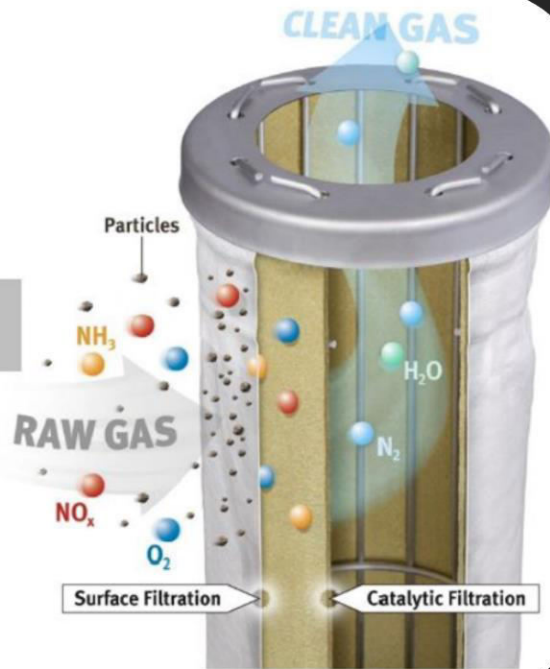
- heater to stabilize the fumes temperature at the filter inlet;
- appropriate dosing system for ammonia or urea solution;
- standard filter equipped with catalytic bags designed to treat off-gases.

A custom-made double bag system is designed to fit an existing bag-house without any modification requirement, thus saving capital and installation costs of new equipment.

- ✓ Outer layer filter bag for particulate removal
- ✓ Catalyst insert for  $\text{NO}_x$  and  $\text{NH}_3$  reduction

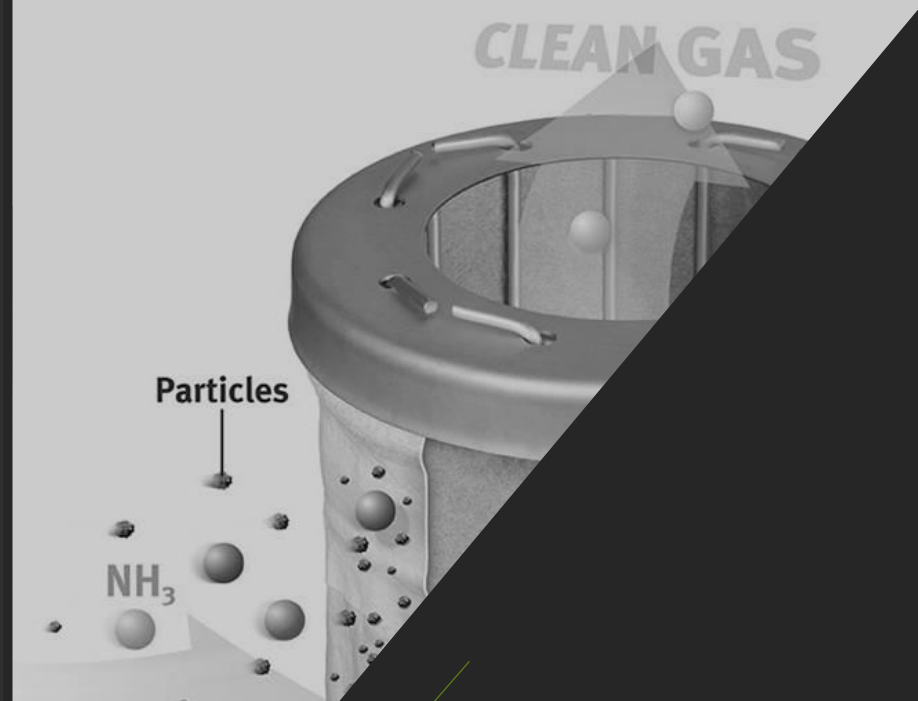


TurNOx<sup>®</sup> is the result of a collaborative partnership with W.L. Gore and Associates, a materials science company focused on product innovation

