**Workshop to Promote the Ratification of Technical Protocols of the UNECE Air Convention with Focus on Countries in the EECCA Region**

14-16 May 2019, Berlin Germany

# BAT in the cement industry, including cost/benefit effects

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# TECHNOLOGICAL CYCLE FOR PORTLAND CEMENT PRODUCTION




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# The Best Available Reference document for Cement sector

The BAT reference document for the cement sector has been issued for the first time in 2001 under the frame of the IPPC Directive. In 2005 it was decided to update the document and the second release appeared as a draft in 2010. In the mean while the IPPC was substituted by the IED Directive (24 November 2010) and the Cement Bref was completed with a new paragraph, the Bref Conclusion, and finally issued on march 2013. According to the IED Directive within four years (dead line march 2017) all the permits should have been revisited following the provisions of the BAT conclusion document.

# BAT Associated Emission Levels (BAT-AEL)

- The BAT-AEL are 24 hour average values referred to dry gas in standard conditions (0°C,1 atm) and 10% oxygen.

| POLLUTANT | BAT-AEL (mg/Nm$^3$) |
|---|---|
| **TOTAL DUST** | **<10-20** |
| **$NO_X$ (preheater kiln)<br>(Lepol-long kiln)** | **200-450<br>400-800** |
| **$SO_2$** | **50-400** |
| **HCl** | **10** |
| **HF** | **1** |
| **Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V** | **0,5** |
| **Cd+Tl** | **0,05** |
| **Hg** | **0,05** |
| **Dioxin and furans** | **0,05-0,1 I-TEQ ng/Nm$^3$ (*)** |
| **$NH_3$ (ammonia slip from injection system)** | **<30-50** |



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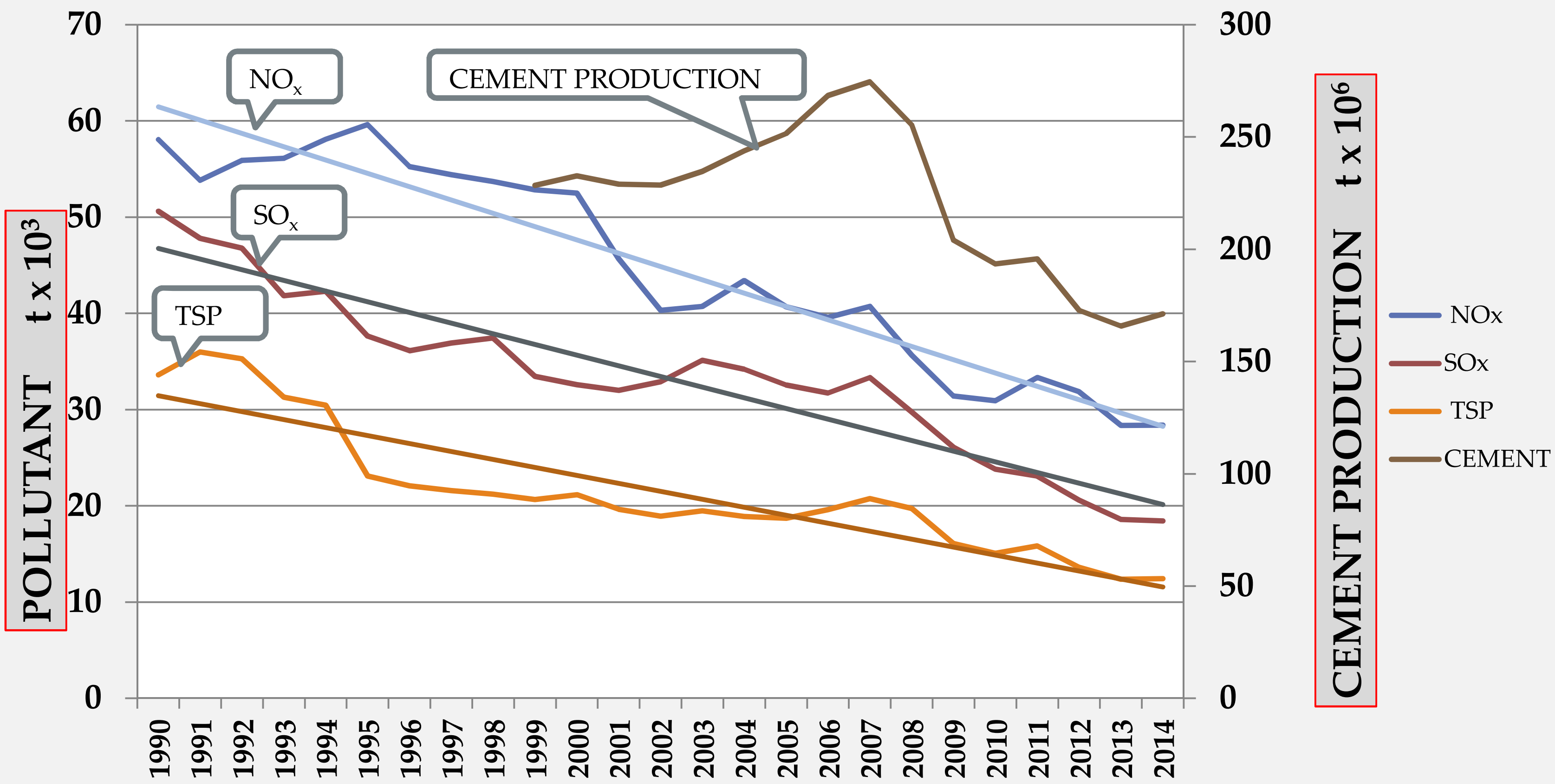
# EU 28 global trend of pollutant emissions




**Source EEA**



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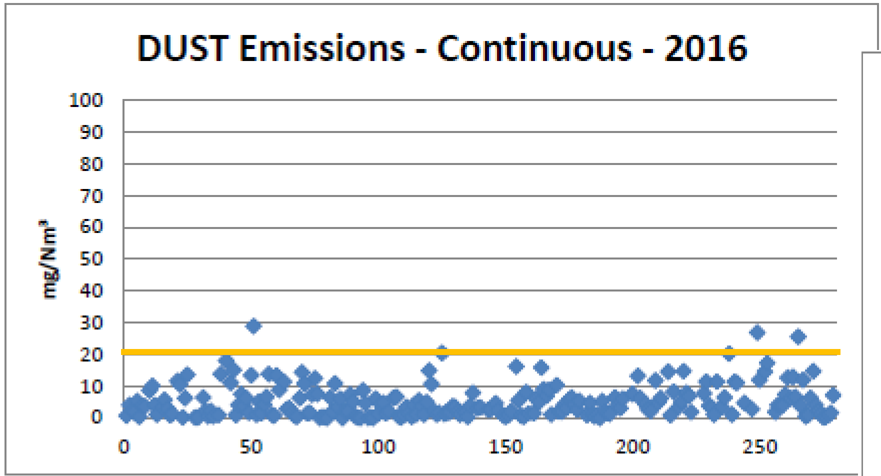
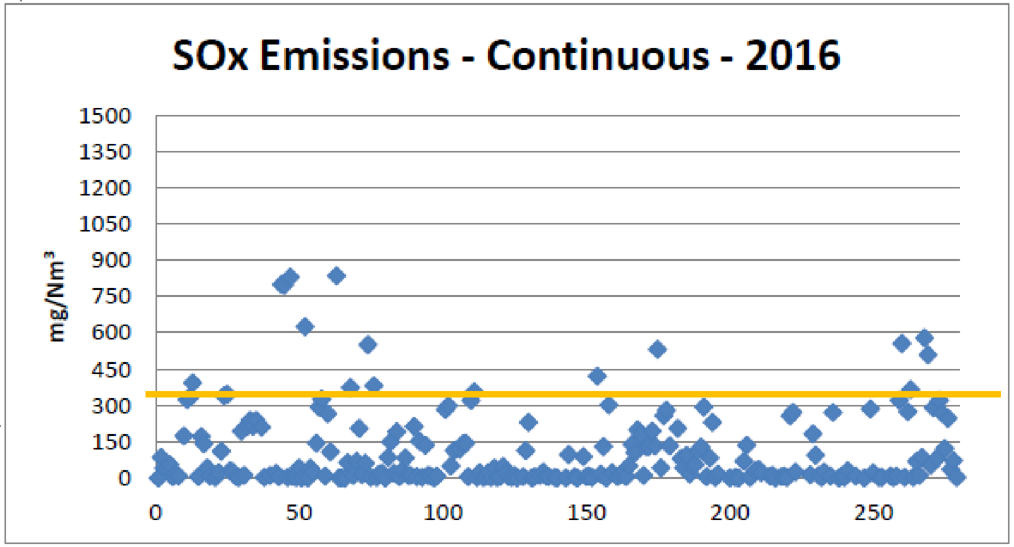
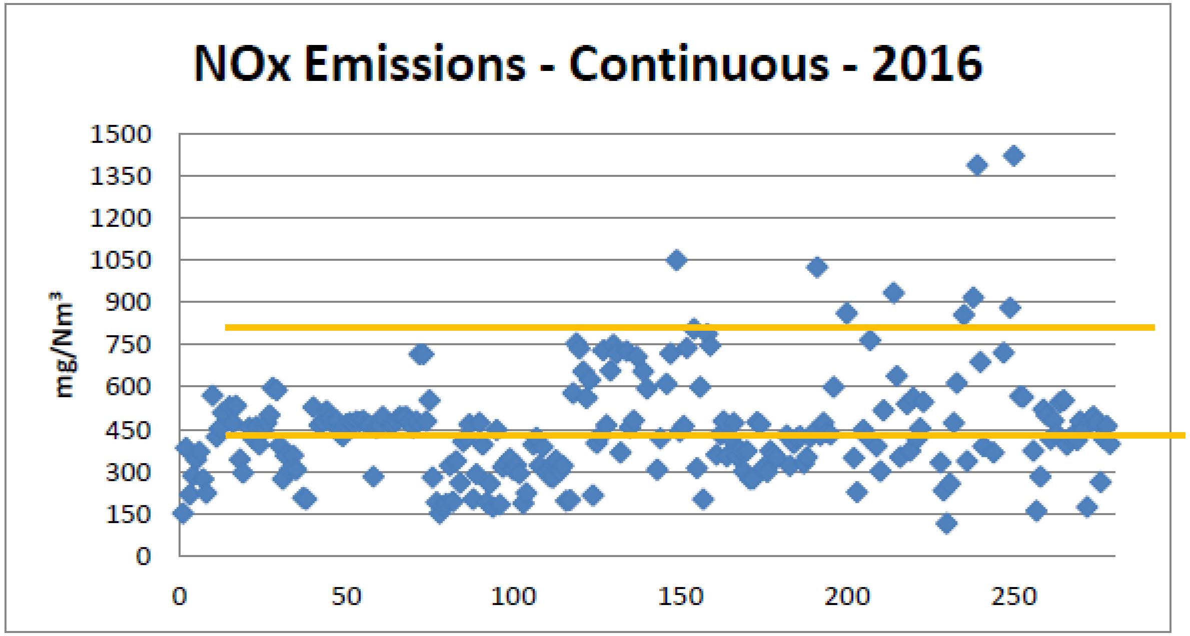
# EU 28 global trend of pollutant emissions (CEMs 2016)




Source Cembureau

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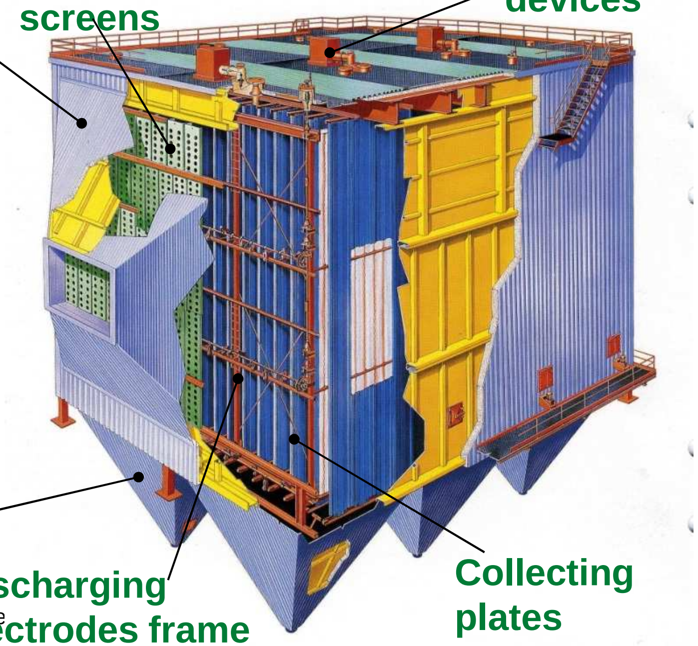
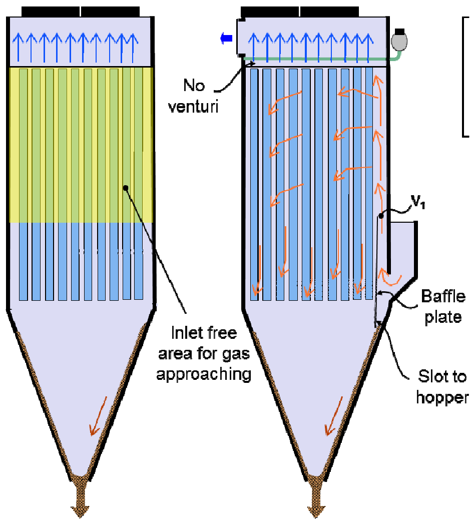
# DUST: Electrostatic Precipitator (ESP) and Bag Filter (BF)

ESP are constant efficiency devices that are not always able to manage upset conditions. ESP pressure drop is low compared with the one of a BF. In stable operations ESP can guarantee emission values below the BAT AEL reported by the cement Bref.




BF are constant emission devices that can tolerate reasonable changes in the process gas. BF are in continuous evolution in term of design and filtering media. The upgrading of an ESP consists in many case in a conversion to BF.



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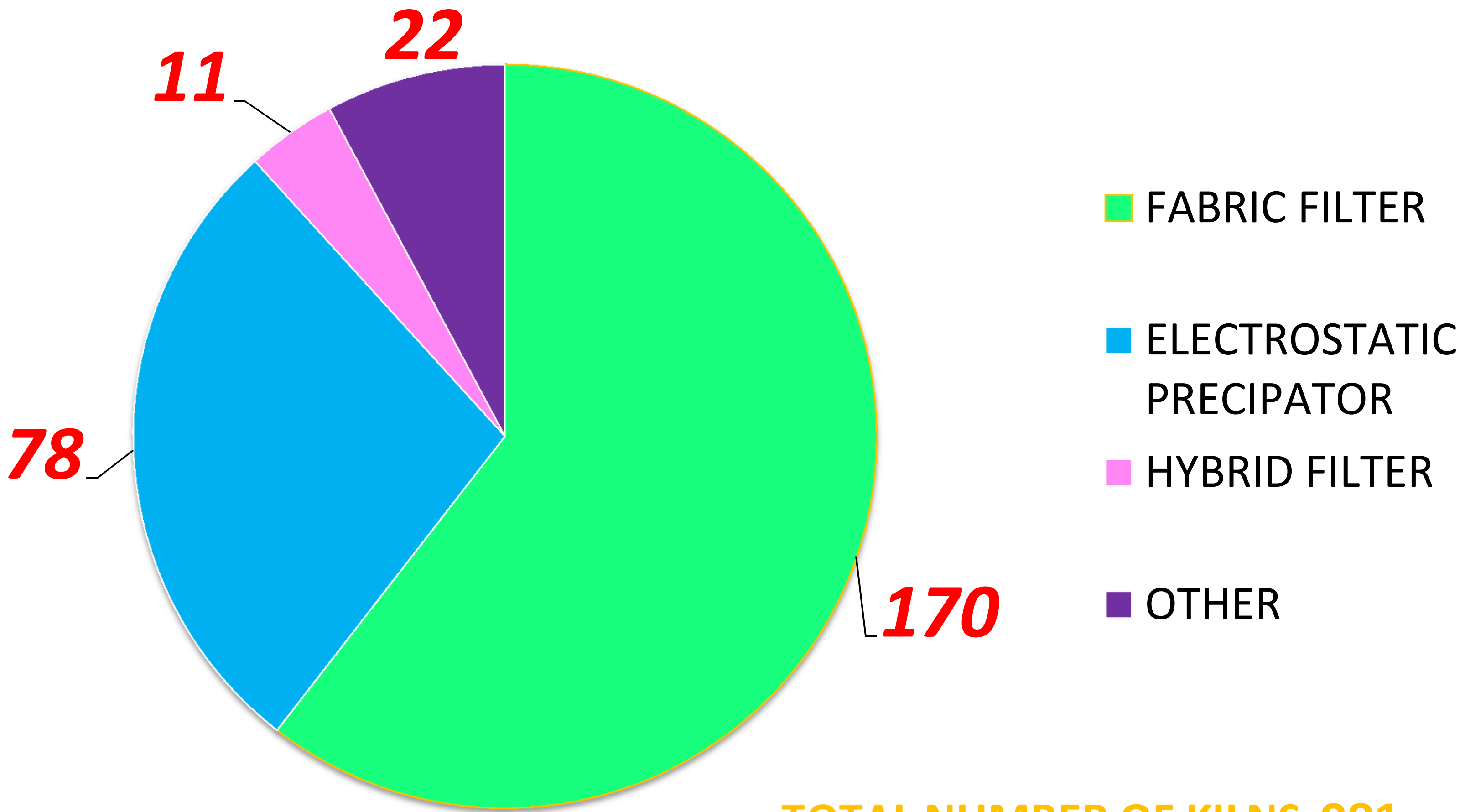
# CEMBUREAU EMISSION REPORT 2018 FOR THE YEAR 2016 DUST ABATEMENT SYSTEMS INSTALLED IN EU 28