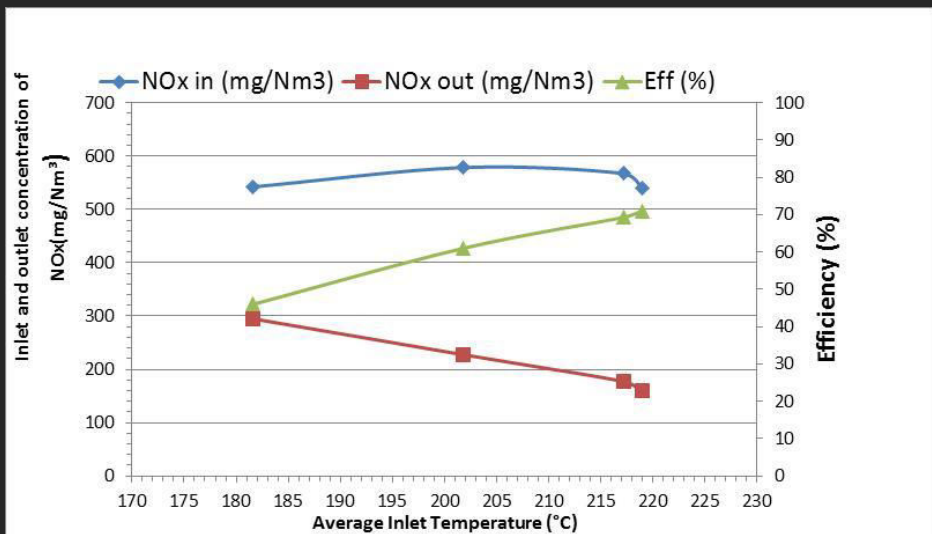


*Courtesy of W.L. Gore and Associates*

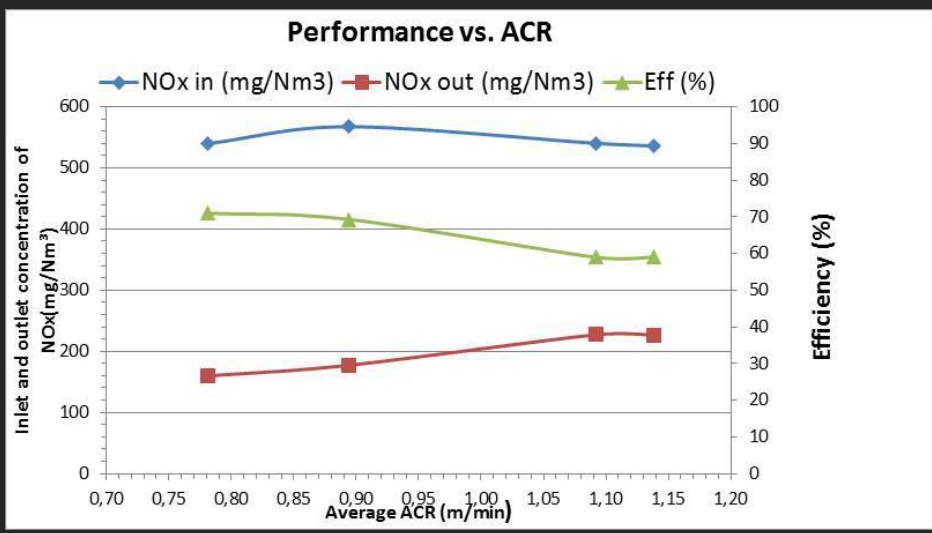
## USE YOUR EXISTING BAGHOUSE CHANGE THE FILTER BAGS



1. Low capital investment for new equipment;
2. Minor changes to process and operation;
3. No additional footprint;
4. No differential pressure increase;
5. Easy to install. Easy to maintain.



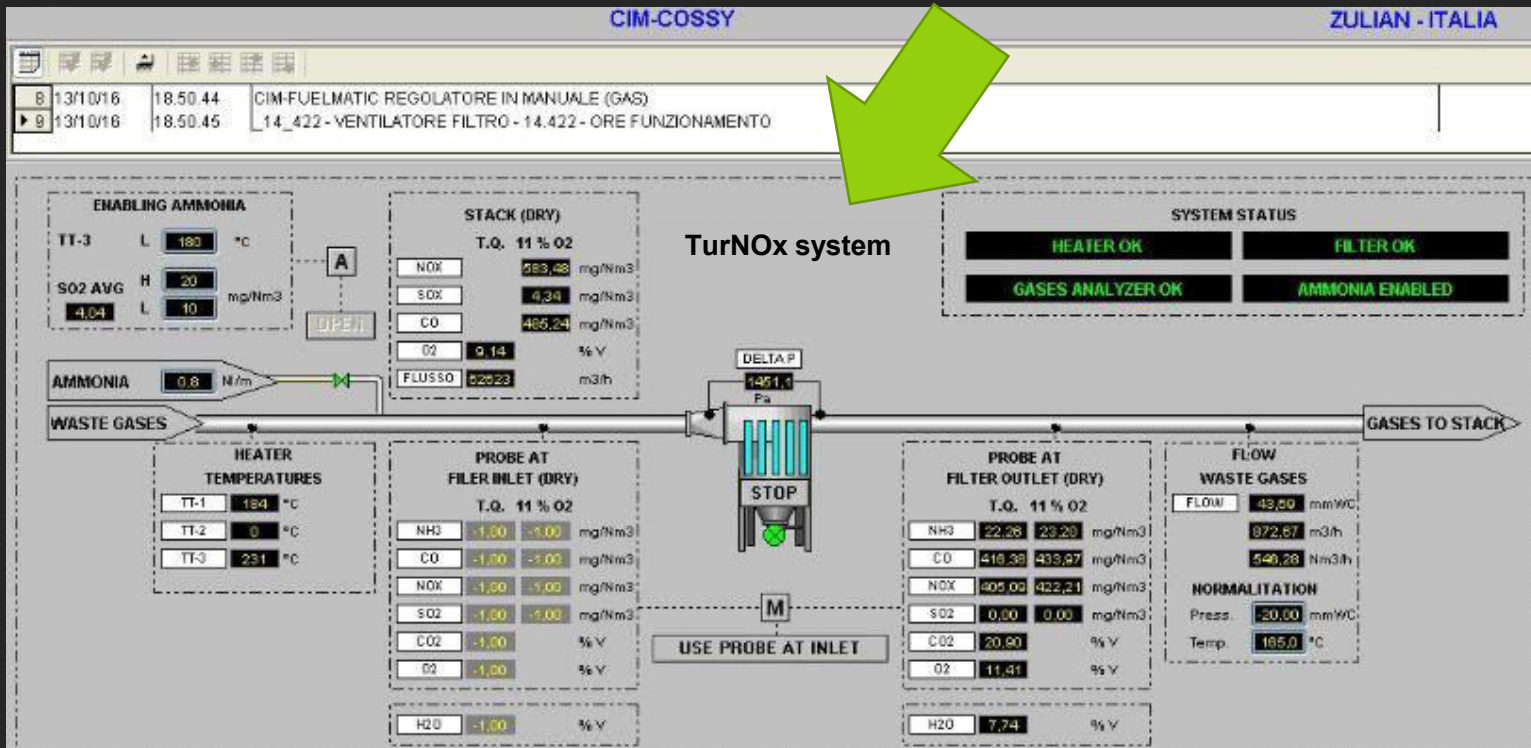
NOx abatement efficiency shows dependency on temperature and air cloth ratio (ACR).