TOTAL NUMBER OF KILNS 281

# Costs for dust abatement

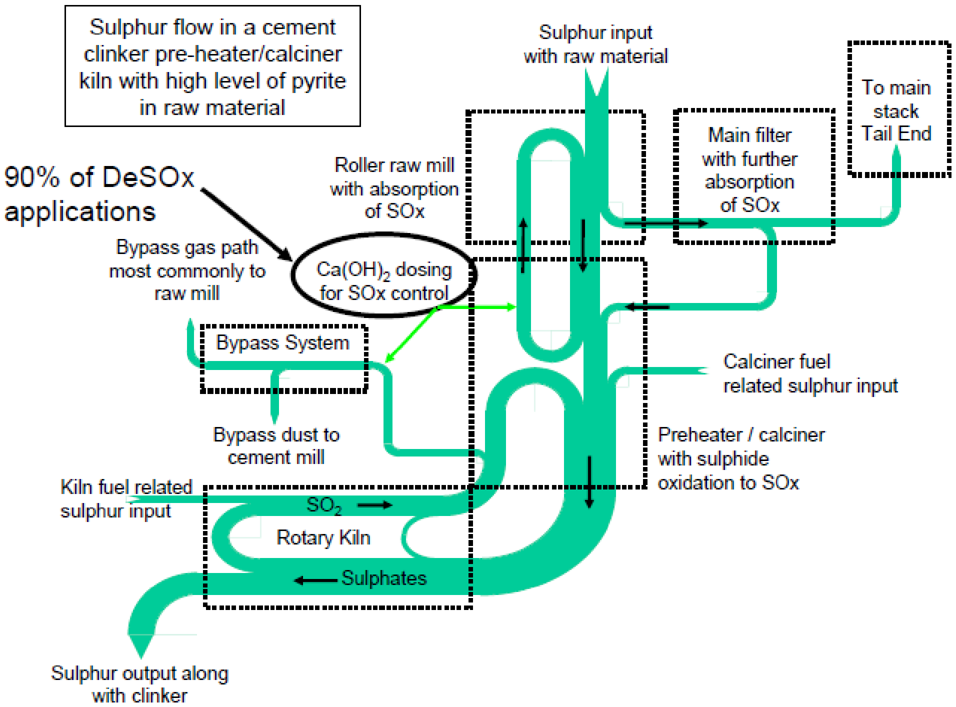
| M€ | Capital expenditure | Operational expenditure |
|---|---|---|
| ESP | 2,1-6,0 | 0,1-0,2 |
| Bag Filter | 2,1-6,0 | 0,15-0,35 |

**Source: cement Bref 2013**

The capital cost range for both the technologies can be restricted between 2 and 3 M€, being the cost of ESP closer to 2 M€ and that of a fabric filter equipped with high quality bags (fiber glass PTFE coated) closer to 3 M€.
The operational costs are clearly in favor of ESP, because the bag life is in general no longer than 3 years and to the cost of each single bag it is necessary to add the costs for the bag substitution, about 30 % of the bag.
Nevertheless the performance reliability of bag filters makes this technology the preferred between the two, even if more expensive.

# $SO_2$

- In Europe the large majority of the burning lines is not affected by $SO_2$ emission problems, because, in normal operating conditions, all the Sulphur introduced in the process with fossil fuels is absorbed by the process itself.
- Nevertheless, whenever reduced Sulphur compounds are presents in the raw materials, $SO_2$ emissions may appear at the stack at levels exceeding the emission limits.



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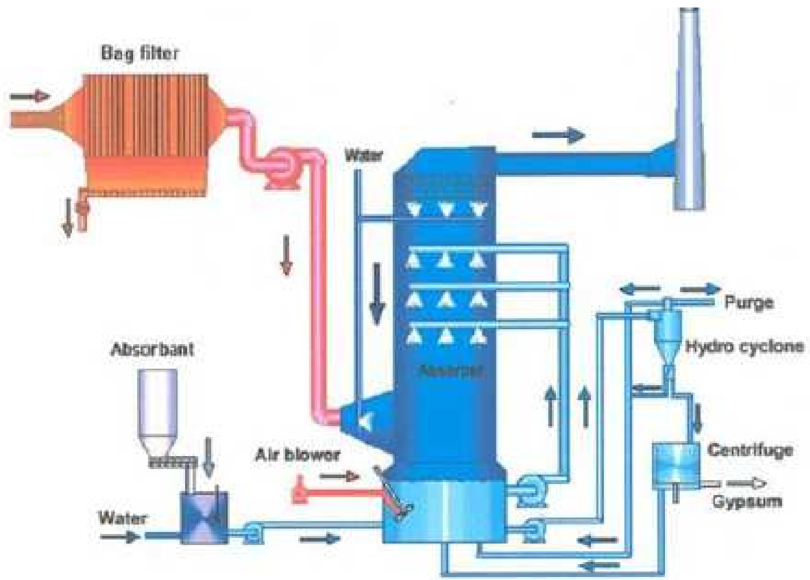
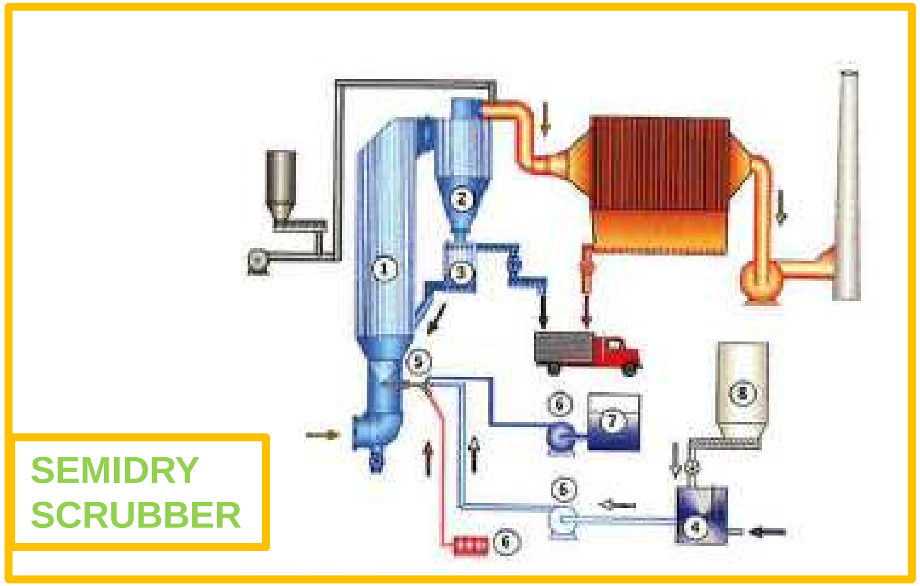
## $SO_2$ : Wet Scrubber

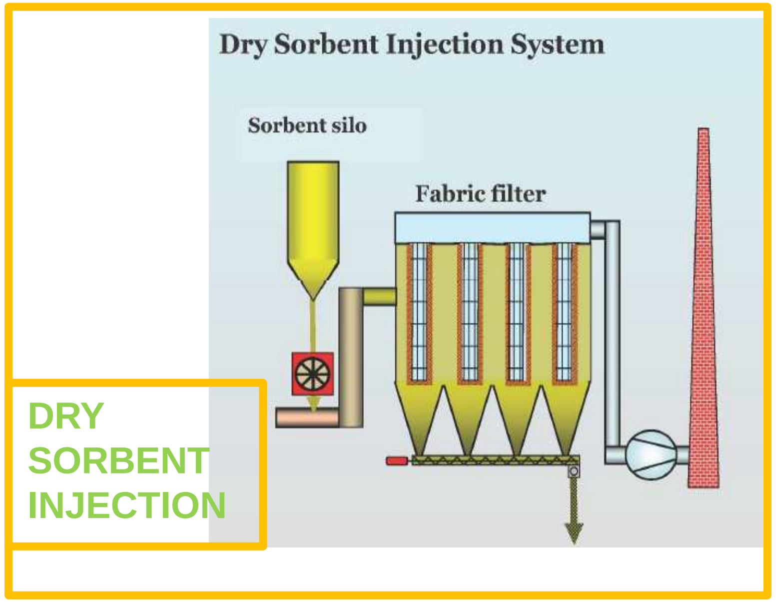
The Wet Scrubber Technology is applied when the uncontrolled emission levels are high, hundreds or even thousands of mg/Nm$^3$. The advantage of this technology is that in some case it is possible to use the same raw meal prepared for the kiln as sorbent and, on top of that, the slurry, after mechanical drying, can be reused in the cement as natural gypsum. This technology is characterizes by high levels of electrical energy and water consumption.




## $SO_2$ : Semidry Scrubber and Dry Sorbent injection

- The Semidry Scrubber Technology is less expensive than the Wet but it is necessary to use more expensive sorbents like hydrated lime and the conversion to gypsum is limited to 20-25%, the rest being calcium sulphite not suitable for cement production.
- The Dry Technology is applied mainly to control low emission levels or emission spikes. The sorbent is Calcium Oxide or Sodium Bicarbonate. It is applied also to keep the $SO_2$ emissions always under control when SCR technology is used for $NO_x$ abatement, to avoid damages to the catalyze**r.**



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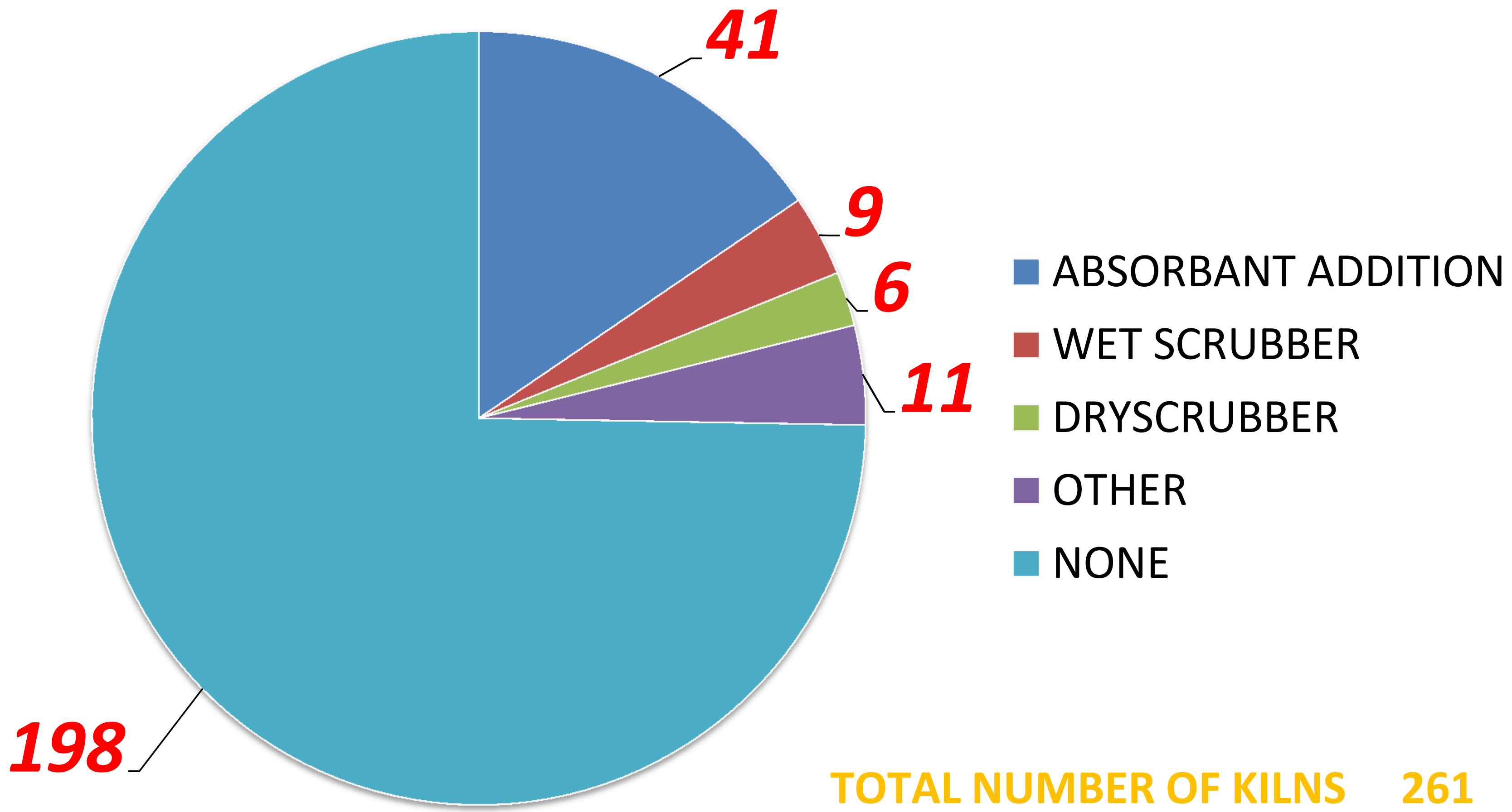
# CEMBUREAU EMISSION REPORT 2018 FOR THE YAR 2016
# $SO_2$ ABATEMENT SYSTEMS INSTALLED IN EU 28




TOTAL NUMBER OF KILNS 261



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# Costs for $SO_2$ abatement

| | Capital expenditure M€ | Operational expenditure €/t $_{clinker}$ |
|---|---|---|
| Wet Scrubber | 5,8 - 23 | 0,5 - 2 |
| Semidry Scrubber | - | - |
| Dry Sorbent Injection | 0,2 - 0,3 | 0,1 - 0,4 |

**Source: cement Bref 2013**

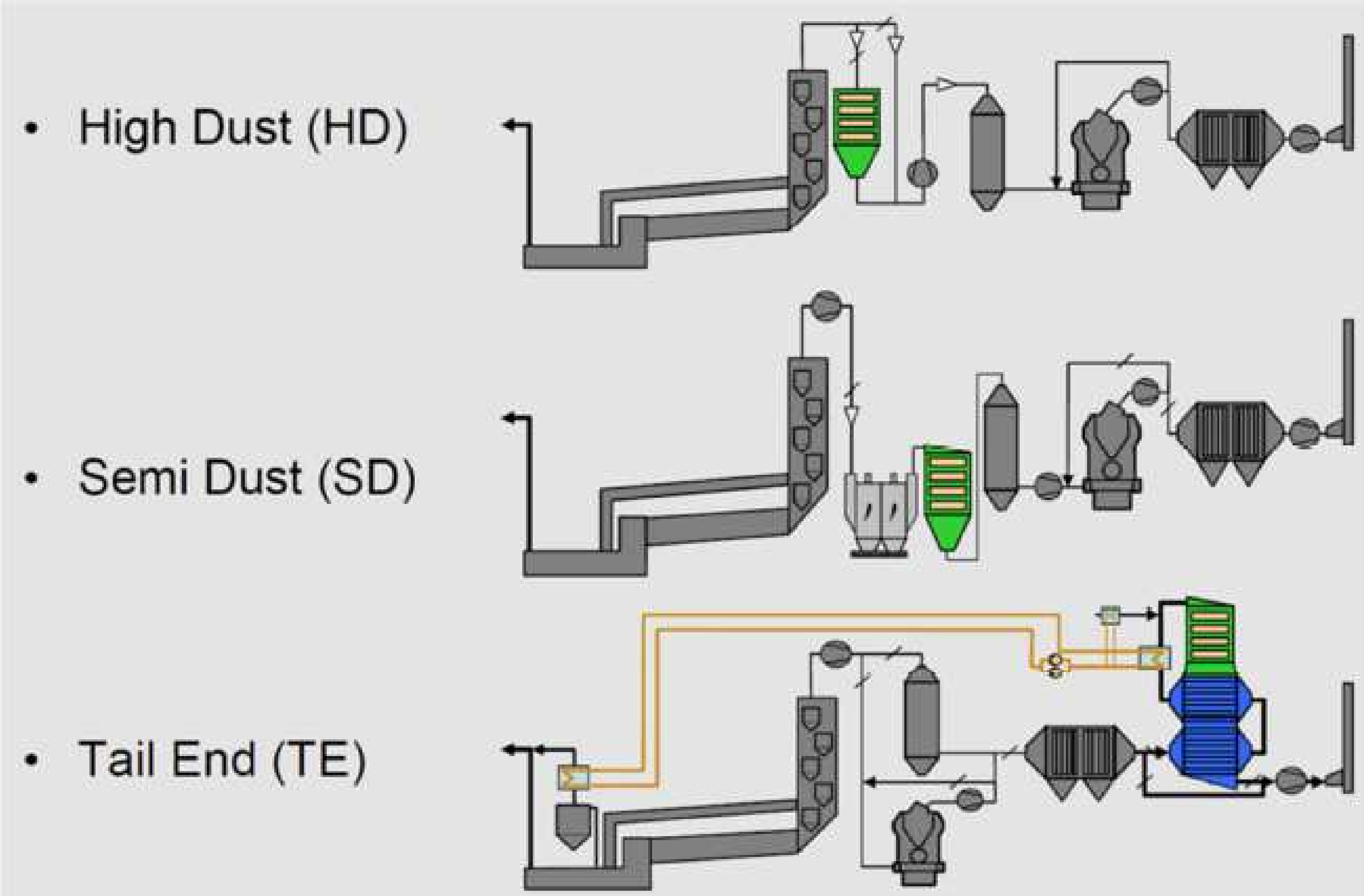
The costs reported by the Cement Bref can be confirmed. Unfortunately for wet scrubbers site specific situations influence a lot the level of investment and consequently the range is very large. Values around 10 M€ are more frequent.