**60% efficiency at approx. 220°C with less than 1 m/min ACR**

Cimprogetti introduced an integrated system of NOx emission control in its automation & supervision system with the possibility to modulate the process parameters without affecting the calcination process.

Trial



# Ammonia dosing system

Filter equipped with catalytic bag



## Capital and operating costs for a 400 t/d coal-fired lime kiln

Cost items	Unit	Cost value
OPEX for ammonia injection (*)	€/t CaO	0,10
OPEX for Waste gas heating system (calculated with NG) (*)	€/t CaO	0,005
Total increasing OPEX including filter media (**)	€/t CaO	0,50
Total Investment cost calculated with the existed bag-house (*)	€	600.000

(\*) ammonia cost is average 0,16 €/kg - Natural Gas (NG) cost is average 0.5 €/m<sup>3</sup>.

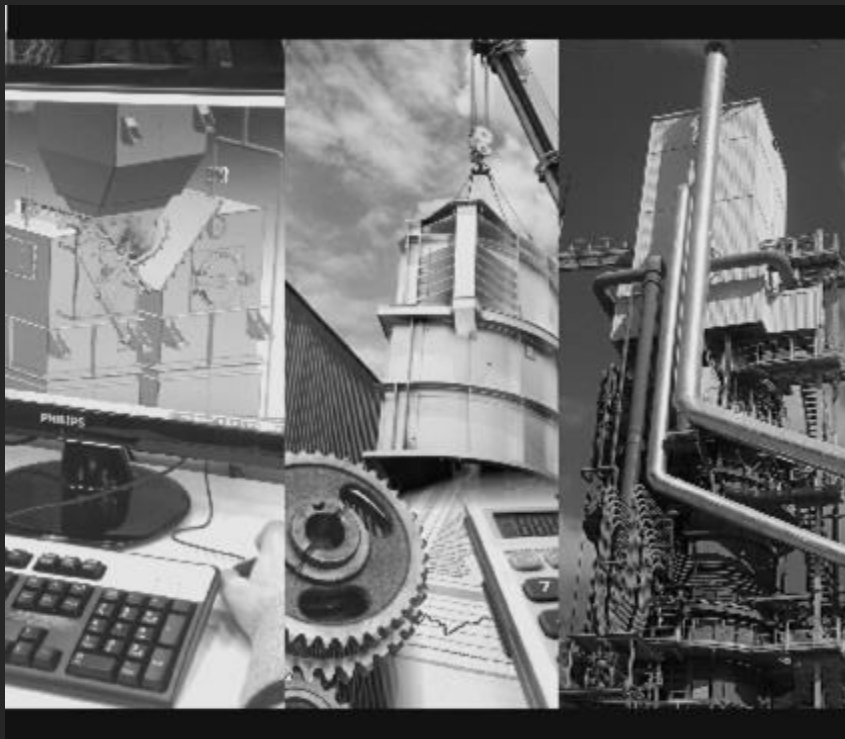
(\*\*) Opex calculated assuming a lifetime of 5 years for the filter media and catalyst.

The advantages of this new device as a state-of-the-art solution are:

- ❑ application to new kilns and to existing plant configurations;
- ❑ lime production process not altered;
- ❑ remarkable reduction in nitrogen oxides which is reasonably round about 60% while remaining within the limits set by environmental norms for ammoniacal slipvalues;
- ❑ competitive advantage of the market, part of the new environmental sustainability contexts.

# CIMPROGETTI®

THE GREEN EDGE OF  
LIME TECHNOLOGIES



*Your right partner for  
Lime processing*

*Thank you*