Dry sorbent injection is frequently connected with the SCR technology for $NO_x$ abatement, because even low concentration of $SO_2$ can seriously damage the catalyzer (formation of ammonium sulphate on the catalyzer surface). To this purpose the use of Sodium Bicarbonate (~ 300 €/t) is preferred to Calcium oxide (~100 €/t) or hydrated lime because of its higher reactivity.

# $NO_x$

- The abatement technologies for $NO_x$ reduction are still under development. The primary measures, implemented to reduce the amount of $NO_x$ produced by the burning line, are widely used but in the majority of the cases it is very difficult to guarantee emission values below 700-800 mg/Nm$^3$. Secondary measures are consequently necessary for the respect of ELV lower than 800 mg/Nm$^3$.
- Two technologies are today available:
  - SNCR: water- urea solution or water-ammonia solution injection in the kiln calciner at around 900°C
  - SCR: catalytic reduction per ammonia-$NO_x$ reaction at 300-400°C.
- The first is a well developed technique and it is capable to reduce emissions below 500 mg/Nm$^3$ up to 200 mg/Nm$^3$.
- The second has still a limited number of applications and not always the performance, mainly in terms of continuous operation and catalyst operating life, are met.

# Three possible technical solutions for SCR application



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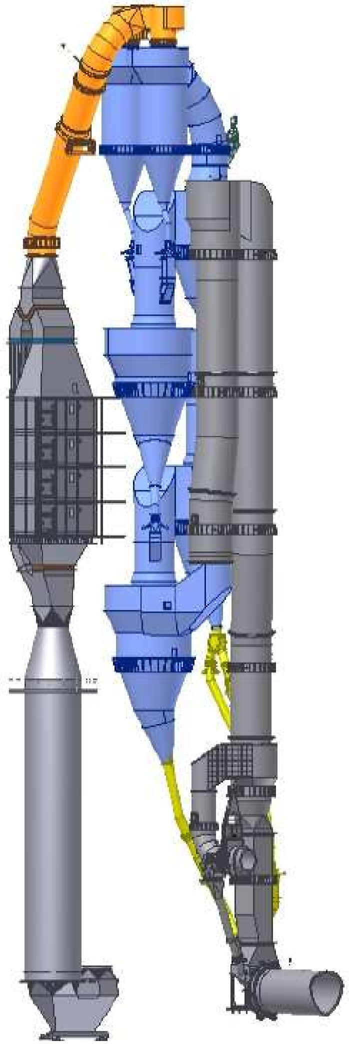
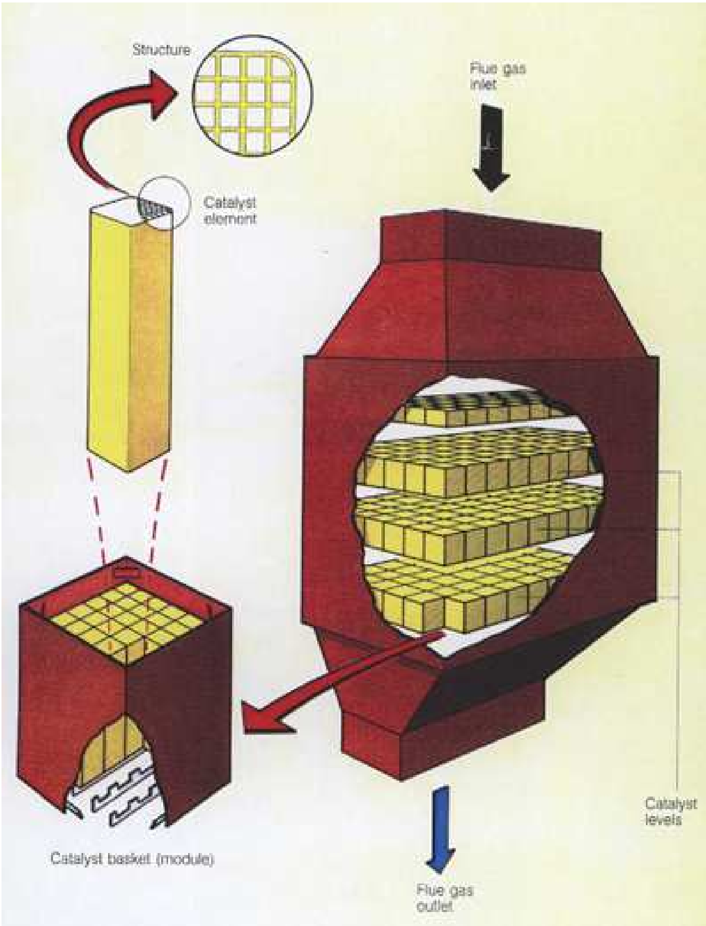
# High dust SCR





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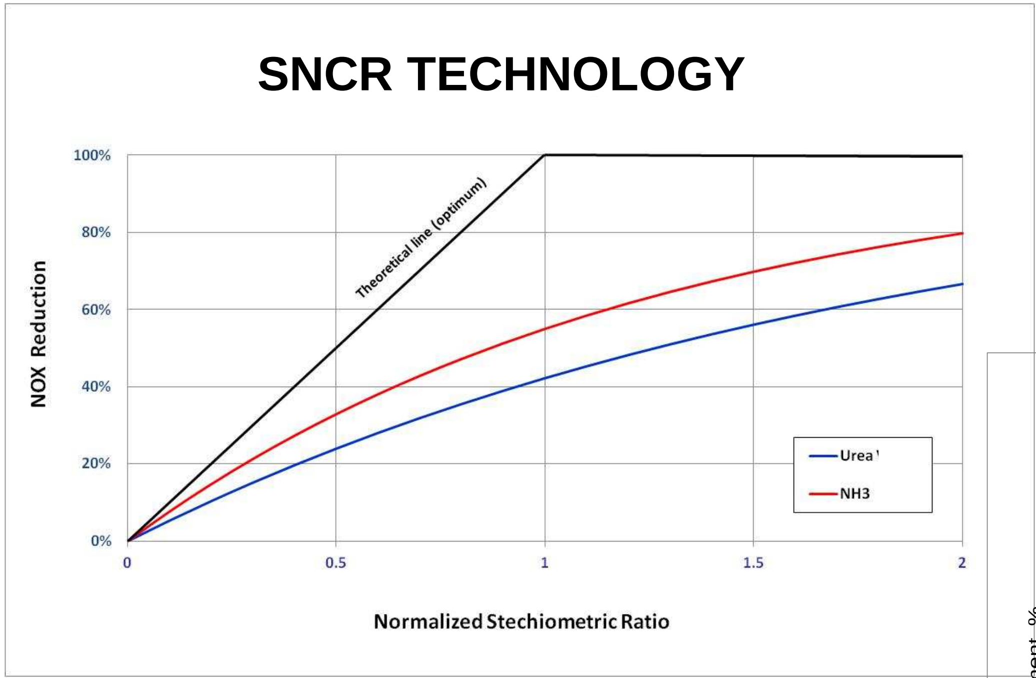
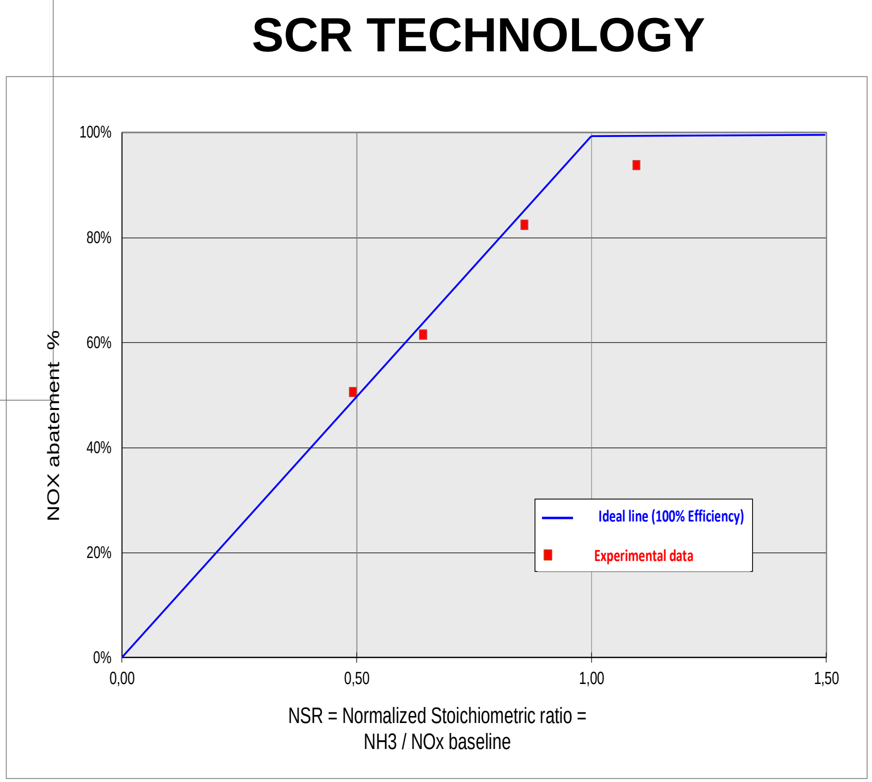
# Efficiency comparison



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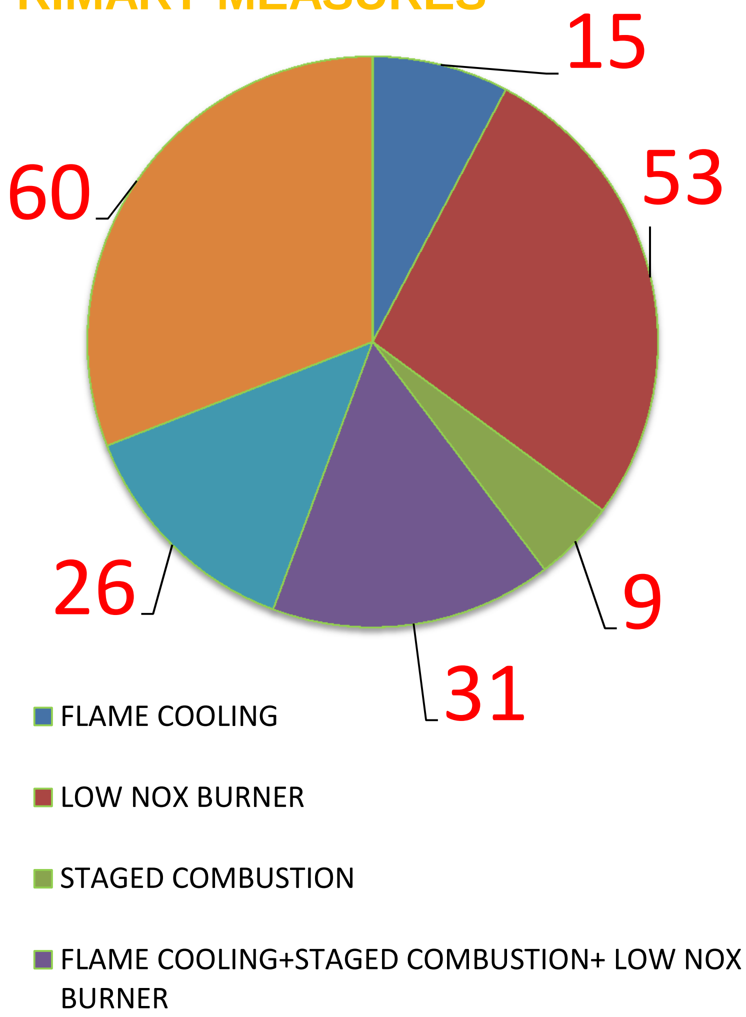
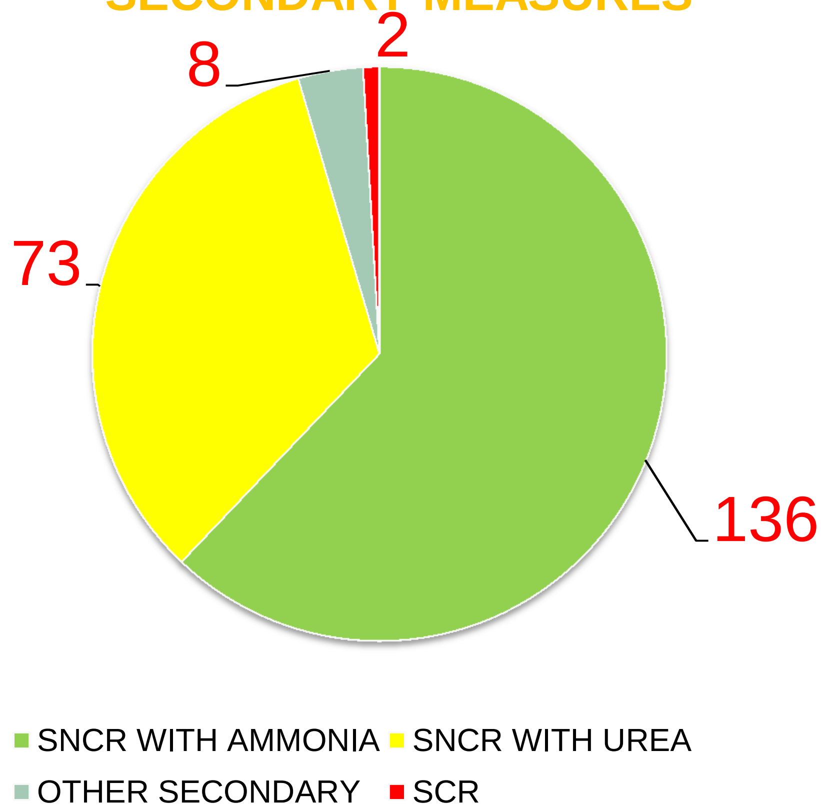
# CEMBUREAU EMISSION REPORT 2018 FOR THE YEAR 2016 $NO_x$ ABATEMENT SYSTEMS INSTALLED IN EU 28

PRIMARY MEASURES




SECONDARY MEASURES




TOTAL NUMBER OF KILNS 261



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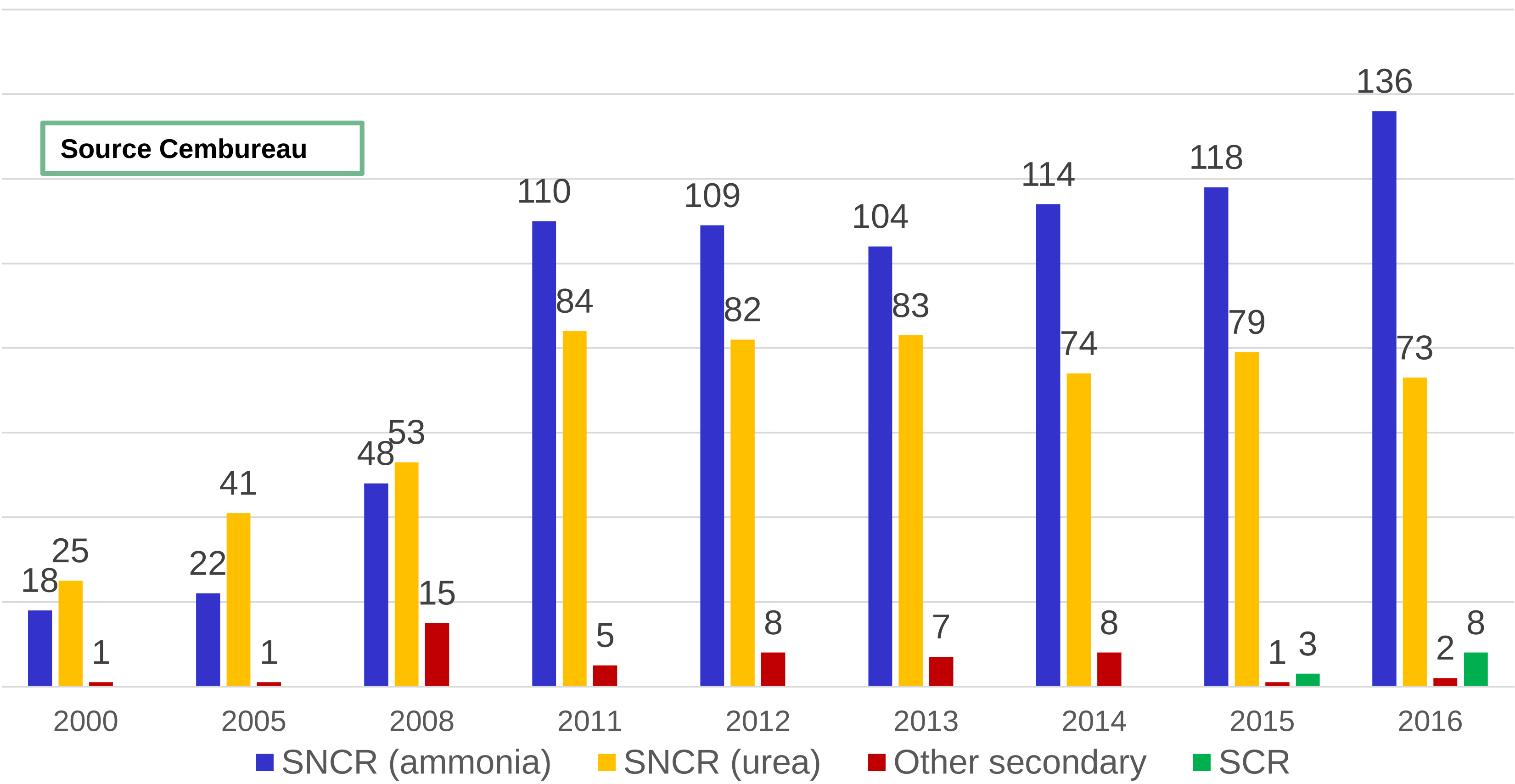
# NO$_x$ secondary abatement installed



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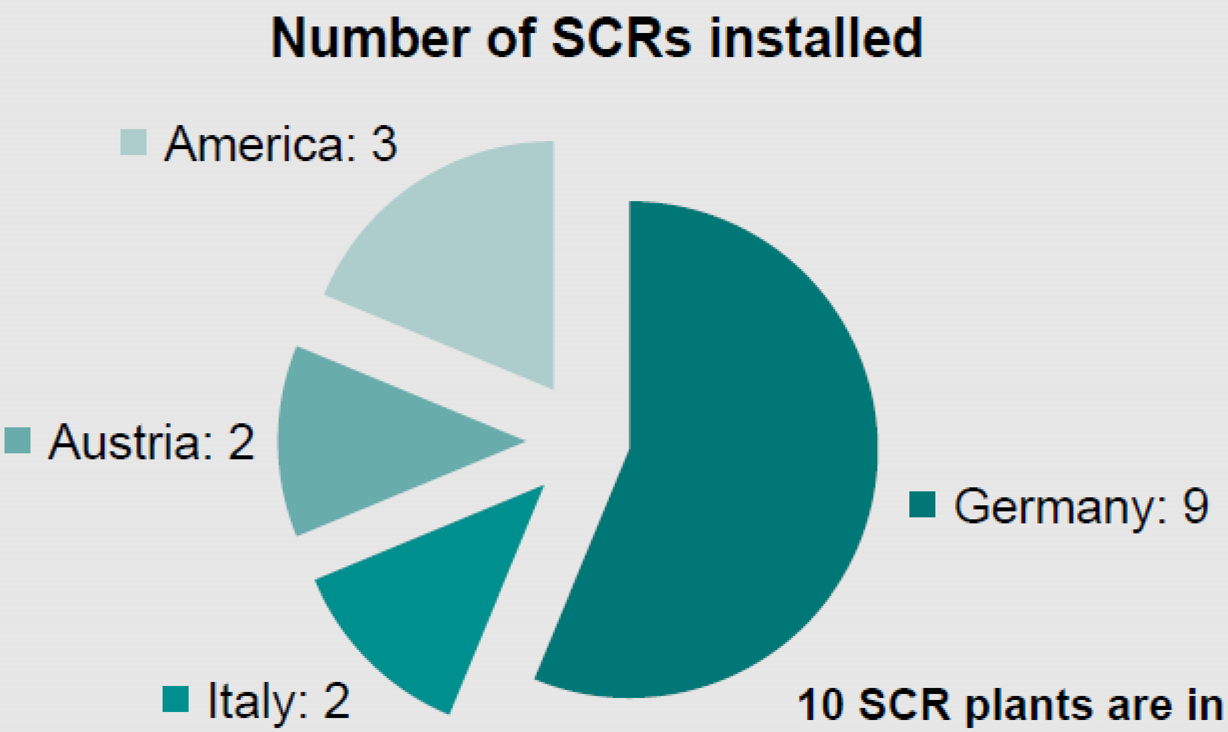
# NO$_x$ secondary abatement installed

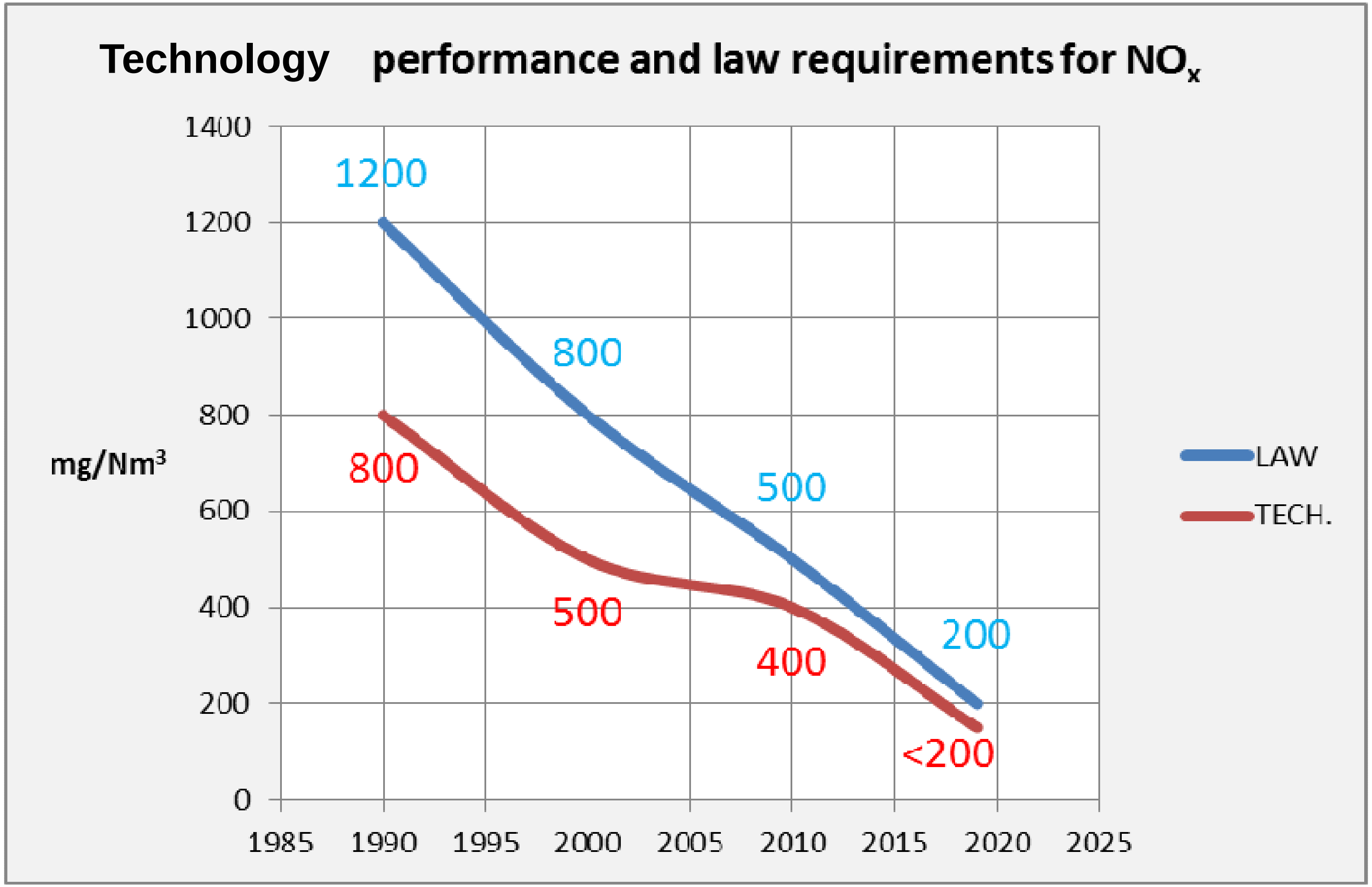
## SCRs installed – status 2018




**10 SCR plants are in concrete planning;**
**⇒ 19 SCR plants in near future**

**Source VDZ**

# Progressive gap reduction between technology performance and law requirements



# Costs for $NO_x$ abatement

| | Capital expenditure M€ | Operational expenditure €/t $_{clinker}$ |
|---|---|---|
| SNCR | 0,5 – 1,2 | 0,1 – 1,7 |
| SCR | 2,2 – 4,5 | 0,33 – 3,0 |

**Source: cement Bref 2013**

The cost evaluation reported by Cement Bref can be confirmed only as far as the SNCR technology is concerned. The operational expenditure for SCNR is in general close to 0,7 €/t of clinker and more and more ammonia-water solution (~150 €/t) is used instead of urea solution, having almost the same price but a lower efficiency.
At the time of Bref document, basically written in 2009-2010, the SCR technology, not labeled yet at full right as a BAT, had just a couple of applications and only one -HD type- in full operation. Since then steps forward have been done to avoid and to solve the problems put in evidence by those first trials.

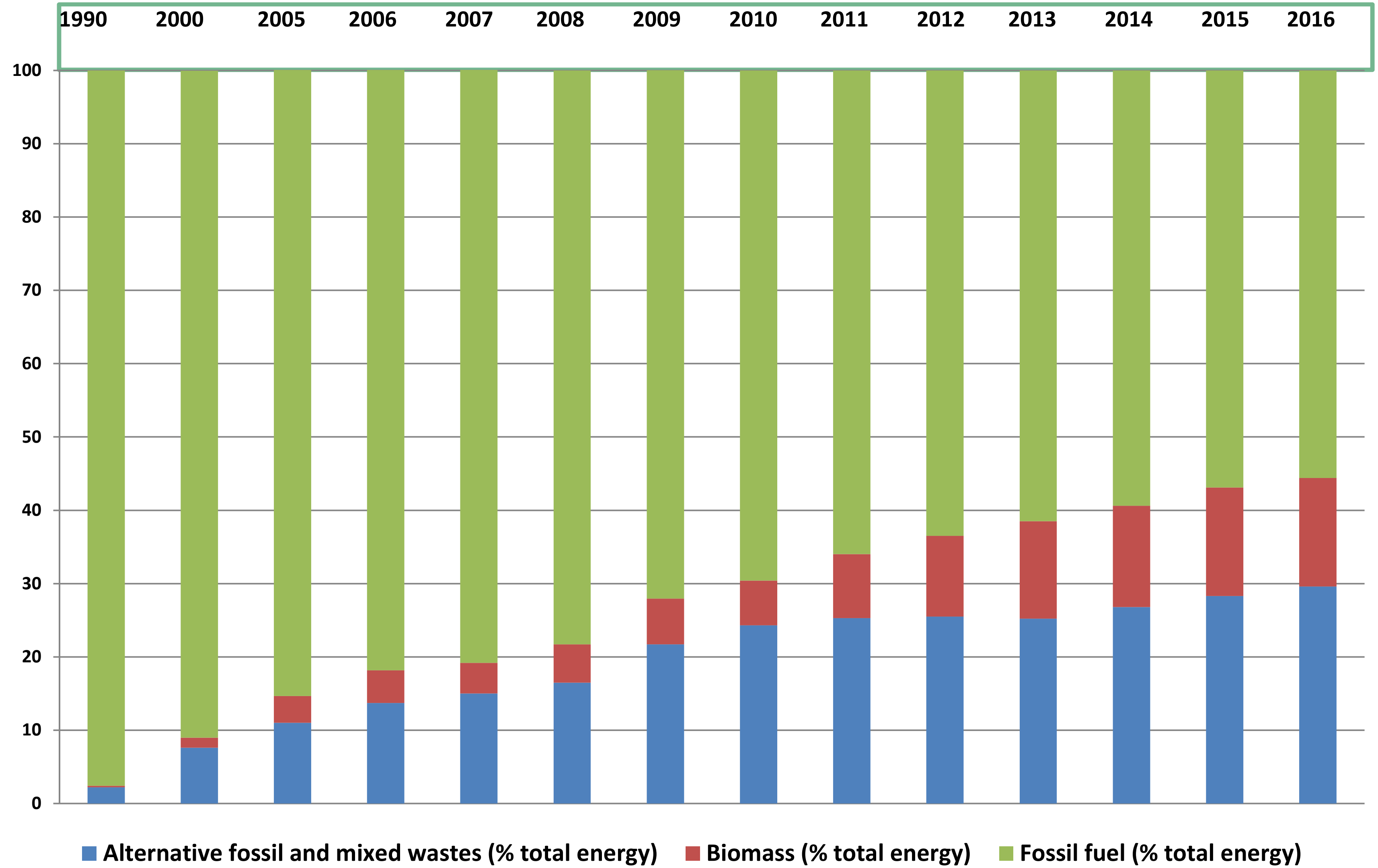
# Costs for $NO_x$ abatement

| Costs | $NO_x$ abatement technique | | |
|---|---|---|---|
| | SNCR | HD-SCR | LD-SCR |
| Investment (Mio. Euro) | 1 | 10 * | 15 * |
| Operating costs (Euro/t clinker) | 0.7 | 0.8 – 1.5 ** | 0.5 *** |
| Total ownership cost (Euro/t clinker) | 0.8 | 2 – 3 | 2.5 – 3 |

* 3000 tpd cli. capacity
** lifetime 2 - 4 years
*** lifetime 10 years

The costs reported in the table issued by VDZ, based on the last generation of abatement devices, include also Low Dust SCR, much more expensive because of more complex connections with the burning line, but operating in better conditions due to the absence of high dust levels. It is probably too early to draw final conclusions. For future projects it is expected that the investment will be a little reduced by the fact that the increase in experience will limit the oversizing of the installations. To be considered also that the increase in the use of alternative fuel progressively reducing the amount of $NO_x$ emission**. At present catalyzer life is still an issue, jeopardizing the applicability in general sense of this technology.**

# EU 28 THERMAL ENERGY SOURCES % DISTRIBUTION




Source Cembureau

# Major benefits associated with BAT implementation but also some drawbacks

Keeping in mind that the priorities are site specific, it is possible to identify at least the following benefits and drawbacks deriving from the adoption of BAT techniques:

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1. Compliance of the plant with the EU regulations.
2. Possibility to obtain permits for the use or further increase of the use of waste fuels (45% in term of thermal energy in 2016) and secondary raw materials (8,36 Mt in 2016) in the burning process.
3. Possibility to justify the necessity of process modifications in order to update the existing technology.
4. Production capacity increase without increment in term of environmental footprint.
5. Improvement of the relationships with the local community and of the image and the value of the plant.

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6. E.E. consumption increase (in some case more than 10 kWh/t cement).
7. Maintenance cost increase.
8. Introduction of chemicals, Ammonia water solution or Urea in particular.

# Thanks for your attention.

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